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Chapter 3

# Labor per Unit of Product in Individual Industries

THE factors making for change in the ratio of employment to product have acted on all industries, but in varying degree. For this reason the trends in labor per unit have differed not only among groups of manufacturing industries, as we observed in the preceding chapter, but also among industries within the same group. These movements are examined in the present chapter.

## INDUSTRIAL VARIATION AMONG TRENDS IN LABOR PER UNIT

The reader may recall from Chapter 1 that by 1937, in all manufacturing industries combined, the number of workers employed per unit of product had dropped to approximately one half of the number required to produce the same amount of goods in 1899. This average for manufacturing in the aggregate conceals wide variations from industry to industry. Thus Chart 11, which provides a summary of the indexes of workers per unit for 51 industries (the only ones for which data spanning the period 1899–1937 are available) shows an index of less than 20 percent at one extreme and an index of 225 at the other. The majority of the 51 industries are found within a fairly wide belt: in the middle two thirds, representing 33 industries, the ratio of labor to product in 1937 ranged from less than 40 percent to about 90 percent of the 1899 ratio. In only 8 of the 51 industries are indexes of employment per unit of product found above the 1899 level.

The details are presented in Table 1 (pp. 47-51). Besides the industries covered in the chart, for which data are available for 1899 and 1937, many others with series which do not go all the way back to 1899 or forward to 1937 appear here, as do also several for which we have been able to push our indexes even farther back than 1899. This table differs further from Chart 11 in that the measures represent average annual percentage rates of change in wage earners per unit, rather than indexes for 1937 relative to 1899.

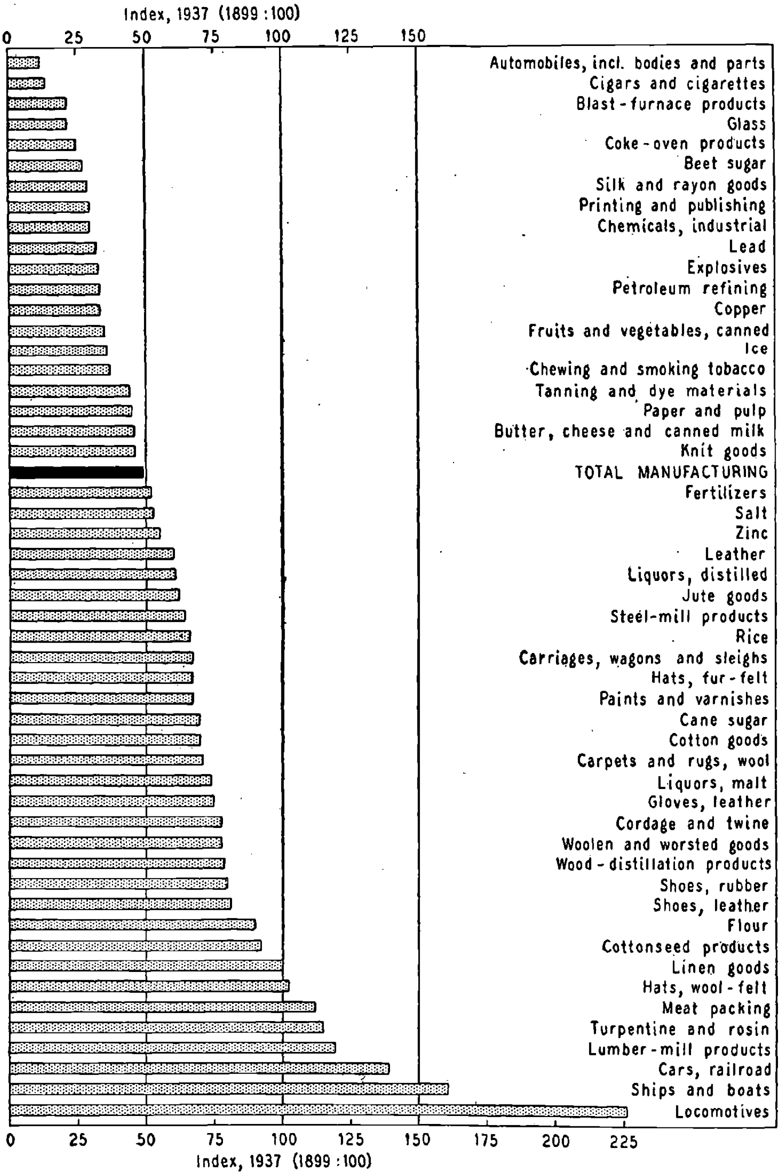
There was a variety of trends in employment per unit of output not only within manufacturing as a whole, as was indicated by Chart 11, but also within each of the major categories into which the individual industries are grouped in Table 1. Among the industries in the food group, for example, the most rapid rate of decline over the period 1899–1937 was 3.5 percent per annum in beet sugar manufacture, while in meat packing during the same period there was an average annual rise of 0.3 percent. An even more striking illustration of wide dispersion is provided by the transportation equipment group: in automobiles there was an average annual decline of 5.4 percent and in locomotives an annual rise of 2.2 percent between the years 1899 and 1937. These two industries producing transportation equipment are, of course, the extremes which are found also in Chart 11.

The addition of industries for which the indexes apply to less than 38 years provides some instances of decline in labor per unit even more spectacular than that found in automobile manufacture. In three of the industries for which the period covered is shorter than 38 years—nonalcoholic beverages, knit cloth, and pens and penpoints—the annual rate of decline exceeded 10 percent. Nevertheless when we add up all the industries for which data are available, including those for which the series apply to more as well as less than 38 years, the proportion with increases in wage earners per

Chart 11

## INDIVIDUAL MANUFACTURING INDUSTRIES

### Index of Wage Earners Employed per Unit of Product, 1937 (1899 : 100)




Based on Table 1

unit goes up. Whereas among the industries which appear in Chart 11 (covering 1899–1937) less than 14 percent showed rises in the employment-output ratio, among the entire collection of industries for which there are data (here the periods covered range from 1869–1939 in some industries to 1931–1939 in one) the percentage of those with rises in the ratio of workers to product is almost 19. This increased proportion may be explained by the fact that most of the added indexes are rather short series which cover only the more recent years (1927 or 1929 to 1937 or 1939) during which there was little decline, on the average, in wage earners per unit. The longer series cover not only this period of little change but also preceding periods during which employment per unit declined rapidly. The differences between the last two columns of Table 1 therefore reflect primarily the presence of fluctuations in the rate of decline in employment per unit. These fluctuations will be considered later in this chapter.[1]

Rises in employment in relation to output must reflect cuts in the work week, or increases in the number of man-hours required per unit of product, or both. As we have already seen, reductions in hours per week occurred in manufacturing considered as a whole. There were cuts also in every

[1] A word must be said about total employment (including proprietors and salaried personnel as well as wage earners) per unit of product. Total employment offered by all manufacturing industries combined rose a little more rapidly during the last four decades than did the number of wage earners alone. For this reason all workers per unit of product fell a little less rapidly than wage earners per unit. The close correspondence is found not only in aggregate manufacturing, but also in individual industries. Total employment per unit fell a little less rapidly (or rose a little more rapidly) than wage earners per unit in 33 out of 61 industries, was equal to the latter in one industry, and fell somewhat more rapidly (or rose a little less rapidly) in 27 industries. In practically all cases the differences between the two were slight. Only in one industry was there a difference of sign: in wire manufacture wage earners declined slightly in relation to output, while total employment rose. (The preceding comparison relates to the period 1909–37. The complete series for individual industries, available at best for 1904–39, appear in Appendix F.)

TABLE 1

INDIVIDUAL MANUFACTURING INDUSTRIES

Average Annual Percentage Changes in Wage Earners per Unit of Product

| *Industry* | *Number of Wage Earners Employed in 1929* (1,000) | *Period Covered* | *Average Annual Percentage Rate of Change* In Period Covered | 1899–1937 |
|---|---|---|---|---|
| *Foods* | | | | |
| Meat packing | 122 | 1879–1939 | 0.5 | 0.3 |
| Sausage | 6 | 1929–1939 | −1.7 | |
| Oleomargarine | 2 | 1925–1939 | −6.5 | |
| Shortenings | 3 | 1927–1939 | 1.4 | |
| Flour | 27 | 1869–1939 | −0.9 | −0.3 |
| Feeds | 10 | 1927–1939 | 1.2 | |
| Cereals | 6 | 1925–1939 | 1.4 | |
| Rice | 2 | 1899–1939 | −1.2 | −1.1 |
| Macaroni | 5 | 1927–1939 | −0.6 | |
| Bread and cake | 167 | 1923–1939 | 1.1 | |
| Biscuits and crackers | 34 | 1923–1939 | −3.1 | |
| Fish, canned | 14 | 1904–1939 | 0.6 | |
| Fruits and vegetables, canned | 99 | 1899–1939 | −3.1 | −2.7 |
| Butter, cheese and canned milk | 30 | 1899–1939 | −2.2 | −2.0 |
| Milk, canned | 7 | 1904–1939 | −4.3 | |
| Butter | 19 | 1904–1939 | −1.8 | |
| Cheese | 3 | 1904–1939 | −0.9 | |
| Ice cream | 22 | 1923–1939 | −4.9 | |
| Beet sugar | 7 | 1899–1939 | −3.5 | −3.5 |
| Cane sugar, total | 16 | 1899–1939 | −0.8 | −1.0 |
| Cane sugar, not elsewhere made | 2 | 1909–1939 | −1.1 | |
| Cane-sugar refining | 14 | 1909–1939 | −0.0 | |
| Confectionery | 64 | 1925–1939 | −3.3 | |
| Chocolate | 6 | 1921–1939 | −5.0 | |
| Corn products | 7 | 1909–1939 | −1.3 | |
| Baking powder | 3 | 1927–1939 | −0.1 | |
| Ice | 32 | 1899–1939 | −2.9 | −2.7 |
| *Beverages*[a] | | | | |
| Liquors, malt | [b] | 1899–1939 | −1.3 | −0.8 |
| Liquors, distilled | 1 | 1899–1939 | −1.1 | −1.3 |
| Malt | 1 | 1925–1939 | −0.7 | |
| Liquors, vinous | * | 1923–1939 | −8.5 | |
| Beverages, nonalcoholic | 28[b] | 1931–1939 | −10.4 | |
| *Tobacco products* | | | | |
| Cigarettes and cigars | 105 | 1899–1939 | −5.0 | −5.0 |
| Cigarettes | 21 | 1904–1939 | −5.9 | |
| Cigars | 84 | 1869–1939 | −1.0 | |
| Chewing and smoking tobacco | 11 | 1899–1939 | −2.4 | −2.6 |

*For footnotes see page 51.*

TABLE 1 (continued)

INDIVIDUAL MANUFACTURING INDUSTRIES

Average Annual Percentage Changes in Wage Earners per Unit of Product

| *Industry* | *Number of Wage Earners Employed in 1929* (1,000) | *Period Covered* | *Average Annual Percentage Rate of Change* In Period Covered | 1899–1937 |
|---|---|---|---|---|
| *Textile products* | | | | |
| Cotton goods | 425 | 1869–1939 | −1.4 | −0.9 |
| Lace goods | 7 | 1914–1939 | −2.9 | |
| Woolen and worsted goods | 147 | 1879–1939 | −0.7 | −0.6 |
| Woolen goods | 58 | 1909–1931 | −0.4 | |
| Worsted goods | 88 | 1909–1931 | −0.2 | |
| Silk and rayon goods | 130 | 1879–1939 | −3.4 | −3.2 |
| Knit goods, total | 208 | 1869–1939 | −1.8 | −2.0 |
| Hosiery, knit | 130 | 1923–1939 | −2.4 | |
| Underwear, knit | 41 | 1923–1939 | −2.0 | |
| Outerwear, knit | 29 | 1923–1939 | −2.8 | |
| Cloth, knit | 8 | 1923–1931 | −10.7 | |
| Carpets and rugs, wool | 33 | 1899–1939 | −1.2 | −0.9 |
| Asphalted-felt-base floor covering and linoleum | 8 | 1919–1939 | −2.0 | |
| Asphalted-felt-base floor covering | 2 | 1921–1937 | −2.4 | |
| Linoleum | 6 | 1921–1937 | −0.1 | |
| Oilcloth and artificial leather | 4 | 1923–1939 | −1.5 | |
| Oilcloth | 1 | 1904–1937 | 0.8 | |
| Artificial leather | 3 | 1923–1937 | −0.8 | |
| Cordage and twine | 14 | 1899–1939 | −1.0 | −0.7 |
| Jute goods | 5 | 1899–1939 | −1.7 | −1.3 |
| Linen goods | 2 | 1899–1939 | 0.2 | 0.1 |
| Clothing, men's, incl. work clothing | 189 | 1927–1939 | 0.3 | |
| Gloves, textile | 9 | 1927–1939 | 2.2 | |
| Shirts and collars, men's | 63 | 1927–1939 | 0.4 | |
| Clothing, women's | 188 | 1927–1939 | 0.6 | |
| Corsets | 14 | 1927–1937 | −0.9 | |
| Handkerchiefs | 6 | 1927–1939 | −1.8 | |
| Elastic woven goods | 4 | 1927–1939 | −3.0 | |
| Hats, fur-felt | 16 | 1899–1939 | −1.3 | −1.0 |
| Hats, cloth | 6 | 1927–1937 | 0.0 | |
| Hats, straw, men's | 3 | 1927–1939 | −1.3 | |
| Hats, wool-felt | 2 | 1879–1939 | −0.3 | 0.1 |
| Wool shoddy | 2 | 1889–1933 | −1.5 | |
| *Leather products* | | | | |
| Leather | 50 | 1889–1939 | −0.7 | −1.3 |
| Shoes, leather | 206 | 1869–1939 | −0.9 | −0.6 |
| Gloves, leather | 9 | 1899–1939 | −0.9 | −0.8 |
| Belting, leather | 3 | 1927–1939 | 1.1 | |

| *Industry* | *Number of Wage Earners Employed in 1929* (1,000) | *Period Covered* | *Average Annual Percentage Rate of Change* In Period Covered | 1899–1937 |
|---|---|---|---|---|
| *Rubber products* | | | | |
| Shoes, rubber | 26 | 1899–1939 | −0.7 | −0.6 |
| Rubber goods, other, incl. tires and tubes | 123 | 1919–1939 | −4.3 | |
| Tires and Tubes | 83 | 1921–1939 | −4.3 | |
| Rubber goods, other | 40 | 1927–1939 | −1.6 | |
| *Paper products* | | | | |
| Paper and pulp | 128 | 1879–1939 | −2.7 | −2.1 |
| Paper | 103 | 1927–1939 | −1.8 | |
| Pulp | 25 | 1927–1939 | −3.7 | |
| Wall paper | 5 | 1929–1939 | −1.5 | |
| *Printing and publishing* | | | | |
| Total | 358 | 1899–1939 | −3.0 | −3.1 |
| *Chemical products* | | | | |
| Chemicals, industrial, incl. rayon and compressed gases | 105 | 1899–1939 | −3.4 | −3.1 |
| Chemicals, industrial | 62 | 1927–1939 | −3.4 | |
| Gases, compressed | 3 | 1927–1939 | −4.0 | |
| Rayon | 39 | 1923–1939 | −7.8 | |
| Cottonseed products | 16 | 1899–1939 | −0.5 | −0.2 |
| Linseed products | 3 | 1923–1939 | −0.5 | |
| Carbon black | 2 | 1914–1939 | −4.3 | |
| Soap | 14 | 1904–1939 | −2.3 | |
| Wood-distillation products and charcoal | 5 | 1921–1939 | −2.9 | |
| Wood-distillation products | 5 | 1899–1937 | −0.6 | −0.6 |
| Charcoal | * | 1921–1937 | −1.4 | |
| Explosives | 6 | 1889–1939 | −2.5 | −2.9 |
| Fertilizers | 21 | 1899–1939 | −1.7 | −1.7 |
| Glue and gelatin | 3 | 1927–1939 | −2.5 | |
| Paints and varnishes | 29 | 1899–1939 | −1.3 | −1.0 |
| Salt | 6 | 1869–1939 | −1.8 | −1.7 |
| Tanning and dye materials | 2 | 1899–1939 | −2.6 | −2.2 |
| *Petroleum and coal products* | | | | |
| Petroleum refining | 81 | 1879–1939 | −3.6 | −2.8 |
| Coke-oven products | 21 | 1879–1939 | −2.2 | −3.6 |
| Fuel briquettes | * | 1909–1939 | −1.9 | |

TABLE 1 (concluded)

INDIVIDUAL MANUFACTURING INDUSTRIES

Average Annual Percentage Changes in Wage Earners per Unit of Product

| *Industry* | *Number of Wage Earners Employed in 1929* (1,000) | *Period Covered* | *Average Annual Percentage Rate of Change* In Period Covered | 1899–1937 |
|---|---|---|---|---|
| *Stone, clay and glass products* | | | | |
| Asbestos products | 8 | 1927–1937 | 1.7 | |
| Roofing | 6 | 1929–1939 | 0.5 | |
| Cement | 33 | 1904–1939 | −2.9 | |
| Lime | 9 | 1904–1939 | −1.5 | |
| Wallplaster and board | 7 | 1927–1939 | −1.1 | |
| Concrete products | 16 | 1925–1939 | −3.8 | |
| Sand-lime brick | 1 | 1914–1939 | −2.4 | |
| Clay products | 93 | 1914–1939 | −0.9 | |
| Glass | 68 | 1899–1939 | −3.7 | −3.8 |
| *Forest products* | | | | |
| Lumber-mill products | 419 | 1899–1939 | 0.2 | 0.5 |
| Planing-mill products | 90 | 1925–1939 | −0.7 | |
| Boxes, wooden, cigar | 4 | 1927–1939 | −1.4 | |
| Cooperage | 11 | 1927–1939 | 1.6 | |
| Caskets and coffins | 13 | 1927–1939 | −2.0 | |
| Excelsior | 1 | 1925–1939 | 0.3 | |
| Turpentine and rosin | 40 | 1899–1939 | −0.3 | 0.4 |
| *Iron and steel products* | | | | |
| Blast-furnace products | 25 | 1889–1939 | −3.4 | −3.9 |
| Steel-mill products | 395 | 1869–1939 | −2.2 | −1.2 |
| Wire | 22 | 1909–1939 | −0.4 | |
| Wrought pipe | 11 | 1925–1939 | 0.6 | |
| Cast-iron pipe | 20 | 1914–1939 | 0.4 | |
| Files | 4 | 1929–1939 | 0.1 | |
| Firearms | 7 | 1921–1939 | −3.1 | |
| Tin cans and tinware | 32 | 1927–1939 | −4.6 | |
| *Nonferrous-metal products* | | | | |
| Primary nonferrous metals | 31 | 1899–1939 | −2.5 | |
| Copper | 14 | 1899–1937 | −2.8 | −2.8 |
| Lead | 5 | 1899–1937 | −3.0 | −3.0 |
| Zinc | 12 | 1899–1937 | −1.6 | −1.6 |
| Secondary metals, nonprecious | 4 | 1925–1939 | −0.3 | |
| Collapsible tubes | 2 | 1925–1939 | −2.1 | |
| Nonferrous-metal products, not elsewhere classified | 79 | 1925–1939 | −0.9 | |
| Clocks, watches, and materials | 21 | 1927–1939 | −1.9 | |

| *Industry* | *Number of Wage Earners Employed in 1929* (1,000) | *Period Covered* | *Average Annual Percentage Rate of Change* In Period Covered | 1899–1937 |
|---|---|---|---|---|
| *Machinery* | | | | |
| Agricultural implements | 42 | 1921–1931 | 2.6 | |
| Phonographs | 14 | 1899–1929 | −0.4 | |
| Refrigerators, mechanical[b] | 17 | 1927–1939 | −9.6 | |
| Scales and balances | 4 | 1927–1937 | −2.2 | |
| Sewing machines | 10 | 1927–1939 | 0.8 | |
| Typewriters | 17 | 1921–1937 | −1.6 | |
| Washing and ironing machines | 8 | 1927–1939 | −5.3 | |
| *Transportation equipment* | | | | |
| Automobiles, incl. bodies and parts | 447 | 1899–1939 | −5.1 | −5.4 |
| Carriages, wagons and sleighs | 3 | 1889–1939 | −1.1 | −1.0 |
| Cars, railroad | 40 | 1899–1939 | 1.6 | 0.9 |
| Locomotives | 11 | 1889–1939 | 2.4 | 2.2 |
| Ships and boats | 55 | 1899–1939 | 0.7 | 1.3 |
| Motorcycles and bicycles | 4 | 1899–1929 | −3.4 | |
| Carriages and sleds, children's | 7 | 1925–1939 | −3.0 | |
| *Miscellaneous products* | | | | |
| Organs | 2 | 1904–1935 | −0.3 | |
| Pianos | 10 | 1904–1939 | −2.3 | |
| Buttons | 9 | 1914–1939 | −2.2 | |
| Brooms | 5 | 1927–1939 | −0.3 | |
| Pencils | 6 | 1929–1939 | −4.5 | |
| Pens and points | 5 | 1929–1939 | −10.6 | |
| Sporting goods | 11 | 1929–1939 | −0.3 | |

*Source:* Number of wage earners from data in Appendix Table B-1. Rates of change based on the indexes given in detail in Appendix F.

* 500 or less.

[a] Employment in the legal liquor industries was very low in 1929 because of enforcement of the prohibition amendment. In 1937 wage-earner employment was as follows:

| | (1,000) |
|---|---|
| Liquors, malt | 47 |
| Liquors, distilled | 6 |
| Malt | 2 |
| Liquors, vinous | 3 |
| Beverages, nonalcoholic | 28[b] |

[b] The malt liquor industry was not shown separately in 1929; it was included in nonalcoholic beverages.

individual industry of which we have record. The most comprehensive data available for individual industries, the Census reports on full-time hours for 1909 (adjusted roughly to an actual-time basis) and the Census and Bureau of Labor Statistics data on hours actually worked in 1937, indicate that all of 38 separate industrial series on hours declined from 1909 to 1937 (Table 2). The decline in hours per week was as large, in one case, as 24 hours (or 38 percent of the 1909 figure), and in none was it less than 9 hours (or 18 percent of the 1909 level).

The cuts in hours help to explain why the employment-output ratios of some industries failed to drop. It is true that reductions in hours tend to cause declines in manhours per unit of product by enhancing labor efficiency. But in the exceptional industries which did not reduce the employment-output ratio this indirect influence apparently was too weak (taken together, of course, with other factors affecting manhours per unit) to negate the direct effect upon employment of reductions in hours. As we see when we combine the information on changes that occurred in the length of the work week with what we know about workers per unit, and thus measure changes in manhours per unit (Table 3), the reduction in manhours per unit was so slight in some industries that there the decline in hours was sufficient to cause employment (in terms of number of workers) to rise in relation to output.

In view of the industrial variation with respect to curtailment of working time, it is pertinent to inquire whether hours were cut most severely in the industries which effected the greatest reduction in number of workers per unit and much less drastically in those which achieved only slight declines. Recourse to the data reveals no very significant correlation between long-term changes in hours in individual industries and corresponding changes in employment per

TABLE 2

INDIVIDUAL MANUFACTURING INDUSTRIES

Hours Worked per Week per Wage Earner, 1909 and 1937

| *Industry*[a] | *1909* | *1937* | *Change* Number | Percent |
|---|---|---|---|---|
| Cement | 61 | 38 | −23 | −38 |
| Cane-sugar refining | 60 | 38 | −22 | −38 |
| Carpets and rugs, wool | 53 | 33 | −20 | −38 |
| Blast-furnace products | 66 | 42 | −24 | −36 |
| Cotton goods | 55 | 35 | −20 | −36 |
| Woolen and worsted goods | 54 | 34 | −20 | −36 |
| Knit goods | 54 | 35 | −19 | −35 |
| Petroleum refining | 55 | 36 | −19 | −34 |
| Automobiles, incl. bodies and parts | 53 | 35 | −18 | −34 |
| Silk and rayon goods | 53 | 35 | −18 | −34 |
| Hats, fur-felt | 50 | 33 | −17 | −34 |
| Steel-mill products | 57 | 38 | −19 | −33 |
| Chemicals, industrial, incl. rayon and gases | 58 | 39 | −19 | −32 |
| Zinc | 58 | 39 | −19 | −32 |
| Canned fish, fruits and vegetables | 56 | 38 | −18 | −32 |
| Wire | 55 | 37 | −18 | −32 |
| Shoes, leather | 52 | 36 | −16 | −31 |
| Glass | 52 | 36 | −16 | −31 |
| Sugar, beet | 64 | 45 | −19 | −30 |
| Tobacco products, total | 50 | 35 | −15 | −30 |
| Paper and pulp | 58 | 41 | −17 | −29 |
| Fertilizers | 57 | 40 | −17 | −29 |
| Leather | 54 | 38 | −16 | −29 |
| Soap | 52 | 38 | −14 | −29 |
| Ships and boats | 52 | 37 | −15 | −28 |
| Liquors, distilled | 55 | 40 | −15 | −27 |
| Explosives | 55 | 40 | −15 | −27 |
| Cars, railroad | 53 | 39 | −14 | −27 |
| Lime | 57 | 42 | −15 | −26 |
| Lead | 55 | 42 | −13 | −24 |
| Meat packing | 54 | 41 | −13 | −24 |
| Flour | 57 | 44 | −13 | −22 |
| Lumber-mill products | 56 | 43 | −13 | −22 |
| Locomotives | 56 | 44 | −12 | −21 |
| Paints and varnishes | 52 | 41 | −11 | −21 |
| Cottonseed products | 65 | 52 | −13 | −20 |
| Printing and publishing, total | 47 | 38 | −9 | −19 |
| Copper | 55 | 45 | −10 | −18 |

*Source:* Appendix Table C-2. Only those industries for which indexes of physical output are available are listed here.

[a] Ranked according to percentage change in hours.

TABLE 3

INDIVIDUAL MANUFACTURING INDUSTRIES

Aggregate Wage-Earner Hours and Wage Earners Employed per Unit of Product: Percentage Changes, 1909-37[a]

| Industry[b] | Total Change: Wage-Earner Hours per Unit | Total Change: Wage Earners per Unit | Average Annual Rate of Change: Wage-Earner Hours per Unit | Average Annual Rate of Change: Wage Earners per Unit |
|---|---|---|---|---|
| Automobiles, including bodies and parts | −92 | −87 | −8.5 | −7.1 |
| Tobacco products, total | −85 | −79 | −6.7 | −5.5 |
| Glass | −78 | −68 | −5.3 | −4.0 |
| Silk and rayon goods | −77 | −66 | −5.1 | −3.7 |
| Blast-furnance products | −75 | −60 | −4.8 | −3.2 |
| Chemicals, industrial, incl. rayon and gases | −73 | −61 | −4.6 | −3.3 |
| Liquors, distilled | −67 | −54 | −3.9 | −2.8 |
| Knit goods | −67 | −49 | −3.9 | −2.4 |
| Beet sugar | −65 | −51 | −3.7 | −2.5 |
| Petroleum refining | −64 | −45 | −3.6 | −2.1 |
| Printing and publishing, total | −62 | −53 | −3.4 | −2.7 |
| Cement | −61 | −38 | −3.3 | −1.7 |
| Paper and pulp | −61 | −45 | −3.3 | −2.1 |
| Canned fish, fruits and vegetables | −60 | −41 | −3.2 | −1.9 |
| Explosives | −59 | −43 | −3.1 | −2.0 |
| Copper | −56 | −46 | −2.9 | −2.2 |
| Soap | −55 | −39 | −2.8 | −1.8 |
| Lead | −55 | −41 | −2.8 | −1.9 |
| Leather | −54 | −35 | −2.8 | −1.5 |
| Fertilizers | −54 | −35 | −2.8 | −1.6 |
| Lime | −54 | −37 | −2.7 | −1.6 |
| Carpets and rugs, wool | −51 | −22 | −2.5 | −0.9 |
| Cotton goods | −50 | −22 | −2.4 | −0.9 |
| Hats, fur-felt | −47 | −20 | −2.3 | −0.8 |
| Zinc | −45 | −20 | −2.1 | −0.8 |
| Shoes, leather | −43 | −19 | −2.0 | −0.7 |
| Woolen and worsted goods | −42 | −13 | −2.1 | −0.5 |
| Cane-sugar refining | −42 | −8.2 | −2.0 | −0.3 |
| Steel-mill products | −40 | −11 | −1.8 | −0.4 |
| Paints and varnishes | −39 | −24 | −1.8 | −1.0 |
| Flour | −37 | −20 | −1.7 | −0.8 |
| Lumber-mill products | −32 | −12 | −1.4 | −0.5 |
| Wire | −32 | 0.9 | −1.3 | 0.0 |
| Cottonseed products | −31 | −14 | −1.3 | −0.5 |
| Cars, railroad | −21 | 4.9 | −0.9 | 0.2 |
| Meat packing | −17 | 11 | −0.6 | 0.4 |
| Ships and boats | 0.8 | 41 | 0.0 | 1.2 |
| Locomotives | 142 | 209 | 3.2 | 4.1 |

*Footnotes to Table 3 at bottom of next page.*

unit of product. The amount by which hours were reduced in industries that cut employment per unit sharply differed only slightly from the amount by which hours were shortened in industries that lagged in decreasing employment per unit.[2] This does not mean that long-run declines in hours are entirely unrelated to changes in employment per unit; it points rather to the universality of the cut in the working week among all types of industries, including those with low rates of decline in manhours per unit.[3]

Manhours per unit of product fell in all but two of the industries for which we have reasonably adequate information. The exceptions are locomotive manufacture and shipbuilding, which were found among the eight industries listed above (Chart 11) as those in which *workers* per unit of prod-

[2] The coefficient of rank correlation between changes in hours (Table 2) and changes in workers per unit (Table 3) is .19 for 38 industries.

[3] Much the same phenomenon seems to characterize hourly earnings, as we shall see in Chapter 4.

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*Source:* Appendix F.

[a] For several industries not listed in Table 3, or not shown separately, there are available data on manhours per unit for somewhat shorter periods; see Appendix F.

For a few industries the 1909 Census data on full-time hours may be carried back to 1899 by indexes based on samples collected by the Bureau of Labor Statistics (see source cited in Appendix C). Indexes of manhours per unit for these industries may therefore be computed for 1899–1937 and percentage changes between these years determined:

| *Industry* | *Total Percentage Change, 1899–1937* Wage Earners per Unit of Product | Hours per Week | Manhours per Unit of Product |
|---|---|---|---|
| Meat packing | 12 | −24 | −15 |
| Cotton goods | −30 | −38 | −56 |
| Knit goods | −54 | −38 | −71 |
| Silk and rayon goods | −71 | −35 | −81 |
| Shoes, leather | −19 | −33 | −46 |
| Lumber-mill products | 19 | −25 | −10 |
| Printing and publishing, total | −70 | −25 | −78 |
| Cars, railroad | 39 | −30 | −2.0 |
| Steel-mill products | −36 | −32 | −57 |

[b] Ranked according to change in aggregate wage-earner hours per unit.

uct rose. As for the other six, when labor is measured in terms of manhours instead of men, we find that they too are to be classed with the industries which reduced the amount of factory work needed to turn out a unit of product.[4]

Both locomotives and ships improved substantially in quality. No doubt the exceptional position in Table 3 of the industries manufacturing these products is to be attributed in some degree to our inability to take statistical account of such advances. The average tractive power of steam locomotives in operation on American railroads rose from 27 thousand pounds in 1910 to 49 thousand in 1937, indicating a very considerable increase in the power of new locomotives produced. And this, of course, points merely to one of many improvements. It is likely that a similar explanation applies to some of the other industries that lagged in reducing labor per unit of output; railroad cars and even meat-packing products have undergone considerable quality change requiring the expenditure of labor effort.[5]

Even the most drastic declines shown in Table 3 may

[4] For the industries producing linen goods, wool-felt hats, and turpentine and rosin, no data on hours are available for 1937. Here, however, the increases in wage earners per unit were slight. Even a comparatively moderate decline in the hours worked in these industries (say, a decline of 18 percent, the smallest in Table 2) would mean a reduction in manhours per unit.

[5] It is possible, too, that industries engaged in producing locomotives, ships and railroad cars have been changing the character of the materials they assemble into the final products. If the parts they require were formerly machined in other industries but then came to be machined in the assembly industries themselves, we should expect this increasing burden to be reflected in a rise in manhours of work relative to the number of units of final product. This sort of trend might be caused simply by change in the definitions of the various industrial categories set up by the Bureau of the Census, as well as by actual shifts between industries whose scope has not undergone revision. Unfortunately, no reliable information is available on this point.

Note should be made also of a factor affecting all industries, namely, change in the composition of output. As demonstrated in Chapter 2, such changes may have considerable effect on the ratio of labor to product. For information on changes in composition of the output of individual industries see Part Two of *The Output of Manufacturing Industries, 1899–1937* (National Bureau of Economic Research, 1940).

understate the actual cuts in unit labor requirements because they do not allow for quality improvements, and for the same reason most of the percentages given in the table should be regarded as conservative estimates of the reductions in manhours per unit since 1909. Yet even these figures, with all their tendency to understatement, record rapid declines in manhours per unit for many industries. In comparison with the 2.7 percent decline in manhours per unit for all manufacturing combined some of the per annum rates for individual industries are phenomenal. In the automobile industry the average annual reduction was 8 percent (over the period 1909–37); in tobacco manufacture, 7 percent; and in glass, silk and rayon goods, blast-furnace products, and industrial chemicals, 5 percent. Reductions in the manhour-output ratio of 10, 15, or 20 percent were therefore sometimes a matter of a few years, not of decades; an average annual decline of, say, 5 percent, amounts in three years to 14 percent. As we shall see in the next section, in some periods the annual rates were substantially above the averages for all periods combined. Evidently important changes often took place well within the span of a single business cycle.

## CHANGE IN THE RATE OF DECLINE IN LABOR PER UNIT

None of the average rates of decline recorded in Table 3 reflects the tempo of change during each portion of the period since 1909. The averages, in other words, fail to show variation in the rate of change in the ratio of employment, or of manhours, to product.

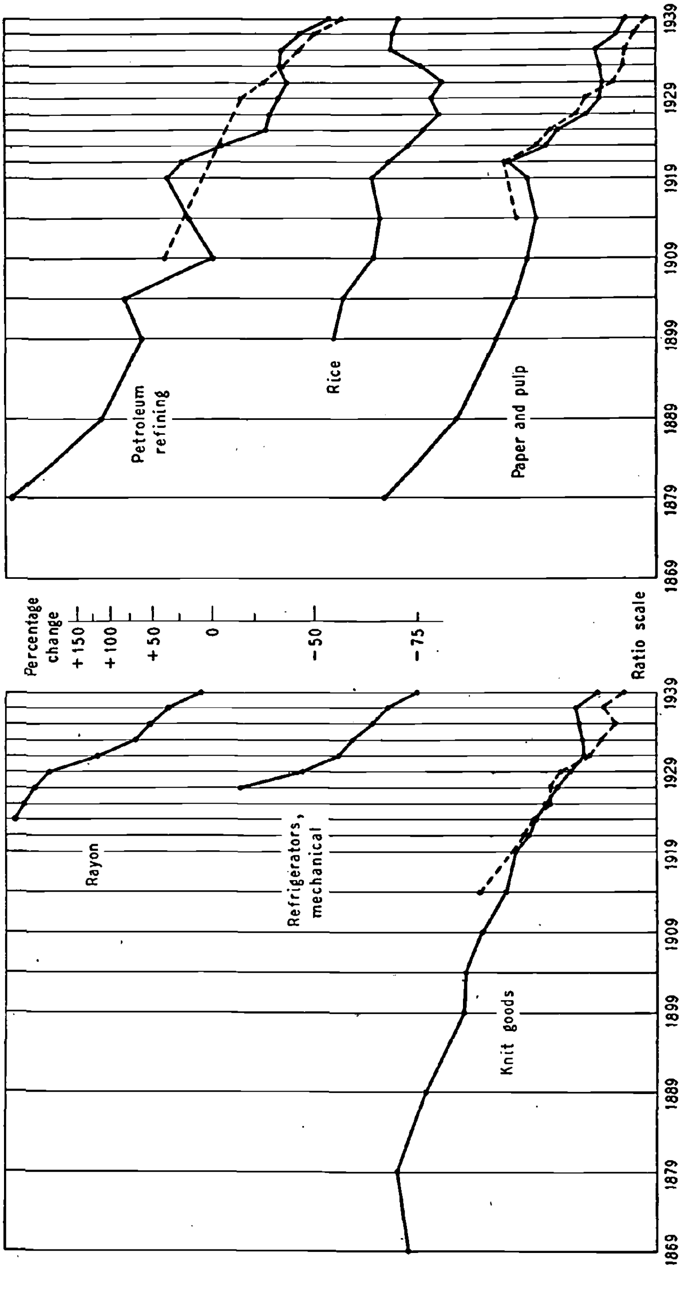
Besides short-period fluctuations the rate of decline in labor per unit also underwent more persistent changes, which become evident when periods of around 10 years are compared with one another. Limited though our information is to crude measures of shifts between selected years (Table 4, pp. 65-67), it is quite clear that the rate of decline in wage earners per unit fluctuated in practically all industries. From Chart 12, in which the course of labor per unit is plotted for a number of industries, one can observe, for example, that in cotton goods production the number of wage earners employed per unit rose at a rate of 0.1 percent per annum between 1909 and 1919 and again between 1929 and 1937, but fell at annual rates ranging from 0.3 percent to 2.9 percent during the other 5 decades covered in the table. In steel mills, though employment per unit declined on the average by as much as 5.1 percent annually between 1879 and 1889, it actually rose 2.8 percent per annum during the 1930's. The extraordinary average annual rate of decline in unit labor requirements for motor vehicle manufacture, 5.4 percent, is seen to be an average of extreme rates of decline, 11.8 and 9.5, a moderate rate of decline, 0.6, and a 2.2 percent rate of increase. The available data on manhours per unit, though less comprehensive and covering somewhat different periods than those on number of workers per unit, bear out this impression of widespread change in rate of decline (Chart 12; and Table 5, p. 68).

Now that we have found that the labor-output ratio declines at a variable rate, we should like to determine whether the variation in tempo follows some general pattern from stage to stage in the development of an industry. The most interesting possibility is that the decline decelerates from stage to stage. In terms of absolute changes per annum (or annual changes expressed as a percentage of a fixed base), there can hardly be any question that on the average there has been retardation in the rate of decline in employment per unit. For example, the reduction in the number of factory workers needed to assemble a dozen motorcars, from seven in 1899 to less than one in 1937, cannot be matched in

Chart 12

SELECTED MANUFACTURING INDUSTRIES

Indexes of Wage Earners per Unit of Product (———), and Manhours per Unit of Product (- - - - - -)

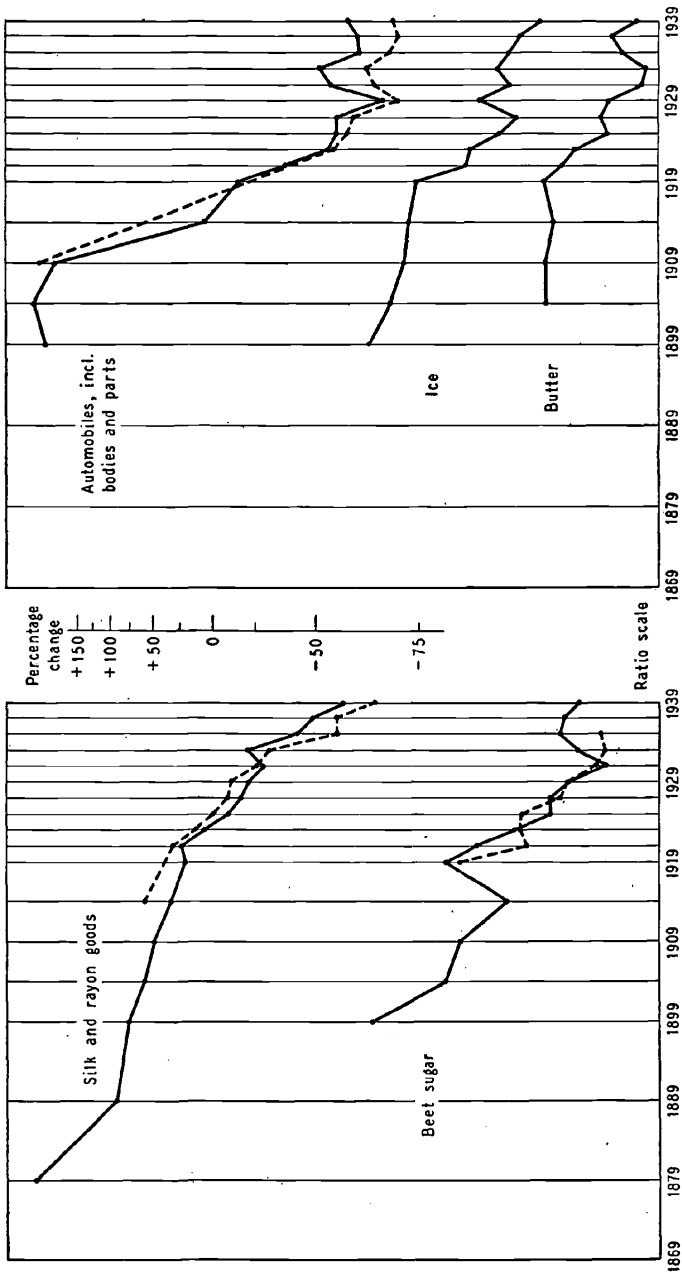



Based on Table F-1

Chart 12 (cont.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Wage Earners per Unit of Product (———), and Manhours per Unit of Product (- - - - - -)

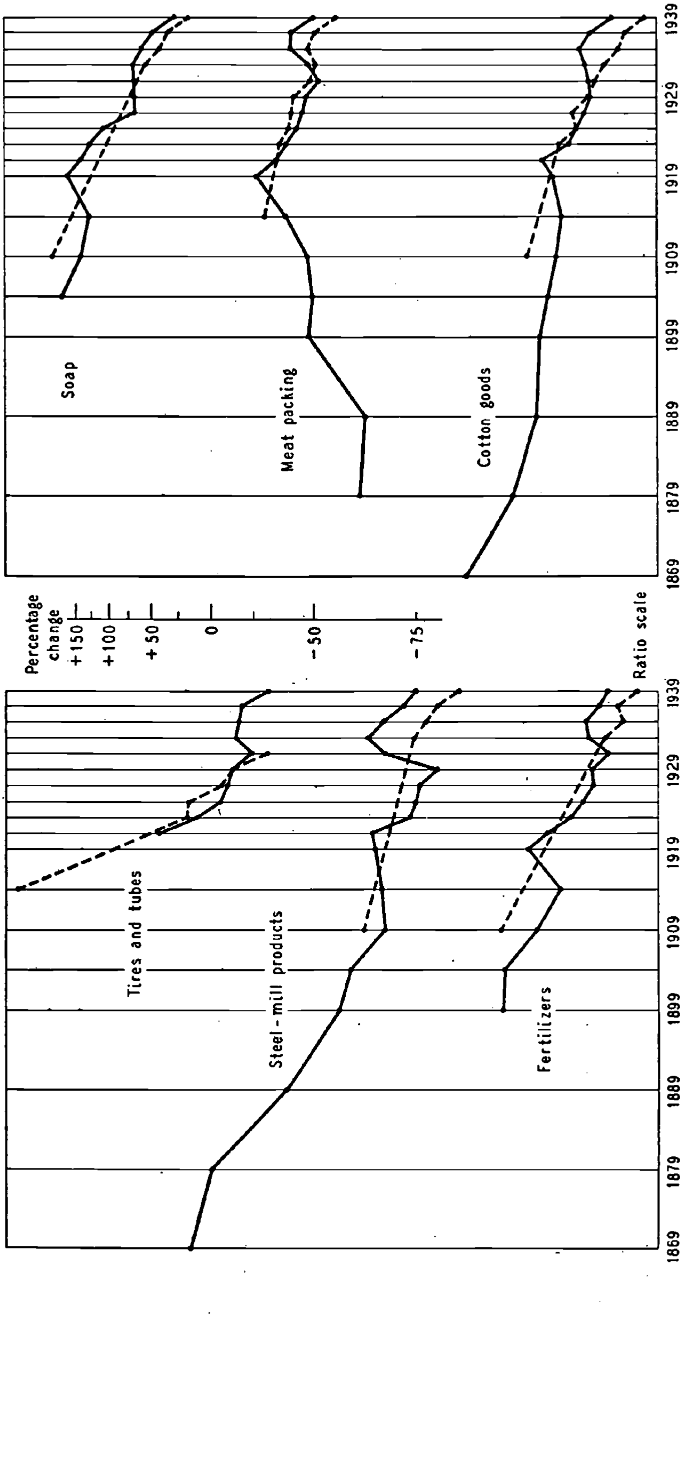



Based on Table F-1

Chart 12 (cont.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Wage Earners per Unit of Product (——), and Manhours per Unit of Product (- - - - - -)

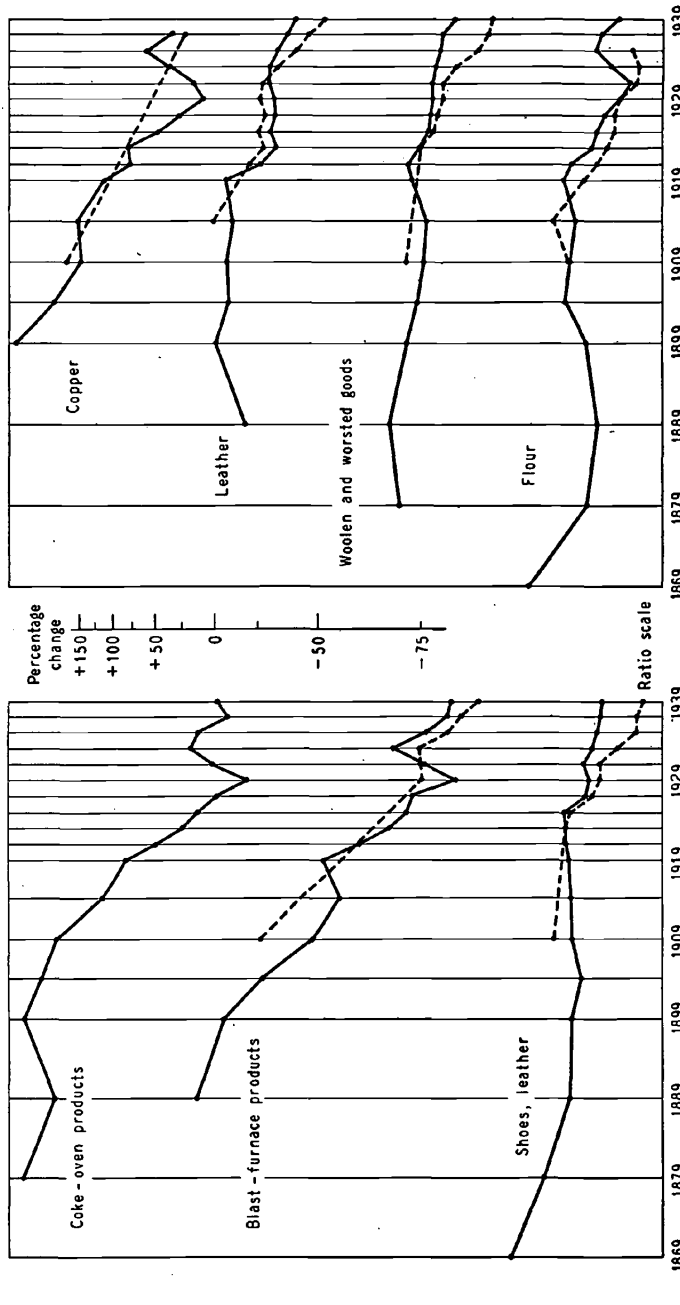



Based on Table F-1

Chart 12 (cont.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Wage Earners per Unit of Product (——), and Manhours per Unit of Product (- - - - -)

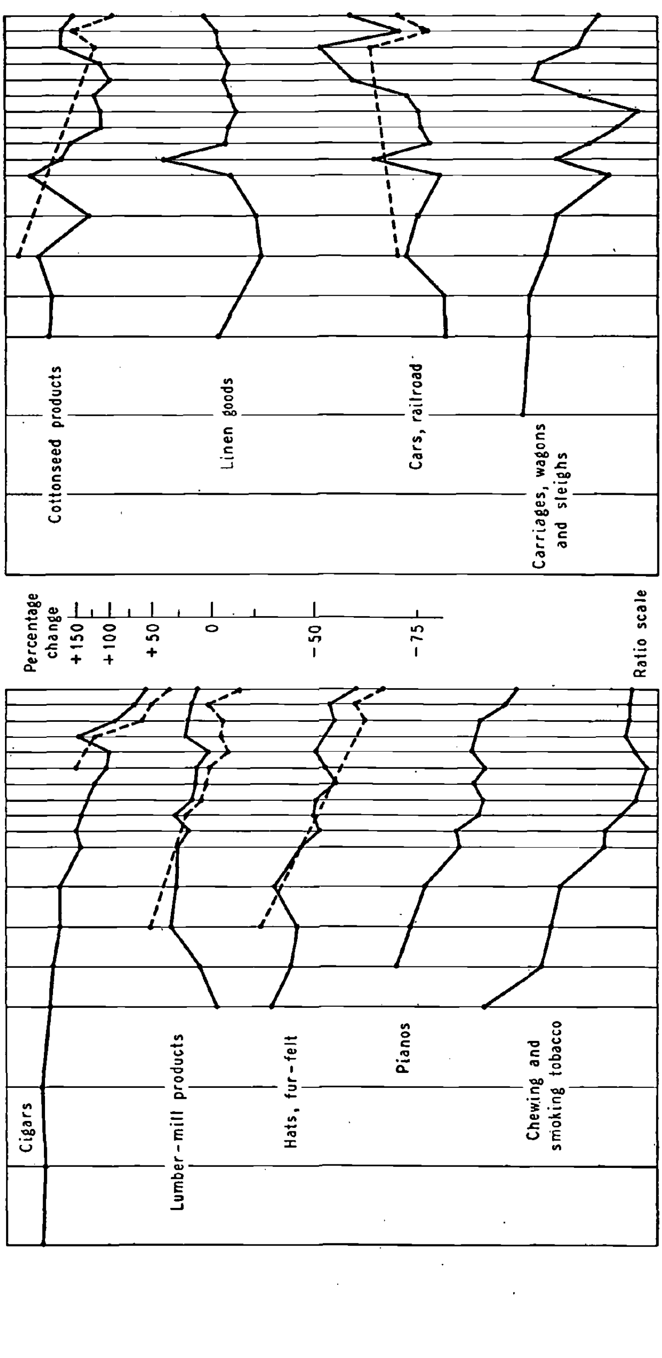



Based on Table F-1

Chart 12 (concl.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Wage Earners per Unit of Product (———), and Manhours per Unit of Product (- - - - - -)




Based on Table F-1

the future. But whether there is a decline in the rate of change in labor per unit when the latter is expressed as a percentage of the preceding year's level is quite another question. It is true that some authors have explained retardation of growth in output [6] in part by the slowing down of technical progress, which implies, of course, a slackening in the rate of decline in labor per unit.[7] Such a slackening should be expected also 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. But these hypotheses cannot be put to the test. Lack of sufficiently long series on manhours worked per unit unfortunately precludes a definite answer to the question posed. The data on workers per unit are seriously affected by changes in hours, as a comparison of the fluctuations in Tables 4 and 5 shows. Even if one could conclude unequivocally that manhours per unit do fall at a declining rate, the finding might be unimportant. For it is possible that such deceleration, if it could be proven, would take the form not of a series of gradual changes from stage to stage, but of a single rather abrupt change from a very rapid rate of decline during the first stages of an industry's growth to a moderate rate persisting with little change during the rest of its career. That is, the shape of an industry's labor-output curve could reasonably be 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 were the situation, the phenomenon of deceleration would hardly be observable in the available data, which seldom cover the very early years of an industry's life. If there were gradual deceleration in an industry's unit

[6] See the discussion in Chapter 5.

[7] Evidence of a slackening in the rate of technical progress in the cotton, woolen and worsted, iron and steel, shoe, paper, and copper industries is presented in Simon Kuznets' *Secular Movements in Production and Prices* (Houghton Mifflin, 1930), Ch. 1.

TABLE 4

## INDIVIDUAL MANUFACTURING INDUSTRIES

### Wage Earners per Unit of Product: Average Annual Rates of Change between Selected Years

*Unit: 1 percent*

| | Average Annual Rate of Change | | | | | | |
|---|---|---|---|---|---|---|---|
| *ndustry* | 1869 to 1879 | 1879 to 1889 | 1889 to 1899 | 1899 to 1909 | 1909 to 1919 | 1919 to 1929 | 1929 to 1937 |
| *Foods* | | | | | | | |
| Meat packing | | −0.3 | 3.9 | 0.0 | 3.5 | −3.4 | 1.3 |
| Flour | −3.8 | −0.7 | 0.8 | 1.1 | 0.4 | −3.8 | 1.6 |
| Rice | | | | −2.8 | 0.0 | −4.0 | 3.5 |
| Fish, canned | | | | | 1.4 | −0.7 | 3.2 |
| Fruits and vegetables, canned | | | | −4.0 | −2.1 | −3.4 | −1.0 |
| Butter, cheese, and canned milk | | | | −1.1 | −1.0 | | |
| Milk, canned | | | | | −3.5 | −8.0 | −0.1 |
| Butter | | | | | 0.1 | −4.2 | −0.4 |
| Cheese | | | | | −0.5 | −3.0 | 0.3 |
| Beet sugar | | | | −6.0 | 1.0 | −8.1 | 0.5 |
| Cane sugar, tota | | | | −3.0 | 3.7 | | |
| Cane sugar, not elsewhere made | | | | | 7.1 | −7.2 | −0.7 |
| Cane-sugar refining | | | | | 3.0 | −4.9 | 1.6 |
| Corn products | | | | | 1.0 | −5.0 | 2.7 |
| Ice | | | | −2.6 | −0.7 | −4.3 | −3.2 |
| *Beverages* | | | | | | | |
| Liquors, malt | | | | −1.0 | 2.5 | | |
| Liquors, distilled | | | | 2.9 | 20.9 | 1.5 | −29.8 |
| *Tobacco products* | | | | | | | |
| Cigarettes | | | | | −9.7 | −8.7 | −1.0 |
| Cigars | −0.1 | 0.2 | −0.6 | −0.7 | −1.3 | −1.8 | −2.3 |
| Chewing and smoking tobacco | | | | −4.4 | −3.7 | −2.8 | 1.5 |
| *Textile products* | | | | | | | |
| Cotton goods | −2.9 | −1.6 | −0.3 | −1.0 | 0.1 | −2.6 | 0.1 |
| Lace goods | | | | | | −0.8 | −3.2 |
| Woolen and worsted goods | | 0.2 | −1.0 | −1.1 | 0.8 | −1.5 | −0.8 |
| Silk and rayon goods | | −5.3 | −0.8 | −1.7 | −2.3 | −4.1 | −5.0 |
| Knit goods | 0.7 | −1.9 | −2.5 | −1.1 | −2.3 | −3.9 | −0.5 |
| Carpets and rugs, wool | | | | −1.0 | −1.4 | −1.3 | 0.3 |
| Asphalted-felt-base floor covering and linoleum | | | | | | −2.2 | −0.1 |

TABLE 4 (concluded)

## INDIVIDUAL MANUFACTURING INDUSTRIES

### Wage Earners per Unit of Product: Average Annual Rates of Change between Selected Years

*Unit: 1 percent*

| *Industry* | *Average Annual Rate of Change* 1869 to 1879 | 1879 to 1889 | 1889 to 1899 | 1899 to 1909 | 1909 to 1919 | 1919 to 1929 | 1929 to 1937 |
|---|---|---|---|---|---|---|---|
| *Textile products (concluded)* | | | | | | | |
| Oilcloth | | | | | 6.6 | −7.0 | 4.0 |
| Cordage and twine | | | | −1.0 | 0.7 | −2.7 | 0.6 |
| Jute goods | | | | −1.8 | −0.0 | −2.1 | −1.0 |
| Linen goods | | | | −2.9 | 2.1 | 0.0 | 1.2 |
| Hats, fur-felt | | | | −1.8 | −0.1 | −1.7 | −0.5 |
| Hats, wool-felt | | −0.6 | −0.5 | 2.3 | −0.8 | 1.1 | −3.1 |
| Wool shoddy | | | −0.1 | −1.6 | −0.8 | −3.9 | |
| *Leather products* | | | | | | | |
| Leather | | | 2.0 | −0.7 | −0.0 | −3.2 | −1.2 |
| Shoes, leather | −2.3 | −1.4 | −0.3 | −0.0 | 0.0 | −1.4 | −0.9 |
| Gloves, leather | | | | −3.6 | −1.3 | −0.5 | 3.2 |
| *Rubber products* | | | | | | | |
| Tires, tubes and other rubber goods | | | | | | −7.2 | 0.0 |
| Shoes, rubber | | | | | | −1.1 | −3.5 |
| *Paper products* | | | | | | | |
| Paper and pulp | | −4.8 | −2.8 | −2.1 | 0.4 | −5.1 | −1.3 |
| *Printing and publishing* | | | | | | | |
| Total | | | | −4.4 | −3.1 | −4.1 | −0.3 |
| *Chemical products* | | | | | | | |
| Chemicals, industrial, incl. rayon and compressed gases | | | | −2.4 | 0.2 | −6.8 | −3.2 |
| Cottonseed products | | | | 0.7 | 0.3 | −4.1 | 3.0 |
| Carbon black | | | | | | −4.2 | −1.9 |
| Soap | | | | | 0.8 | −4.5 | −1.4 |
| Wood-distillation products | | | | −0.9 | 2.8 | −3.6 | −0.6 |
| Explosives | | | −1.1 | −5.4 | −0.3 | −5.5 | 0.5 |
| Fertilizers | | | | −2.2 | 0.7 | −4.4 | −0.7 |
| Paints and varnishes | | | | −1.4 | 0.8 | −3.4 | −0.1 |
| Salt | −1.5 | −5.1 | 0.6 | −2.0 | 0.1 | −2.9 | −1.7 |
| Tanning and dye materials | | | | −3.5 | 1.8 | −7.6 | 1.7 |

| Industry | 1869 to 1879 | 1879 to 1889 | 1889 to 1899 | 1899 to 1909 | 1909 to 1919 | 1919 to 1929 | 1929 to 1937 |
|---|---|---|---|---|---|---|---|
| | *Average Annual Rate of Change* | | | | | | |
| *Petroleum and coal products* | | | | | | | |
| Petroleum refining | | −5.9 | −2.8 | −4.7 | 3.2 | −7.4 | −1.8 |
| Coke-oven products | | −2.2 | 1.8 | −2.0 | −4.6 | −8.1 | 1.7 |
| Fuel briquettes | | | | | −3.1 | −6.3 | 3.9 |
| *Stone, clay and glass products* | | | | | | | |
| Cement | | | | | −3.2 | −2.9 | 1.9 |
| Lime | | | | | −0.3 | −5.2 | 1.4 |
| Sand-lime brick | | | | | | −5.2 | 1.2 |
| Clay products | | | | | | −2.5 | 0.7 |
| Glass | | | | −3.2 | −2.4 | −5.6 | −4.0 |
| *Forest products* | | | | | | | |
| Lumber-mill products | | | | 3.1 | −0.5 | −1.4 | 0.8 |
| Turpentine and rosin | | | | 2.2 | −1.6 | 0.9 | 0.0 |
| *Iron and steel products* | | | | | | | |
| Blast-furnace products | | | −1.9 | −5.9 | −0.6 | −8.7 | 0.6 |
| Steel-mill products | −1.4 | −5.1 | −3.4 | −3.4 | 0.7 | −4.0 | 2.8 |
| Wire | | | | | 0.5 | −2.4 | 2.5 |
| Cast-iron pipe | | | | | | −3.8 | 3.3 |
| *Nonferrous-metal products* | | | | | | | |
| Copper | | | | −4.4 | −1.4 | −6.7 | 2.7 |
| Lead | | | | −5.9 | −1.4 | −7.3 | 4.6 |
| Zinc | | | | −3.6 | 1.3 | −4.6 | 1.5 |
| *Machinery* | | | | | | | |
| Phonographs | | | | 1.5 | −1.2 | −0.9 | |
| *Transportation equipment* | | | | | | | |
| Automobiles, incl. bodies and parts | | | | −0.6 | −11.8 | −9.5 | 2.2 |
| Carriages, wagons and sleighs | | | −0.4 | −1.1 | −4.3 | 1.8 | −0.4 |
| Cars, railroad | | | | 2.8 | −2.3 | 2.2 | 1.0 |
| Locomotives | | | 0.8 | −3.1 | 4.6 | 2.9 | 5.0 |
| Ships and boats | | | | 1.3 | 2.5 | −2.4 | 4.3 |
| Motorcycles and bicycles | | | | −5.6 | −1.3 | −3.1 | |
| *Miscellaneous products* | | | | | | | |
| Organs | | | | | 0.9 | 1.3 | |
| Pianos | | | | | −2.9 | −2.0 | −1.8 |
| Buttons | | | | | | −3.4 | 0.7 |

*Source:* Appendix F.

TABLE 5

INDIVIDUAL MANUFACTURING INDUSTRIES

Aggregate Wage-Earner Hours per Unit of Product: Average Annual Rates of Change between Selected Years

*Unit: 1 percent*

| Industry | Estimate[a] | 1914 to 1921 | 1921 to 1929 | 1929 to 1937 | Estimate[a] | 1909 to 1923 | 1923 to 1929 | 1929 to 1937 |
|---|---|---|---|---|---|---|---|---|
| | | *Average Annual Rate of Change* | | | | | | |
| Meat packing | B | −1.3 | −1.6 | −1.7 | A | 0.5 | −1.4 | −2.2 |
| Flour | A+B | −4.0 | −1.9 | −0.5 | | | | |
| Beet sugar | A+B | | −5.3 | −3.5 | | | | |
| Cotton goods | | | | | A | −1.6 | −3.2 | −3.0 |
| Knit goods | A | −3.9 | −3.1 | −3.7 | | | | |
| Silk and rayon goods | A | −2.7 | −4.9 | −8.6 | | | | |
| Woolen and worsted goods | B | −0.4 | −2.0 | −4.2 | A | −0.8 | −2.5 | −3.6 |
| Leather | B | −3.5 | −1.0 | −3.9 | A+C | | −1.3 | −3.6 |
| Shoes, leather | B | −1.8 | −2.4 | −2.6 | A | −0.6 | −3.7 | −3.1 |
| Rubber products, total | B | | −5.7 | −4.1 | | | | |
| Paper and pulp | B | 1.2 | −6.7 | −3.9 | | | | |
| Printing and publishing, total | B | −1.9 | −4.6 | −2.2 | A | −4.2 | −2.8 | −2.3 |
| Paints and varnishes | B | −1.2 | −2.7 | −2.9 | | | | |
| Chemical products, total | B | −1.1 | −5.9 | −4.1 | | | | |
| Cement | A+B | | −5.6 | −0.3 | | | | |
| Clay products | A+B | | −1.0 | 3.8 | | | | |
| Lumber-mill products | | | | | A | −1.8 | −2.6 | 0.2 |
| Blast-furnace and steel-mill products | B | 0.4 | −5.4 | −2.3 | A | −2.6 | −4.3 | −0.2 |
| Automobiles, incl. bodies and parts | B | −9.3 | −7.4 | −1.3 | A | −13.3 | −7.3 | 0.0 |

[a] The estimates are identified in Appendix F, where the indexes are presented in detail.

labor requirements, but at a low rate, it could not be found in the available statistics because of the presence of long cycles and erratic movements.[8]

There is some reason to expect a pulsating, though not necessarily periodic, rate of decline in unit labor requirements: startling innovations, for example, are not introduced in every year, although minor improvements in techniques may be effected almost continuously. The data in Tables 4 and 5 are not inconsistent with this hypothesis.

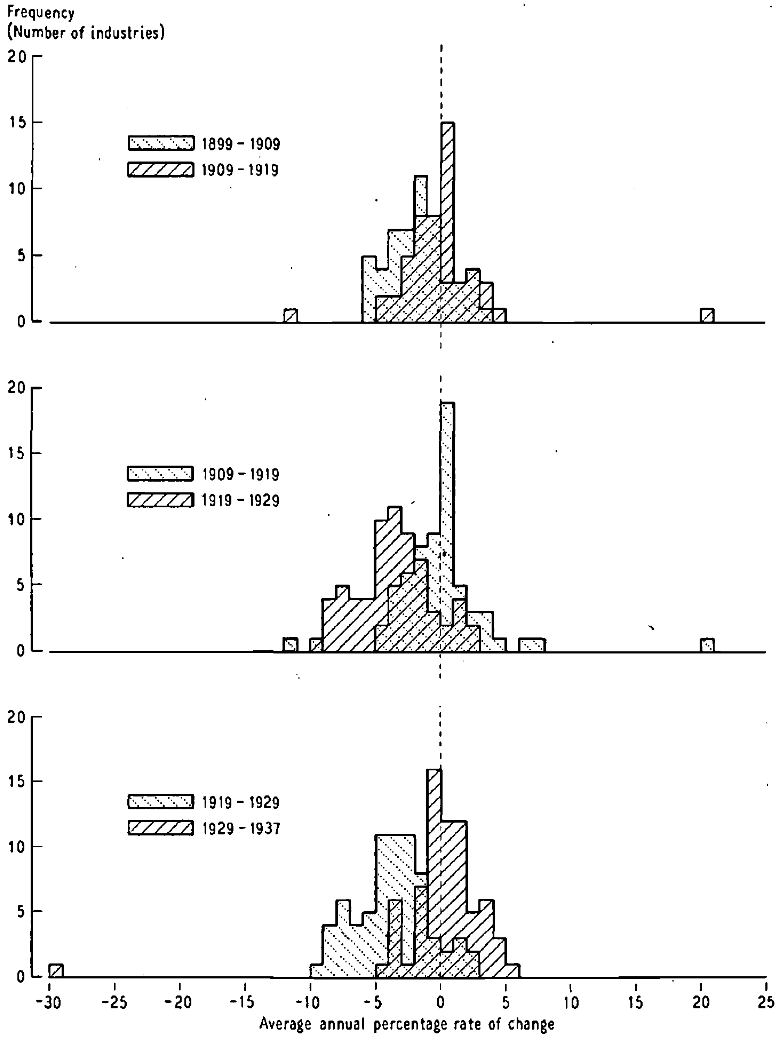
One might speculate also on the possibility that long cycles in unit labor requirements are more or less synchronous in different industries. General waves of rationalization (which many economists believe did occur during the 1920's), extensive changes in the work week and in labor relations, generally high levels of output and capital investment and similar developments could account for such a phenomenon. The data given in detail in Table 4 and summarized in Charts 13 and 14 lend support to the view that there has been synchronization of rates of change in wage earners per unit. Amidst the very considerable variation between columns and lines in Table 4 a certain degree of order can be detected. The first and third decades of the twentieth century are characterized, rather generally, by sharp declines in employment per unit of product, and the second and fourth by rises or

[8] Material in the following chapter indicates a negative correlation between trends in output and in employment per unit of output. Since, as we shall see, the rate of growth in output declines progressively as an industry approaches maturity, one might infer the existence of retardation of rate of decline in the employment-output ratio. But such an inference is dangerous. The rate of increase in production characteristic of a given stage of development is not necessarily or even usually identical from industry to industry (barring that stage wherein output is at a maximum and not growing at all, which by definition would be the same stage in every industry's development). Thus, in an industry characterized by rapid growth to an early maximum, it is possible that output may rise during the period including the inflection point in the industry's curve of output (traced on an arithmetic scale) at a rate that is greater than the corresponding one characteristic of an industry growing more slowly and reaching maturity much later.

Chart 13

WAGE EARNERS PER UNIT OF PRODUCT

Frequency Distributions of Individual Manufacturing Industries by Average Annual Rate of Change between Selected Years

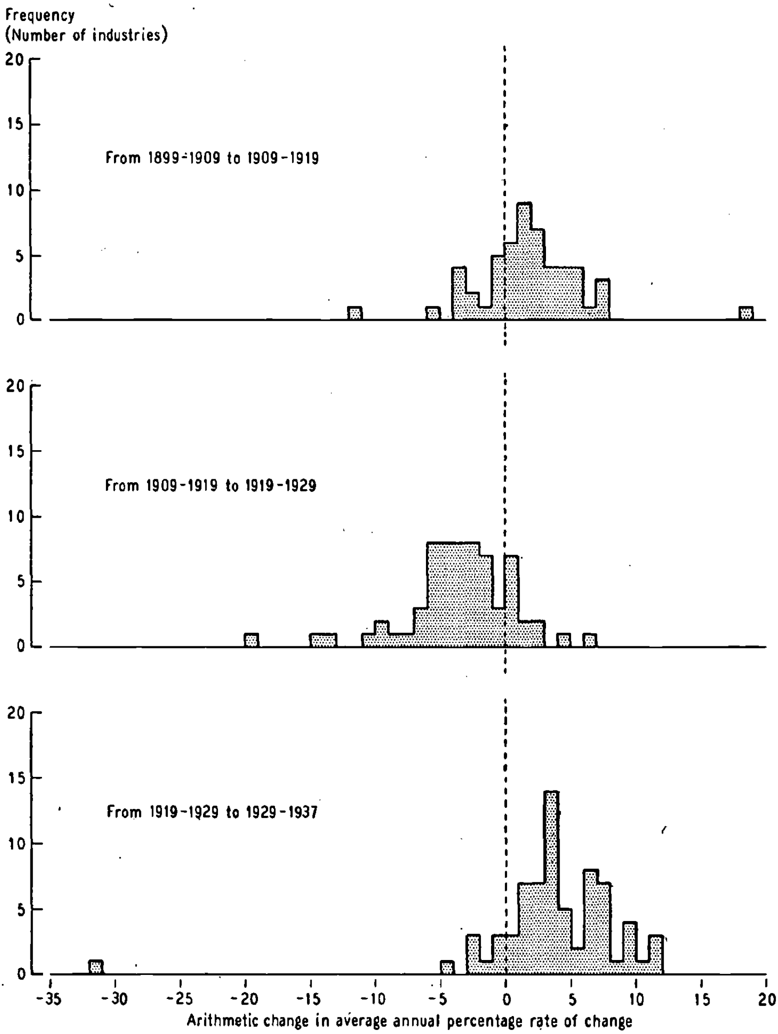



Based on Table G-2

Chart 14

WAGE EARNERS PER UNIT OF PRODUCT

Frequency Distributions of Individual Manufacturing Industries by Changes in Average Annual Rate of Change between Selected Years




Based on Table G-2

The number of industries included in the 1899-1909 and 1909-1919 comparison is 53; in the 1909-1919 and 1919-1929 comparison, 66; and in the 1919-1929 and 1929-1937 comparison, 71.

slight declines.[9] Comparisons of somewhat different periods, say 1899–1914 with 1914–19, or 1923–29 with 1929–37, produce like results.

The similarity of these cycles in employment per unit among different industries may well be attributed to the drastic reductions in hours of labor that have occurred more or less simultaneously in various branches of manufacturing. Between 1914 and 1919 and again between 1929 and 1937 there were large and fairly general reductions in the hours of labor per week. As a consequence, the ratio of employment to product usually did not fall as rapidly during these periods as it did when changes in hours were relatively slight.[10]

Whether changes in hours were the sole factor or only one of several causes of the widespread fluctuations in workers per unit is more difficult to determine because data on hours are inadequate; and for this reason too one cannot make definite statements concerning changes between successive periods in the rates of decline in *manhours* per unit. Accurate data on hours are not available for all of the Census years after 1909, or for all individual industries. Such scanty information as can be mustered (Table 5) shows that the rate

[9] Though the data (Table 4) are hardly adequate to establish this definitely, it is noteworthy that the period 1889–99 was characterized by rates of decline in employment per unit that were rather low relative to the rates in the preceding and following decades.

[10] This fact alone makes it impossible to consider Table 4 as establishing retardation in the rate of decline in employment per unit. Suppose we were to compare rates of change in wage earners per unit between 1869 and 1879 with those between 1879 and 1889, and so on for all contiguous periods, representing each increase in rate of change (i.e., a decrease in rate of decline) by a plus, and each decrease in rate of change (increase in rate of decline) by a minus. Then, of the 231 comparisons made possible by Table 4, we would find 134 to be plus, 96 minus, 1 zero. This would seem to indicate a slight tendency toward decrease in rate of decline. But preponderance of pluses would be found merely because most of our series cover only the last four decades, during the second and fourth of which there was widespread decline in hours and, therefore, widespread deceleration in rate of decline in wage earners per unit. This, too, would account for the fact that 43 of the 76 industries listed in the table are characterized by more pluses than minuses, as just defined.

of decline in manhours per unit during the earlier war period was usually (though not always) less rapid than during the 1920's. As for any change in trends after 1929, the picture is even less definite, though it seems reasonably safe to say that the rate of decline was usually more rapid during the 1920's than during the 1930's. Yet it is true, too, that the average rate of fall in manhours per unit during the troubled years between 1929 and 1937 was rather speedy in quite a few industries, and in several compared favorably with the rate of decline during the preceding period of prosperity and expansion.[11]

## UNIT LABOR REQUIREMENTS AND INDUSTRIAL EVOLUTION

The most striking conclusion brought out by the figures presented in this chapter is that nearly all industries effected a long-run reduction in the labor they employed per unit of product. Output soared appreciably higher than manhour employment in industries producing different kinds of commodities, making use of different sorts of manufacturing processes, and at different stages of development. Because the products and processes are so numerous and diverse in manufacturing industries, the immediate means by which labor per unit has been cut must have been correspondingly heterogeneous.

Even for single industries the list of changes in the process of fabrication has commonly been long. It is true, of course, that now and then in almost every industry there are developments so spectacular that they come to the attention even of the outsider. In the automobile industry, for example, one of the most revolutionary advances in the manufacturing

[11] Note, however, the possible effect on this comparison of changes in quality of product, mentioned above, p. 20.

process was the straight-line system of routing and dividing work by means of mechanical conveyors; and it is largely to the introduction of this system that the annual decline of more than 10 percent in workers employed per automobile, between 1909 and 1919, has been ascribed. In cigar manufacture the invention of the automatic cigar-making machine goes far to explain the cut of almost half in the number of workers employed per thousand cigars between 1909 and 1939, a reduction far exceeding that which took place during the half-century preceding 1909. In the manufacture of pneumatic tires the outstanding change during the 1920's was the displacement of the core process of tire building by the flat-drum process; this new technique helps to account for the two-fifths reduction in workers per unit in the rubber-tire industry between 1921 and 1929. But besides the great upheavals in manufacturing processes which occur from time to time, there are always the less spectacular but more frequent minor changes in almost all industries. These small improvements, which affect the industrial organization of the enterprise, the layout of the job, and the equipment used, have a powerful cumulative effect. One observer holds that minor advances of this sort are ultimately of greater importance, as a rule, than the major changes which are introduced only occasionally.[12]

The technical and organizational modifications that affect labor per unit are naturally conditioned by the kind of product and process predominant in a particular industry. Because these improvements take on special characteristics in each industry, and because they are so very numerous, the changes that have occurred in factories since 1899 cannot even be listed in a report devoted to all manufacturing industries. Yet no single industry exists in a vacuum, separated

[12] Boris Stern, "Labor Productivity in the Automobile Tire Industry," *Bulletin 585,* Bureau of Labor Statistics, Washington, 1933, p. 24.

from contact with other industries. If we care to look beneath the peculiarities of the changes in each industry, we can detect and remark upon certain common features even in an over-all report such as the present one.

One common characteristic of the manifold changes that have affected manufacturing processes is their origin in the fund of ideas current at the time. New ideas eventually become common property. Efficient arrangements of work initiated in one plant are sooner or later copied in other plants of the industry, and, after experiment and adaptation to different conditions, are taken over by outside industries. Thus the straight-line system which helped to revolutionize the automobile industry was suggested by methods already in successful use in Chicago meat-packing establishments.[13] Its adaptation to motorcar manufacture stimulated its spread to many more industries, with cotton garment manufacture most notable among these in recent years.[14]

Scientific plant and labor management is another development that has permeated industry fairly generally since the 1890's. Frederick W. Taylor and his followers worked out their ideas and made their experiments in metalworking, construction, shipbuilding, steel manufacture, machinery production, and arsenals. It is true that even as late as 1912 there was some question as to the practicability and usefulness of modern management methods, but the war years following brought fruition to the ideas which had been developing during the preceding decades. During the 1920's profit-sharing plans for reducing occupational hazards and diseases, and studies of labor turnover began to appear in many widely different fields. Incentive wage plans, for example, were operating in 37 industries in 1924.[15] Systematic

[13] Henry Ford, *My Life and Work* (Doubleday Page, 1923), p. 81.

[14] N. I. Stone, "Productivity of Labor in the Cotton-Garment Industry," *Bulletin 662* (Bureau of Labor Statistics, Washington, 1938), Ch. IV.

[15] L. P. Alford, *Laws of Management Applied to Manufacturing* (Ronald Press, 1928).

research and application of ideas of this sort have been changing the organization of plants in many different industries and altering the activities of the working force within the factory walls. The resulting elimination of waste and the reduction of effort and time have played an important role in increasing the productivity of industry. Taylor, with the enthusiasm of the innovator, felt that the general adoption of scientific management would of itself readily double the productivity of the average worker in industry.[16] At any rate, there can be little doubt that advance in managerial technique is to be counted among the important factors that have aided in doubling the average output of the factory worker since 1899.

Accounting and statistical controls have spread from industry to industry, furthered by enterprises manufacturing devices used in these systems or rendering services in their application. Again, standardization has been widely accepted in most industries in one form or another. Standard weights and measures are old, of course; the requirement that parts be interchangeable was written into contracts for pistols and muskets given Simeon North and Eli Whitney at the end of the eighteenth century. But the widespread systematic application of standardization is essentially modern, and in many respects a phenomenon of the 1920's. Uniformity of dimensions, essential to secure interchangeability and interworking, of necessity implies standards set up through cooperation between plants, regions and industries. The post-war drive toward standard quality specifications, testing methods, machinery ratings, grading and simplification[17] was fostered throughout industry by organizations cutting across industrial boundaries: technical and professional societies, national and international standardizing societies and the National Bureau of Standards. It was widely stimulated also by govern-

[16] *Principles of Scientific Management* (Harper, 1911), p. 142.
[17] Reduction of number of types, sizes and grades.

ment purchasing requirements, trade associations and some large companies. The setting of standards for materials purchased has in turn encouraged the creation of similar standards for products sold, and so in this way too standardization has spread. Its influence is now felt in every department of contemporary industrial and domestic life.

Besides ideas concerning arrangement, combination, procedure, control, and so forth, new instruments become generally available to industry at large. The steam engine, of early assistance in mining, was soon exploited, in one form or another, in many fields. So also runs the history of the electric motor and the electric light, and the application of such relatively new devices as air conditioning may well follow a similar pattern. Machine tools are not restricted to use by one or two industries; nor are typewriters and bookkeeping machines employed only in banks.

Instruments used as indicators, recorders and controllers of pressure, temperature, fluid flow, liquid level, speed, concentration of solution, composition of gases, and duration of process, are found in varying degree and form in practically every industrial plant.[18] These instruments are making possible the use of large capacity machines which cannot be controlled manually, result in more uniform and better products, and lessen the danger of breakdown and excessive wear.[19] Savings of fuel and greater safety of operation are also credited to the use of control instruments.

The flow of goods through plants of all kinds has been accelerated by steam and electric shovels, belt conveyors, trucks, portable conveyors and loaders, chutes, pneumatic

18 George Perazich, Herbert Schimmel and Benjamin Rosenberg, *Industrial Instruments and Changing Technology* (National Research Project, Philadelphia, 1938), pp. 20, 51.

19 David Weintraub ("Effects of Current and Prospective Technological Developments upon Capital Formation," *American Economic Review, Supplement,* Mar. 1939) cites a test case in which boilers under hand control had to be rebricked every three months, whereas with instrument control even annual rebricking was unnecessary.

devices, cranes, and electric hoists. These developments have not been limited to the heavy industries alone. Belt conveyors, for instance, are utilized in packing foods and in the manufacture of auto seat covers and backs.

The electric motor is an especially interesting example of a labor-saving device now in universal use. Its contribution to the development of automatic tools can hardly be exaggerated. Without the individual electric motor, which can be started and stopped in an instant and can be controlled automatically even at a distance, most automatic machines and processes could not have been developed. And on still another count the displacement of the nonelectric by the electrically-driven motor has contributed to a reduction of labor requirements, for it has meant a shift in the production of the power used in factories from the factory itself to the central power station.

New and improved materials also make their way into various industries. Artificial leather is a familiar example. The extraordinary new metals, metallic alloys, and coated metals which are resistant to acids, durable,[20] light, with good edging properties, or with combinations of these and other virtues, have found their uses in cans for foods and beverages, motorcars, home appliances, and tools and machines of all kinds. Rayon, nylon and plastics are repeating the old story. Cellophane and paper boxes have displaced other wrapping materials in many different lines of business. Electric lights have rendered obsolete other means of illumination, and now the electric filament bulb is being superseded, in turn, by the gas-filled fluorescent type.

Improvements in such materials as paints, varnishes and

[20] Research in corrosion and in protective coatings and the development of alloy steels raised the average life expectancy of all iron and steel from 15 years in 1899 to 22 years in 1910 and 35 years in 1935. F. T. Sisco, in National Resources Planning Board, *Research—A National Resource* (Washington, 1940), Part II, p. 169.

lacquers have affected the many industries using them. Easier application to the object to be covered, quicker drying time, and greater durability of the surface have reduced the amount of labor required and resulted also in savings of space and inventory of work in process.

Business concerns purchase from other enterprises not only equipment and materials but also services. The important services rendered by the transportation and communication systems have improved very greatly, and since these services have been extensively utilized by all industry, the resulting advantages have been enjoyed at large. Contributing significantly to increased efficiency are the professions of accountancy and management engineering, the commercial laboratories, the trade associations and trade journals, professional societies of all kinds, and government in certain of its activities.

A striking development of recent years is the growing habit of industrial research—the "mass production of ideas," as Charles F. Kettering calls it.[21] Before 1914, though academic research and the creative work of individual inventors had of course affected many industries, organized industrial research was relatively rare. Since then, however, research has become to a considerable extent a function of industry itself, carried on by individual companies in many diverse fields. Research expenditures in relation to dollar output (gross sales or value added) and number of research employees in relation to total employment are highly variable, it is true; in such industrial groups as chemicals and electrical machinery they have acquired impressive proportions, but in no industrial group are they altogether absent.[22] In addition

[21] Hearings before the Temporary National Economic Committee (Washington, April 1940), Part 30, p. 16292.

[22] See National Resources Planning Board, *op. cit.*, pp. 122, 125 and 181; and George Perazich and P. M. Field, *Industrial Research and Changing Technology* (National Research Project, Philadelphia, 1940), p. 21.

to research carried on by individual companies, some work of this kind is done by trade associations and commercial laboratories, and by foundations set up by industry. The ideas thus developed, because they have originated at many separate points in industry and are extensively exchanged and broadcast through elaborate media of communication, have affected virtually all factory products and processes.

The advances we have just mentioned have meant much more than mere savings of labor. They have contributed also to economies in materials and machines, and to improvements in quality of product.[23] Indeed, there may be some cases in which labor per unit of product has been increased in order to effect savings of plant space and equipment, utilize byproducts, reduce waste, and so on. But more generally, when reductions in nonlabor factors of production have taken place they have coincided with cuts in unit labor requirements. The secular rise in the level of wages, the more or less steady decline in hours of work, the improvements in working conditions—themselves made possible by the increased productivity of the industrial system—have made labor expensive in relation to other factors of production. This costliness of labor has acted as a powerful incentive to the development and application of techniques, ideas and tools which promise to reduce the amount of labor needed to produce a unit of goods. The competition for labor, capital and materials by almost all new industries—and in particular the encroachment of new products in the sales markets

[23] The money spent for research in the iron and steel industry in 1938 was distributed, according to American Iron and Steel Institute, *Steel Facts* (Aug. 1938), p. 4, approximately as follows:

| *Project* | *Percent* |
|---|---|
| Improving quality | 33 |
| Improving methods of manufacture and reducing cost | 19 |
| Developing new products | 20 |
| Developing new uses and markets | 28 |

—has caused even relatively unenterprising managements to resort to the latest ideas, devices, machines and materials, and thus, whether incidentally or intentionally, to reduce labor input per unit of product. Here too, legislation setting minimum wage standards, restricting hours, and so on, has supplied added impetus to the great drive to reduce costs.

The widespread decline in unit labor requirements, it should now be apparent, can be explained in part by the fact that many of the forces instrumental in this reduction are at the command of all types of industry. Though superficially diverse in character, labor-saving means and methods in different industries have a common core. Efficient plant layout and labor management, powerful tools like the electric-motor, useful devices such as the telephone—all these can be applied in one form or another and in greater or less degree in all manufacturing industries. Similarly, the basic factors that impel management to cut labor per unit operate in all industries. As we have seen, reductions in unit labor requirements in one industry stimulate reductions in other industries, through competitive cuts in prices and increases in wage rates.

The industrial changes noted here have not appeared with equal prominence in all sectors of manufacturing, and as we now know, the rate of decline in labor per unit has varied from industry to industry. Technical conditions differ widely among industries, for one thing, and it will take some time for even a revolutionary improvement to win the approval of every entrepreneur. Perhaps in the failure of some industries to expand output one can find a more cogent reason for the uneven use made of new ideas, devices and methods, and the uneven rate of decline in unit labor requirements. It is certain, at any rate, that the industries which made the most exhaustive use of new ideas and processes, and thus effected especially drastic cuts in labor per unit, usually increased output faster than the average. This relationship will be considered in the following chapter, in which we shall study the varied movements of employment and output, and try to assess the role of capital investment, unit costs and prices in the changing status of American manufacturing industries.