Chapter 5

Trends in the Output of Individual Manufacturing Industries

THE account of the changes in the aggregate output of the seventeen groups of manufacturing industries, presented in the preceding chapter, provides a broad outline of the course of manufacturing production in the 38 years from 1899 to 1937. But any group classification must necessarily gloss over the rich variety of trends, since each group is composed of industries that have grown more or less rapidly than the group aggregate. Indeed, few industries have advanced, even approximately, at the same rate as the group of which they are part. In many instances new industries have displaced their older competitors within the same group. Even industries engaged in successive stages of fabrication of the same materials have diverged. In the present chapter we treat first the more important changes that have occurred within each of the groups of manufacturing industries, and then cut across group lines to trace similarities and differences in trends of output for a number of industries which, though classified in separate groups, are related to one another.

A CONSPECTUS OF CHANGES IN OUTPUT, 1899–1937

In Table 10 the 61 individual industries for which we have indexes of physical output for the entire period are arranged in order of percentage change in physical output from 1899 to 1937. Here the divergence of individual industries is shown to have been greater than the variation from group to group

brought out in Chapter 4. The group of industries classified under transportation equipment increased in output by more than 1,000 percent from 1899 to 1937, but this aggregate change included automobiles, which rose 180,000 percent, and at the other extreme, carriages and wagons, which declined 95 percent. Whereas the output of only one *group*, forest products, decreased absolutely over the long period, 11 out of the 61 individual *industries* for which we have indexes suffered actual declines in output.[1] These are found in the following groups: transportation equipment; textiles; stone, clay and glass products; foods; tobacco products; forest products; and miscellaneous products. There were only two groups —forest products and leather products—whose aggregate output increased less rapidly than population, but the growth of 24 out of the 61 individual industries for which we have complete indexes fell short of the population increase of 73 percent.

The table shows, moreover, certain interrelations among the trends of separate industries. The automobile industry stands at the top of the list and the carriage industry at the bottom. Automobiles are followed closely by petroleum refining. Paper and pulp are not far from each other. On the other hand the differences in the ranking of what might be expected to be closely related industries seem more striking, in some instances, than the similarities. For example, blast-furnace products and steel-mill products are rather far apart in the list.

[1] Some industries are not listed in Table 10 because the indexes for them do not cover the entire period 1899–1937. Among these, high points were reached in Census years prior to 1927 in the series for organs, motorcycles and bicycles, phonographs, charcoal, planing-mill products and lime. These industries, therefore, appear to have been declining in recent years. (The recent revival in bicycle output may indicate a change in the trend of that industry.) The high point in clay products occurred in 1927, and the decline from 1899 to 1937 may reflect the severity of the fall in building construction from 1927 to 1937, rather than a true secular decline.

TABLE 10

INDIVIDUAL MANUFACTURING INDUSTRIES[a]

Ranked According to Percentage Change in Physical Output, 1899–1937[b]

Industry	*Percentage Change*	*Industry*	*Percentage Change*
Automobiles	+180,100	Cotton goods	+101
Cigarettes	+4,226	Cane-sugar refining	+101
Petroleum refining	+1,920	Fish, canned	+96
Milk, canned	+1,810	Hats, wool-felt	+90
Beet sugar	+1,688	Shoes, leather	+87
Hosiery, knit	+1,202	Salt	+82
Cement	+838	Cane sugar, not elsewhere made	+67
Fruits and vegetables, canned	+792	Meat packing	+66
Chemicals, not elsewhere classified	+741	Cottonseed products	+63
Ice	+668	Leather	+61
Silk and rayon goods	+512	Woolen and worsted goods	+60
Pulp	+505	Liquors, malt	+60
Printing and publishing	+494	Underwear, knit	+52
Paper	+465	Carpet and rugs, wool	+52
Rice	+416	Lead	+51
Outerwear, knit	+393	Cordage and twine	+38
Paints and varnishes	+391	Hats, fur-felt	+26
Coke-oven products	+380	Gloves, leather	+16
Zinc	+318	Cigars	0
Liquors, distilled	+315	Pianos	−5
Steel-mill products	+313	Tobacco products, other	−6
Butter	+309	Flour	−8
Tanning and dye materials	+292	Clay products	−15
Copper	+272	Ships and boats	−17
Explosives	+267	Cars, railroad, not elsewhere made	−22
Wood-distillation products	+259	Lumber-mill products, not elsewhere classified	−32
Fertilizers	+248	Turpentine and rosin	−32
Blast-furnace products	+171	Linen goods	−44
Cheese	+158	Locomotives, not elsewhere made	−79
Jute goods	+134	Carriages, wagons and sleighs	−95
Wool shoddy	+116		

[a] The industry titles are short. Full titles appear in the index at the end of this volume.

[b] The indexes of physical output have been constructed from basic data in the U. S. Census of Manufactures and other sources, by methods described briefly in Chapter 2 and in detail in Appendix A. Appendix B presents these data, together with the indexes derived from them. The indexes have been adjusted to take account of changes in the coverage of the respective samples, except when such adjustment has been impossible.

CHANGES IN THE COMPOSITION OF THE MAJOR GROUPS OF INDUSTRIES [2]

Some of the component industries of the first major group, foods, are found among the first ten industries listed in Table 10; others are much farther down the list. Canned milk and canned fruits and vegetables, beet sugar and ice all augmented their output by more than 600 percent during the 38 years, whereas flour production dropped by 8 percent and meat packing and cane sugar increased less rapidly than population grew. Reflecting these diverse trends, the composition of manufactured food output changed markedly between 1899 and 1937. The major declines occurred in the relative importance of the flour and meat-packing industries. In 1899 flour and meat packing together contributed almost half of the physical output of the entire foods group; in 1937 their contribution was not quite one fifth. Canned fruits and vegetables, bakery products and dairy products were the chief gainers. An important factor in this shift in relative contributions to the group total was the change in the diet of the American people. Per capita consumption of grain products and meats declined, but consumption of fruits, dairy products and sugar rose. Another factor was the varying rate of shift from farm and domestic production to factory production. In some food industries, notably flour and cheese, the transfer of processing to the factory had been substantially completed by the opening of the twentieth century; for others, especially butter, baking, and canned fruits and vegetables, a large part of the growth must be ascribed to the substitution of factory for home and farm processing. Declines in the export of flour and meat products also contributed to the transformation in the group's output.

[2] This section is a brief summary of portions of Part Two, Chapters 6–22, to which the reader is referred for complete indexes and more detailed discussion.

In the beverage group the most important industry both in 1899 and in 1937 was malt liquors, including beer. Distilled liquors came second, and nonalcoholic beverages third, with minor industries in the group trailing after. During the post-war decade nonalcoholic beverages ranked first in importance as a result of the prohibition legislation. Although nonalcoholic beverages reverted to third place after the repeal of prohibition, the position of this industry, measured by its contribution to the group's value added, improved between 1914 and 1937, probably because of a change in drinking habits, and also of a shift from home-made to factory-bottled soft drinks. The increase in the output of distilled liquors from 1899 to 1937, over 300 percent, was much greater than the corresponding rise in malt liquors, only 60 percent. The marked variance results in large part from the consignment to warehouse stocks of a substantial proportion of the 1937 output of distilled liquors.

The several tobacco products show wide divergence of trends. The gain in the group's output between 1899 and 1937 is attributable entirely to cigarettes: this industry ranks second among the 61 manufacturing industries listed in order of percentage increase in output. Cigars remained almost constant while smoking and chewing tobacco actually declined. Cigarettes, the minor industry of 1899, accounted for four fifths of the output of the group in 1937.

The most important changes in the composition of the textile group's output, so far as we can tell from available data, occurred in the relative standing of cotton and woolen and worsted woven goods on the one hand, and silk and rayon woven goods and knit goods on the other. Hosiery and silk and rayon goods rose by more than 500 percent from 1899 to 1937. Cotton goods merely doubled in output, and woolen and worsted goods rose 60 percent. Knit underwear too made a poor record, but this was more than offset by the gains in the other knit goods divisions, and as a result the aggregate out-

put of the entire knit goods industry increased 500 percent. Stated in other terms, the contribution of cotton goods to the physical output of the textile group fell from 22 percent in 1899 to 17 percent in 1937. Woolen and worsted goods, which contributed 14 percent in 1899, accounted for only 8 percent in 1937. The relative contribution of silk and rayon goods rose from 3 to 7 percent, and of knit goods, from 5 to 11 percent. There were mild increases also in the output of wool carpets and rugs, cordage and twine, and fur-felt hats. Since they were of minor importance, these industries had slight effect upon the general character of the group's output. No quantitative data on the physical output of the major clothing industries (other than knit goods) are available for the entire period. In terms of value added, men's clothing declined in relative importance (from 15 to 12 percent of the group total) between 1899 and 1937, and women's clothing rose sharply (from 10 to 16 percent of the total).

The modifications in the composition of the textile group's output are attributable in part to changes in the fibers utilized. The consumption of flax, hemp, jute and similar fibers actually declined; the amount of wool used rose, but less than did the total consumption of all fibers; cotton went up both absolutely and in relation to the total; silk, never an important fraction of the total quantity of fibers, increased at a very rapid rate; rayon, introduced in 1909, constituted 5 percent by weight of all fibers used in textile mills in 1937. Another significant cause of the change in the composition of textile production was the shift from home and retail fabrication to the factory. No figures measuring this shift are available, but it is probable that a large part of the rise in knit goods represented such a transfer, and that the increase in the factory production of women's and children's clothing is to be credited to it.

No especially important changes occurred in the composition of the output of the leather products group. It is note-

worthy, however, that shoe output increased 87 percent from 1899 to 1937, whereas leather rose only 61 percent. One reason for the disparity was the decline in leather exports. Another was the relatively slow rise in other leather-consuming industries. Leather gloves rose only 16 percent from 1899 to 1937; and there was an actual decline in the output of the saddlery and harness industry, an important consumer of leather at the opening of the century.

None of the rubber products industries is listed in Table 10, since our indexes for this group do not go back to 1899. According to available figures, the increase in the output of rubber shoes was rather moderate from 1914 to 1937—only 39 percent. Tires and tubes rose at a very much faster rate; during these 23 years their output increased more than 500 percent. Other rubber products appear to have made substantial gains, though they fell short of the tremendous advance in tires and tubes. The growth in tires and tubes, attendant as it was upon the development of the automobile, quite transformed the output of the rubber group. In 1899 tires and tubes accounted for a very minor fraction of the group's production. In 1937, however, these products constituted over one half of the entire output of the group. The relative importance of the other industries naturally declined.

No radical changes occurred within the paper products group despite the fact that the two basic industries, pulp and paper, are not tied together very closely. A fair fraction of the wood pulp consumed in domestic paper mills is imported, and pulp itself constitutes less than two thirds of the materials consumed in paper mills, the remainder consisting of rags, old and waste paper, and straw. It is rather surprising, therefore, that the output of both pulp and paper rose from 1899 to 1937 by substantially similar amounts, 505 and 465 percent respectively.

The industries within the printing and publishing group also maintained a rather stable interrelationship. Book and

job printing and publishing rose only slightly in relative importance, from 28 percent of the total in 1899 (in terms of value added), to 29 percent in 1937. Periodical printing and publishing fell from 57 to 56 percent. Although most of the subsidiary industries, like engraving and lithographing, kept their positions unchanged, photo-engraving increased its relative contribution from 1 to 4 percent.

Despite the very great gain in the aggregate output of the chemicals group, which far exceeded the rise in total manufacturing, most of the industries in the group failed to grow as rapidly as that total. However, these industries, which include cottonseed products, fertilizers, explosives, wood distillation products, and salt, among others, are the less important members of the group when measured in terms of value added. The large Census industries, "chemicals, not elsewhere classified," and paints and varnishes, gained 700 and 400 percent, respectively. Although rayon did not come into use until around 1909, it soon became one of the larger industries of the group, and by 1937 its output was 150 times that of 1914. Compressed and liquefied gases, and carbon black (an important material in rubber manufacture), also made very substantial gains. The pattern of production for the entire chemicals group clearly reflects this great divergence of trends. "Chemicals, not elsewhere classified," rayon, and gases contributed only 10 percent to the group's output in 1899, and as much as 42 percent in 1937.

In the petroleum and coal products group both the principal component industries rose, but the increase in petroleum refining, almost 2,000 percent from 1899 to 1937, exceeded by far the increase in coke-oven products, 380 percent. The more rapid growth of petroleum reflects, of course, the rising demand for gasoline and lubricants. As a consequence, petroleum refining raised its contribution to the group's output from less than half in 1899 to eight tenths in 1937.

The stone, clay and glass products group includes rapidly

growing industries like cement, which increased by more than 800 percent from 1899 to 1937, and glass, for which no exact figure can be given; and declining industries like marble and granite and clay products (brick). The output of the last industry fell by 15 percent in the 38-year period. Cement and glass increased their contributions to the group's output, as did several smaller industries, pulp goods, asbestos products and concrete products. On the other hand marble and granite, clay products, and pottery declined in relative importance: in 1899 these industries accounted for well over half the group's value added, but in 1937 for only one quarter.

The decreasing use of lumber as a building material (output fell 32 percent from 1899 to 1937), and the growing substitution of metal for wood in furniture, caused lumber to decline in relation to the total output of the forest products group. Lumber-mill products contributed three fifths of the group's value added in 1899 but only two fifths in 1937. The major part of the rise occurred in furniture.

Steel-mill products increased in physical output by more than 300 percent from 1899 to 1937. In contrast, blast-furnace products rose only 170 percent. This is a surprisingly wide difference, since iron, practically the only product of blast-furnaces, constitutes the essential material in steel manufacture. The principal cause of the divergence was the displacement of pig iron by iron and steel scrap, made possible by the development of the open-hearth process of steel manufacture. A contributing factor was the increased efficiency in the utilization of iron for steel production, and the decline in the fraction of total iron output absorbed by foundries.

Within the nonferrous-metal products group, too, the increased use of secondary or scrap metal helped to bring about a divergence of trends. The primary smelting and refining industries accounted for 36 percent of the group's value added in 1899 but for only 13 percent in 1937. The nonferrous-metal products industries using copper, lead and zinc rose in im-

portance. Also contributing to the divergence was the decline in the percentage of domestically produced nonferrous metals exported to other countries. Although all three primary nonferrous-metal industries were subject to these influences, the rate of increase in their physical product nevertheless varied. Zinc and copper are in the upper half of the list in Table 10, whereas lead is in the lower half.

The machinery industries are not listed in Table 10. No adequate indexes of physical output are available for most of these industries, and for none do the indexes cover the entire period 1899–1937. The data on value added do, however, provide some information on changes in the composition of the group's output. The major decrease came in agricultural implements, which contributed one eighth of the group's value added in 1899, but less than one thirtieth in 1937. Sewing machines also declined in relative importance. The major increase occurred in the relative contribution of electrical machinery, which rose from 9.5 percent of the group's total value added to 25 percent. Pumps, business machinery and refrigerators likewise gained in relative importance. The largest machinery industry, foundry and machine-shop products, remained in the same position in the group over the long period.

The most striking divergence of trends is found in the transportation equipment group. We have already noted that automobiles head the list in Table 10, while carriages, wagons and sleighs are at the foot. The decline in railroad cars and locomotives, too, is closely bound up with the development of the motor car. It is interesting to trace the course of the displacement of carriages and railroad equipment by the automobile. According to the figures given in the tabulation on page 97, automobile production rose by 3,500 percent during the decade 1899–1909. It must be remembered that though this growth was immense, it started from a very low level. In 1899 the value added in automobile manufacture

was $3,000,000, less than one tenth of one percent of the total value added in all manufacturing industries. In the manufacture of carriages, wagons and sleighs the value added in 1899 was $60,000,000; and in the fabrication of railroad cars and

	Percentage Change in Physical Output				
	1899–1937	1899–1909	1909–1919	1919–1929	1929–1937
Automobiles (incl. bodies and parts)	+180,100	+3,500	+1,467	+255	−10
Carriages, wagons and sleighs	−95	+1	−52	−84	−29
Cars, railroad, not elsewhere made	−22	−5	+50	−41	−7
Locomotives, not elsewhere made	−79	+7	+14	−69	−45

	Value Added as a Percentage of Value Added by All Manufacturing Industries				
	1899	1909	1919	1929	1937
Automobiles (incl. bodies and parts)	.06	1.47	4.88	6.66	5.86
Carriages, wagons and sleighs	1.31	.78	.16	.03	.02
Cars, railroad, not elsewhere made	.70	.61	.81	.35	.42
Locomotives, not elsewhere made	.33	.21	.36	.10	.13
TOTAL	2.40	3.07	6.21	7.14	6.43

locomotives $32,000,000 and $15,000,000, respectively. The 3,500 percent rise in automobile production during the decade left these competitor industries relatively untouched. The railroad equipment industries were not notably affected, and carriages and wagons simply stopped growing. In the next decade, although automobile production rose at a slower rate (the percentage increase from 1909 to 1919 was about 1,500) the rise started from a much higher point: in 1909 the value added in the automobile industry already constituted one and a half percent of the grand total, almost as much as the aggregate percentage of value added contributed by the carriage and railroad equipment industries together. Thus in 1909–19

the output of the carriage industry suffered a decline of 50 percent, while the output of the railroad equipment industries failed to grow.[3] During the third decade of the century automobile output rose 250 percent. Now the industry was full-grown and one of the most important in all manufacturing. In those ten years the output of carriages fell by 84 percent, of railroad cars by 41 percent, and of locomotives by 69 percent. The decline in the two latter industries is exaggerated somewhat because quality improvements are not taken into account; but no corrections for quality changes would seriously alter the basic relations among the trends in output. In the last period, 1929–37, the output of all four industries fell. The competitive interrelation was overshadowed by more general forces affecting the industries, yet the output of carriages fell 29 percent, while automobile production declined only 10 percent. The development of the automobile resulted not only in the displacement of the other types of transportation equipment, but also in the growth of the group aggregate. The group total rose also in relation to total manufacturing, as is indicated by the increase in value added by the four industries as a percentage of total value added: from 2.4 in 1899 to 6.4 in 1937.

Another important member of the transportation equipment group, ships and boats, passed through an extraordinary development during the war of 1914–18. Shipbuilding rose 650 percent from 1909 to 1919, but fell 82 percent from 1919 to 1929.

In the miscellaneous products group only one industry, pianos, appears in Table 10. The data on value added for the industries in this group show a large decline in the relative importance of all the musical instruments industries, and in

[3] The rise in the output of railroad equipment from 1909 to 1919 must be ascribed to the depression in the industry in 1909. See Chapter 21, footnote 14.

brooms and brushes, artificial flowers, feathers and plumes, and umbrellas and canes. The outstanding rises occurred in the manufacture of professional instruments used in surveying, navigation and industrial measurement and control; photographic supplies; signs; and toys and games.

INTERRELATIONS OF INDUSTRIAL TRENDS

The preceding discussion has provided abundant illustration of the diversity in the movements of output among individual manufacturing industries. This diversity, to be sure, is far from unexpected. Industries that compete with one another would naturally grow at diverse rates, and changes in income, tastes and fashion would accentuate the tendency toward differentiation. Even if demand were unchanged, modifications of the conditions of supply would affect competing industries in diverse degree. Differences in rates of advance in technology and in industrial organization, as well as variations in the drain upon natural resources, must inevitably result in uneven changes in cost, which in turn lead to differences in price trends and hence in output trends.

There are many examples of divergence in the trends of competing manufacturing industries. Since many of the major groups are composed of industries devoted to commodities satisfying the same or similar needs, a good deal of the divergence of trends within groups reflects shifts among competing commodities. Thus, rises in sugar, ice cream and cereal preparations have been at the expense of other food industries. Beet sugar increased many-fold, while cane sugar barely doubled. Nonalcoholic beverages rose more rapidly than population, but total alcoholic beverages barely kept pace with the gain in population. Cigarettes displaced cigars and other tobacco products. Fashion changes, in conjunction with differing rates of technological advance and the development of new

fibers, were responsible for the rapidity of the growth in silk, rayon goods and knit goods as compared with the slower rise in output of cotton and woolen goods. The vinegar and cider industry declined because its products were displaced by the vinegar and cider produced as secondary products in the growing canned fruits and vegetables industry. A similar development probably lies behind the decline in the charcoal industry: there was an increase in the output of the wood-distillation products industry, and with it an increase in the output of by-product charcoal. Industries refining nonferrous metals from scrap increased more rapidly than those smelting ores. Phonographs tended to decline when radios increased. Cement production grew, but brick and stone production dropped off. Most spectacular, of course, was the divergence between automobile and carriage production.

Cutting across group lines, we find that leather rose relatively slowly as compared with various substitute textile products. Ice-boxes and manufactured ice declined during the last decade, whereas mechanical refrigerators grew at a rapid pace. Structural steel and cement increased at the expense of lumber, brick and stone. The output of phonographs, itself declining in relation to that of radios, nevertheless increased in relation to organs and pianos. Paper boxes displaced wooden boxes. Wood-distillation products rose, turpentine and rosin fell.

Divergence of trends is found not only among competitively related industries but among sequentially related industries as well. It is true that there is some similarity of trend among related industries in the latter group. Both malt and malt liquors fell together upon the enactment of prohibitive legislation and increased rapidly after its repeal. Shoe, glove and leather production all rose at moderate rates. Printing kept pace, approximately, with paper, and paper with pulp. Steel-mill products, blast-furnace products and coke-oven products

are found together near the middle of the list in Table 10. Rayon production in chemical factories and the output of rayon goods in textile factories both rose at high rates. Carbon black and rubber products increased rapidly. Tin can production and food canning advanced together.

Nevertheless there is a noticeable degree of diversity in trend even among these closely related industries. Industries sequentially related have diverged in output because of changes in foreign trade; because of inventions and other improvements conducive to savings in materials; because of changes in domestic tasks brought about by higher standards of living; and because of shifts in the kind and quality of products made from given materials. The drop in the production of flour, attributable to a fall in exports, was not accompanied by a corresponding decline in domestic bakery output. The consistently slower rate of growth in blast-furnace products, as compared with steel-mill products, reflected the increasing use of scrap steel as a raw material in steel mills; the same influence is apparent in the diversity between the growth of the primary nonferrous-metal industries and the development of the industries using these metals. Rising incomes and the entry of women into industry caused the clothing and baking industries to increase in output more rapidly than the industries producing commodities such as cloth and flour. Further, sequentially related industries are not always tightly articulated. While blast-furnaces transfer three quarters of their product to steel mills, they also supply pig iron to foundries. Coke-oven products rose more rapidly than blast-furnace products because many of the increasingly important by-products of the coke process are not sold to blast furnaces.

Industries producing goods related complementarily to one another also tended to grow or decline together. Two outstanding examples are presented in the following tabulation:

	Value Added as a Percentage of Value Added in All Manufacturing Industries				
	1899	1909	1919	1929	1937
Automobiles and related industries					
Automobiles (incl. bodies and parts)	.06	1.47	4.88	6.66	5.86
Petroleum refining	.46	.47	1.65	2.02	1.90
Lubricants, not elsewhere made	.01	.01	.02	.10	.07
Tires and tubes, and other rubber products	.46	.68	2.05	1.57	1.29
Carriages and related industries					
Carriages, wagons and sleighs	1.31	.78	.16	.03	.02
Carriage and wagon materials	.26	.21	.05	.00	[a]
Saddlery, harness and whips	.33	.29	.14	.03	.02
Horse blankets	.01	.02	.01	.00	[a]

[a] No longer shown separately.

An expansion of petroleum refining, lubricants, and tires and tubes accompanied the growth of automobiles. Conversely, obsolescence of carriages, wagons and sleighs dragged down the related industries producing carriage materials, harness and horse blankets. Similar relations are found among other complementary industries. Cigars and cigar boxes both declined. Smoking tobacco and pipes fell together. The rise in printing and publishing stimulated such subsidiary industries as engraving, lithographing, stereotyping, and printers and engravers' materials. Shoes, shoe-cut stock, shoe findings and lasts moved together. Watches and watch cases fell in relative importance. Manufactured ice, ice-boxes, fresh meat and refrigerator cars all rose together; and in the recent period, with the advent of mechanical refrigeration, the first two industries both declined. As in the case of industries related sequentially, the rates of growth or decline in the output of industries complementarily related were not identical. Foreign trade and the manufacture of secondary products helped to cause the divergence. There was, however, another feature peculiar to this group of industries—a difference in durability of product. This difference may be illustrated by reference to automobile, tire, and gasoline production. These all made

tremendous advances, but because of variation in their life spans the advances were not maintained at the same pace. Automobile tires do not last as long as automobiles, and gasoline, of course, is consumed at once. Thus the output of gasoline would be expected to change with the number of automobiles in use rather than with the number produced. Another factor making for change in the degree of divergence of these related industries was the increase in the length of life of some of the products. Automobiles now last longer and tires are much more durable. In addition, the changing economy of gasoline utilization has affected the degree of divergence in the rates of growth of these industries.

The rapid advance in total manufacturing output between 1899 and 1937 and the divergence of trends of the individual industries are not unrelated. We have already noted that a rise in total production brings about a reallocation of consumer purchasing power. Foods came to occupy a smaller place in the consumer's budget, while other commodities grew in importance. The housewife rid herself of domestic chores and factories increasingly took over these activities. The rise in total output and in population exerted pressure on natural resources, which vary in abundance. Technological progress helped to make possible the rise in the aggregate national product, but its effects were far from uniform in all industries. Finally, increased division of labor among industries, which also contributed to the rise in the total, necessarily caused divergence in the rates of growth. Thus "the very causes which have determined the rapid advance of general production in this country . . . have also determined the divergence in the trends of its separate industries." [4]

[4] A. F. Burns, *Production Trends in the United States since 1870* (National Bureau of Economic Research, 1934), p. 63. The causes of divergence are systematically discussed by Dr. Burns in Chapter 3, Sec. 1–2. Divergence in trends may be expected also in a retrogressive economy, as Dr. Burns points out. In this case, the forces determining the decline in general output would be those which also determine the divergence in trends, but the divergence would be different from that which characterizes a progressive economy.

THE RELATION BETWEEN GROWTH IN OUTPUT AND CHANGE IN THE PRICE OF FABRICATIONAL SERVICES

Divergence in the trends of physical output of American manufacturing industries was accompanied by divergence in the trends of pecuniary output, selling price, employment, wage rates, capital investment, and so on. It is safe to say that few of the industries that make up the manufacturing sector of our economy changed in any important characteristic at the same or approximately the same rate. In respect of each of these economic quantities the relations among them were subject to continued flux: patterns of production, employment and capital investment, and the structure of prices and wage rates did not remain rigid.

The likenesses and dissimilarities among these long-term changes require investigation. Since comprehensive and reliable data are lacking, an extensive study along these lines is a long and difficult task beyond the scope of the present survey. The relations between trends in physical output and in employment will be considered in a separate volume devoted entirely to them. In this volume it is possible only to point out rather briefly what we can learn from the indexes of physical output and from the Census data on value added concerning the relation between the trends in physical output on the one hand, and on the other, the trends in pecuniary output, particularly in the average pecuniary receipts per unit of output (the average price obtained for the services of fabrication).

Along with the changes in the industrial pattern of the physical output of manufacturing, described above, there were similar changes in the industrial pattern of the money received for the fabricational services involved in the making of the physical product—that is, the value added by manufac-

turing, which is equal to the value of products minus the cost of materials and fuels. This correspondence has already been shown for major groups of industries in Chapter 4. It may easily be illustrated also in terms of individual industries. Thus the automobile industry increased its physical output 1,800 times from 1899 to 1937, more than any other manufacturing industry for which data are available. The rise in the value added by the industry was considerably less, for it increased only 500 times, but this figure too surpasses the records of other industries. At the other extreme we find the industry producing carriages, wagons and sleighs; its physical output fell 95 percent from 1899 to 1937, and the value added by it dropped 90 percent—greater declines than have been observed in any other industry for which we have comparable information. Table 11 shows the same sort of correspondence between the two figures for other industries. It is because of this correspondence that we have felt justified in utilizing the data on value added, not only in the preceding discussion but also even more extensively in Part Two (below), to throw some light on the more pronounced changes in the physical output of those industries for which no adequate direct indexes of physical output can be computed.[5]

The relation between the indexes of output and those of value added is significant on still another count. A careful study of the changes in the pattern of physical output and in that of value added reveals that the changes in the former differ among themselves more widely than do the corresponding changes in value added. In particular, there is a tendency for

[5] The correlation between the ranks of the indexes of physical output and of value added is measured by a coefficient of +.84. The coefficient of correlation between the logarithms of the indexes is +.88. It is true, of course, that even if the correlation coefficients were equal to unity, there might be some risk of error if we inferred from the change in the value added by an industry what had happened to the physical output of that industry. Because the correlation is in fact imperfect, this is almost a certain risk. But while in a particular case an inference of the kind mentioned might well be wrong, it is probable that the number of such inferences that are right, within reasonable margins of error, considerably outweighs the number that are wrong.

TABLE 11

INDIVIDUAL MANUFACTURING INDUSTRIES

Indexes of Value Added, Physical Output, and Value Added per Unit of Physical Output, 1937 relative to 1899[a]

Industry	Index			Rank		
	Value Added	Physical Output	Value Added per Unit of Physical Output	Value Added	Physical Output	Value Added per Unit of Physical Output
	(1)	(2)	(1) ÷ (2) × 100			
Foods						
Meat packing	391	166	236	26½	32	9
Flour	183	92	200	41	43	16½
Rice	727	516	141	12½	13	30
Fish, canned	426	196	217	23	27	11
Fruits and vegetables, canned	1,020	892	114	6	5	40
Butter, cheese and canned milk	644	560	115	15	11	38½
Beet sugar	1,536	1,788	86	4	4	44
Cane sugar and cane-sugar refining	385	186	207	28	30	14
Ice	1,047	768	136	5	6	32½
Beverages						
Liquors, malt	314	160	196	35	35½	18
Liquors, distilled	92	415	22	48	17	50
Tobacco products						
Cigarettes and cigars	800	554	144	10	12	29
Tobacco products, other	122	94	130	46	42	34
Textile products						
Cotton goods	346	201	172	31	26	25
Woolen and worsted goods	324	160	202	34	35½	15
Silk and rayon goods	410	612	67	25	8	45
Knit goods	760	605	126	11	9	36
Carpets and rugs, wool	379	152	249	29	37	7
Cordage and twine	254	138	185	36	39	20½
Jute goods	517	234	221	18	25	10
Linen goods	144	56	256	45	48	6
Hats, fur-felt	227	126	180	38	40	23
Hats, wool-felt	467	190	246	22	28	8

Leather products						
Leather	236	161	147	37	34	28
Shoes, leather	391	187	209	26½	29	12
Gloves, leather	212	116	183	40	41	22
Paper products						
Paper and pulp	852	618	138	8	7	31
Printing and publishing	652	594	110	4	10	42
Chemicals						
Chemicals, not elsewhere classified, including rayon and compressed gases	2,713	2,600	104	2	2	43
Cottonseed products	340	163	208	32½	33	13
Wood-distillation products	592	359	165	16	22	26½
Explosives	500	367	136	20	21	32½
Fertilizers	418	348	120	24	23	37
Paints and varnishes	913	491	186	7	14	19
Salt	472	182	260	21	31	5
Tanning and dye materials	504	392	129	19	19	35
Petroleum and coal products						
Petroleum refining	2,319	2,020	115	3	3	38½
Coke-oven products	532	480	111	17	15	41
Forest products						
Lumber-mill products	180	68	267	42	46½	4
Turpentine and rosin	112	68	165	47	46½	26½
Iron and steel products						
Blast-furnace products	170	271	62	43	24	46
Steel-mill products	727	413	176	12½	18	24
Nonferrous-metal products						
Copper	164	372	44	44	20	47
Lead	63	151	41	49	38	48
Zinc	835	418	200	9	16	16½
Transportation equipment						
Automobiles, including bodies and parts	52,123	180,200	29	1	1	49
Carriages, wagons and sleighs	10.0	5.4	185	50	50	20½
Cars, railroad, not elsewhere made	340	78	434	32½	45	3
Locomotives, not elsewhere made	219	21	1,049	39	49	1
Ships and boats	366	83	440	30	44	2

[a] The indexes of value added are derived from data in the U.S. Census of Manufactures, given in detail in Appendix C.

The indexes of physical output have been constructed from basic data in the Census of Manufactures and other sources by methods described briefly in Chapter 2 and in detail in Appendix A. Appendix B presents the data on physical output together with the indexes derived from them. The indexes have been adjusted to take account of changes in the coverage of the respective samples, except when such adjustment was impossible.

Because the data on value added are available in some cases only for combinations, such as butter, cheese and canned milk, the number of separate indexes shown here is smaller than the number given in Table 10.

the change in the physical output of an industry to be further away from the average change in physical output than the change in the industry's value added is from the average change in value added. This divergence is well illustrated by the figures for automobiles and carriages. Value added rose less than physical output in the case of automobiles; it fell less than physical output in the case of carriages.[6]

The same finding may be expressed more significantly in terms of the relation between physical output and value added *per unit* of physical output (third column of Table 11). Greater-than-average rises in physical output were accompanied, more often than not, by less-than-average rises in value added per unit of output; and, correspondingly, less-than-average rises in physical output were accompanied, more often than not, by greater-than-average rises in value added per unit of physical product. For example, the large increase in the number of automobiles produced was accompanied by a relative decline in the amount of money received per automobile (after deduction of cost of materials).[7] And a concomitant of the drastic decline in the number of carriages, wagons and sleighs manufactured was a greater-than-average rise in the value added in the production of each carriage, wagon or sleigh. Other examples are to be noted in Table 11. Thus, the second largest rise in value added per unit is credited to lumber-mills, which declined in output 32 percent.

It is not invariably true, however, that an inverse relation exists between the rate of growth in output and the change

[6] The degree of variation about the mean for all the items in Table 11 may be measured by the standard deviation. The standard deviation of the value added relatives, after conversion to logarithms, is .51; of the physical output indexes, .62.

[7] It is important to remember that value added per unit is simply the selling price minus the cost of materials and fuel per unit of product. It is a pecuniary quantity, not the utility added to the raw materials. The physical unit—one auto—was a far more efficient machine and more valuable in that sense in 1937 than in 1899, although both its price and the value added per unit were much lower in 1937 than in 1899.

in value added per unit. Lead production rose only 51 percent, yet the value added per pound of lead fell drastically in relation to the average. Nevertheless, there appears to have been a definite tendency, over the long run, for an industry with a greater-than-average growth in physical output to have had a lower-than-average increase in value added per unit of output, and vice versa.[8]

Still closer examination of the relation between output and value added per unit shows up certain interesting details. Table 12 and Chart 7 bring together the complete series for

[8] If the indexes of physical output are correlated with value added per unit of physical output for the longest period, 1899–1937, a coefficient of rank correlation equal to −.66 is obtained.

There is, of course, a danger of spurious correlation between changes in physical output and changes in value added per unit of physical output. Thus if our estimate of the true index of output of an industry is too high, the derived estimate of value added per unit for that industry will be too low; if the estimate of output is too low, the derived estimate of value added per unit will be too high. It was impossible to avoid this danger entirely although every effort was made to compute accurate estimates of output. The probability of spurious correlation may be reduced by exclusion from the correlation of the industries with the more doubtful indexes of physical output. After such exclusion we obtained about the same degree of correlation as we had by using the entire sample.

The present finding is supported, further, by the statistical relation between output and value added per unit that can be derived from the regression lines obtained in the correlation, mentioned in footnote 5 above, of the logarithms of physical output and value added. (For a discussion of the meaning and the method of derivation of the regression lines see F. C. Mills, *Statistical Methods* [Henry Holt, 1938], pp. 359–66.) The two regression lines are:

$$\log y = a + .93 \log x, \text{ and}$$
$$\log y = A + .72 \log x,$$

in which y is the index of value added, x is the index of physical output, and a and A are constants which need not be specified in numerical form. These equations may be transformed into:

$$\log \left(\frac{y}{x}\right) = a - .07 \log x, \text{ and}$$

$$\log \left(\frac{y}{x}\right) = A - .28 \log x.$$

Since the coefficients of log x are both negative, $\log \left(\frac{y}{x}\right)$ and log x are related inversely in both equations. The relation thus obtained between output and value added per unit of output also is negative. Since it is not subject to spurious correlation it confirms the inverse relation found by direct correlation of output and value added per unit.

TABLE 12

SELECTED MANUFACTURING INDUSTRIES

Indexes of Physical Output and of Value Added per Unit of Physical Output[a] (1929:100)

Industry and Index	*1899*	*1904*	*1909*	*1914*	*1919*	*1921*	*1923*	*1925*	*1927*	*1929*	*1931*	*1933*	*1935*	*1937*
Rayon														
Physical output	..	..	..	2.0	6.7	12	28	40	60	100	138	201	253	310
Value added per unit	..	..	..	..	..	..	143	149	120	100	60	48	41	48
Radios[b]														
Physical output	..	..	..	..	..	..	2.6	33	28	69	51	52	74	100
Value added per unit	..	..	..	..	..	..	..	..	..	..	84	51	78	100
Refrigerators, mechanical														
Physical output	..	..	..	..	..	0.6	2.0	8.4	44	100	118	130	212	317
Value added per unit	..	..	..	..	..	..	..	..	138	100	78	46	42	44
Washing and ironing machines														
Physical output	..	..	..	..	..	..	..	..	73	100	79	92	132	146
Value added per unit	..	..	..	..	..	..	..	..	117	100	80	53	46	47
Automobiles, including bodies and parts														
Physical output	0.05	0.25	1.8	8.5	28	25	63	72	63	100	44	35	74	90
Value added per unit	200	320	328	162	202	154	116	121	116	100	108	92	76	84
Petroleum refining														
Physical output	5.9	7.2	11	17	34	40	56	73	81	100	91	86	99	119
Value added per unit	59	82	56	69	186	141	109	110	79	100	57	60	60	68
Beet sugar														
Physical output	6.7	23	45	68	67	96	68	100	84	100	107	151	111	120
Value added per unit	98	116	122	82	245	48	184	120	82	100	58	90	57	85
Milk, canned														
Physical output	7.2	10.9	18	36	84	69	73	76	88	100	100	98	115	128
Value added per unit	..	85	103	83	149	142	100	90	102	100	87	77	78	76
Ice														
Physical output	9.8	17	30	44	60	67	77	88	88	100	96	74	72	75
Value added per unit	62	62	62	57	91	93	90	95	96	100	96	88	81	85

Industry and Index	*1899*	*1904*	*1909*	*1914*	*1919*	*1921*	*1923*	*1925*	*1927*	*1929*	*1931*	*1933*	*1935*	*1937*
Fruits and vegetables, canned														
Physical output	17	24	29	42	55	38	67	82	82	100	91	88	127	151
Value added per unit	59	58	54	59	119	118	112	97	92	100	73	68	66	67
Paints and varnishes														
Physical output	22	28	38	41	52	45	67	76	87	100	69	62	87	109
Value added per unit	48	48	52	59	101	97	99	99	103	100	97	93	90	88
Flour														
Physical output	94	98	102	108	114	94	106	102	100	100	91	80	82	86
Value added per unit	41	50	59	60	116	103	80	89	92	100	79	87	87	81
Lumber-mill products, n.e.c.[c]														
Physical output	107	96	105	96	97	80	99	106	97	100	51	40	55	72
Value added per unit	31	44	51	50	107	74	107	92	86	100	65	65	72	84
Cars, railroad, n.e.m.[d]														
Physical output	119	122	114	154	171	96	229	139	101	100	31	..	30	93
Value added per unit	26	32	41	42	106	129	80	86	98	100	122	..	126	112
Carriages, wagons and sleighs														
Physical output	1,317	1,392	1,333	1,123	647	182	300	216	173	100	36	40	59	71
Value added per unit	52	54	54	56	70	82	78	70	64	100	114	92	83	96
Clay products														
Physical output	77	85	102	83	63	57	99	106	107	100	48	28	40	66
Value added per unit	..	..	..	52	106	104	109	104	97	100	87	74	85	91
Linen goods														
Physical output	137	..	200	192	86	72	125	117	120	100	68	72	73	77
Value added per unit	29	..	27	31	72	114	94	91	92	100	88	68	67	75

[a] The indexes of physical output have been constructed from basic data in the U. S. Census of Manufactures and other sources, by methods described briefly in Chapter 2 and in detail in Appendix A. Appendix B presents these data, together with the indexes derived from them. The indexes of physical output have been adjusted to take account of changes in the coverage of the respective samples, except when such adjustment was impossible.

The indexes of value added per unit have been derived from the Census data on value added, given in Appendix C, and the indexes of physical output, given in Appendix B.

[b] Base is 1937.

[c] Not elsewhere classified.

[d] Not elsewhere made.

Chart 7

SELECTED MANUFACTURING INDUSTRIES

Indexes of Physical Output and of Value Added per Unit of Physical Output Expressed as Percentages of the Corresponding Indexes for All Manufacturing Industries Combined

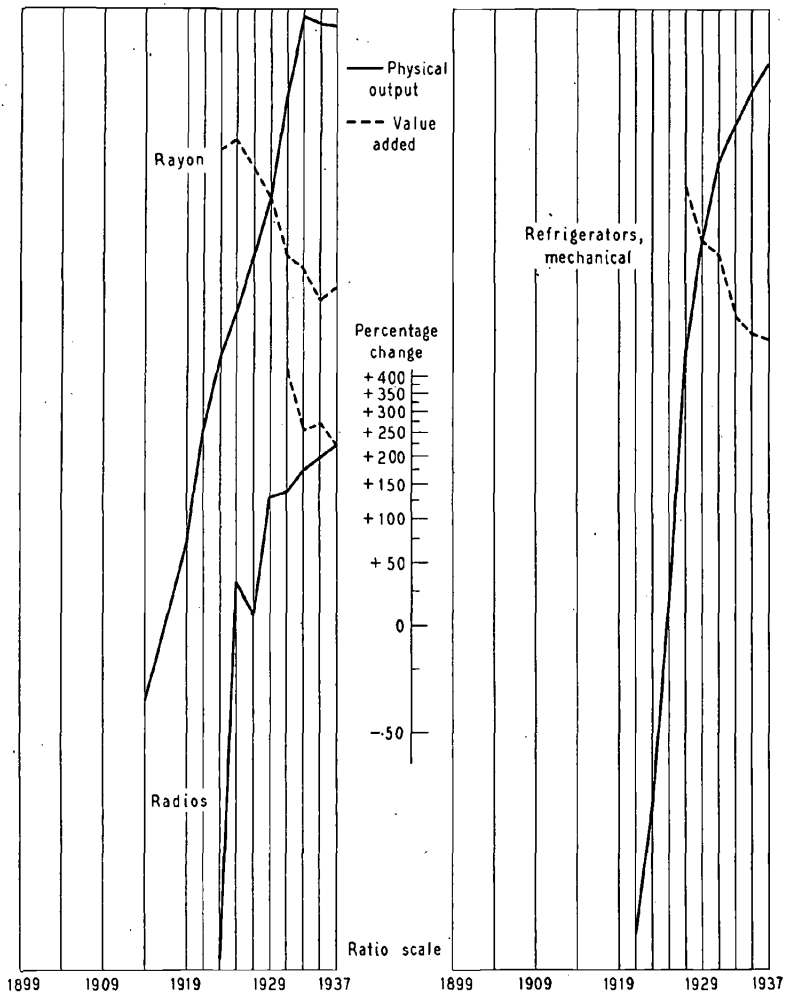


Chart 7 (cont.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Physical Output and of Value Added per Unit of Physical Output Expressed as Percentages of the Corresponding Indexes for All Manufacturing Industries Combined

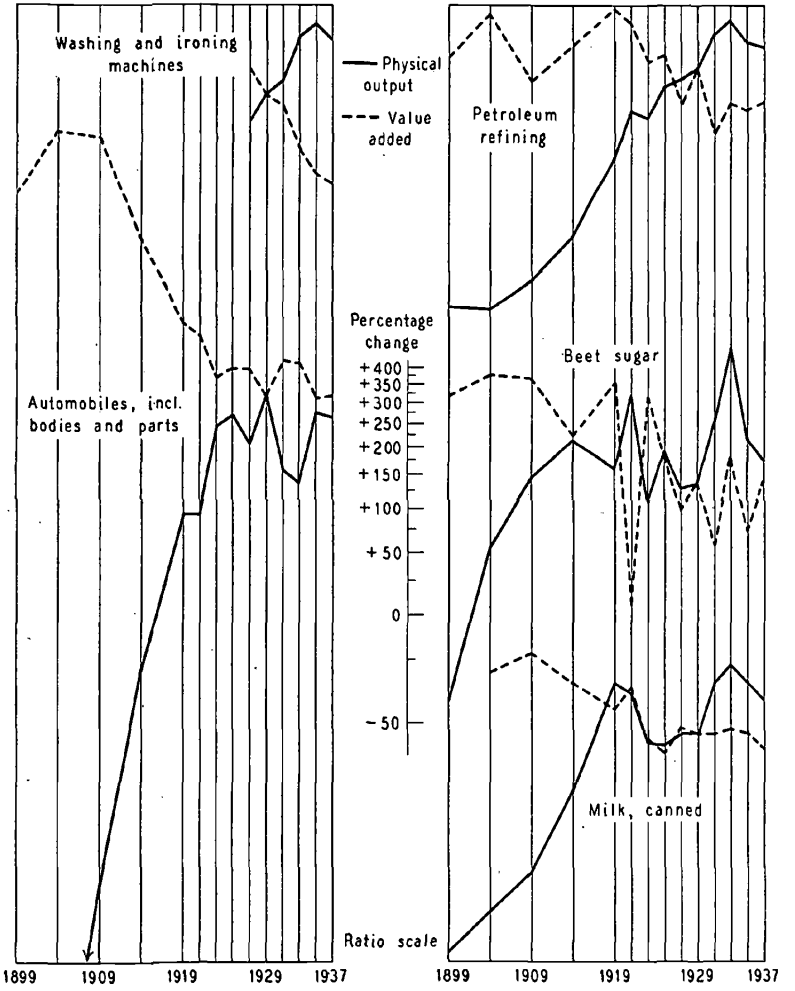


Chart 7 (cont.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Physical Output and of Value Added per Unit of Physical Output Expressed as Percentages of the Corresponding Indexes for All Manufacturing Industries Combined

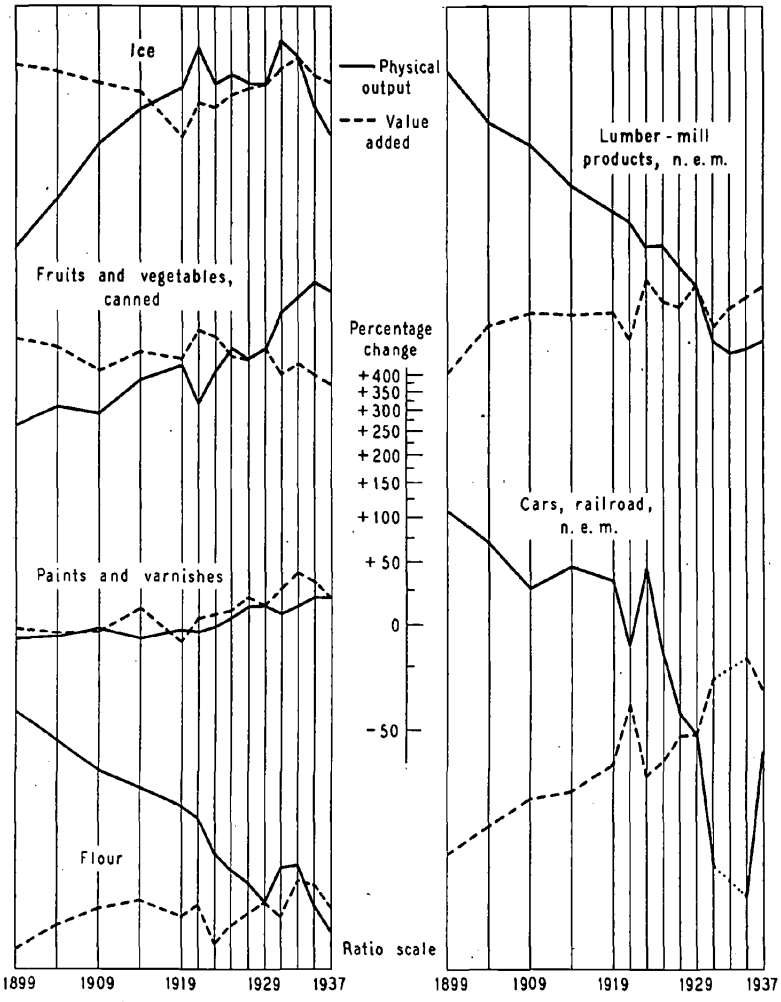
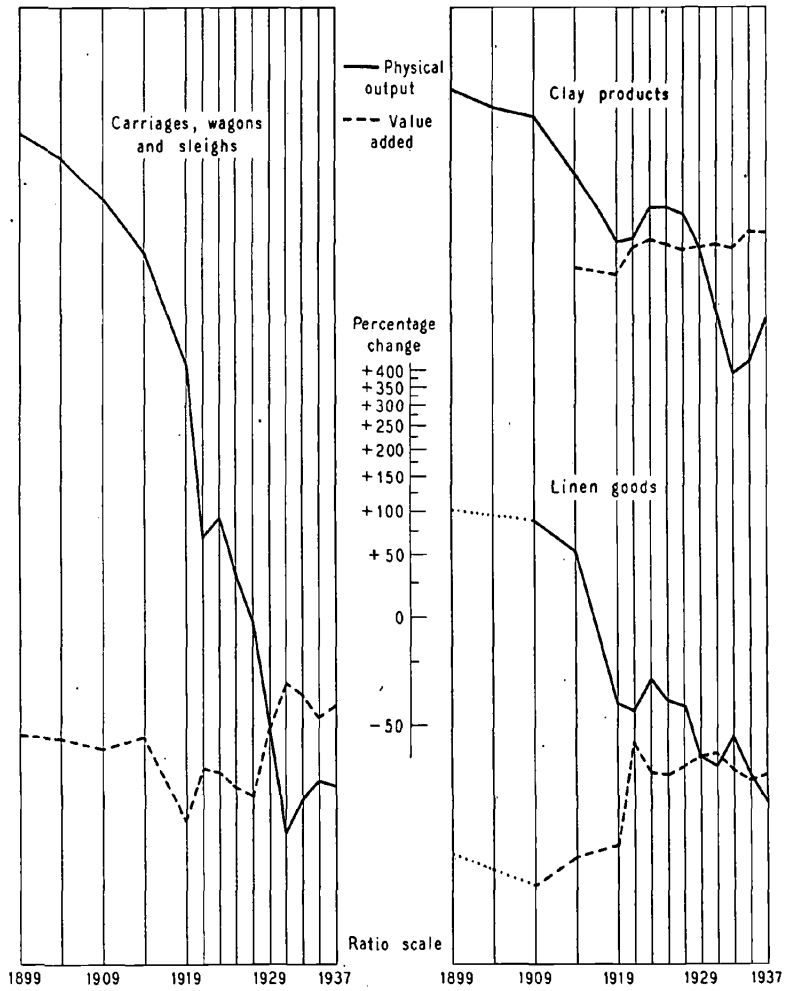


Chart 7 (concl.)

SELECTED MANUFACTURING INDUSTRIES

Indexes of Physical Output and of Value Added per Unit of Physical Output Expressed as Percentages of the Corresponding Indexes for All Manufacturing Industries Combined



several industries. Included are some industries that came into existence after 1899 and are therefore not listed in Table 11. The selection consists of industries growing very rapidly, or very slowly, or actually declining. Each of the indexes of physical output in the chart has been divided by the corresponding index for all manufacturing combined, and similarly, each of the indexes of value added per unit of physical output has been divided by the corresponding index for all manufacturing. The division by the average serves to indicate more clearly the movement of output and unit value added for each industry in relation to the average.

The figures for the very new industries, rayon, radios, mechanical refrigerators, and washing and ironing machines, follow a distinct pattern. In each of these new industries physical output rose rapidly in relation to total manufacturing, while value added per unit of product fell rapidly, also in relation to the corresponding figures for all manufacturing industries combined. Deterioration of quality would explain the latter decline. But it is doubtful that such deterioration did in fact occur, at least to an extent sufficient to make it the sole explanatory factor. Even radios, which probably have decreased in average size, have improved in most other respects.

The industries which were still in an early stage when the period 1899–1937 opened, and which have by now attained a certain degree of maturity, do not follow exactly the pattern found for the very new industries. The rapid growth in automobile output in the first five years was accompanied by a rise in value added per unit. This rise might conceivably be explained by the growing tendency for automobile manufacturers to make their own parts, but the meager evidence at hand suggests a contrary tendency during this period.[9] After 1904 value added per unit declined drastically, while output

[9] See Chapter 21 below.

continued to rise at a rapid pace. These steep movements persisted until 1923, by which time the industry had more or less reached a state of maturity. Between 1923 and 1937 the changes in both series were slight in comparison with earlier trends. If the trends were adjusted for improvements in quality, both the rise in output and the fall in value added per unit from 1899 to 1937 would be even sharper than the present indexes indicate.

In petroleum refining, too, the relation between trends in output and in the price of fabricational services is complex. During the period when output was rising most rapidly, 1909–19, value added per unit also climbed in relation to total manufacturing. The demand for gasoline was increasing at an accelerated pace during this period, and it stimulated attempts to extract, even at high cost, additional quantities of gasoline from given quantities of crude petroleum. As noted in Chapter 15, below, commercial use of the revolutionary cracking process was still in its infancy in 1914. During the 18 years after 1919, however, when output continued to rise, value added per unit fell, reaching a level lower than that prevailing in the pre-war period. By 1930 about 38 percent of the total production of gasoline was made by the cracking process, whereas in 1920 only 13 percent had been so treated. Over the 38-year period, taken as a whole, output rose and unit value added fell.

Value added per unit by the beet sugar industry changed but little during the first decade of the century, when output rose very rapidly not only in relation to total manufacturing output, but also in relation to cane sugar. This relative growth, despite the absence of a decline in relative costs, has been ascribed to the sugar tariff.[10] During the succeeding two decades, output fluctuated about an approximately horizontal

[10] R. K. Adamson and M. E. West, *Productivity and Employment in Selected Industries: Beet Sugar*, Report No. N–1 (National Research Project, October 1938), pp. 47–53.

trend while value added per unit declined. In this industry, also, the net relative movement from 1899 to 1937 was upward for physical output and downward for value added per unit.

The next four industries, canned milk, manufactured ice, canned fruits and vegetables, and paints and varnishes, are all characterized by relative increases in physical output, though none is a new industry in the ordinary sense of the term. In three of the four, value added per unit fell from 1899 to 1937 in relation to value added per unit for all industries combined. Paints and varnishes is a distinct exception. Even in the other industries, however, no continuous decrease is found in unit value added.

Flour, lumber-mill products, railroad cars, linen goods, clay products and carriages have all been declining industries. In each one, over the long period as a whole, value added per unit has risen in relation to the corresponding index for total manufacturing. However, the rise in the series for carriages has developed only since 1927, whereas the rise in linen goods occurred mainly between 1909 and 1921. A significant part of the upswing in railroad cars must be ascribed to improvements in quality.

The relation between trends in physical output and in the money received by agents of fabrication per unit of product is not completely uniform, as is now apparent. The most distinct inverse relation [11] appears when output is rising

[11] A similar inverse relation appears to hold true also for all manufacturing industries combined in comparison with the economy at large. Thus the aggregate physical output of manufacturing industries increased in relation to the total national output (real national income). Between 1899 and 1937 manufacturing output rose 276 percent, while the rise in real national income was somewhat over 100 percent. This relative growth in total manufacturing output was accompanied also by an increase in the net value added by manufacturing industries in relation to the total net value added by all industries. But the latter relative increase was not of corresponding amount; it was smaller than the former. The fraction of national income (the best available measure of net value added) paid out by manufacturing industries was about 17 percent in 1899 and 24 percent in 1937. Reflecting this

rapidly, especially in a new industry, though here too there are exceptions.

It is impossible, of course, to determine merely from an examination of the summary indexes why, in particular industries during particular periods, growth or decline in output was associated with decline or growth in the price received by fabricational agents for their services. Still less is it possible to determine in this way whether in any particular case growth in output followed or preceded a decline in price. These questions can be answered, if at all, only after an intensive study of the detailed records not only of the industry concerned, but also of related industries.

Many economists have speculated about the more general factors involved in the relation between long-term trends in physical output and in unit prices of fabrication. Some have stressed the causal influence of invention and other technological advances upon costs, hence upon prices, and ultimately upon output. This chain of relationship is not a simple one, however. It is affected, in varying degree, by the character of the product and the elasticity of demand for it. A disturbing factor is the price of related commodities. The product of every manufacturing industry is used, in some sense, in conjunction with the product of another industry—for example, the industry supplying the raw materials. A rise (or decline) in the price of the related product may more than counterbalance a decline (or rise) in the price of the product under consideration. The state of the markets in which labor, capital and other agents are traded is relevant also, since a given technological advance may lead not to a lowering of costs but to a rise in the prices paid for labor or other agents of production. Still another complicating factor is the degree of monopoly enjoyed by the business enterprise

difference is the relative decline in the price of fabricational services (value added per unit of output). This price rose less, between 1899 and 1937, than did the general price level as measured by the cost of living, by wholesale price indexes, or by Snyder's index of the general price level.

whose costs are cut: a decline in selling price may not follow upon a decline in cost.

Causal influences running in the other direction have been emphasized in some discussions. Lower prices, by leading to increases in output, eventuate in economies of large-scale production. There are limits to these economies, however, because there are also diseconomies of large-scale output. While these limits have been noted not only in such fields as agriculture and mining, but also in manufacturing, their magnitudes have not been measured in specific terms.

The possible causal relations just mentioned are circular. Technological progress induces growth, and growth leads to lower costs and thereby to further growth which may stimulate additional technological advances, and so on. If any factor has been taken as prime it is technological progress in the early stages of an industry's growth—particularly as the consequence of invention.[12] This consideration suggests, in turn, that a more or less typical chronological pattern of the cost and price of an industry's output may be followed during an industry's growth and maturity. Since growth is most rapid in the early stages of an industry's life, declines in unit costs and prices also tend to be greatest at that time. As the industry approaches maturity, its unit costs and values decline less rapidly and tend to become subject to influences more important, at that stage, than technological progress.

At this time we cannot tell how closely the complex of hypotheses outlined here resembles the facts. The relation between the size of an industry or a business enterprise and the level of costs, the relation between costs and prices, and the relation between prices and sales are all largely matters of conjecture, and a resolution of these problems still waits upon the future.

[12] See Simon Kuznets, *Secular Movements in Production and Prices* (Houghton Mifflin, 1930), pp. 11–41.