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CHAPTER I

Pre-War Changes in the Volume and Character of Production in the United States

IN describing productive processes during a given period two matters are of immediate interest. These are the degree of change in the total physical volume of production in an economy, and the regularity or stability of this change. The flow of real income and the stability of economic processes in general rest upon these fundamental conditions of production. But even more valuable information may be gained by a study of the working of the productive mechanism in detail. The rates of exploitation and the stability of growth (or decline) among the various extractive industries, agricultural and non-agricultural, are of obvious concern. The relations between extraction and fabrication help to reveal the direction in which an economy is moving. Again, the relation between the output of goods destined for human consumption and of goods destined for use as capital equipment serves as an index of the manner in which human effort is being expended—toward the direct satisfaction of wants, or toward that indirect satisfaction of wants which involves the construction of ever more elaborate equipment for the roundabout production of consumable goods. For other purposes a classification of output by industries is significant. Measurements of changes in these various categories, measurements based upon accurate and comprehensive production statistics, record the story of a nation's development and trace the persistent tendencies of an era.

The statistical record of the physical volume of production in the United States during the years preceding the World War is not as complete as is the corresponding post-war record. In constructing the present series of index numbers of productive activity use has been made of available annual data, supplemented by census statistics of manufacturing production. Technical details are given in Appendix I.

Changes in the Volume of Production, 1901-1913

The increase in aggregate physical production in the United States between 1901 and 1913 is defined by the index numbers in the following table. These, with corresponding population figures, are plotted in Figure 1.

TABLE 1

Growth of Physical Volume of Production in the United States, 1901-1913

Year	Volume of production	Year-to-year change in volume of production (per cent)
1901	100	....
1902	116	+16
1903	115	− 1
1904	118	+ 3
1905	129	+ 9
1906	137	+ 6
1907	134	− 2
1908	126	− 6
1909	136	+ 8
1910	142	+ 4
1911	139	− 2
1912	158	+14
1913	156	− 1
Average annual rate of change (per cent)[a]	+3.1	
Index of instability of growth[a]	3.7	

[a] The method of deriving these measurements is explained in a note at the end of this chapter.

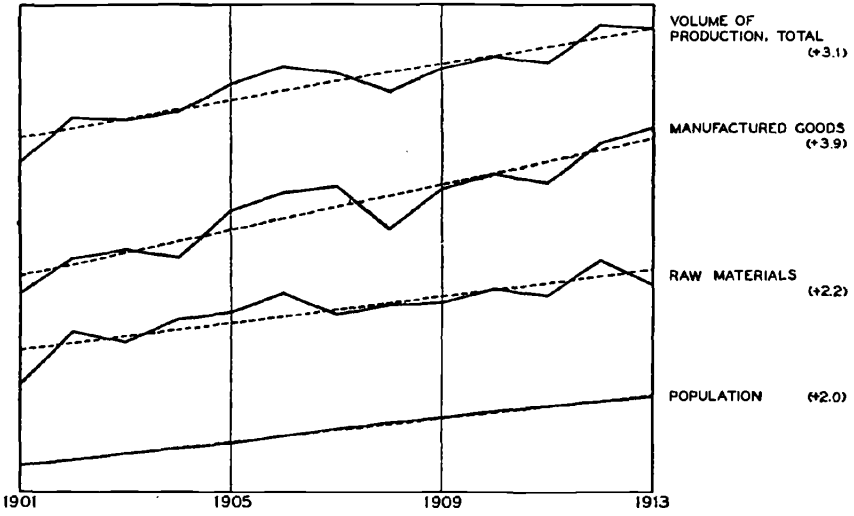
During the period covered by these measurements the volume of production in the United States increased at a rate of approximately 3.1 per cent a year. Over the same period the population of the United States increased at an average annual rate of 2.0 per cent a year. Per capita of the total population, the stream of goods increased at an average rate approximating 1.1 per cent a year. There was here the material basis, clearly, of a notable gain in national wealth and well-being, an advance which, if sustained, would result in a doubling of aggregate physical income in some 23 years, of per capita physical income in about 63 years.

Perhaps of equal importance with the rates of growth of these

series is the degree of steadiness of the advance. Between 1901 and 1913 the average annual deviation from constancy of growth in aggregate production amounted to approximately 3.7 per cent.[1] These rather wide changes occurring from year to year in the growth of the physical volume of goods are in pronounced contrast to the relatively smooth and regular growth of population.

FIGURE 1

GROWTH OF POPULATION AND OF PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913*



* This is a ratio chart, as are all following charts of the same general type. The solid lines trace the actual movements of the several series. Trends, or tendencies, between 1901 and 1913 are shown by the broken lines. Numbers in parentheses define average annual rates of change (in percentage form).

Instability of population change, as determined from rough annual population estimates, averaged 0.3 per cent.[2] During these years a

[1] This means that the average yearly departure from the values which would have been recorded had the growth of production been perfectly regular, at a constant rate of 3.1 per cent a year, amounted to 3.7 per cent. Not variations from year to year, nor deviations from a constant figure, but departures from regularity of growth (or decline) are measured by this index of instability. This measurement conforms to the concept of stability of growth as a desirable objective in a dynamic economy.

[2] This measurement has been derived from estimates of the growth of population made by W. I. King from available information on births, deaths and migra-

population subject to but slight undulations in its growth produced and supported itself by a stream of goods with annual fluctuations many times as wide.

Production of Raw Materials and of Manufactured Goods

The story of production in terms of aggregates is incomplete. What was the rate of change in the output of important types of goods? What were the variable elements of the aggregate output? To appreciate the economic significance of the figures we have cited, we must know more about the behavior of the constituent elements of the total stream of goods.

Index numbers relating to the growth of production of raw and manufactured goods are given below. The series are shown graphically in Figure 1.

Products of extractive industries were turned out in a volume

TABLE 2

RAW MATERIALS AND MANUFACTURED GOODS

Index Numbers of Physical Volume of Production in the United States, 1901-1913 [a]

Year	Raw materials	Manufactured goods
1901	100	100
1902	119	112
1903	115	115
1904	124	112
1905	127	131
1906	135	139
1907	126	142
1908	130	123
1909	131	141
1910	137	148
1911	134	144
1912	151	164
1913	139	173
Average annual rate of change (per cent)	+2.2	+3.9
Index of instability of growth	3.8	4.7

[a] A description of these index numbers is given in Appendix I.

tion. Deficiencies in the statistical records of this period prevent the attainment of any high degree of accuracy in the measurement of the year-to-year variations in population growth.

which increased at a rate of 2.2 per cent a year between 1901 and 1913. The output of manufacturing industries rose during the same period at a rate of 3.9 per cent a year. The margin of almost two per cent which represents the more rapid advance in the output of industries engaged in fabrication is the resultant of several forces. Within the group of raw materials, as we shall see, those entering in considerable degree into manufacturing processes were increasing more rapidly in volume of output than were those subject to but slight processing, or consumed in a raw state. On the manufacturing side fundamental changes were occurring. The factory was performing new functions, taking over tasks formerly performed in the home. Again, the degree of fabrication through which materials passed was tending in many lines to increase. This has been one of the outstanding features of modern economic development. The intermediary processes of fabrication, particularly fabrication outside the home, become increasingly important in an industrial civilization.

The changes in our foreign trade during this period also affected the course and character of production. We were exporting smaller quantities of crude foodstuffs, and importing more, while exports of semi-manufactured and finished goods were increasing at very rapid rates.[1] These developments contributed to the growth of domestic manufactures.

Such index numbers, defining movements of output by broad classes, do not permit a full comparison of the processes of production within the groups distinguished. Analysis of the individual production series, which are plotted in Figure 2, reveals wide differences in growth tendencies during this period. In the group of raw materials 28 series were studied in detail. These show rates of change between 1901 and 1913 varying from —3.0 per cent a year for flaxseed to +13.8 per cent a year for cement.[2] Among 31 series

[1] Average annual rates of change between 1901 and 1913 in the major export groups were as follows:

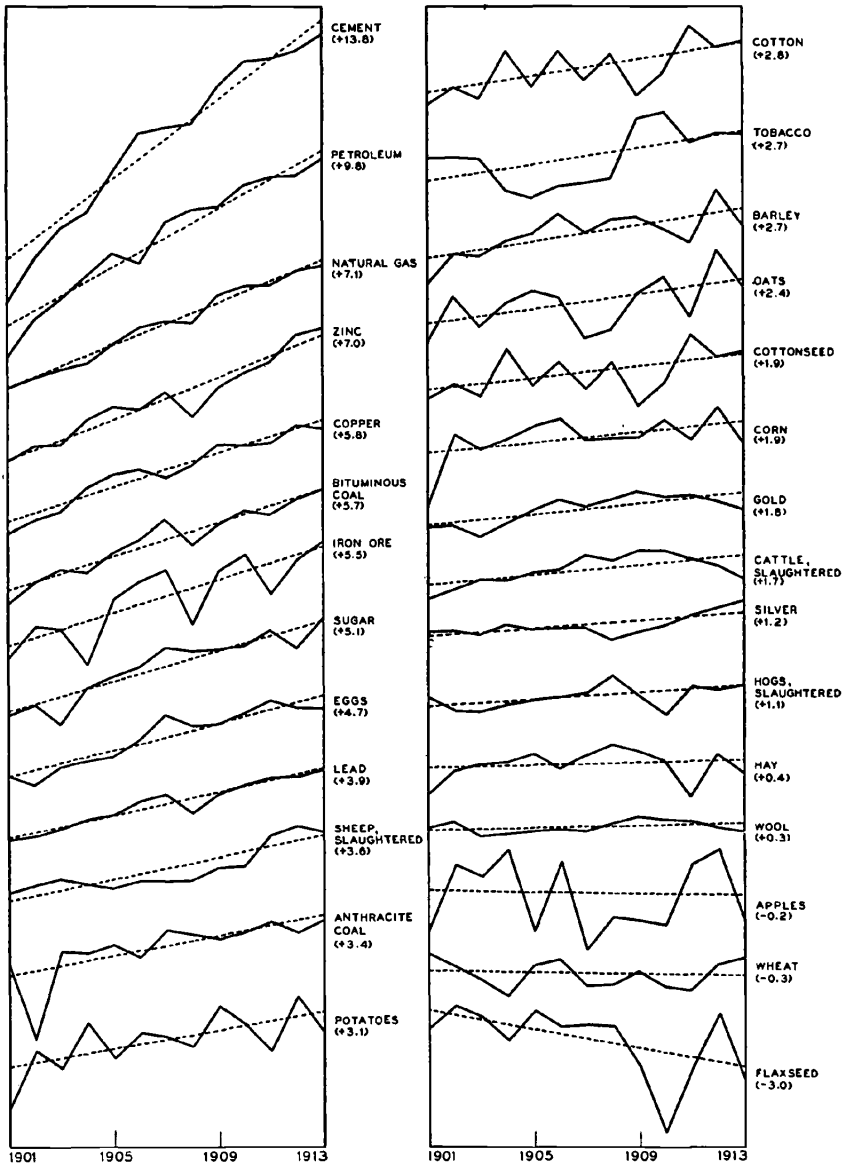
Crude foodstuffs	— 2.4 per cent
Manufactured foodstuffs	— 0.7 " "
Crude materials	+ 5.9 " "
Semi-manufactures	+ 8.7 " "
Finished manufactures	+ 7.6 " "

[2] Cement production has been included in the classification of raw materials (as well as among manufactured goods) as representative of changes in the output of materials utilized in cement manufacture. Use has been made of 58 independent production series. Because of the double use of the cement statistics, the sum of the series in the two major groups is 59.

FIGURE 2

CHANGES IN PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913

A- RAW MATERIALS

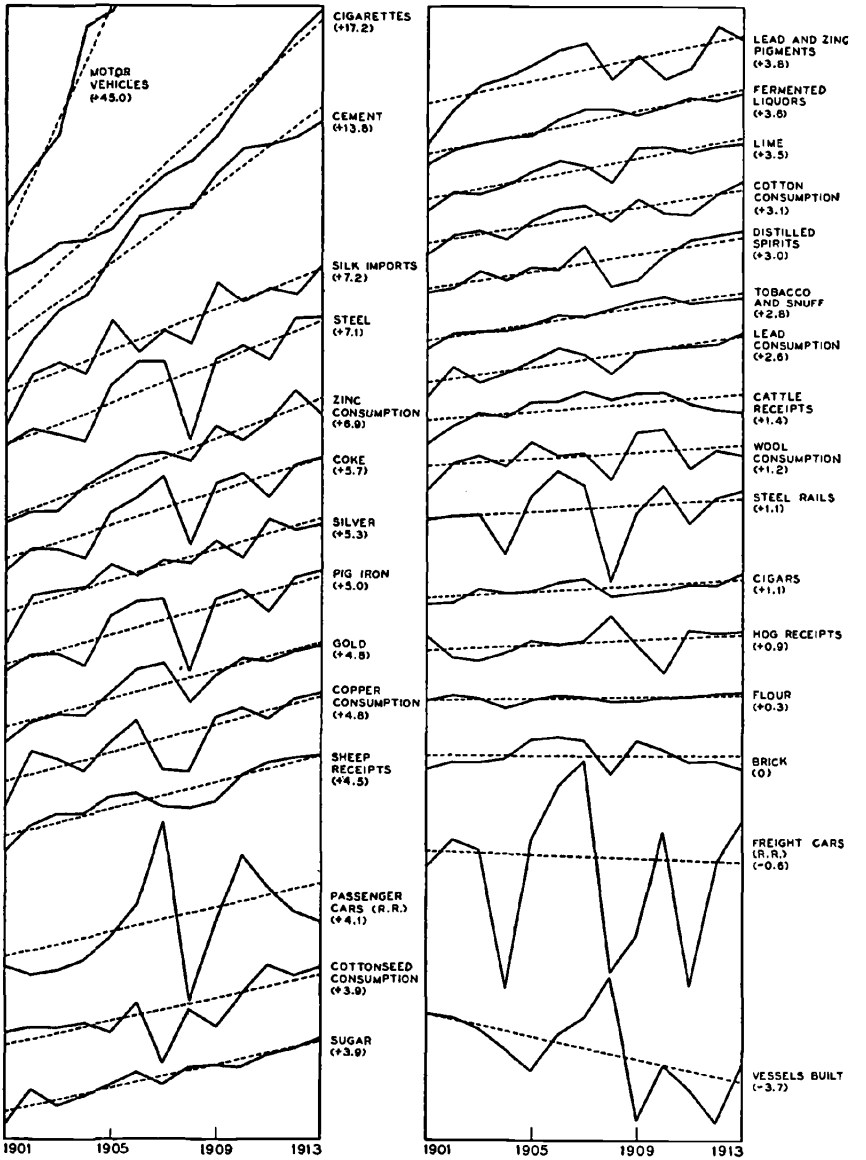


PLOTTED ON RATIO SCALE. THE FIGURES IN PARENTHESES DEFINE AVERAGE ANNUAL RATES OF CHANGE.

FIGURE 2 (CONT.)

CHANGES IN PHYSICAL VOLUME OF PRODUCTION
IN THE UNITED STATES, 1901-1913

B- PROCESSED GOODS



PLOTTED ON RATIO SCALE. THE FIGURES IN PARENTHESES DEFINE AVERAGE ANNUAL RATES OF CHANGE.

relating to processes of fabrication the rates of change varied from —3.7 per cent a year for vessels built, to +45.0 per cent a year for the production of motor vehicles.[1] The degree of variation among commodities within these groups in respect of growth rates is graphically portrayed in Figure 3, in which lines measuring the rates of change of the individual series in the two groups are plotted together. A more exact comparison is possible when the divergence of rates of change is expressed in numerical form. For raw materials, the weighted[2] standard

[1]Following are measurements of the rates of change in the individual series studied:

Series relating to production of materials	Average annual rate of change 1901-1913 (per cent)
Cement, total	+ 13.8
Petroleum, crude	+ 9.8
Natural gas	+ 7.1
Zinc	+ 7.0
Copper	+ 5.8
Bituminous coal	+ 5.7
Iron ore	+ 5.5
Sugar, domestic	+ 5.1
Egg receipts	+ 4.7
Lead	+ 3.9
Sheep, total slaughter	+ 3.6
Anthracite coal	+ 3.4
Potatoes	+ 3.1
Cotton	+ 2.8
Tobacco	+ 2.7
Barley	+ 2.7
Oats	+ 2.4
Cottonseed	+ 1.9
Corn	+ 1.9
Gold	+ 1.8
Cattle, total slaughter	+ 1.7
Silver	+ 1.2
Swine, total slaughter	+ 1.1
Hay	+ 0.4
Wool	+ 0.3
Apples	— 0.2
Wheat	— 0.3
Flaxseed	— 3.0

Series relating to processes of fabrication	Average annual rate of change 1901-1913 (per cent)
Motor vehicles	+ 45.0
Cigarettes	+ 17.2
Cement, total	+ 13.8
Silk imports, raw	+ 7.2
Steel	+ 7.1
Zinc consumption	+ 6.9
Coke, total	+ 5.7
Silver (mfr. and arts)	+ 5.3
Pig iron	+ 5.0
Gold (mfr. and arts)	+ 4.8
Copper consumption	+ 4.8
Sheep receipts	+ 4.5
Passenger cars, railroad	+ 4.1
Cottonseed consumption	+ 3.9
Sugar, total supply	+ 3.9
Zinc and lead pigments	+ 3.8
Fermented liquors	+ 3.6
Lime	+ 3.5
Cotton, mill consumption	+ 3.1
Distilled spirits	+ 3.0
Tobacco and snuff	+ 2.8
Lead, available for consumption	+ 2.6
Cattle receipts	+ 1.4
Wool consumption	+ 1.2
Steel rails	+ 1.1
Cigars	+ 1.1
Hog receipts	+ 0.9
Flour, wheat	+ 0.3
Common brick sold	0.0
Freight cars	— 0.6
Vessels built	— 3.7

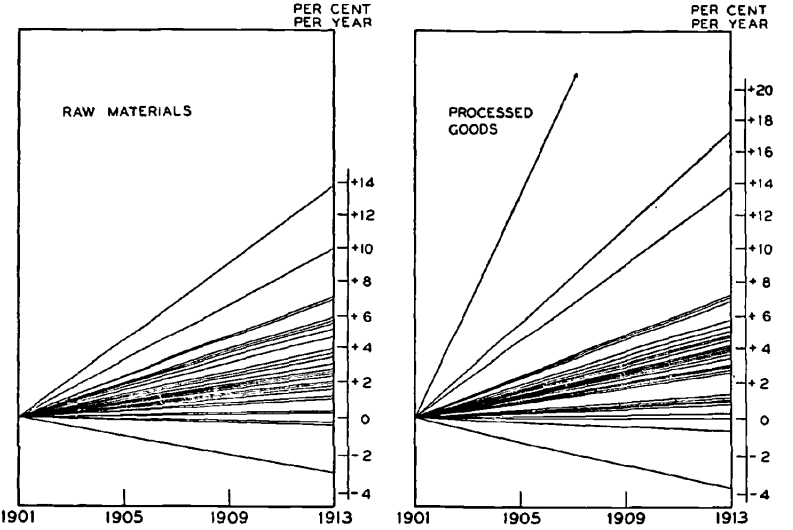
In certain cases the trends of production during this period are not defined with the greatest accuracy by the function here employed. This is clear from the graphs in Figure 2. The rate of growth of cement production, for example, was somewhat above 13.8 per cent a year during the earlier years of this period, somewhat below that figure during the later years.

Sources and descriptions of these series are given in Appendix V.

[2] Weights are those used in the construction of the index numbers based upon these series. The standard deviation of the unweighted measures relating to raw materials is 3.3; for those relating to manufactured goods it is 8.2.

FIGURE 3

ILLUSTRATING THE DIVERGENCE OF PRODUCTION TRENDS IN THE UNITED STATES, 1901-1913*



* Plotted on ratio scale. The lines here plotted relate to the commodities listed in footnote, p. 8, in the order of that listing.

deviation [1] of the 28 measurements of rates of change is 2.1; for the 31 fabricated goods it is 5.7.

These several comparisons point clearly to the same conclusion. Not only was the rate of increase in the physical volume of production of fabricated goods distinctly higher than the rate of increase in the output of raw materials during the period 1901-1913, but within the manufacturing group the divergences among the rates of change for different commodities were much greater. This is probably to be expected. In the manufacturing field we are accustomed to find new industries coming into favor, pushing ahead at exceptional rates, only in time to be supplanted by others. The automobile, the radio and artificial refrigeration devices are recent examples of commodities produced under such conditions. Extreme differences among the rates of exploitation of raw materials are more rare.

[1] The standard deviation is a measure of the dispersion of numerical items about their average. It is expressed in terms of the unit of measurement used for the original observations. When a distance equal to the standard deviation is laid off on each side of the arithmetic average, about two-thirds of all the items will be included.

Differences among long-time rates of growth (or decline) constitute a highly important feature of modern industrial systems. They involve shifting capital investments and a mobile labor supply, and probably necessitate material changes in the distributive organization of a country. These differences among manufacturing industries render flexibility and adaptability prime requisites of modern economic systems. Constant readjustment to changing conditions, readjustments far-reaching in their effects, are called for when such differences in growth rates persist. Technological unemployment is one manifestation of this constant necessity for readjustment, a readjustment which is never completed so long as the differing rates of secular change persist. The greater these differences the more difficult will be the employment shifts and the other changes in economic organization necessitated by the shouldering forward of some industries and the loss of absolute or of relative position by others.[1]

§ *On the stability of productive processes, 1901-1913.*—Measurements defining the stability of change in volume of production appear in certain of the preceding tables. Total production, we have seen, gained in volume somewhat irregularly, showing annual variations averaging 3.7 per cent of the aggregate volume. For the index numbers relating to extractive and fabricating industries measurements of instability are, respectively, 3.8 and 4.7. These probably reflect with reasonable accuracy the relative stability of change in the output of these two industrial groups.[2]

[1] It is a plausible hypothesis that the amplitude and, perhaps, the duration of business cycles are functions of the degree of difference among rates of change in important industries. The greater the differences the more economically painful and difficult the readjustments. These readjustments are probably closely related to the fluctuations commonly identified as cyclical. Under certain circumstances the readjustments of capital and labor and the changes in economic organization necessitated by differing rates of secular change may be made without major breakdowns. Under other conditions these readjustments may involve rather widespread disturbances. The conditions which conduce to economic flexibility and adaptability, and which engender ability to make readjustments readily, are undoubtedly complex and difficult to classify. Yet this type of flexibility in an operating economy is so important today that the conditions essential to it (conditions of interchangeability and mobility of labor, liquidity of capital, flexibility of transportation and distributive organizations) are worthy of detailed study.

[2] The annual values of the index of production of manufactured goods are not derived directly from statistics of quantities produced. For inter-censal years this

The aggregate production of raw materials is more stable, in its year-to-year change, than is the total output of manufactured goods. There are unstable elements in the first group, but many of these instabilities are of independent origin, and hence their fluctuations may be of an offsetting character. A good year for wheat may be a poor year for iron ore. Such offsettings tend to reduce the variations of the aggregate. More closely linked, on the whole, are the fluctuations in output of manufacturing industries. Here business considerations, rather than the vagaries of weather, dominate production, and these considerations tend toward reënforcing rather than offsetting variations of output.

Figures not affected by such offsettings are secured by averaging the instability measurements relating to the various individual production series. In doing this we are not dealing with irregularities in the aggregate output, but with the irregularity of flow of the individual streams making up the aggregate. As regards the fortunes of individual producers and the stability of employment in particular industries, the measurements of the instability of production of individual commodities are more important than are those relating to the aggregate volume of production, an aggregate which has social rather than individual significance. For all production series the weighted arithmetic average of the measures of instability of output is 8.2. This means that among the individual elements of the total stream of production the annual deviations from constant rates of change averaged 8.2 per cent of the normal volume of production. This figure, which is distinctly greater than the index of 3.7 defining variations in the growth of aggregate production, is perhaps the most significant available measure of the irregularity of production growth in the United States between 1901 and 1913. If stability of growth be a desirable condition, average annual departures of eight per cent from such stability represent a rather erratic course of economic development.

For raw materials and for manufactured goods, respectively, the weighted averages of instability measurements are 8.3 and 8.0.

One further measurement is of interest. The degree of difference among the instability indexes for raw materials is indicated by a weighted standard deviation of 2.8, among manufactured commodities by a weighted standard deviation of 4.8. The latter is substantially larger, suggesting differences among the commodities in that group, in respect of stability of production, rather greater than those found among raw materials. That is, certain manufactured goods are highly stable in their output, from year to year, while certain others are highly

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index is secured by interpolation, in which account is taken of the fact that the total volume of manufacture is more stable than is the output of those goods for which statistics of production are readily available. This same comment applies to variations in total output, as measured by the index numbers given in Table 1 above.

unstable. It is the latter series which give manufactured goods as a class the high measure of instability we have secured.[1]

In summary: Between 1901 and 1913 the output of manufactured goods in the United States advanced at a rate of approximately 3.9 per cent a year; the volume of raw materials produced increased at an average rate of 2.2 per cent a year. The increasing proportion of fabricated goods consumed with rising living standards, the steady advance in fabrication outside the home and changes in the character of our foreign trade help to account for these differences. Rates of growth in different industries were markedly uneven, the differences being most pronounced among manufacturing industries. Such differences, which are doubtless necessary accompaniments of economic progress, involve readjustment and adaptation not always effected without friction.

The advance of this pre-war period was not a smooth and regular movement; economic progress was jerky and uneven.

[1] Following are the indexes of instability for the individual series studied:

Series relating to production of materials	Index of instability of growth	Series relating to processes of fabrication	Index of instability of growth
Lead	2.7	Flour, wheat	1.7
Natural gas	2.7	Tobacco and snuff	2.6
Wool	3.4	Fermented liquors	3.1
Silver	3.6	Cigars	3.6
Swine, total slaughter	4.0	Sugar, total supply	3.8
Bituminous coal	4.4	Lead, available for consumption	4.5
Egg receipts	4.7	Lime	4.7
Copper	4.8	Cotton, mill consumption	5.4
Gold	4.8	Sheep receipts	5.8
Sugar	5.0	Zinc consumption	6.0
Zinc	5.4	Distilled spirits	6.0
Cattle, total slaughter	5.4	Gold (mfr. and arts)	6.1
Sheep, total slaughter	6.6	Cattle receipts	6.4
Petroleum, crude	6.6	Silver (mfr. and arts)	6.4
Hay	7.5	Hog receipts	6.4
Wheat	7.7	Common brick sold	7.5
Barley	7.9	Wool consumption	8.2
Anthracite coal	8.0	Cottonseed consumption	8.9
Cottonseed	9.3	Silk imports, raw	9.0
Cement, total	9.3	Cement, total	9.3
Corn	9.4	Cigarettes	9.4
Cotton	9.5	Coke, total	10.2
Potatoes	11.4	Pig iron	10.2
Iron ore	11.5	Copper consumption	10.5
Oats	11.7	Steel	10.8
Tobacco	12.9	Zinc and lead pigments	10.9
Flaxseed	13.6	Steel rails	12.4
Apples	22.2	Motor vehicles	12.6
		Vessels built	16.5
		Passenger cars, railroad	22.4
		Freight cars	33.6

The index of instability for cement is somewhat greater than it would be if the line of average growth defined the secular movement more accurately.

Yearly variations in the growth of aggregate production averaged 3.7 per cent of normal output. Fluctuations among the 58 constituent elements of the total averaged 8.2 per cent a year. These departures from constant rates of growth appear to have been about the same among manufacturing and among extractive industries, considered individually, though the aggregate output of manufactured goods was somewhat less stable than the aggregate output of raw materials.

Physical Output of Products of American Farms and of All Other Products

In any general survey of productive processes particular interest attaches to the distinction between products of cultivation and other products. The latter are, in considerable part, products of exploitation, materials definitely withdrawn from the natural resources of the earth. There can be, of course, predatory exploitation of the soil, precisely similar in results to the depletion of mineral resources or the destruction of forests. Under modern conditions in this country, however, farm crops and animal products probably represent no such depletion of the soil, and the distinction between cultivated and non-cultivated products is a significant one. The measurements given in Table 3 relate to this classification. They are plotted in Figure 4.

The growth of production in the years preceding the World War was attributable in large degree to the development of our mineral resources and to the increasing volume of fabricated goods into which raw mineral products enter. There was a steady increase in the volume of agricultural production, at a rate about equal to that at which population increased, but the greatest advance occurred in the output of non-cultivated products. With regard both to the character of the resources and the nature of the wants to be satisfied, rapid expansion in the output of agricultural products is probably not to be expected. The rapid exploitation and utilization of mineral resources, on the other hand, gives to the present age its distinctive industrial tone.

There is a notable difference between these groups in respect to degree of divergence of the rates of change of the constituent elements. Among American farm products, raw and processed, the standard deviation of the rates of change (weighted) is 1.5; for

TABLE 3

PRODUCTS OF AMERICAN FARMS AND ALL OTHER PRODUCTS [a]

Index Numbers of Physical Volume of Production in the United States, 1901-1913

Year	Products of American farms (raw and processed)	All other products (raw and processed)
1901	100	100
1902	118	115
1903	114	116
1904	121	111
1905	125	134
1906	132	145
1907	124	149
1908	128	121
1909	130	143
1910	133	155
1911	131	149
1912	146	173
1913	136	184
Average annual rate of change (per cent)	+2.1	+4.3
Index of instability of growth	3.4	6.1

[a] The individual series included in these two commodity groups are given in Appendix I.

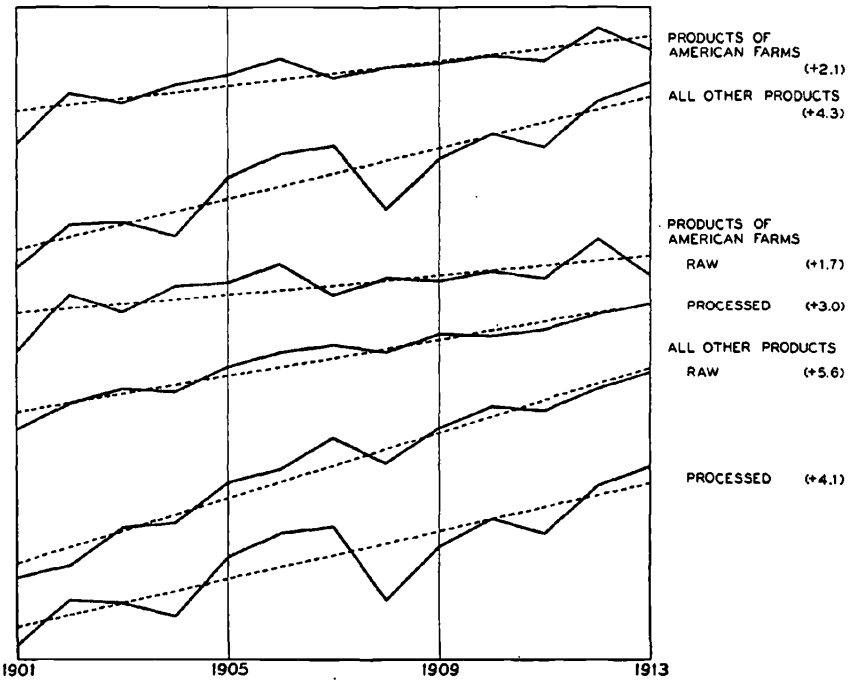
products not originating on American farms it is 6.7. Although products of cultivation differ somewhat among themselves in their rates of change, they constitute a quite uniform group in comparison with commodities not originating on American farms. Agricultural products meet certain basic needs for food and clothing, and here there is not the room for variety and rapid expansion of wants that exists for non-agricultural products.

Irregularity of growth in the aggregate volume of production of American farm products and of non-farm products is measured by indexes of instability of growth of 3.4 and 6.1, respectively. The aggregate output of non-farm products is distinctly more variable than is that of farm products. When measurements relating to the individual series in two groups are combined, we obtain 7.7 as the average index of instability of growth for 30 series relating to the output of farm products, raw and processed, and 9.8 as the average for 31 series relating to products other than those of

FIGURE 4

GROWTH OF PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913

PRODUCTS OF AMERICAN FARMS AND ALL OTHER PRODUCTS



Plotted on ratio scale. The figures in parentheses define average annual rates of change (in percentage form).

American farms.[1] These figures confirm the result secured in the comparison of aggregates, though the difference is less pronounced.

Subdividing products of American farms and all other products into raw and processed forms, we have the measurements in Table 4, which are shown graphically in Figure 4.

These figures indicate that the output of manufactured farm products increased at a higher rate over this period than did the output of raw farm products. The latter were marked by much

[1] Two series relating to manufacturing production (wool consumption and sugar, total supply) have been included in the averages for both commodity groups. The weight in each case has been divided on the basis of the relative importance of imports and domestic production in the supply of raw materials utilized in the manufacturing process.

TABLE 4

PRODUCTS OF AMERICAN FARMS AND ALL OTHER PRODUCTS, RAW AND PROCESSED
Index Numbers of Physical Volume of Production in the United States, 1901-1913

(1) Year	(2) (3) Products of American farms		(4) (5) All other products	
	Raw	Processed	Raw	Processed
1901	100	100	100	100
1902	121	109	104	116
1903	114	114	118	115
1904	125	113	120	110
1905	126	123	137	134
1906	134	129	143	145
1907	121	132	159	148
1908	128	129	146	116
1909	127	137	164	139
1910	131	136	176	152
1911	128	139	174	145
1912	146	146	187	170
1913	130	152	198	181
Average annual rate of change (per cent)	+1.7	+3.0	+5.6	+4.1
Index of instability of growth	4.7	2.3	3.8	6.8

greater instability of growth. Among non-farm products the fabricated forms show a somewhat less rapid increase and, at the same time, a much higher degree of variability than do the raw materials.[1]

This general comparison reveals one of the most important features of the table just presented. The aggregate output of fabricated products not originating on American farms was distinctly less stable than the output of any other of the four groups shown. Raw farm products come next in order, well below the manufactured non-farm products, while raw non-farm and fabricated farm products stand at the bottom of the list. This evidence suggests that the irregularities in the growth of the productive stream are found in the initial stages of cultivation and in the final stages of the fabrication of non-farm products. (In this latter group, how-

[1] The importance among raw non-farm products of coal and natural gas, which advanced with but slight fluctuations over this period, helps to account for the relative stability of this group.

ever, are many quite stable series. Instability in the production of a few highly important commodities appears to be responsible for most of the variation in this class of goods.)

We must look in quite different directions for explanations of the variability here observed. Variability in the output of raw products of cultivation is doubtless attributable in considerable part to the vagaries of the weather. Fluctuations in the output of manufacturing industries working on non-agricultural materials are due, presumably, to changes in wants and in purchasing power, and to fluctuations of business. The weather at one end, the erratic processes of business at the other—these are suspect as contributing to economic instability.

Production of Foods and of Non-foods

The fortunes of food producing and non-food producing industries during pre-war years may now be traced. The index numbers given in the next table are plotted in Figure 5.

TABLE 5

FOODS AND NON-FOODS

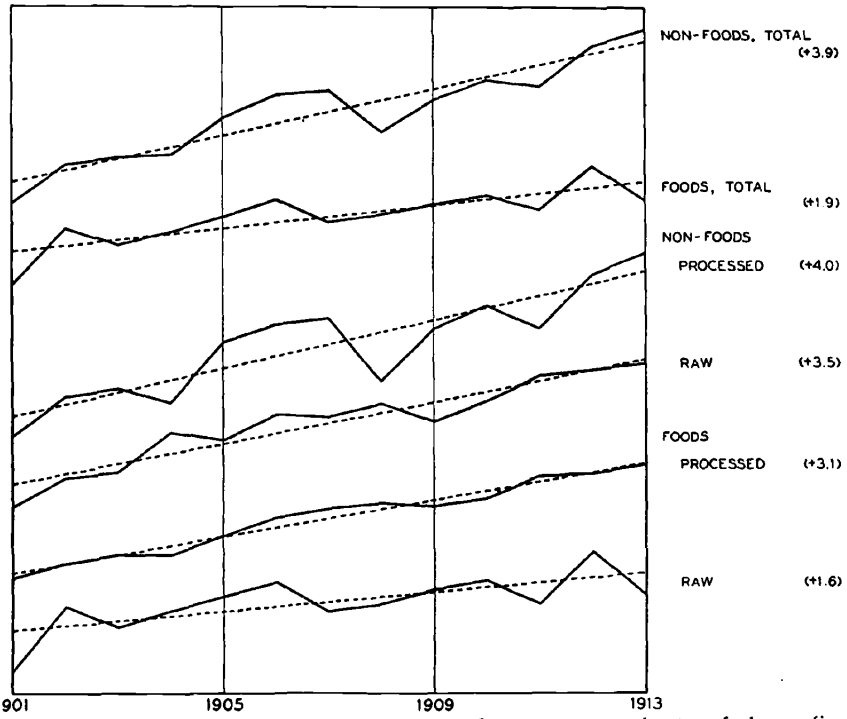
Index Numbers of Physical Volume of Production in the United States, 1901-1913

Year	Foods (raw and processed)	Non-foods (raw and processed)
1901	100	100
1902	120	113
1903	114	116
1904	119	117
1905	125	132
1906	132	142
1907	123	144
1908	126	126
1909	130	140
1910	134	149
1911	128	146
1912	147	166
1913	132	175
Average annual rate of change (per cent)	+1.9	+3.9
Index of instability of growth	4.0	4.7

FIGURE 5

GROWTH OF PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913

FOODS AND NON-FOODS



Plotted on ratio scale. The figures in parentheses define average annual rates of change (in percentage form).

The output of foods increased between 1901 and 1913 at a rate of 1.9 per cent a year, a figure approximately equal to the rate at which population grew. For non-foods the rate of growth averaged 3.9 per cent a year. Some such difference as this is to be expected. The expansibility of human wants for food is limited, once the standard of normal requirements is attained, but in the satisfaction of other wants and the building up of capital equipment there is no such necessary limit. In respect of instability, the index is slightly greater for the non-food than for the food products group.

Subdivision of each classification according to degree of fabrication gives the following index numbers.

TABLE 6

FOODS AND NON-FOODS, RAW AND PROCESSED

Index Numbers of Physical Volume of Production in the United States, 1901-1913

(1) Year	(2) Foods	(3) Foods	(4) Non-foods	(5) Non-foods
	Raw	Processed	Raw	Processed
1901	100	100	100	100
1902	124	105	110	114
1903	116	108	112	117
1904	122	108	128	112
1905	128	115	125	136
1906	134	122	136	144
1907	122	126	135	147
1908	125	128	141	120
1909	131	127	133	142
1910	135	130	142	153
1911	125	140	154	142
1912	148	141	157	169
1913	129	145	160	181
Average annual rate of change (per cent)	+1.6	+3.1	+3.5	+4.0
Index of instability of growth	5.1	1.6	3.4	6.3

Processed non-foods show the greatest advance in output and the greatest instability of growth found in any of these groups. Within the food group the high rate of growth of the output of manufactured foodstuffs, as contrasted with that of unprocessed foods, is notable. Particularly striking is the high degree of instability in the production of raw foodstuffs and the marked stability of the finished products.[1]

[1] These measurements are substantiated by the averages (weighted) of the indexes of instability for the individual series. In two cases the same series is included in two different groups. The classification of the 58 independent series is given in Appendix I.

Group	Number of series	Average of indexes of instability, individual series	Group	Number of series	Average of indexes of instability, individual series
Foods			Non-foods		
Raw	14	8.8	Raw	15	7.3
Processed	11	4.4	Processed	20	9.5
Total	25	7.8	Total	35	8.9

Production of Consumption Goods and of Capital Equipment

Significant from another point of view is the distinction between articles intended for direct human consumption (and use) and articles destined for use as capital equipment.[1] During the period of fairly rapid economic advance which fell between the beginning of the century and the outbreak of the war, was the emphasis in production placed on the output of goods for direct consumption, such as food, clothing, passenger automobiles, or on the swelling of our supply of machines, tools and implements intended for use in further production? The following measurements, which are shown graphically in Figure 6, throw light on this question.

It should be understood that the index numbers of capital equipment (and also of consumption goods) refer to annual production, not to the total existing stock. If we could measure changes in the total stock of capital equipment in the country the picture would be quite different. But data for such a series of index numbers are not available. What we do measure are annual increments to the existing stock, increments which include replacements as well as net additions to that stock. Such index numbers are properly comparable with measurements of changes in the annual output of goods intended for human consumption.

We can not define with precision the proportion of the total annual production consisting of goods intended for use as capital equipment. If we restrict ourselves to physical, movable goods (i.e., excluding services, and all products of the construction industries) we may estimate that approximately 20 per cent of the total production of the year 1909, by value, consisted of goods intended for use as capital equipment, while 80 per cent consisted of goods intended for human consumption. These rough figures,

[1] This classification differs, of course, from one which would distinguish consumers' goods and producers' goods. Among articles of human consumption and use there are here included raw and semi-finished goods which will ultimately become consumers' goods proper. Capital equipment includes only those articles, raw and processed, which are intended for ultimate use as instruments of production. In general the classification has been based upon the chief use made of the product, although in some instances it has been necessary to include the same series in both groups, apportioning the weight in accordance with the use made of the commodity represented. This method fails to take into account relative changes in the use made of the products in question, but in the absence of adequate data it is the only procedure available. The actual classification of the series used in the preliminary annual index numbers is indicated in Appendix I.

TABLE 7

ARTICLES OF HUMAN CONSUMPTION AND ARTICLES ENTERING INTO CAPITAL EQUIPMENT

Index Numbers of Physical Volume of Production in the United States, 1901-1913

Year	Goods destined for human consumption (raw and processed)	Goods destined for capital equipment (raw and processed)
1901	100	100
1902	116	115
1903	115	114
1904	120	106
1905	126	140
1906	132	158
1907	128	162
1908	128	117
1909	134	145
1910	137	167
1911	136	155
1912	150	189
1913	146	197
Average annual rate of change (per cent)	+2.6	+5.0
Index of instability of growth	2.8	8.8

based on the value of raw materials produced, and on 'value added', indicate the relative importance of the two categories under review.

The output of articles of human consumption increased between 1901 and 1913 at a rate of 2.6 per cent a year, a rate comfortably in excess of the rate of growth of population (2.0 per cent a year). The margin of approximately 0.6 per cent a year represents the increase in volume of consumption goods available, per capita of the population, for raising the standard of living. (Changes in the character of imports and exports are not here considered, since their effect on the figure cited would be negligible.) The growth of production of this type was relatively stable, fluctuations averaging but 2.8 per cent a year.

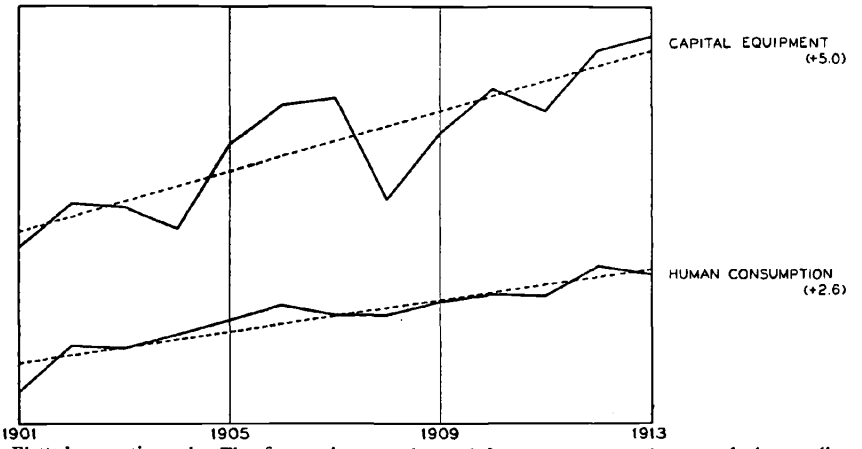
The output of additions to the total supply of capital equipment increased by 5.0 per cent a year.[1] The much more rapid rate of

[1] There are very definite indications that the rate of obsolescence of machine equipment is increasing from year to year. This tends to increase the gross figures for additions to capital goods. Figures for physical production that add, to the production of consumption goods, the *tools* consumed in such production may tend to be deceptive.—M. C. Rorty.

FIGURE 6

GROWTH OF PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913

ARTICLES OF HUMAN CONSUMPTION AND ARTICLES ENTERING INTO CAPITAL EQUIPMENT



Plotted on ratio scale. The figures in parentheses define average annual rates of change (in percentage form).

advance of this series indicates that the proportion of our annually available productive resources which was devoted to the output of articles of capital equipment was increasing during this period. Per capita of the population, the annual increments to the country's stock of capital equipment (including replacements) were increasing at a rate close to 3.0 per cent a year. Current well-being, as affected by the output of consumption goods, was being steadily enhanced during this period. More rapid, however, was the flow of new goods (and replacements) into the fund of capital. The margin between the two rates of advance is wide. Lacking figures for other times and other places we cannot say whether this margin represents an abnormally rapid rate of accumulation of capital equipment. As a standard of reference the figure will be useful in later chapters, in appraising the post-war record.

The growth in the output of capital equipment during this period was not steady. The advance recorded occurred as a result of three remarkable spurts, one beginning in 1904 and culminating in 1907, one beginning in 1908 and culminating in 1910, the third extending from 1911 to 1913. This irregularity of growth is evidenced by an index of instability of 8.8 per cent, a figure notably

higher than the corresponding measure of 2.8 for consumption goods. Wide variations in the output of capital goods are, of course, a customary feature of cycles in industrial activity.

Production of Non-durable, Semi-durable and Durable Goods

An economic system in which the output of durable goods bulked large would possess characteristics quite different from those of an economic system devoted to the production of perishable goods for immediate consumption. The output of goods of the latter type must always be a major economic concern, but with the increased use of capital equipment and the growing diversity of consumer wants durable goods increase in relative importance, and corresponding changes take place in the behavior of the economic system as a whole. If we divide all movable goods into non-durable, semi-durable [1] and durable goods, as in Table 8, we may trace cer-

TABLE 8

NON-DURABLE, SEMI-DURABLE AND DURABLE GOODS

Index Numbers of Physical Volume of Production in the United States, 1901-1913

Year	Non-durable goods (raw and processed)	Semi-durable goods (raw and processed)	Durable goods (raw and processed)
1901	100	100	100
1902	116	116	115
1903	114	117	114
1904	118	127	109
1905	126	127	134
1906	131	136	152
1907	128	129	154
1908	129	129	114
1909	134	132	141
1910	138	134	158
1911	134	146	145
1912	151	147	181
1913	141	154	191
Average annual rate of change (per cent)	+2.5	+2.6	+4.6
Index of instability of growth	3.0	3.4	8.1

[1] Semi-durable goods include, for the most part, textile and leather products.

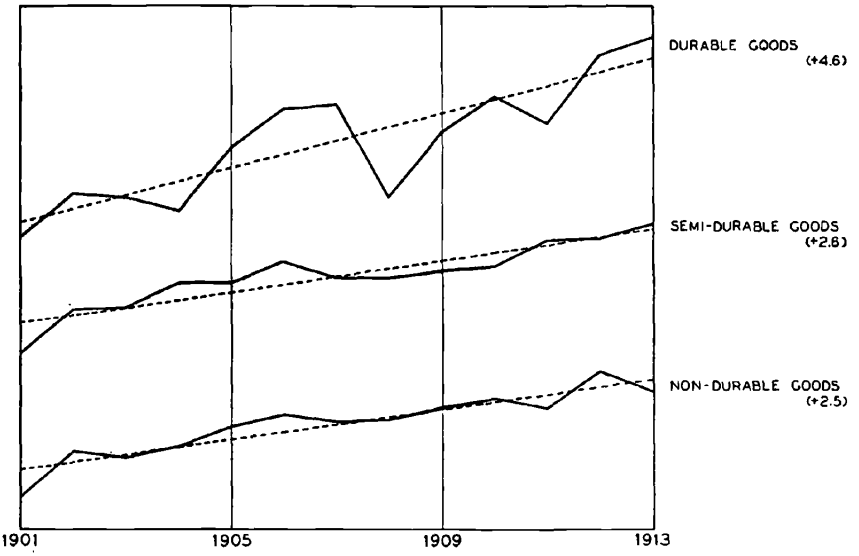
tain changes in the direction in which productive energies were being expended during the years preceding the war.

These index numbers are plotted in Figure 7.

FIGURE 7

GROWTH OF PHYSICAL VOLUME OF PRODUCTION IN THE UNITED STATES, 1901-1913

DURABLE, SEMI-DURABLE AND NON-DURABLE GOODS



Plotted on ratio scale. The figures in parentheses define average annual rates of change (in percentage form).

Non-durable goods (which in 1909 made up approximately 55 per cent, by value, of all movable goods produced in the United States) increased in volume of output between 1901 and 1913 at a rate of 2.5 per cent a year. The growth was regular, even the years of recession bringing only minor checks to the steady advance. Slightly more rapid and slightly less regular was the increase in output of semi-durable goods. Most rapid and most erratic was the gain in the volume of production of durable goods. Over the thirteen-year period the annual output of such goods increased 91 per cent, at an average annual rate of 4.6 per cent.

It is a leading attribute of durable goods, whether intended for capital equipment or for consumption, that demand for new supplies is subject to rapid expansion and sharp curtailment. These

constitute the highly variable elements in the aggregate annual production of economic goods. Perishable goods, which are consumed as purchased, are subject to no such sharp fluctuations in demand. Users of durable goods are able to withdraw from the market if business prospects darken, or if incomes decline, to a degree not possible in the case of goods which are consumed over a short period of time. For this reason exceptionally rapid exploitation of the markets for durable goods might be expected to pave the way for exceptionally severe declines. The sharp drop from 1907 to 1908 in the production of goods of this type is a case in point. Here again we lack criteria as to what constitutes 'exceptionally rapid' growth in the output of such goods. The record of the pre-war years may serve, however, as a standard for use in the study of more recent developments.

Physical Output and Productivity of Manufacturing Industries, 1899-1914

In the preceding pages we have presented measurements of annual changes in the physical volume of production. This material may be supplemented by the more detailed statistics of manufacturing production available for the years 1899, 1904, 1909 and 1914. These data do not cover precisely the period selected for analysis in terms of annual data, but the census statistics are significant in their own right.[1]

Growth of Manufacturing Production and Number of Wage-earners Employed

Changes in physical volume of manufacturing production, and in certain related elements, are defined by the index numbers in

[1] In the interpretation of census data we should recall that the year 1899 was one of marked prosperity in the United States, with a particularly pronounced boom in the iron and steel trades. In 1914 a general state of depression prevailed. The existence of these conditions during the terminal years would tend to dampen apparent rates of growth, and to accelerate apparent rates of decline, in industries materially affected by cyclical fluctuations of business.

The index numbers of manufacturing production and of productivity employed in this section differ somewhat from index numbers constructed from census data by other investigators. This is due, in part, to differences in methods of construction, in part, to differences in the industries represented. A detailed explanation of procedure is given in Chapter III, which deals with the general problem of deriving index numbers of production, prices and costs from census data.

the following table.[1] These measurements are shown graphically in Figure 8.

TABLE 9

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Index Numbers of Physical Volume of Production, Number of Wage-earners and per Capita Output [a]

Year	Physical volume of production	Number of wage-earners	Output per wage-earner
1899	100.0	100.0	100.0
1904	120.2	108.1	111.2
1909	154.5	130.0	118.9
1914	176.3	136.1	129.6
Average annual rate of change [b] (per cent)	+3.9	+2.2	+1.7

[a] These index numbers are based upon direct data of physical production. Modifications designed to correct for the omission of output not measured in physical units are made at a later point.

In the derivation of these index numbers a variation of the 'ideal' formula was employed. The form used is

$$I_q = \sqrt{\frac{\Sigma \frac{q_1}{q_0} w_0}{\Sigma w_0} \cdot \frac{\Sigma w_1}{\Sigma \frac{q_0}{q_1} w_1}}$$

where q_0 = quantity produced in base year
q_1 = quantity produced in given year
w_0 = weight in base year
w_1 = weight in given year

As is explained more fully in Chapter III, the weights used depend on the purpose to which the index is to be put. Value of product, 'value added', cost of materials, or another value may provide appropriate weights for a particular purpose. In the above table, 'value added' has been used. (For a full discussion of the 'ideal' formula see Irving Fisher, *The Making of Index Numbers*, Houghton Mifflin Co., Boston, 1927.)

In constructing index numbers for the pre-war period, 1914 has been employed as the base year in all calculations. For convenience of presentation the base has been shifted to 1899 in the exposition of results.

[b] The average rate of growth over the three quinquennial census periods, reduced to an annual basis. Because of the greater length of the period covered, differences in general business conditions in the four census years and the character of some of the omitted years, comparison of these rates of change with those based upon annual data must be made with care.

[1] The industries represented by these index numbers do not include all those covered in the Census of Manufactures, for data relating to physical output are not available in all cases. The proportion of the total value of product of all manufacturing industries included in this sample at different dates is shown below:

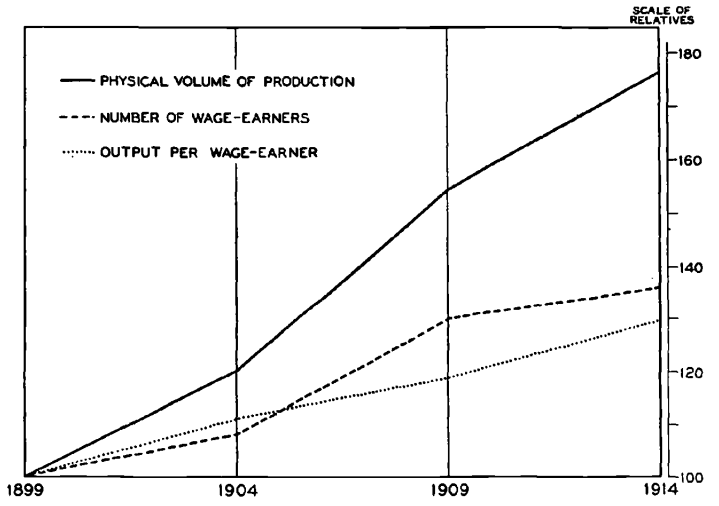
Year	Percentage of total value of manufactures included in index
1899	40.9
1904	38.9
1909	38.1
1914	39.2

In general, in the construction of these index numbers, weights are based upon 'value added' in the particular industries included. Imputed weights (i.e., weights

FIGURE 8

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

PRODUCTION, NUMBER OF WAGE-EARNERS AND OUTPUT PER WAGE-EARNER



During this fifteen-year period there was an increase of 76.3 per cent in the physical volume of production of manufacturing

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derived from larger industrial groups which the industries actually included are supposed to represent) have not been employed. For three of the industries included (industries producing motor vehicles, lumber products at the sawmill stage, and petroleum products) weights have been reduced, in order that they might not exercise excessive influence upon the results. These industries have been given the weights they would have if the sample included all census industries.

There is two-fold justification for this. Each of these three industries is in many respects distinctive, subject to special influences which did not affect manufacturing industries in general. Total and per capita output increased far more rapidly between 1899 and 1914 in the automotive and petroleum refining industries than in manufacturing industries in general, while the reverse was true of the lumber and timber industry. These industries should not, therefore, be over-weighted in index numbers of output and of productivity. Yet over-weighting results from the use of weights based upon actual values added in these industries, for practically all their products are included among the commodities for which statistics of quantities produced are available. There is almost complete coverage for automotive products, for example, whereas the textile products included represent only a portion of all textile products. In view of the rather exceptional character of the changes occurring in these three industries and the high degree of coverage of the quantity statistics available for them, it has seemed proper to reduce their weights to approximately the proportion that would prevail if there were complete coverage of all industrial groups.

plants. The average annual rate of increase was 3.9 per cent. We may view this increase as the resultant of two factors—number of wage-earners employed and the combination of elements (human, mechanical, organizational) which affect the per capita output of labor.[1] Taking this period as a whole the major factor in the increased output of manufacturing establishments was an increase of 36.1 per cent in the number of wage-earners, an increase which averaged 2.2 per cent a year. Only slightly less important was the effect of advancing productivity, as shown by an increase of 29.6 per cent in per capita output among the manufacturing industries included in the present sample. This gain averaged 1.7 per cent a year.

These changes deserve somewhat more detailed study. Considering the movements by census periods, we have the following record:

Census interval	Increase in volume of manufacturing production (per cent)	Increase in number of wage-earners (per cent)	Increase in output per capita (per cent)
1899-1904	+20.2	+ 8.1	+11.2
1904-1909	+28.5	+20.2	+ 6.9
1909-1914	+14.1	+ 4.7	+ 9.0

The first of these intervals bridges a gap between a year of prosperity and a year marked by a minor business depression. Yet the increase in volume of production was substantial. Among the industries here included the gain in output per wage-earner slightly exceeded the increase in number of wage-earners. The next five-year period opens in a year of slight depression and ends in a year of mild prosperity. The increase in physical volume of production amounted to no less than 28.5 per cent. By far the most important factor in this advance was an increase of 20.2 per cent in number

[1] In interpreting the index of per capita output it is to be borne in mind that index numbers of per capita output do not measure changes in the specific productivity of labor. Per capita productivity may increase because of improvements in equipment or in industrial organization, increased skill on the part of personnel or enhanced productive capacity due to changes in any of the factors of production. Indexes of per capita productivity may be accepted as measures of changes in the productive efficiency of industrial organizations viewed as functioning units, but not as measures of the net contribution of any one factor to these changes.

The index of per capita output here employed is based upon the number of wage-earners in manufacturing plants. No account is taken of salaried workers, nor of changes in hours of employment of wage-earners.

of wage-earners employed. This was a period of unrestricted immigration, and reviving industry called upon an elastic labor market for the instruments of expansion. Output per capita increased 6.9 per cent between 1904 and 1909.

During the next period there was another shift in the relative position of these two factors. In spite of the fact that 1914 was a year of depression, the volume of production exceeded that of 1909 by 14.1 per cent. The chief factor in this advance was an increase of 9.0 per cent in output per worker employed. (This increase reflected, in part, the increasing importance of certain industries in which production per capita was relatively large, and was expanding.) Number of workers increased by but 4.7 per cent between 1909 and 1914.

Among the 35 industries represented by these index numbers the main factor in the increase of production between 1899 and 1914 was an expanding working force. The survey by periods shows, however, that the only notable gain in number of workers occurred during the expansion from 1904 to 1909. From 1899 to 1904 and from 1909 to 1914 the main agencies of increased production were those elements of skill, mechanism and management which affect per capita output. Twice thereafter, during the exigencies of the war years and in the sharp recovery from 1921 to 1923, the chief factor in expanding production was a rapidly swelling labor force, but after 1923, as we shall see, there was again a remarkable shift from the worker to mechanical and organizational factors as the readiest instruments of expanding production.

§ *Changes in physical volume of production and in output per wage-earner, individual industries.*—When individual observations differ widely, the representative value of an average is seriously impaired. This is particularly true in the present case. Difficulties due to pronounced variation among industries are enhanced by perplexing problems of weighting. There is no clear justification for an elaborate system of imputed weights, for we can not assume that changes in production, productivity, prices and costs in the various individual industries included in the sample paralleled those occurring among selected excluded industries. Nor may we assume that weights based on the relative importance of the included industries will yield results representative of all manufacturing industries. Some industries fully represented in the sample would by this procedure be obviously over-weighted, as regards manufacturing industries in general. The method of weighting actually employed is a compromise, being of the second type (i.e., with weights based on the relative importance of individual industries among

TABLE 10

CHANGES IN PHYSICAL VOLUME OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Index Numbers for 35 Industries, with Average Annual Rates of Change

Industry	Index numbers of physical volume of production				Average annual rate of change 1899-1914 (per cent)
	1899	1904	1909	1914	
Automobiles, including bodies and parts	100.0	609.7	3758.1	16129.0	+36.8
Sugar, beet	100.0	309.9	621.5	934.6	+13.6
Ice, manufactured	100.0	171.8	306.7	450.9	+10.4
Gas, manufactured, illuminating and heating	100.0	174.1	250.5	349.9	+ 8.2
Petroleum, refining	100.0	123.5	188.6	296.5	+ 8.0
Fertilizers	100.0	131.0	199.1	296.4	+ 7.8
Explosives	100.0	190.6	302.5	337.4	+ 7.6
Salt	100.0	112.3	198.9	228.3	+ 6.2
Canning and preserving: fruits and vegetables; pickles, preserves, and sauces	100.0	138.6	163.9	239.2	+ 5.8
Paper and wood pulp	100.0	147.3	186.3	230.8	+ 5.4
Silk goods	100.0	135.5	184.1	219.6	+ 5.3
Hosiery and knit goods	100.0	131.9	182.3	215.3	+ 5.3
Coke, not including gas-house coke	100.0	129.8	213.7	205.3	+ 5.1
Rice, cleaning and polishing	100.0	255.2	257.2	273.1	+ 4.9
Butter, cheese, and condensed milk	100.0	121.6	147.9	199.2	+ 4.7
Paint and varnish	100.0	124.6	175.1	187.3	+ 4.4
Iron and steel: steel works and rolling mills	100.0	122.8	181.2	178.6	+ 4.2
Wood distillation, not including turpentine and rosin	100.0	139.2	175.2	180.5	+ 3.8
Iron and steel: blast furnaces	100.0	116.3	178.9	163.3	+ 3.7
Musical instruments: pianos	100.0	132.4	184.7	166.8	+ 3.6
Cotton goods	100.0	112.4	140.2	153.9	+ 3.1
Woolen and worsted goods	100.0	118.6	146.6	145.4	+ 2.6
Slaughtering and meat packing	100.0	113.1	127.8	127.1	+ 1.7
Carpets and rugs, other than rag	100.0	114.0	132.8	121.3	+ 1.4
Hats, fur-felt	100.0	131.9	158.2	113.9	+ 1.1
Flour-mill and gristmill products	100.0	103.8	109.0	114.1	+ 0.9
Gloves and mittens, leather	100.0	114.1	115.7	107.2	+ 0.4
Lumber and timber products	100.0	91.1	98.2	102.2	+ 0.3
Musical instruments: organs	100.0	103.9	81.4	111.5	+ 0.2
Motorcycles, bicycles, and parts	100.0	21.4	47.8	92.6	+ 0.1
Turpentine and rosin	100.0	80.5	75.9	69.2	− 2.4
Hats, wool-felt	100.0	51.3	75.4	45.5	− 4.1
Boots and shoes, other than rubber	100.0	110.4	—	131.4	—
Cordage and twine	100.0	—	121.8	144.4	—
Jute and linen goods	100.0	—	159.5	187.5	—
Average[a]	100.0	118.5	164.3	165.6	+ 3.6

[a] An arithmetic average of the central items of a weighted frequency distribution, with weights based on 'value added', averaged for the base year and the given year. The central one-fifth of the items, by weight, were included in computing the average.

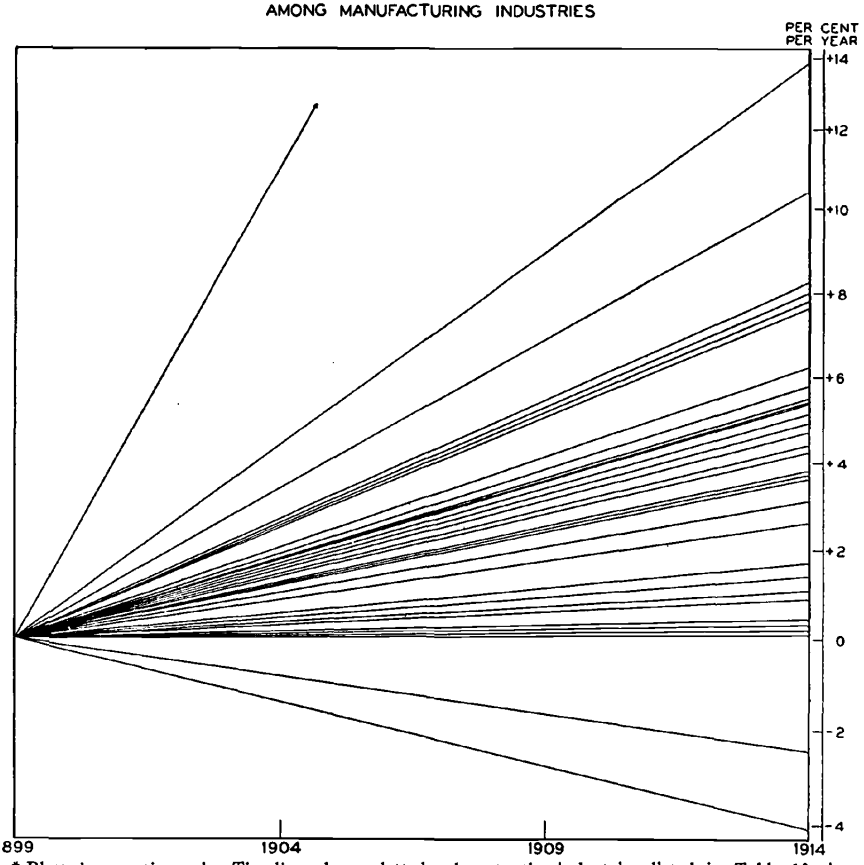
those actually included in the sample) but with reduced weights for three large industries which would otherwise dominate the sample.

In the face of these differences and complexities no set of averages may be taken to measure with precision changes occurring in manufac-

FIGURE 9

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914*

ILLUSTRATING THE DIVERGENCE OF PRODUCTION TRENDS AMONG MANUFACTURING INDUSTRIES



* Plotted on ratio scale. The lines here plotted relate to the industries listed in Table 10, in the order of that listing.

turing industries at large. For a more accurate though less simple picture it is well to go beyond the averages to the records of individual industries. Index numbers measuring the changes in volume of production between 1899 and 1914 in 35 industries are given in Table 10. Their trends are graphically pictured in the above figure.

Averages such as those previously given lead us to think of manufacturing industries as a whole, reacting uniformly to certain general influences in respect of productivity, mass output, etc. The index numbers for separate industries show how divergent, in fact, are the fortunes of different manufacturing industries. Between 1899 and 1914 the production of wool-felt hats declined 55 per cent; over the same period the output of automobiles increased over 16,000 per cent. These are extreme cases, of course, but even when these are excluded the variations are of extraordinary amplitude. The divergence is vividly portrayed in Figure 9, in which the rates of change of production in the different industries are plotted, radiating from a common point. Differences among these rates of change are measured by a standard deviation (weighted) of 5.7.

Less pronounced but still significant are the differences among industries in respect to changes in per capita output. Index numbers for the industries entering into the general averages previously presented are shown in Table 11.

Between 1899 and 1914 output per wage-earner declined 23 per cent in the production of wool-felt hats and advanced 184 per cent in the production of automobiles. Other industries fall within these limits. In each industry, of course, productivity was affected by numerous factors—technical and organizational changes, variations in the relative degree of prosperity in the two years compared, etc. In addition, we should note the fact of changes in quality which are not reflected in the index numbers of physical volume of production. To the extent that quality was improved, the index numbers of production and of productivity understate the actual changes occurring. In the main, however, the commodities upon which the index numbers are based are of standard quality, and we may accept the measurements as indicative of the general tendencies characteristic of the period.[1]

Average annual rates of change in per capita output, which are plotted in Figure 10, vary from —1.5 per cent a year, for wool-felt hats and turpentine and rosin, to +7.8 per cent a year, for automobiles. This chart, perhaps better than any other, indicates the diversity of

[1] Perhaps more important than changes in quality are changes in the relative importance of cheap grades and of more expensive grades in the products of certain industries. If, for example, we measure the change in output of carpets and rugs, other than rag, in terms of aggregate production in yards, adding together the output of all grades, we find a decline of 16 per cent between 1899 and 1914, with a decline of 24 per cent in output per worker. During this period, however, there was a marked increase in the relative importance of high grade rugs in the total output, and a decline in the relative importance of cheap rugs. If the rugs of different grade be treated as separate commodities, and an index be constructed on this basis, we find an increase of 21 per cent in total output between 1899 and 1914, and a gain of 10 per cent in output per worker. The latter measurements are, of course, the proper ones to employ. Index numbers of this type have been constructed wherever possible in the present study, in place of indexes based upon aggregate quantities, summed without regard to differences of quality.

TABLE 11

CHANGES IN OUTPUT PER WAGE-EARNER IN MANUFACTURING INDUSTRIES OF THE UNITED STATES, 1899-1914

Index Numbers for 35 Industries, with Average Annual Rates of Change

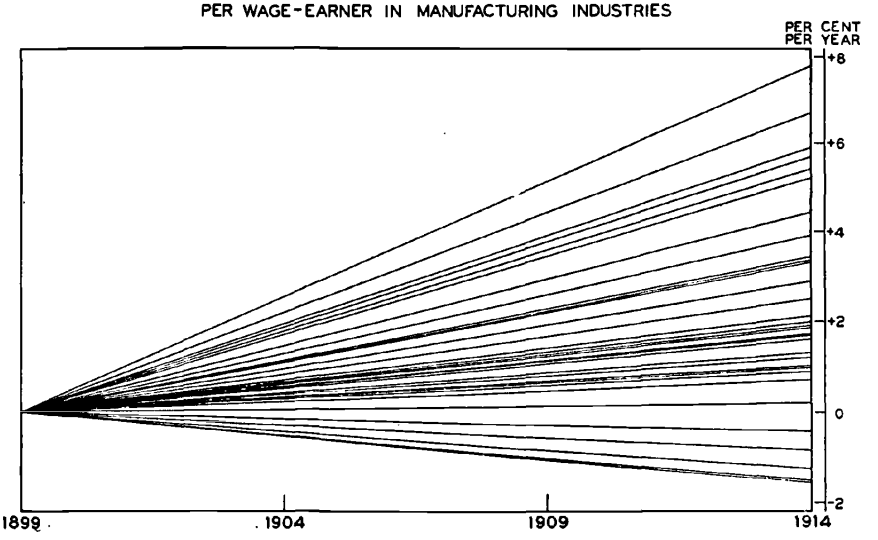
Industry	Index numbers of physical volume of production per wage-earner				Average annual rate of change 1899-1914 (per cent)
	1899	1904	1909	1914	
Automobiles, including bodies and parts	100.0	113.2	111.0	283.8	+7.8
Motorcycles, bicycles, and parts	100.0	112.9	188.9	243.0	+6.7
Explosives	100.0	147.9	217.1	240.8	+5.9
Salt	100.0	114.9	192.4	214.2	+5.7
Iron and steel: blast furnaces	100.0	130.1	182.7	218.3	+5.4
Sugar, beet	100.0	154.0	169.9	230.2	+5.2
Wood distillation, not including turpentine and rosin	100.0	145.6	174.7	200.4	+4.4
Gas, manufactured, illuminating and heating	100.0	127.9	151.2	179.5	+3.9
Canning and preserving: fruits and vegetables; pickles, preserves, and sauces	100.0	126.9	145.4	168.9	+3.4
Petroleum, refining	100.0	89.8	165.2	142.6	+3.3
Coke, not including gas-house coke	100.0	116.3	124.1	165.3	+3.3
Fertilizers	100.0	107.0	125.9	150.4	+2.9
Rice, cleaning and polishing	100.0	111.3	135.2	141.9	+2.5
Iron and steel: steel works and rolling mills	100.0	108.4	138.3	131.6	+2.1
Ice, manufactured	100.0	117.0	131.0	134.8	+2.0
Silk goods	100.0	111.4	121.6	132.8	+1.9
Gloves and mittens, leather	100.0	153.7	146.2	144.1	+1.9
Paper and wood pulp	100.0	110.9	121.7	129.5	+1.7
Musical instruments: organs	100.0	98.5	117.3	125.1	+1.7
Musical instruments: pianos	100.0	113.0	129.8	125.2	+1.6
Hosiery and knit goods	100.0	106.1	118.0	119.7	+1.3
Cotton goods	100.0	107.9	112.5	120.8	+1.2
Paint and varnish	100.0	103.8	119.3	112.9	+1.0
Woolen and worsted goods	100.0	105.2	113.1	115.4	+1.0
Carpets and rugs, other than rag	100.0	97.5	113.3	110.1	+0.9
Butter, cheese, and condensed milk	100.0	100.0	102.7	110.6	+0.7
Hats, fur-felt	100.0	113.0	119.1	100.8	+0.2
Flour-mill and gristmill products	100.0	85.5	89.1	92.6	−0.4
Slaughtering and meat packing	100.0	104.3	99.6	88.0	−0.8
Lumber and timber products	100.0	93.1	74.2	88.0	−1.2
Hats, wool-felt	100.0	72.0	80.1	76.8	−1.5
Turpentine and rosin	100.0	101.0	80.4	83.2	−1.5
Boots and shoes, other than rubber	100.0	104.4	—	97.3	—
Cordage and twine	100.0	—	109.2	120.0	—
Jute and linen goods	100.0	—	121.3	126.4	—
Average[a]	100.0	107.4	117.7	119.9	+1.3

[a] An arithmetic average of the central items of a weighted frequency distribution, with weights based on 'value added', averaged for the base year and the given year. The central one-fifth of the items, by weight, were included in computing the average.

FIGURE 10

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914*

ILLUSTRATING THE DIVERGENCE OF TRENDS IN PRODUCTION PER WAGE-EARNER IN MANUFACTURING INDUSTRIES



* Plotted on ratio scale. The lines here plotted relate to the industries listed in Table 11, in the order of that listing.

the factors affecting manufacturing industries, and the resulting divergence of tendencies. Here, as units in the same industrial structure, are industries in which output per worker had more than doubled in fifteen years, and industries in which output per worker had declined from 7 to 23 per cent. In making use of index numbers defining general tendencies amid this diversity of movement, we must do so with the clear recognition that any measure secured will be a statistical average, standing for values which, in fact, are marked by wide variation.

The degree of variation in the rates of change of index numbers of per capita output is defined by a standard deviation (weighted) of 2.0. This is materially smaller than the standard deviation of 5.7, which measures divergence of rates of change in volume of production.

The index numbers of physical volume of production and of output per wage-earner among manufacturing establishments given in Table 9 were derived by means of the 'ideal' formula, a procedure which has the virtue of insuring consistent results among index numbers of aggregate output, output per worker and number of workers. There are certain objections to its use when some industries are growing much more rapidly than others, both in output

per capita and in aggregate output. It may be desirable to allow these rapidly growing industries to influence the averages, but for some purposes one may wish to follow the course of manufacturing industries in general, without allowing changes in a few industries to exert too strong an influence upon the index numbers which are taken to be representative. Tables 10 and 11 show the behavior of the constituent elements of the sample of manufacturing industries we have employed. These are the basic figures to which one must turn in securing a true conception of the tendencies prevailing in American industry. At the foot of each of these tables there appears a series of index numbers, secured by averaging the central one-fifth of the items in the sample, by weight. These averages have not the mathematical elegance of the 'ideal' index, but they are in some respects better representatives of typical conditions in manufacturing industries in the several census years. Exceptional changes occurring in outlying industries will not be reflected in these averages, which define the movements among the central items. These two sets of index numbers are brought together in the next table.

TABLE 12

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Averages of Aggregate Production and of per Capita Output
(Derived from the central items of frequency distributions)

Year	Physical volume of production	Output per wage-earner
1899	100.0	100.0
1904	118.5	107.4
1909	164.3	117.7
1914	165.6	119.9
Average annual rate of change (per cent)	+3.6	+1.3

These measurements show smaller gains in aggregate output and in output per wage-earner than do the 'ideal' index numbers derived from the same data. The latter are materially affected by the rapidly growing industries in which the force of secular advance outweighs the cyclical recessions which are more apparent in the figures for industries at large. The present representative values show a greater gain in aggregate output between 1904 and 1909, a

much smaller gain between 1909 and 1914. With respect to output per worker, the chief difference is found in the record for the period 1909-1914. Only a slight gain is indicated by the averages derived from central values in the frequency distribution, while a substantial advance is recorded by the 'ideal' index. This latter figure reflects the shouldering forward of the automotive industries, of petroleum refining, and of other new industries which were marked by relatively large increases in output per capita, and which were gaining rapidly in relative importance. Typical manufacturing industries, if we may so view those which lie close to the center of the general array, were not marked by such a rapid growth during this five-year period. But for the entire pre-war period a substantial advance in productivity, a total gain of 20 per cent and an annual increase of 1.3 per cent, is shown by the averages which reflect tendencies among representative American industries.

Manufacturing Establishments and Volume of Manufacturing Production

Certain of the tendencies prevailing in manufacturing industries are revealed when the establishment is viewed as the unit of production.[1] The records in the following table define these movements.

TABLE 13

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Index Numbers of Physical Volume of Production, Number of Establishments and Output per Establishment

Year	Physical volume of production	Number of establishments	Output per establishment
1899	100.0	100.0	100.0
1904	120.2	98.1	122.6
1909	154.5	118.4	130.5
1914	176.3	113.0	156.0
Average annual rate of change (per cent)	+3.9	+1.1 [a]	+2.8

[a] Measurements of average annual rates of change are based upon data for intermediate as well as for terminal years. In this case, the low value for 1904 and the high value for 1909 serve to give the measurement of average growth a higher value than it would have if data for terminal years alone were employed.

[1] The Bureau of the Census publishes the following explanation of its use of the term 'establishment'.

"As a rule the term 'establishment' signifies a single plant or factory. In some cases, however, it refers to two or more plants operated under a common ownership

Between 1899 and 1914 there was a net increase of but 13.0 per cent in the number of manufacturing establishments in the 35 industries included in the sample. The physical volume of manufacturing production was increased primarily by greater output per establishment. But here again the story is one of uneven and irregular growth, with the factors varying in importance from period to period.

During the first of the five-year periods covered by the table there occurred a moderate increase in volume of production, accompanied by a decline of some 2 per cent in number of establishments, and by an advance of 23 per cent in output per establishment. The first of these years (1899) was relatively prosperous, the last (1904) slightly depressed. The change between 1909 and 1914, which also marks a transition from prosperity to recession, was marked by a similar, but greater, decline in number of establishments and by another pronounced increase in production per establishment. Production was maintained, and increased, during these periods by a greater flow of goods from individual plants, though the number of plants actually declined under the competitive stresses of liquidation and depression. In sharp contrast is the story of the change from 1904 to 1909, an advance from depression to a state of relative prosperity. During this period (more exactly, between the terminal years of this period) output per establishment advanced but 6 per cent. The chief factor in the substantial increase in physical volume of production was an advance of over 20 per cent in the number of establishments in operation.[1]

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and located in the same city, or in the same State, but in different municipalities or unincorporated places having fewer than 10,000 inhabitants. On the other hand, separate reports are occasionally obtained for different industries carried on in the same plant, in which event a single plant is counted as two or more establishments." *Biennial Census of Manufactures, 1927*, U. S. Department of Commerce, Washington, 1930, p. 7.

Essentially the same definition of the term has appeared in all reports of the Census Bureau. The establishment is not as clearly defined a unit as is a wage-earner. Variations in the interpretation of the term and variations between census dates in the accounting records of given enterprises would tend to cloud the statistics of number of establishments and of output per establishment. There is no reason to believe, however, that such variations have been of sufficient magnitude materially to affect the general tendencies shown by the census statistics.

[1] It is probable that changes during specific census periods are not as accurately measured as are changes over longer periods. Manufacturing census compilations which were made in connection with the general decennial censuses (relating to production in 1899 and 1909) are somewhat broader in their coverage than are those made in intervening years (1904, 1914). The difference in coverage is not great enough materially to affect any of the derived measurements given in this

One more step may be taken in tracing the factors that affect production. The increase in production per establishment may be due to an increasing number of workers per establishment, or to increasing output per worker. The chief factor in enhancing output per worker has probably been improved material equipment. The present contrast, therefore, is primarily one between an increased number of workers and improved tools, equipment and working facilities generally. The relative importance of changes in these two factors is indicated in the next table.

TABLE 14

GROWTH OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Factors Affecting Output per Establishment

Year	Output per establishment	Number of workers per establishment	Output per worker
1899	100.0	100.0	100.0
1904	122.6	110.3	111.2
1909	130.5	109.8	118.9
1914	156.0	120.4	129.6
Average annual rate of change (per cent)	+2.8	+1.1	+1.7

For the period as a whole the chief factor in increasing output per establishment was the combination of improved material instruments and enhanced skill which leads to increasing output per worker. If the story be followed by census intervals shifts in emphasis are found, but because of the greater coverage of the 1909 Census, as regards number of establishments included, too much significance should not be attached to these inter-censal changes.

The record of the fifteen years from 1899 to 1914 indicates that the factors responsible for the great advance in production of

study except those relating to output per establishment and to number of workers per establishment. The decennial censuses include proportionally more small establishments, establishments making only slight contributions, in the aggregate, to total volume of production and to number of wage-earners employed. (Cf. *Thirteenth Census of the United State, Vol. VIII, Manufactures,* 1910, p. 20.)

In the analysis of changes in manufacturing production after 1914, only those establishments producing goods of an aggregate annual value of $5,000 or more were included. (For the years 1899 to 1914 the lower limit was $500.) This raising of the limit probably served to reduce discrepancies due to varying coverage of decennial and other censuses.

manufactured goods were an increasing number of workers, larger and better equipped establishments, and steadily rising output per worker employed. (The growth of demand was, of course, essential to the realization of the advantages of large-scale production.) The stream of manufactured goods produced in 1914, a stream greater by 76 per cent in volume than that of 1899, was turned out by a working force (of wage-earners) only 36 per cent greater, and by a number of establishments only 13 per cent greater. There are clear signs here of the growing emphasis upon technical efficiency and enhanced productivity per unit as factors of increased production, an emphasis which has been even more pronounced in recent years.

§ *A revision of the index numbers of manufacturing production.*— Index numbers of the physical volume of production of the type employed in the immediately preceding pages are subject to two limitations. In the first place they are restricted to commodities for which adequate quantity statistics are available. This means, in general, that they are restricted to commodities of standardized types, with units of output which are uniform and easily enumerated. Complex machines, more highly fabricated articles of all sorts, are usually excluded from such index numbers. Secondly, they are generally restricted to commodities for which statistics are available over the entire period covered in a given study. Thus, with a few exceptions, new products developed after 1899 are not included in the index of production of manufactures given above. But new products, properly weighted, should be included in a comprehensive index of volume of production. If this is not done, the rate of increase of production in an economy marked by increasing diversification is understated.

The significance of these limitations, with reference to the measurement of output of manufacturing industries in the United States, is indicated by the figures in Table 15, on the following page.

The 'value added' by all census industries increased 104.5 per cent between 1899 and 1914. For the industries included in the present sample the increase amounted to 92.2 per cent; for industries not included in the sample the increase in value added by manufacture amounted to 110.5 per cent. This difference between the gains shown for included and for excluded industries calls for investigation. The more rapid advance in 'value added' in industries for which quantity statistics are not available may be due to a more rapid growth of physical output among the excluded industries, or to a more rapid advance in the cost of fabrication, per unit of product, among these industries. It does not seem likely that this latter condition prevailed. The survey of census industries in detail has revealed far greater uniformity in respect to changes in fabricating costs than in respect to changes in volume of output, and it is reasonable to assume that this

TABLE 15

CHANGES IN VALUE ADDED BY MANUFACTURE, 1899-1914

(1) Year	(2) (3) 'Value added', all census industries		(4) (5) 'Value added', industries included in sample [a]		(6) (7) 'Value added', industries not included in sample [a]	
	In millions of dollars	In relatives	In millions of dollars	In relatives	In millions of dollars	In relatives
1899	4,831	100.0	1,583	100.0	3,248	100.0
1904	6,294	130.3	1,906	121.3	4,388	134.6
1909	8,529	176.5	2,546	171.6	5,983	179.2
1914	9,878	204.5	3,042*	192.2	6,836*	210.5
1914	9,878		3,019**		6,859**	
1914	9,878		2,851***		7,027***	

[a] The values for 1914 marked with a single asterisk (*) are comparable with the data for 1899, those marked with two asterisks (**) are comparable with 1904, and those marked with three asterisks (***) are comparable with 1909. Relatives were first computed on 1914 as base and then shifted to 1899.

is true of all manufacturing industries. As between the two alternatives, it is far more probable that the excluded industries showed more rapid gains in volume of physical production.[1] The index of physical output derived from 35 industries probably understates the true gain in output registered by all manufacturing industries between 1899 and 1914.

The data available permit us to approximate the rate of increase of production among all industries, taking account of new products as well as of the possibly more rapid growth of output of commodities for which quantity statistics are not available. This may be done by two partially independent operations, to permit checking of results. We may assume, first, that output per capita for all census industries increased at the rate found to prevail, on the average, among the 35 industries studied. Multiplying the index of per capita output by an index of the total number of wage-earners employed, we secure the desired index of physical production. Again, we may assume that the cost of fabrication, per unit of product, changed at the same rate among all census industries as among the sample industries studied.[2] Having

[1] It is impossible to say to what extent more rapid growth in the production of excluded industries is due to the appearance of new products among these industries, to what extent to the increasing output of old commodities. Though the Bureau of the Census publishes statistics showing the quantities and values of new classes of products, when practicable, it is generally impossible to set up separate industrial classifications for new products. In many cases, indeed, the manufacture of both old and new products is reported by the same establishment.

[2] This method permits certain changes in the quality of manufactured goods to be measured, when such changes occur in greater degree among the excluded than

figures as to aggregate cost of fabrication (i.e. aggregate 'value added') in all census industries, an index of physical production may be readily derived. The procedure followed is illustrated in Table 16.

TABLE 16

ILLUSTRATING THE DERIVATION OF INDEX NUMBERS OF THE PHYSICAL VOLUME OF MANUFACTURING PRODUCTION, 1899-1914

All Census Industries

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Derivation of index numbers based on 'value added'				Derivation of index numbers based on number of wage-earners employed			
Year	Total 'value added', all census industries		'Value added' per unit of product, industries included in sample	Derived index of physical volume of production	Number of wage-earners, all census industries		Index of per capita production, industries included in sample	Derived index of physical volume of production
	In millions of dollars	In relatives			In thousands	In relatives		
1899	4,831	100.0	100.0	100.0	4,713	100.0	100.0	100.0
1904	6,294	130.3	98.5	132.2	5,468	116.0	111.2	129.0
1909	8,529	176.5	108.2	163.2	6,615	140.4	118.9	166.8
1914	9,878	204.5	104.6	195.4	7,036	149.3	129.6	193.4

The results secured by the two methods appear in columns (5) and (9). Their close agreement tends to confirm their substantial accuracy as indexes of the actual change in volume of manufacturing production between 1899 and 1914. Averages of the index numbers derived from fabrication costs and from number of wage-earners employed may be taken to represent the best approximations to the changes we seek to measure. This average shows an increase of 94.4 per cent in volume of output over this period, an average annual increase of about 4.5 per cent. These figures are appreciably higher than those derived from the sample of 35 industries, which indicated a gain of about 76 per cent during this period. The rate of increase in these industries averaged 3.9 per cent per year.

If it be true that the output of industries for which quantity data

the included industries. This would be the case if the more rapid increase in 'value added' among the excluded industries was due to a more rapid increase in degree of fabrication (assuming the cost of a given degree of fabrication to change at the same rate among excluded and included industries). The measurement of changes in fabrication costs, per unit of product, is explained in Chapter III.

are not available increased at a higher rate than did the output of industries for which production is readily measured, indexes of production based on annual data probably understate the true rate of growth in physical output. We may estimate the degree of understatement by comparing index numbers of manufacturing output based on annual data (before adjustment to the census averages) with corresponding index numbers derived from census data.

TABLE 17

COMPARISON OF INDEX NUMBERS OF PHYSICAL VOLUME OF MANUFACTURING PRODUCTION IN THE UNITED STATES, 1899-1914

Year	Census index numbers of volume of fabrication		Unadjusted annual index numbers of manufacturing output
	Based on 35 industries	Derived from 'value added' and number of employees for all industries	
1899	100	100	100
1904	120	131	120
1909	154	165	158
1914	176	194	176

The two series of index numbers based on directly measurable output are almost identical, both being substantially lower than the corrected census index which includes elements of physical production not capable of direct enumeration.

The general index of physical volume of production shown in Table 1, which represents our best estimate of the true course of aggregate production between 1901 and 1913, was derived from a combination of index numbers of raw material production and revised index numbers of manufacturing production based on census data. In deriving corrected annual indexes of manufacturing production, interpolation for inter-censal years was based upon independently constructed annual index numbers of manufacturing output. In this interpolation account was taken of the fact that the volume of all manufacturing production is more stable than is the volume of production among the selected industries represented by the annual data.

It is clear that the correction of census index numbers in order to approximate the course of manufacturing production at large, and the subsequent interpolation to secure index numbers for inter-censal years, involve a departure from numerical accuracy based upon direct measurement of quantities produced. The formal accuracy which is possible when such direct methods are employed does not necessarily yield the best approximation to the true course of production. The present index numbers are frankly estimates, based in the first instance upon direct

measurement of physical output in a wide range of industries, but adjusted, by methods which have been described, in order to overcome the obvious limitations of such enumeration.

Summary: Production Tendencies in the United States, Pre-war

During the thirteen years preceding the World War the physical volume of production in the United States increased at a rate approximating 3.1 per cent a year; population increased at a rate of 2.0 per cent. Oscillations in the growth of aggregate production averaged about 3.7 per cent a year, being many times as wide as the fluctuations in population growth. The meaning, for the country at large, of unstable processes is suggested by the difference between the amplitude of the variations in population growth (variations probably not exceeding an average of 0.3 per cent) and the deviations from stability of growth in the volume of goods which support that population.

During the pre-war period the rate of increase in the production of manufactured goods exceeded that of raw materials. Changes in our foreign trade, diversification of domestic demand, the taking over by organized industry of operations formerly performed in the home—all those processes which accompanied the increased industrialization of American life—contributed to the more rapid development of manufacturing. In the mass, the output of raw materials was more stable than was the output of manufactured goods, but the production of certain classes of manufactured goods was marked by notable instability.

Far greater than the difference between the rates of increase in the output of raw and manufactured goods was the margin between the output of farm and non-farm products. A population growing at the rate of 2.0 per cent a year was increasing the exploitation of its raw mineral resources [1] at a rate of 5.6 per cent a year, between 1901 and 1913. The rapid exploitation of mineral resources is a characteristic of the age in which we live. The output of raw American farm products, on the other hand, increased by but 1.7 per cent a year, a rate of advance less than the rate of increase in population.

The trend toward industrialization characteristic of this period

[1] The commodities included among raw materials other than products of American farms are all minerals.

is even more clearly revealed by the contrast between the output of goods intended for use in capital equipment and of goods intended for direct human consumption. Capital equipment, though making up a minor part of the total productive stream, set the pace of the industrial advance between 1901 and 1913. The production of such goods was increasing at a cumulative rate of 5 per cent a year, as compared with a rate of 2.6 per cent for goods intended for consumption. It was an irregular growth, this increase in the annual output of capital equipment, reflecting in intensified form the ebbs and flows of industrial activity, but it was none the less persistent. Each interruption was followed by an elastic rise to new heights.

Another distinctive attribute of the movement toward a more complex economic life is found in the relatively rapid growth of durable goods. While the production of non-durable and semi-durable goods increased between 1901 and 1913 at rates approximating 2.5 per cent a year, the output of relatively long-lived goods increased at a rate of 4.6 per cent a year. Such goods, we have noted, are characterized by relatively high elasticity of demand and instability of production. The problem of maintaining equilibrium in an economic system may be expected to become more difficult as more of its productive energies are devoted to the output of capital equipment, and of durable goods generally.

In discussing the growth of manufacturing production attention has been directed to certain of the factors affecting volume of production. Viewing the two factors of production as number of wage-earners employed, and the technical, mechanical, educational and organizational elements which affect the per capita output of labor, we observe that these varied in importance during the different inter-censal periods falling between 1899 and 1914. In the first and third of these five-year period (periods which opened in prosperity and closed in depression) technical and organizational elements were the more potent as factors tending to increase production. Between 1904 and 1909, on the other hand, an increase in the number of wage-earners was the chief factor in expanding production.

It is a suggestive fact that in two of the three pre-war inter-censal periods under review, technical skill and improved equipment were of greater importance than an increase in the number of working units, in stimulating the growth of manufacturing production.

The great increase in number of workers between 1904 and 1909 tends to obscure the other tendencies which were affecting manufacturing industries before the war. There were periods later, notably during the war, when numbers again played a dominant part, but in retrospect these appear to have been interludes. The tendency to subordinate numbers to mechanical and organizational factors, a tendency which has attracted so much attention in recent years, was clearly in evidence during these pre-war years.

Manufacturing output is seen in a different light if the establishment be viewed as the unit of production. Production may expand through an increase in number of establishments, or through increased output per establishment. An index of output per establishment is an index of the growth of large-scale production. A survey of these elements during the years 1899 to 1914 reveals a clear tendency toward large-scale production, with a declining number of establishments, except between 1904 and 1909.[1]

A final analysis was made of the factors affecting output per establishment. Here again we may set in opposition the human factor, as measured by an index of number of workers per establishment, and the complex of technical, mechanical and organizational factors reflected in output per worker. The evidence indicates that during the early years of the century the movement toward large scale production was promoted by putting more men into a smaller number of establishments and by means of technical and mechanical improvements which permitted increased output per worker. From 1904 to 1909 the movement toward more workers per establishment appears to have been checked, though conclusions are clouded by the fact of variation in coverage. After 1909 both elements of large scale production were again called into play. The number of employees per establishment increased sharply, and further play was given to the elements of technique and equipment which stimulate output per worker. During the war years, as we shall see, the factor of technical efficiency was subordinated to the cruder instrument of numbers, but it again became the dominant

[1] It is worth noting that the combination movement in American industry, so active after 1899, was checked in 1904 by the decision in the Northern Securities case. The growth of new establishments between 1904 and 1909 may have been in part a result of this check to integration. Probably more important, however, was the fact that the degree of coverage was somewhat higher in the Census of 1909 than in the Census of 1904. Variation in coverage was not significant except as regards number of establishments.

agent of advance when the war-time boom had passed. It is this factor, of course, which has placed its impress on recent economic changes.

A detailed picture of the course of production in the United States between the turn of the century and the outbreak of the World War reveals a host of productive elements changing at rapidly diverging rates. Virile young industries were moving forward rapidly; others were keeping comfortable pace with the growth of population; still others were dropping behind, many with volume of output declining. These differing rates of change present in concrete form one of the pressing problems of an industrial civilization, the problem of securing that flexibility and adaptability which will permit prompt readjustment to changing industrial demands. The persistence of differing rates of secular advance makes these demands—demands for a mobile and adaptable labor force, for a liquid supply of capital, for flexible transportation and distributive organizations, and demands for social machinery which will lighten the human burdens arising from rapid technical changes and from shifting tides of employment.[1]

§ *On methods of measuring economic movements.*—The measurements used in this and the following chapters require brief explanation. The prevailing tendency of a statistical series during a period is given by the average annual rate of change, as defined by the value of r in the equation to an exponential curve fitted to the data in question.[2] This is the slope of a line which is straight on ratio paper. Measure-

[1] It has not been possible in this chapter to go into a number of questions which might properly be treated in connection with the measurement of volume of production. For discussions of various technical matters relating to the measurement of changes in physical volume see:

Edmund E. Day, "An Index of the Physical Volume of Production", *Review of Economic Statistics,* September, October and November, 1920;

Walter W. Stewart, "An Index Number of Production", *American Economic Review,* Vol. XI, No. 1, March, 1921, pp. 57-70;

Woodlief Thomas, "The Economic Significance of the Increased Efficiency of American Industry", *Supplement, American Economic Review,* Vol. XVIII, No. 1, March, 1928, pp. 122-138;

E. E. Day and W. Thomas, *The Growth of Manufactures, 1899 to 1923.* Census Monograph, No. VIII, Bureau of the Census, Washington, D. C., 1928;

A. W. Flux, "Indices of Industrial Productive Activity", *Journal of the Royal Statistical Society,* Vol. XC, Part II, 1927, pp. 225-271;

J. W. F. Rowe, "An Index of the Physical Volume of Production", *The Economic Journal,* Vol. XXXVII, No. 146, June, 1927, pp. 173-187;

Carl Snyder, *Business Cycles and Business Measurements,* Macmillan, New York, 1927, pp. 44-51.

[2] More precisely, the value we have used is that of $(r - 1) \times 100$, r being taken from the equation $y = ar^x$. The curve is fitted to the data by the use of

ments of this type, which were employed in the opening section of this chapter, possess the advantages of simplicity and ease of calculation. They lend themselves readily, moreover, to comparison and combination, since they are expressed in percentage form.[1]

There is one obvious objection to the employment of a single curve type to represent the secular changes found in a wide variety of economic series. It may be said that the type of curve employed to measure secular tendency in each case should be adapted to the particular series being studied, that no single type can be thus generally employed. There is merit in this objection, if we are thinking of these tendencies as secular trends in the usual sense. The first answer must be that we are not concerned with the measurement of secular trends in the abstract; our interest is in persistent tendencies during definite periods of time. Each of these periods is assumed to be a reasonably homogeneous economic era, an era during which the direction of the general economic development of a nation was not altered by catastrophic events. During such periods, it is here suggested, the single function proposed for the measurement of secular tendencies gives an adequate and satisfactory representation of these movements for a very large percentage of all economic series. This claim cannot be supported by *a priori* argument; the proof is to be found in a study of the data. The series employed in the present study are presented graphically, and the reader may judge for himself as to the accuracy of each measure em-

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Glover's mean value table (cf. James W. Glover, *Tables of Applied Mathematics,* George Wahr, Ann Arbor, Michigan, 1923, pp. 468 ff.)

Rates of change derived from census data have been reduced to an annual basis by taking the fifth root of the rate of change for a five-year period, as determined by fitting a line to data for the years 1899, 1904, 1909, and 1914.

[1] A further technical virtue of this method, which has important practical consequences, may be pointed out. When the values of a and of r (in the equation $y=ar^x$) have been secured for two annual series, which we may designate series A and series B, it is possible to determine quite readily the values of a and of r for a third series C, secured by dividing the annual values of series A by the corresponding annual values of series B. Under these conditions, we have

$$a_C = \frac{a_A}{a_B}$$

$$r_C = \frac{r_A}{r_B}$$

This relationship prevails when lines have been fitted to the logarithms of the data by the method of least squares. It is not a necessary relationship when the fitting has been effected by the use of Glover's table, but the margin of error involved in the application of the method is slight.

This procedure is extremely useful in securing the rate of change in the purchasing power of a commodity, or of wages, when the rates of change in the original price or wage series, and in indexes suitable for reducing prices or wages to a purchasing power basis, have been computed. It may also be employed in deriving rates of change in per capita earnings of factory labor, when total payroll and employment figures are given, as in the publications of the U. S. Bureau of Labor Statistics.

ployed. A detailed inspection of the series used indicates that, during the periods here studied, economic series have tended to increase (or decrease) by fairly constant percentage increments (or decrements), year by year. During an era marked by no sudden breaks in the general economic development of a country, sharp interruptions in the rates of change of individual series are the exception, not the rule. In the body of the present study special reference is made to the few cases in which such sharp breaks have been observed.

There is a final justification for the employment of the procedure here described. This method yields, for each series, a single measurement which summarizes the direction and degree of change of that series during a stated period and which is directly comparable with similar measures derived from other series, regardless of the units of measurement in which the various series may have been expressed and of the magnitude of the figures in the various series. Unrestricted comparison and combination of measures relating to this aspect of economic change are possible only if a function of the general type here suggested be employed. This last consideration would have no weight, of course, if the particular function did not provide an accurate measurement of the economic change in question. This, fortunately, it does in the great majority of cases.

The second measurement descriptive of the behavior of individual series, the mean percentage deviation about the line measuring average rate of change, is an index of instability of growth. This measurement, being in percentage form, is suitable for comparison and combination with similar measurements for other series, regardless of the magnitudes of the items in the other series and of the nature of the original units. It is a statistically simple measure, but adequate to the present purpose. The more stable and regular the growth or decline of a given series, the smaller will this measure be.[1]

The characteristic measured by such an index is instability of growth (or decline), not the variability of given economic series. Various statistical devices are available for the measurement of variability, devices adapted to the measurement of seasonal or cyclical variability, or of

[1] This method of measuring stability of economic growth (or decline) during a stated period ensures comparability, in so far as the observations included in the original series are comparable. When the original data are annual aggregates or monthly averages of simple economic series the measures of instability are fully comparable. But the annual data of certain economic series are not aggregate or averages of monthly items; they relate to specific dates. A series of this type might be expected to show somewhat less regularity in its secular change than would a corresponding series of aggregates or monthly averages. Difficulties of another sort arise in handling series relating to annual increments to an existing total. Fluctuations in such increments are not comparable with fluctuations in aggregates. Again, indexes or averages representing combinations of several series tend to be somewhat more stable than items representing the movements of individual economic series. But such difficulties are due to differences in the structure of the original series, not to the method of measurement employed. They must be borne in mind in making comparisons among different series.

week-to-week, month-to-month or year-to-year changes. If variability is to be measured the significant fluctuations are the actual changes, not deviations from hypothetical or 'normal' values. But if *stability of growth* is in question the measures which possess significance are those defining departures from values which would have been recorded if a given rate of change had prevailed with absolute regularity. (Stable growth might be defined, of course, by a function involving changing rates of growth. The simpler function furnishes the present standard.) The magnitude of these departures, in relation to the expected values, is defined by the index of instability.