Volume Title: Production Trends in the United States Since 1870

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Volume Publisher: NBER

Volume ISBN: 0-87014-022-1

Volume URL: http://www.nber.org/books/burn34-1

Publication Date: 1934

Chapter Title: The Growth of Total Production

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Chapter URL: http://www.nber.org/chapters/c2265

Chapter pages in book: (p. 249 - 278)

Chapter VI

THE GROWTH OF TOTAL PRODUCTION

OUR national industry has experienced a continual transformation in its pattern since the Civil War. Yet, the change in pattern has been marked by a fair degree of order and regularity: individual industries have grown at widely unequal rates, but their rates of advance have generally declined with their age; retardation in the growth of individual industries has not been continuous, but the fluctuations in the rates of industrial growth have been synchronous in considerable degree; periods of exceptionally rapid advance and rapid change in the pattern of production have been terminated by general crises, but the sequence itself has been regular. The vast changes in the pattern of production have accompanied and in very large part have expressed the same forces as the astonishing increase in the size of total production.

The preceding chapters contain considerable information bearing on the size of total production, but that information lacks compactness. It remains in this final chapter to consider systematically the quantitative increase in the physical volume of total production. In an age dominated by the idea of material progress, this is the most important question that economic history can consider. Our present concern will be with the rate of advance of the secular trend of total production, especially with the degree of regularity of that advance. While the preceding analysis of the elements of order in the

secular changes in the pattern of production resolved itself into a study of the common characteristics of the production trends of individual industries, the present analysis of elements of order in the secular trend of total production will constitute a study of the elements of regularity in the single trend of total production.

I. MEASUREMENT OF TOTAL PRODUCTION

Measurements of changes in the physical volume of total production have only recently been attempted; but a fair number of indexes of production are already available, some of them going far back into the past. These long-range indexes are the data for our immediate inquiry. Before putting the indexes to specific use, it is necessary, however, to understand their logical basis and to grasp their shortcomings firmly.[1]

The 'production' of any industry is measured by the valuable utilities which the industry adds to the materials and supplies that it works up, that is, by the 'net value product' of the industry. Correspondingly, the total production of an economy is given by the sum of the net value products of its industries. But the individual goods to which valuable utilities have been added have a physical side; and, just as in the case of individual goods we obtain measurements of such of their distinguishable physical characteristics as are of economic interest, so in the case of the ensemble of goods we may seek a measure or index of the physical quantity of the ensemble. The available measurements of the physical volume of production of individual goods are expressed in

[1] This section is in some ways a continuation of section I of Chapter I. In the present section, the consideration of defects in production indexes is confined to indexes of the total movement of production, running over a long period. The same defects characterize also indexes of total movement running over a short period, and indexes of 'cycles' in production—irrespective of the length of period they may cover; but other considerations are more important in such indexes.

divers physical units, since statistical agencies ordinarily follow the usages of commerce. In practice, therefore, the problem of devising a measure of changes in the physical volume of total production is a problem in making the right combination of the divers measurements for the individual goods.

Some makeshift is obviously necessary, and the most plausible is to proceed on the assumption that the 'net value product' per unit of output is constant over time for all individual goods. These constants may be obtained from the statistical records of any single year or series of years, and they will vary, of course, from good to good. We may, now, for each year considered, multiply the datum of the physical volume of production of each good by its respective 'net value product' constant, and summate these products for all goods. We will obtain in this way an annual series of dollar sums, which we may regard as an index series of changes in the physical volume of total production.

It is difficult, however, to state in words the exact meaning of these measurements. Unlike measurements of the physical volume of production of individual goods, our indexes of the physical volume of total production no longer express the number of units of some one physical attribute; they state, at best, something hypothetical—viz., what total production (in the sense of economic theory) would have been in each of a series of successive years, if the net value product per unit of output of the actually experienced 'physical' production of each good had remained constant throughout the period. But this statement requires elaboration. When we reduce the net value products of individual goods to constants and allow their physical volumes of production to vary, we obtain, in a sense, measurements of total production corrected for changes in net value products; but this is not equivalent to saying that the net value products do not enter into the indexes of the physical volume of pro-

duction, for our 'net value product' constants are restricted to some one year (or series of years), and if we changed the year (or series of years) we would obtain a different set of constants and therefore a different set of index numbers.[2] All that we can be certain of, then, is that our dollar sum for the year (or series of years) yielding the constants is an accurate measure of the total production (in the sense of economic theory) for that year (or series of years taken as a unit), and that our dollar sums for all other years (in case a series of years yield the constants, also for the individual years of the series) measure neither the total production nor the purely physical aspect of total production. It follows that any so-called index series of the physical volume of production in a changing economic system is inherently ambiguous, quite apart from the limitations of the data on which it must in practice be based; and that the ambiguity is apt to increase with the length of the period covered by the index.[3]

Economic statisticians construct and make extensive use of production indexes, in spite of the fact that their meaning is nebulous in large part and must always remain so in our changing economy. The reason is, perhaps, that economists are most frequently concerned with the utilities which the economic system creates; and, since value measurements reflect the volatility of prices, they seek measurements of production which will be free from the price factor, and which may, therefore, bear a closer correspondence to the volume of created utilities than do the value measurements.[4] So im-

[2] Moreover, in the case of an economy which is continually gaining in new products, it is impossible to obtain a set of 'net value product' constants relating to the same period for all goods. And, as a matter of fact, the procedure of taking weights as of a fixed date or period is not obvious, except as a piece of arithmetic or verbal convenience.

[3] For a fuller discussion, see the writer's "The Measurement of the Physical Volume of Production," *Quarterly Journal of Economics*, February, 1930.

[4] See, however, pp. 8–9, note 2. A theoretical alternative to the procedure described of constructing a measure of changes in the physical volume of total production is to calculate the man-hours of labor expended on 'pro-

portant are the questions which production indexes could answer, were they free from ambiguity, that investigators have ignored the ambiguity and have set about deliberately "to do as logically as possible the illogical." [5] The effectiveness of their labors has been restricted by the quantitative and qualitative shortcomings of the data which are readily available. Next to ambiguity, the principal defect of production indexes is the inadequacy of their composition.

There is an effective statistical method of indicating the nature of the bias that, as a result of the inadequacies of the available data, is likely to be found in a production index covering a long period. In the course of this investigation, a detailed study was made of the decade-by-decade frequency distributions of the decade rates of the eight fixed groups of production series listed in Appendix A, Table 46, with a view (among other purposes) to testing the representativeness of these series for the purpose of constructing an index of the physical volume of total production. The distributions showed, first, a rapid secular shift to ever lower positions on the scale of growth, second, a secular decline in their dispersions, third, a secular decline in their 'positive' skewness—the later distributions generally showing 'negative' skewness. For a rapidly progressive national economy, however, one would expect to find generally increasing dispersion and persistently high positive skewness in frequency distributions of decade rates, and only moderate decline, if any, in the rate of growth of total production. If our series constituted a representative sample of the production universe, the distri-

duced' goods; this is the only physical attribute of 'produced' goods, which admits of their general commensuration (see p. 50, note 1). But this method of measuring the physical volume of production is shunned because it is deemed to understate the volume of utilities created in a progressive industrial economy.

[5] F. G. Perry and A. G. Silverman, "A New Index of the Physical Volume of Canadian Business," *Journal of the American Statistical Association*, June, 1929, p. 127.

butions of their decade rates could not depart so widely from reasonable expectations. The nature of the departures indicates that these series are likely to understate the growth in the 'actual' volume of total production.

A critical examination of the statistical composition of a 'typical' long-term index of the physical volume of total production will lead to the same conclusion.[6] Ordinarily, the index covers material goods only, and though it occasionally includes transportation and trade, it never covers 'services' in the narrow sense of that term; the census of occupations suggests, however, that the latter have grown more rapidly than the production of material goods. The index is based on a fixed, or virtually fixed, list of production series; this is equivalent to saying that the index becomes progressively anachronistic,[7] for the new industries which are not covered are generally in the vanguard of industrial advance. It includes a goodly number of industrial consumption series and, occasionally, some equipment series; but our growing technology has made generally for more effective conversion of raw materials into finished products and for more effective utilization of equipment. It does not, ordinarily, take account of 'secondary' production; but such production has been growing at a more rapid rate than 'primary' production. It gives inadequate representation to such by-products as constitute additions to the production of old commodities, although such by-products are of increasing importance. And

[6] Qualifications would have to be made if the following description were applied to any specific index. It is not feasible to enter here on a comparison of the various indexes.

[7] Statistical data bearing on this point will be found in *A Graphic Analysis of the Census of Manufactures, 1849 to 1919* (National Industrial Conference Board, 1923), pp. 171–3; F. C. Mills, *Economic Tendencies in the United States* (National Bureau of Economic Research, 1932), pp. 39–43, 198–201, 307–10; A. R. Eckler, cited above, p. 86. Some statistical data bearing on the other points are given in Ch. IV, sec. III, 2–3. Concerning the growth bias of individual production series, see pp. 25–7, and Appendix C, I.

it makes no allowance for variations in quality, while improvements in quality have been, as a matter of fact, almost universal in raw materials, and also very extensive in manufactures—as in steel, rayon, automobiles, agricultural machinery, radios, and electric appliances. All of these inadequacies of the data entering into a 'typical' production index tend to make for a downward growth bias. Other inadequacies work in the opposite direction. The index never includes industries which vanished at some point, and ordinarily does not include decadent industries which have lingered on. Also, the index ordinarily includes a few series with an upward growth bias arising out of some peculiarity in their statistical constitution. These factors making for an upward growth bias are obviously less important than those making for a downward bias; the statistical constitution of a 'typical' index is, therefore, such as to tend to understate the physical volume of total production.

The third defect of long-range production indexes derives from the type of formula employed in combining the different goods into an index number series. The various commodities and services cannot be aggregated directly since they are expressed in different units and are of unequal industrial importance. But they may be aggregated once weights are assigned which serve to commensurate, and express the importance of, the various outputs. The mathematical formula which describes this kind of arithmetic operation is the 'weighted aggregate'. This formula alone is logically adequate; for an index of production is conceptually an aggregate of the outputs of different goods, and not some sort of an average of their movements. Most of the existing long-range indexes of production are formally defective, since they are not weighted aggregates. They need not, however, be any worse in practice on this account; for the quality of the data and weights is generally more important than the arithmetic

method of their combination. Yet, there is one formula which must render suspect any production index embodying it—that is, the unweighted arithmetic mean of fixed base relatives. Snyder's index of 49 series with 1910–14 as base is of this type and will serve as an example. If this index were a reliable indicator of the trend of total production, it might be expected that the omission of one or two minor series would not alter its complexion appreciably. But, as a matter of fact, when quicksilver production and New York canals traffic are excluded from the index, its level in the period 1870–80 is reduced by something like 20 per cent, its level in later years but prior to the base period is reduced by a declining percentage, and its level in years subsequent to the base period is raised.[8] The explanation is that prior to the base period the relatives of progressive series could vary only from zero to 100, while the relatives of retrogressive series, the two excluded being of this type, could vary freely between 100 and any higher figure; and that subsequent to the base period, the restrictions on the movements of the relatives of progressive and retrogressive series are reversed.

The defects in long-range production indexes are not peculiar to them alone, but they are probably more serious than in the more familiar long-range indexes of prices. Since monetary factors exercise an influence on all prices, acting as a common brake on their movements, an average of a reasonably large number of commodities is likely to disclose fairly accurately the influence of the common monetary factors. But there is no single dominant force acting pervasively on the production trends of industries; their movements are

[8] It should be noted that Mr. Snyder has recently replaced this index by a long-term weighted index (see pp. 200–1); and that he has recently constructed, for the period since 1919, an exceptionally elaborate and, in every way, improved index. Few statisticians have been as courageous as he in pioneering efforts, as critical of their own work, and as willing to place at the disposal of others the results of their researches.

therefore more heterogeneous, the problem of sampling for an index number is more baffling, and the problem of combining individual elements into index form more exacting. The differential homogeneity of price and production trends bears strongly on the technique of weighting. When price data are available for only a few commodities falling in a group, it may perhaps be assumed with some plausibility that the prices of unrepresented commodities have moved sympathetically with those included, but not so in the case of production data, especially when the groups embrace competing commodities. This is but another way of indicating how intricate is the problem of sampling for a long-range production index.[9]

[9] The series analyzed in this study are more numerous and some of them are, perhaps, also of better quality than those entering into the various long-term production indexes. Nevertheless, the series fall so far short of satisfactory standards of quantity and quality that a new index derived from them would in all likelihood merely add to a growing list of defective indexes. A substantial improvement over any of the existing indexes might possibly be effected if a painstaking study were made of the various discontinuous quantity series scattered through census reports and trade journals, of the extensive data on the pecuniary volume of production contained in the census reports, and of the economic histories of individual industries recorded in countless periodicals and monographs. In this way, many of the gaps in the continuous record of physical output might be filled. With unstinted experimentation, the various data might then be welded together into an index number series inspiring more confidence as an indicator of the trend of the physical volume of total production than any index now available; but any index of production, no matter how ably constructed, can be even roughly true for periods of only intermediate duration, say, no more than twenty years, in a rapidly changing economy such as ours—so that a long index series will best be presented on a shifting base, if misinterpretation is to be minimized. One of the most important questions which would have to be analyzed in the course of a study aiming at improved measurements of changes in total physical production is the degree to which the available data are representative of total production. A partial answer to this question might be obtained by using some such method as we have used to test the representativeness of our series for the purpose of constructing a production index, the method being just as applicable to a variable as to a fixed number of series, though the method yields only a negative test: we can be reasonably certain that a sample is poor when distributions of rates of growth fail to conform to such a priori expectations as we have set forth, but we cannot be at all

II. AVERAGE RATE OF INDUSTRIAL GROWTH

Strict logic is a stern master, and if one respected it, one would never construct or use any production index.[10] Nevertheless, such questions as: How much better off are we now than formerly? How rapid has been our rate of material advance? Has there been any decline in the rate of increase of total physical production? press insistently and cannot be dismissed. If we proceed with caution, something may possibly be learned from such materials as we have. We shall consider in this section the long-term average rate of industrial growth of the nation, and in the next section the changes in the rate of growth. The evidence of indexes of certain major industrial groups will serve to introduce and give content to the evidence of the indexes of total physical production.

The most pertinent data bearing on the average rate of industrial growth since 1870 are summarized in Table 41.[11]

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certain that the sample is satisfactory when the distributions conform to the expectations. A comprehensive study of the kind suggested is a statistical enterprise outside the practical scope of this investigation.

[10] But the same strict logic would forbid also the use of most individual production series, since practically every series is, in miniature, an 'index', and a 'bad' index at that, of physical volume: when commodities are not of uniform quality, which is the case generally, physical volume series—such as bushels of wheat produced, number of locomotives, tons of bituminous coal—may be described as index numbers of the unweighted aggregate type (see Ch. I, sec. I). Yet, it is ironic that economic history and statistics can never report satisfactorily how much the total goods production, in a non-pecuniary sense, of any one time or place exceeds or is exceeded by that of another time or place.

[11] For method of computing the average rates of growth, see pp. 50–1. In the case of population, lumber, and Snyder's index of trade, these several series being discontinuous, the method is the same except that the decade rates do not refer to overlapping periods. In the case of population, the datum used for 1870 is the figure corrected by the Census Bureau for the undercount in that year.

The several indexes referred to as the Day-Persons indexes were constructed by E. E. Day, W. M. Persons, and others. See W. M. Persons, *Forecasting Business Cycles* (John Wiley, 1931), Ch. XI, and the references there

Table 41

RATES OF GROWTH SHOWN BY POPULATION AND INDEXES OF PRODUCTION

Index	Period covered by index	Average annual rate of growth (per cent)
POPULATION	1870–1930	1.9
CROPS		
Day-Persons	1870–1930	2.3
Snyder	1870–1930	2.2
Timoshenko	1870–1927	2.4
Warren-Pearson	1870–1930	2.5
FISHERIES		
Fish, total	1880–1929	0.9
FORESTRY		
Lumber	1869–1929	1.8
MINING		
Day-Persons	1870–1930	5.7
Snyder	1870–1930	5.7
Warren-Pearson	1870–1930	5.7
MANUFACTURES		
Day-Persons	1870–1930	4.3
CONSTRUCTION		
Building permits	1874–1929	4.2
TRADE		
Deflated clearings	1870–1929	5.2
Railway freight	1882–1929	4.3
Snyder	1870–1930	4.7
TOTAL PRODUCTION		
Day-Persons	1870–1930	3.7
Warren-Pearson	1870–1930	3.8

cited. The composite of the separate indexes of crops, minerals, and manufactures is described by Dr. Persons as an index of 'total production'. The several indexes referred to as the Warren-Pearson indexes are given in

The table states the average rate of growth in population, in the physical production of several major groups of industries (as indicated by the best of the available indexes, a few of the series earlier analyzed being now used as 'indexes'), and in total physical production (as indicated by the best of the available indexes). The most obtrusive fact disclosed by the table is that population has grown at a lower rate than the production of any of the industrial divisions except the fisheries and forestry. The considerable excess in the rate of growth of the indexes of the physical volume of total production over the rate of growth of population means that there has been a considerable increase in per-capita production.

The progress of agriculture is recorded by several indexes which are restricted to crops and do not include animal husbandry. The indexes of crop production agree rather well: they indicate an average rate of advance of something like 2.3 per cent per annum. There is considerable evidence, however, that the rate of growth of agriculture has been more rapid. The indications are that the production of truck crops, fruits and vegetables, dairy products, and poultry products has expanded, at least in recent years, at a more rapid rate than other agricultural commodities; but these several groups are either not represented at all, or else inade-

Warren and Pearson, *The Physical Volume of Production,* cited above, pp. 8–10. The indexes here used are those designated by the authors as 'total crop production', 'all minerals and water power', and 'total basic production, variable group weights, weighted by value plus value added by manufacture'; they are referred to in this work as indexes of crops, mining, and total production, respectively. Snyder's index of crop production (index 'A' in Chart 12B) is given in his *Business Cycles,* cited above, p. 237; figures for recent years have been furnished by Mr. Snyder. Timoshenko's index of crop production is given in his *Rôle of Agricultural Fluctuations in the Business Cycle* (Michigan Business Studies, Vol. II, No. 9), pp. 70–1. The figures of Snyder's index of mineral production are given in Warren and Pearson, cited above, p. 64; this index is described by Mr. Snyder as an index relating to the production of 'minerals and metals'. The remaining 'indexes' in Table 41 are series earlier used; for data and sources, see Appendix A, Table 44, and Appendix B.

quately, in the long-range indexes of crop production.[12] The Warren-Pearson index is unique in that it does include a considerable number of truck crops and fruits; and this is reflected in its having a somewhat steeper trend than the other long-range crop indexes. It is significant that a rather comprehensive index of agricultural production, constructed by the Department of Agriculture for the period since 1919, shows a higher rate of growth during 1919–30 than any of the long-term crop indexes.[13]

[12] The annual percentage rates of increase of the components of the index of the 'volume of net agricultural production', constructed by the Department of Agriculture for the period since 1919 (*Yearbook of Agriculture*, 1931, p. 974), are as follows for the period 1919–30: grains, −1.5; fruits and vegetables, 2.2; truck crops, 5.9; meat animals, 0.9; dairy products, 4.0; poultry products, 3.0; cotton and cottonseed, 3.6. (See note 13.) It seems that, at least since the turn of the century, the output of animal products has increased at an average rate more rapid than that of the output of crops. Certain preliminary indexes, made available to the writer by Dr. Baker of the Department of Agriculture, show an average annual rate of increase during 1897–1930 of 1.6 per cent in the production of 'animal products', but only 1.3 per cent in 'plant foodstuffs' and 1.0 per cent in 'industrial crops'. If the production of all animal products has actually increased more than the production of all crops, that is probably due largely to the rapid growth in milk production; for, 'total' meat and lard production (according to data in *Statistics of Meat Production*, cited above) experienced an annual rate of increase of 1.2 per cent during 1900–30, which is about the same as that shown by the indexes of crop production during 1900–30 (the Day-Persons index of crops, 1.1 per cent; Snyder's index, 1.2 per cent; the Warren-Pearson index, 1.2 per cent).

[13] For the period 1919–30, the index of the Department of Agriculture (see note 12) shows an annual rate of increase of 1.8 per cent; but the several crop indexes show very much lower annual rates of advance: the Day-Persons index 0.1 per cent, Snyder's index 0.1 per cent, and the Warren-Pearson index 0.6 per cent. (These several indexes, including that of the Department of Agriculture, are based on unrevised data of crop production; that is to say, they do not take account of the revisions for the period 1919–28, which are reported for major crops in the *Yearbooks of Agriculture* of 1932 and 1933. The revisions for minor crops are as yet uncompleted; but it now seems reasonably certain that if the several indexes were to be recomputed on the basis of the fully revised data, all of them would show a somewhat lower rate of increase, and the discrepancy between the index of the Department of Agriculture and the other indexes would be greater than it now is.) Mr. Snyder is fully aware of the limitations of his index of crops. In a communication to the writer, he makes the interesting comment

The rate of growth of the mining industry has been considerably greater than that of agriculture. The three indexes of mining agree in showing an annual rate of growth of 5.7 per cent during the period 1870–1930 taken as a whole; but the averages conceal the higher rate of advance of the Day-Persons and Snyder indexes prior to about 1900 and the higher rate of advance of the Warren-Pearson index subsequent to that date. The Day-Persons index probably gives a somewhat better indication of the growth of mining than do the others.[14] To be sure, this index falls short of a comprehensive coverage of mining: it does not include the production of sulphur, phosphate rock, gypsum, fluorspar, asphalt, and several other minerals of secondary importance, which have had, for the period since 1870 taken as a whole, an upward trend more rapid than that of the index; but it also does not include the production of mercury, whose trend has been downward, or of salt and several other minerals of secondary importance, whose trend has been upward though at a rate less rapid than that of the index. Taking the Bureau of Mines estimates of the 'value of mineral products' as a base for comparison, the component series of the Day-Persons index account for as much as 80 per cent or more of total

that when he took all the crop data available, the index for 1930 showed a slight advance over 1929, while his index of principal crops (the one used in Table 41) showed a considerable decline.

[14] The Day-Persons index has a greater coverage than Snyder's index, but a smaller coverage than the Warren-Pearson index. The larger coverage of the latter index arises mainly from its inclusion of secondary production of metals, natural-gas gasoline, electricity from water power, and water power other than electric, along with the minerals. The Day-Persons index comes closest to being strictly an index of mining, but even this index prior to 1909 is not confined to mineral series: the encroachment of the Warren-Pearson index on other areas has just been stated; in Snyder's list are found steel (in addition to pig iron) and aluminum (see p. 11, note 5); the Day-Persons list includes coke prior to 1909 (also, pig iron, though this is replaced by iron ore in 1909). It must be repeated, however, (see p. 264, note) that the Warren-Pearson and Snyder indexes, discussed in this chapter as indexes of 'mining', are described by their authors as indexes respectively of 'all minerals and water power' and 'minerals and metals'.

mineral production during most of the period considered.[15] The relative coverage of the index tended to decline for some time, but the inclusion of additional series in 1909 and in subsequent years raised the coverage. The slight decline in the coverage prior to 1909 suggests that the index probably understates somewhat the progress of the mining industry. However, since the coverage of the index has been very large throughout, the understatement, if there be any, is probably small.

Turning to manufactures, we encounter an industry whose 'physical' growth defies anything but the roughest measurement, so great is its variety of products and so changeable their form. The Day-Persons index, the only continuous index of manufactures covering the period since 1870, shows a rate of advance of 4.3 per cent per annum; but there are cogent reasons for regarding this as an understatement of the growth actually experienced. The previous analysis of the factors making for a downward growth bias in a 'typical' index of the physical volume of total production applies with almost full force to the Day-Persons index of manufactures. Moreover, if manufacture is defined, as is customary, to cover factory production alone, then, the index does not reflect even moderately the transfer of elaborative activities from the home and farm to the factory; for its coverage is restricted in large part to the initial stages of fabrication. For recent decades, some statistical evidence can be added to this general statement. Professor Mills' index of manufactures based on from 35 to 62 industries shows an annual rate of increase of 3.9 per cent during 1899–1929, while his index based on an adjustment for the incomplete and variable coverage of the first index shows a rate of increase of 4.2 per

[15] The coverage is 83 per cent for 1880, 83 per cent for 1890, 80 per cent for 1900, and 76 per cent for 1908. After this date, new commodities are included: the coverage rises to 83 per cent for 1910, 89 per cent for 1920, and 85 per cent for 1929.

cent. The Day-Persons index, however, shows a rate of increase of only 3.8 per cent for the same period.[16]

With all their imperfections, the indexes of production of the three great divisions of commodity production, just reviewed, probably suffice to indicate the lower limits of the average year-by-year progress. There is little that can be said concerning the other industrial divisions. The series of total fish catch should record with fair accuracy the progress of the fisheries industry, and the discontinuous series of lumber production the progress of the forestry industry. Some indication of the progress of the construction industry, viewing it as distinct from manufactures, is given by the series of building permits; but the statistical basis of this series is so slender that an average calculated from it can have only slight significance. The progress of trade may be guessed at through the indications given by Snyder's index of trade, the series of deflated clearings, and the series of railway freight. In the case of transportation and the host of service industries, numerical definiteness concerning the average rate of progress is almost out of the question.

All in all, this survey of group indexes indicates, more concretely perhaps than the analysis of the preceding section, how slender is the quantitative basis of indexes of the physical volume of total production; but it also reinforces the previous observation that production indexes (ignoring their intrinsic ambiguity, which, indeed, we must do if we are to use them at all) are likely to have a downward growth bias—all the more so, paradoxically enough, if they are ably con-

[16] See F. C. Mills, *Economic Tendencies*, cited above, pp. 42, 200, and 309. The indexes given by Mills were spliced to form a continuous series on a common base. For the purpose of the present comparison, the Day-Persons and Mills indexes were confined to census years. The average annual rates of growth of the several indexes were determined in each case by fitting a 'least squares' line to the logarithms of the indexes, the figures of the index series being weighted by 5 for the census years through 1919 and by 2 for the census years thereafter.

structed. The Day-Persons and the Warren-Pearson indexes are the only long-range indexes of the physical volume of 'total' production meriting our attention; even though the former is confined to crops, mining, and manufactures; while the latter covers basic production only, the branches of raw material production being covered more thoroughly than in the Day-Persons index, but manufactures being excluded except insofar as they round out the record of 'raw' production and furnish weights for the raw material components of the index. The Day-Persons index shows an average annual rate of growth of 3.7 per cent during 1870–1930, and the Warren-Pearson index a rate of 3.8 per cent; these figures compare with an average annual rate of growth in population of 1.9 per cent. But the indexes probably understate the average rate of advance in the physical volume of total production, even if production be considered in the narrow sense of transformation. The increase of total physical production has almost certainly been greater—quite possibly, a good deal greater.

The moving factors in the rapid increase of total physical production have been technical knowledge, abundance of natural resources, and the industrial intelligence of the population. These factors are interrelated and the efficacy of each has been increased by the progressive improvement in the state of national well-being. If the ambition, sturdiness, and enterprise of the American population have tended to promote rapid industrial advance, it is well to remember that the abundance of natural resources has been important in causing such qualities to be bred in the population and in attracting the more venturesome from foreign lands. The economic significance of our generous store of natural resources has been extended by advances in science and technology. Their progress in turn has been stimulated by the richness of the natural resources awaiting exploitation, the

eagerness of an enterprising people to exploit them, and the improving state of general well-being. And the fundamental forces making for industrial advance have worked themselves out cumulatively through the stimulation coming from some of their effects, such as a population growing in numbers and improving in industrial quality, increasing use of machinery and mechanical power, increasing size of industrial units, and improving technique of industrial and business management.

When we adopt an historical view, we can take considerable satisfaction in the pace at which we have travelled: for the enrichment of the material side of our national life has proceeded at a rather rapid rate. But when we take a normative view, and compare the production of today with the consumption that would be required by even modest standards of comfort and decent living, our quantity of production appears seriously inadequate.[17] It is undoubtedly true that a decrease in the inequality of incomes would go some distance towards improving the welfare of the masses, even if production did not rise above the level of the past decade; and it is probable that a modified system of distribution would result in a more efficient use of our existing productive resources, that it would increase the material product of industry and therefore the general level of real incomes. However, for some time to come, increase in the physical volume of production through improvements in industrial technique will continue to be the road along which the greatest advances in the material improvement of mankind are to be won.

III. CHANGE IN THE RATE OF INDUSTRIAL GROWTH

The average rates of industrial growth, indicated by the

[17] Some pertinent data are presented in P. H. Douglas' *Wages and the Family* (University of Chicago Press, 1925), Chs. I–II.

ensemble of indexes reviewed in the preceding section, testify to the remarkable progress of the American economy during the period investigated; but these averages conceal the variability in the rates of secular advance of both the group and total indexes. Actually, the indications are that while the rate of secular advance in the physical volume of total production has been more nearly uniform than the rates of advance of the generality of individual industries, it has still been decidedly inconstant. Several measures of the inconstancy in the rates of advance of the various continuous production indexes are presented in Table 42; [18] but these measures may reflect chiefly the inconstancy in the rates of increase of the indexes, rather than of the underlying quantities which the indexes purport to measure. Better evidence of inconstancy is afforded by the analysis of Chapter V; for, the considerable synchronism in the undulatory movements of the production trends of numerous individual industries means that the rate of advance in the trend of total physical production has, in all likelihood, also been variable. The instability of the rates of advance of the major industrial groups and of total production, as indicated by various index numbers, is depicted in Charts 11 and 12.

Though the evidence is fairly conclusive that the rate of advance in the secular trend of total physical production in the United States has been variable, it is practically impossible to ascertain from such data as are now available whether or not that variability has expressed itself in the form of a persistent drift over time. Several investigators have, indeed, attempted to demonstrate on the basis of certain production indexes that the rate of material progress has been abating during the past half-century or longer. Attempts have also

[18] Concerning the computation of the measure of continuity of growth, range of decade rates, and standard deviation of decade rates, see p. 74; the measure of continuity of retardation, p. 103; and the measure of trend-cycle amplitude, p. 226.

Table 42

MEASURES OF INCONSTANCY OF GROWTH, FOR INDEXES OF PRODUCTION

Index	Period covered by index	Measure of continuity of growth	Measure of continuity of retardation	Range of decade rates	Standard deviation of decade rates	Measure of trend-cycle amplitude
				(Unit: one per cent)		
CROPS						
Day–Persons ..	1870–1930	1.00	−.60	5.2	1.4	0.6
Snyder	1870–1930	1.00	−.30	5.7	1.5	0.8
Timoshenko ...	1870–1927	1.00	−.78	6.0	1.6	0.9
Warren–Pearson	1870–1930	1.00	−.60	5.2	1.4	0.6
FISHERIES						
Fish, total	1880–1929	.67	.50	2.9	0.8	0.8
MINING						
Day–Persons ..	1870–1930	1.00	−.60	6.5	2.0	1.2
Snyder	1870–1930	1.00	−.40	8.0	2.3	1.7
Warren–Pearson	1870–1930	1.00	−.40	4.4	1.4	1.3
MANUFACTURES						
Day–Persons ..	1870–1930	1.00	−.30	3.6	1.2	0.8
CONSTRUCTION						
Building permits	1874–1929	.40	−.33	20.8	6.0	5.9
TRADE						
Deflated clearings	1870–1929	1.00	−.20	4.7	1.5	1.4
Railway freight	1882–1929	1.00	.00	7.3	2.4	1.4
TOTAL PRODUCTION						
Day–Persons ..	1870–1930	1.00	.00	3.4	1.1	0.6
Warren–Pearson	1870–1930	1.00	−.30	4.0	1.2	0.7

been made to demonstrate on the basis of other production indexes that the trend of total physical production has increased at a constant percentage rate, and this notion has gained wide currency. It is only natural that students concerned with the question of drift in the rate of increase in the physical volume of total production should employ to the full whatever apparatus they command. But production indexes are very crude instruments and must be used cautiously if fictive results are to be avoided.

Our study in Chapter IV of retardation in the growth of individual industries does not, despite its rather extensive industrial coverage, offer any clue to the problem of whether or not the physical volume of our total production has been growing at a declining rate. The pervasiveness of retardation in individual industries does not mean that the rate of progress of total physical production has been slackening; it reflects simply the vigorous growth of the economy, retardation in individual industries being a consequence of the pressure of progressive forces. Even if the stream of aggregate production consisted of a fixed number of industrial components, declining percentage rates of growth in all of the individual industries would still be mathematically consistent with an increase in the percentage rate of growth of aggregate production. Certainly, therefore, the aggregate production of an economy experiencing continual accessions of new industries may, if the new industries be of sufficient scope and their inception properly timed, be growing at a constant or increasing rate, even though both old and new industries experience retardation throughout their history.

The technique which has been used to determine the extent of retardation in the individual production series may be carried over to the production indexes.[19] Table 43 gives average rates of retardation of the indexes whose average

[19] See Ch. IV, sec. I, and p. 105, note 10.

Table 43

RATES OF RETARDATION SHOWN BY POPULATION AND INDEXES OF PRODUCTION

Index	Period covered by index	Average rate of retardation (per cent per decade)
POPULATION	1870–1930	−0.2
CROPS		
Day-Persons	1870–1930	−0.8
Snyder	1870–1930	−0.8
Timoshenko	1870–1927	−0.9
Warren-Pearson	1870–1930	−0.8
FISHERIES		
Fish, total	1880–1929	−0.1
FORESTRY		
Lumber	1869–1929	−0.9
MINING		
Day-Persons	1870–1930	−1.0
Snyder	1870–1930	−0.9
Warren-Pearson	1870–1930	−0.3
MANUFACTURES		
Day-Persons	1870–1930	−0.5
CONSTRUCTION		
Building permits	1874–1929	−0.9
TRADE		
Deflated clearings	1870–1929	−0.3
Railway freight	1882–1929	−1.4
Snyder	1870–1930	−0.8
TOTAL PRODUCTION		
Day-Persons	1870–1930	−0.5
Warren-Pearson	1870–1930	−0.6

rates of advance were presented in a preceding table. All indexes, those for the various industrial groups as well as

those for total production, show retardation. However, the evidence of the indexes must be appraised in the light of what we know concerning their constitution. Some aid may also be obtained, though not very much, from our study of retardation in individual industries.

It is possible to speak with moderate assurance of the several major divisions of the raw materials category. Forestry has certainly grown at a declining rate, its apex having been reached about a quarter of a century ago. It is, also, virtually certain that the mining industry has experienced retardation. It has already been brought out that the Day-Persons index covers a very considerable portion of total mineral production, and that its relative area of inclusion has been fairly constant over the period. These facts coupled with the rather sharp rate of retardation of the index imply almost necessarily that the physical volume of total mineral production has grown at a declining rate. The fairly moderate rate of retardation of the Warren-Pearson index of mineral production in no sense affects this conclusion, for the coverage of this index extends beyond mining. As for crop production, the several indexes of crops (with the possible exception of the Warren-Pearson index) account for a declining percentage of all crop production; but, even as late as 1929, Snyder's index accounted for 72 per cent of the farm value of all crops,[20] and the Day-Persons and Warren-Pearson indexes for a somewhat higher percentage. These facts coupled with the fairly high rates of retardation of the crop indexes make it highly probable that the physical volume of total crop production has increased at a declining percentage rate. The case of animal husbandry is more uncertain, as is the case of total agricultural production. Total meat and lard production, as estimated by the Department of Agri-

[20] This estimate is based on figures of farm value of crop production, given in *Crops and Markets*, September, 1931, p. 402.

culture for the period since 1900, shows very slight retardation for this period; while Dr. Baker's preliminary index of 'animal products', which includes milk and other items in addition to meats, does not show any retardation at all for the period which it covers, 1897 to date. However, these two series show only mild annual rates of advance,[21] 1.2 and 1.6 per cent respectively; and, if the general numerical indications of our series of wool production, hog slaughter, cattle slaughter, and sheep slaughter are at all reliable, it seems likely that the rate of increase of animal products was higher during the closing quarter of the past century, so that the rate of increase has tended, on the average, to decline. If it be true that crop production and animal products have grown at declining percentage rates, then, it is probably true that the physical volume of total agricultural production has also grown at a declining rate; for, when one of two components of an aggregate is consistently the more important (in this case crops) and the declining rates of growth of the two are fairly similar, it is virtually certain that the aggregate will also grow at a declining percentage rate. There are reasonable grounds, then, for believing that each of the several major divisions of raw material production, with the possible exception of the fisheries, has experienced, on the average, abatement in its rate of growth since 1870.

Greater doubts must attach to any generalization one might make for other major divisions of industry. The Day-Persons index of manufactures shows a retardation of −0.5 per cent per decade; but the coverage of this index is all too meagre to warrant the generalization that there has been a downward drift in the rate of growth of the aggregate of manufactures. Mills' 'census' index of manufactures has a more extensive coverage for the period which it covers; but it covers too short a period, especially in view of its

[21] See p. 265, note 12.

discontinuity, to give a reliable indication of change in the rate of growth of the physical volume of manufactures.[22] While it is fairly probable that the Day-Persons index exaggerates the retardation which has taken place in the aggregate of manufactures, there is no way of telling whether or not there has actually been any retardation at all. In the case of other major industrial divisions, our statistical materials are even more imperfect. The indexes of construction and trade do not serve to reveal satisfactorily even those rates of growth which may be accepted as statements of the lower limits of actual progress; they are all too insensitive, therefore, to reveal whether or not there has been any retardation. As for transportation, the rapid growth of certain new transport media—such as the telephone, wireless, automobile, airplane, and pipeline—precludes any extrapolation of the characteristics of the trend of the railway industry, for which alone index numbers are available,[23] to the aggregate volume of transportation. When we pass to other major divisions of industry, we enter what is even more a statistical 'no man's land'.

It should be evident from this survey of industrial groups that only indefinite conclusions are possible concerning the drift in the rate of growth of the physical volume of total production in this country since the Civil War. But it is worth noting that even if we were equipped with exact measurements of the drift in the rates of growth of the various industrial groups, we could not pass at once from such data to a generalization concerning total physical production; for the rate of retardation of an aggregate may differ even in sign from the rates of retardation of each of its components—especially when the components grow at

[22] See pp. 267–8, and p. 117, note 16.

[23] An index of railway transportation for 1890–1919 is presented by Stewart, in his "An Index Number of Production," *American Economic Review*, March, 1921.

widely unequal rates, which is true of the various industrial groups.[24] So, if we wish to discover what the drift in the rate of growth of total physical production has been, we must turn to the most reliable measurements we have of changes in the physical volume of total production. The two indexes of total production given in Table 43 show rates of retardation of −0.5 and −0.6 per cent per decade.

It is impossible to state a priori whether or not the various factors listed in the first section of this chapter as tending to cause a downward growth bias in a 'typical' index of total physical production tend also to exaggerate the retardation of the Day-Persons and Warren-Pearson indexes;[25] but some statistical evidence may be cited which suggests that these indexes do overstate the retardation, while practically no evidence can be cited to the contrary. The Warren-Pearson index of 'all minerals and water power' differs from the Day-Persons index of 'minerals' chiefly in taking greater account of relatively new industries and in including secondary production of metals;[26] and this difference in composition is expressed in a very much lower rate of retardation in the Warren-Pearson index of 'all minerals and water power'. Two of Snyder's indexes of total production, known respectively as the '49 series' and '87 series' indexes,[27] though not

[24] The Day-Persons index of total production and Snyder's '49 series' index of total production throw some statistical light on this mathematical point. Table 43 shows that while the Day-Persons indexes of crops, mining, and manufactures have rates of retardation of −0.8, −1.0, and −0.5 per cent per decade, respectively, the Day-Persons index of total production has a rate of retardation of only −0.5 per cent (however, if carried out to an additional place, the rate of retardation of the index of manufactures is −0.48 per cent, and of total production −0.54 per cent). Snyder's '49 series' index (see p. 200, note 21) affords a more striking instance: while most of its component series evidence fairly marked retardation, the index proper has a retardation of only −0.1 per cent.

[25] See pp. 99–100, note 4.

[26] Electricity from water power, aluminum, natural-gas gasoline, and secondary metals have a combined weight of 26.4 per cent in the Warren-Pearson index; see p. 266, note 14.

[27] See p. 200, note 21, and p. 260.

covered in Table 43, are also of interest in the present connection. While the '49 series' index, which is based on a fixed list of series, shows retardation, the '87 series' index, which is based on a variable and increasing number of series, shows acceleration.[28] Such statistical knowledge as we have suggests, therefore, that since the Day-Persons and Warren-Pearson indexes of total production take insufficient account of new industries, they probably overstate the degree of retardation in the physical volume of total production.

Our evidence is slender, however, and all that it permits is this indefinite conclusion: if there has been any decline in the rate of growth in the total physical production of this country, its extent has probably been slight, and it is even mildly probable that the rate of growth may have been increasing somewhat. This indefinite conclusion is unsatisfactory, but it is as much as the exiguous statistical basis warrants: to profess definiteness would be to ignore or to misread such data as we have. The available evidence simply does not admit of an exact answer to the primary scientific question of this chapter—viz., whether there has been any striking regularity in the secular trend of the physical volume of total production.

However, our conclusion concerning the drift in the rate of growth of total physical production should be read in the light of further data. First, we know definitely that population has grown at a declining percentage rate; it follows, therefore, that if total physical production has experienced retardation, the production per capita has experienced retardation at a lower rate, and that if the rate of retardation of total physical production has been less than that of population, the production per capita has been growing at an increasing percentage rate. Second, if we assume that the

[28] The '49 series' index shows a retardation of −0.1 per cent, the '87 series' index an acceleration of 0.2 per cent. See p. 203, note 24.

percentage rates of retardation shown by the Day-Persons or the Warren-Pearson indexes of total physical production are substantially accurate, it is still true that each of these indexes, and for that matter, all other similar indexes, show an increase, on the average, in the absolute year-by-year increments to the national production aggregate. It goes without saying that the drift in the percentage rate of increase of total physical production per capita is of greater social significance than the drift in the percentage rate of increase of total physical production as such; and though the drift in relative increments to the aggregate of physical production is probably of somewhat greater social significance than the drift in the absolute increments, the latter must not be ignored. Thus, while it may be true that the percentage rate of growth in our total physical production has been declining, that does not mean necessarily that our 'economic welfare'—even if we should view the physical volume of production as the sole factor in economic welfare—has been growing at a 'declining rate'.

These arithmetic considerations are very pertinent on the assumption that the percentage rate of increase in the physical volume of total production has been declining somewhat; though this is, and probably will remain for the period investigated, an assumption whose implications are worth considering, but an assumption and no more. Irrespective of what the exact facts may be, our data suffice to show that there has not been any marked drift in the rate of growth of total physical production during the period since the Civil War; this is of considerable importance, for, as the period advanced, natural factors making for industrial progress became less important and human factors more important.[29] Our data also suffice to show that, while the secular trend of

[29] See E. Durand, *American Industry and Commerce* (Ginn and Company, 1930), Chs. I–V.

the physical volume of total production has escaped but a portion of the undulations in the secular trends of individual industries, the primary trend of the physical volume of total production has definitely escaped the sharp retardation in the primary trends of most individual industries.