Volume Title: Production Trends in the United States Since 1870

Volume Author/Editor: Arthur F. Burns

Volume Publisher: NBER

Volume ISBN: 0-87014-022-1

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

Publication Date: 1934

Chapter Title: Tables of content, Summary of Findings, Foreword

Chapter Author: Arthur F. Burns

Chapter URL: http://www.nber.org/chapters/c2259

Chapter pages in book: (p. -35 - 0)

PRODUCTION TRENDS IN THE UNITED STATES SINCE 1870

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NATIONAL BUREAU OF ECONOMIC RESEARCH

NEW YORK · 1934

Reprinted 1950

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AUGUSTUS M. KELLEY, INC.

PUBLISHED BY SPECIAL ARRANGEMENT WITH
NATIONAL BUREAU OF ECONOMIC RESEARCH, INC.

LITHOGRAPHED IN U.S.A.

PUBLICATIONS OF THE
NATIONAL BUREAU OF ECONOMIC RESEARCH, INC.

NUMBER 23

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(Resolution of October 25, 1926, revised February 6, 1933)

ACKNOWLEDGMENTS

In the course of this study I have received considerable assistance from friends and co-workers, to whom I am deeply grateful.

I am chiefly indebted to the staff of the National Bureau: to Dr. Wesley C. Mitchell for helpful comments on successive versions of the manuscript; Dr. Simon Kuznets for constructive assistance at almost every stage of the inquiry; Dr. F. R. Macaulay for assistance on several points in statistical theory; Dr. A. G. Silverman for stimulating criticisms of the manuscript; and Mr. H. G. Brunsman, formerly with the Bureau, for aid in numerous problems of statistical mechanics.

A number of research workers not connected with the National Bureau generously supplied me with various types of information—in a few cases, with unpublished data. I have tried in the text to acknowledge fully the more important assistance I have received in this manner.

Two of my former students, Mr. M. Friedman and Mr. L. Vass, offered detailed suggestions for improving the manuscript, and checked the accuracy of various mathematical statements.

The bulk of the computing work was done by Mr. Harold Rosen and Mr. Charles Wittmann. In a late revision of the manuscript I was assisted by Miss Dorothy Achilles, who is also responsible for the excellence of the charts.

A. F. B.

THE PROBLEM AND A SUMMARY OF THE FINDINGS

By Wesley C. Mitchell

SINCE its beginning in 1920 the National Bureau of Economic Research has been exploring the wide and intricate realm of social changes. One set of its reports starts with important factors in economic life, such as national income, unemployment, migrations, or prices, and shows how these factors fluctuate through time. A second set of reports starts with significant periods in American history and shows how different economic factors have fluctuated within them. *Recent Economic Changes* and Dr. Mills' *Economic Tendencies* are examples of this approach. A third set of reports starts with recognized types of economic fluctuation and shows what forms they assume in different economic activities. Here belong the National Bureau's several volumes upon business cycles, Dr. Kuznets' study of seasonal variations and the present study of secular trends by Dr. Burns.

Each of these approaches to the study of social changes has its special uses and its limitations. Each has also its established place in men's efforts to understand their shifting economic fortunes. We are prone to identify the third approach with 'time-series analysis' and to think of it as a twentieth-century development. Certainly it has gained much in precision and effectiveness since 1900. But the current classification of economic changes runs back at least to the times of the classical economists, when 'commercial cycles' were recognized, when Ricardo speculated about the long-time trends of wages, rents and profits, when writers upon finance began discussing seasonal variations and when every economist ab-

stracted from 'disturbing circumstances' for the same reason that analytic statisticians now seek to eliminate random perturbations. Indeed, we can borrow from John Stuart Mill's *Principles of Political Economy* a sweeping statement of the general problem, one phase of which is treated in the present volume.

"Production (wrote Mill) is not a fixed, but an increasing thing. When not kept back by bad institutions, or a low state of the arts of life, the produce of industry has usually tended to increase; stimulated not only by the desire of the producers to augment their means of consumption, but by the increasing number of the consumers. Nothing in political economy can be of more importance than to ascertain the law of this increase of production; the conditions to which it is subject: whether it has practically any limits, and what these are. There is also no subject in political economy which is popularly less understood, or on which the errors committed are of a character to produce, and do produce, greater mischief." [1]

Dr. Burns does not undertake 'to ascertain the law of increase of production' at large. His aim is more restricted, but more attainable. He studies the widely varying rates at which many American industries have grown from decade to decade since the 1870's, and seeks to ascertain what general features have characterized this sample of increase in production.

An investigator who essays such a task should begin by subjecting his materials to a rigid inspection and by providing himself with proper tools. The materials are statistical data; the tools are scientific concepts and mathematical procedures. Accordingly Dr. Burns devotes his first two chapters to formulating the basic concepts of 'production' and 'secular trend', describing the production series and methods of anal-

[1] Book I, chapter X, section 1, p. 155 of Sir William J. Ashley's edition.

ysis employed, and discussing the relations of the concepts to the data and technique.

The gentle reader who lends easy credit to any confident author and wishes quick repayment in definite information may feel impatient with the meticulous care lavished upon these preliminaries. But scientific work requires an investigator to know precisely what he is studying, to test his materials, to scrutinize his methods, and to make sure that concepts, materials and methods fit one another. Scientific work requires also that an investigator expose all his concepts, materials and methods to the critical scrutiny of his fellows. It is only by following these honest rules that progress in understanding can be achieved. On the other hand, it is not every reader's duty to share personally in assaying the metal of economic results. To those who will take much on faith the following summary of Dr. Burns' chapters may be helpful in showing what they wish to 'skip' and what they wish to read.

The production studied is the physical output of commodities and services as shown by annual statistics in the United States since the years 1870–85. One hundred and four series are used, 20 for agriculture, 3 for fisheries, 22 for mining, 45 for manufacturing, 2 for construction, 7 for transportation and 5 for trade. It is estimated that about two-fifths of the country's total production is covered by these series in 1925. Though the original data are subject to various defects, they constitute a sample sufficiently representative and reliable to justify analysis.

By 'secular trends' Dr. Burns means economic movements of longer duration than business cycles. He believes that such trends express the relatively long-run effects of forces making for change, and that they are economic realities as fit for

systematic study as are the shorter cycles in business activity to which so much attention is given.

To measure production trends, he breaks each of his series into overlapping eleven-year segments (1870–80, 1875–85, 1880–90 and so on), adjusts these standard periods so that the end years in each segment of each series represent approximately the same phase of a cycle in production, fits exponential curves to the successive segments by the method of moments, and finally computes the average rate of growth during each segment. Thus Dr. Burns describes the trend of a series, not in the usual fashion by fitting a single curve to all the years covered by the data, but by using a number of curves fitted to brief periods with centers five years apart. In this way he is able to give a more faithful picture of the secular movements in production than if he had relied upon the customary technique.

As one would expect, the 'decade rates of growth' yielded by this method show changes of pace. 'Increase in production' is by no means regular even over periods long enough to include two or three business cycles. To take proper account of this fact, Dr. Burns elaborates his first concept of secular trend. "Lines of secular trend trace out paths more or less undulatory and also have an underlying general sweep; both types of movement are of interest and significance." The general sweep of the secular trends of a series is called its 'primary trend'.

The first use to which Dr. Burns puts his measurements in Chapter III is to make broad comparisons among the rates of growth in different branches of industry. For this purpose he reduces the several decade rates computed for each series to a single arithmetic mean. The figures show that "mining has grown at a spectacular rate, manufacture at a somewhat lower rate, and agriculture at a decidedly lower rate." The

fisheries have declined in relative importance, while transportation and trade have gained. In general, the output of producers' goods has grown faster than the output of consumers' goods. When smaller divisions of production are considered, the most rapid growth is found among relatively new industries such as beet sugar, raisins, sulphur, Portland cement, aluminum and cigarettes, while the slowest growth is found among relatively old industries such as cane sugar, whaling, mercury, non-Portland cements and roofing slate.

Turning back from his general averages to the rates of growth for successive decades, Dr. Burns next shows that not a single industry in his list has grown at a constant rate. More than half of the 'basic' industries have undergone a shrinkage in at least one of the eleven-year periods. As measured by the differences between the decade rates, fisheries has had the least variable increase and sulphur the most variable. These extreme differences in the variability of the decade rates lie far apart (under 3 and over 100 per cent). About half of the series show ranges of more than 11 per cent between their slowest and their fastest rates of growth. Thus inconstancy of rate has been a universal characteristic of industrial expansion in the United States so far as our knowledge goes. Yet amidst the maze of variations one element of order stands out boldly: the rates of growth tend to decline as the decades pass.

This significant fact of retardation in industrial expansion is the theme of Chapter IV. From exponential curves fitted to the decade rates, Dr. Burns derives constants which measure retardation or acceleration in growth as shown by his data. To give an example of these measures: he finds the retardation in the growth of pig-iron production to be 1.2 per cent per decade; that is, the annual rate of growth at any given time averaged .988 of the annual rate of growth ten

years earlier. Of the 104 continuous series analyzed, 92 show retardation; of 43 supplementary discontinuous series, 38 show retardation. In most series the rates of retardation are appreciable. The exceptions to the rule are mainly industries of secondary importance. Careful measurements thus bear out the first impression: retardation is a prevailing characteristic of industrial growth. To what is it due?

The gist of Dr. Burns' answer is that rapid growth in general production and decline in the rate of growth of individual industries go together. The latter is as characteristic of a progressive state as the former. The incessant introduction of new commodities restricts the increase in the demand for old commodities. The faster these new industries expand at first the greater is this restrictive influence, and the harder it is to sustain their own rates of growth for long. Doubling output each year may be feasible when a novel product wins favor; but a continuation of that rate of growth for a generation or two would mean the marketing of impossible quantities. Changes in methods also lead to retardation. For example: "The increasing replacement of farm work animals by automobiles and tractors has resulted in a rapid retardation in the production of horses and mules, has tended to retard the lumber industry, and has released millions of acres of crop land—which means that the increasing mechanization of agriculture has contributed to the retarded growth of certain of its branches, especially the production of oats and hay." Similarly, the coal industry is suffering from improved methods of combustion in railway locomotives and electric power plants. Reclamation of raw materials checks the increase in the demand for fresh production: between 1907 and 1929 the smelter output of primary copper increased at the rate of 2.5 per cent annually, that of secondary copper by 7.5 per cent. Further, new products and new processes exert a retarding influence upon other parts of the system by attract-

ing to themselves portions of the capital, labor and materials which might have been used to sustain the growth of older industries. Perhaps the innovations augment the growth of capital; but they have not prevented a retardation in the growth of population, and they have contributed toward the necessity of resorting to inferior natural resources. Invention tends to offset deterioration in natural resources; but it has its limits. After Smeaton and Watt had reduced the coal consumption of steam engines from 30 pounds per horsepower hour to 9 pounds, no genius could make a further reduction of 21 pounds. Fundamental changes in industrial methods still keep occurring—for example, the introduction of the rotary kiln in making Portland cement, the Frasch process of mining sulphur, the use of rubber tires on vehicles. For a time such inventions may accelerate the rate of growth, but once the reorganization has been accomplished retardation reappears. Finally, industries which experience retardation are prone to organize in self-defence; in particular they resort to technical research and more intensive salesmanship. Insofar as these efforts prosper they increase the pressure upon all other industries, limiting the expansion of the latter's markets and so strengthening the forces tending toward retardation.

There seems no warrant for the common notion that industries grow until they approximate some maximum size and then maintain a stationary position indefinitely. No one of Dr. Burns' series shows a broad plateau at the apex; once an industry has ceased to advance it soon begins to decline. Several decadent industries appear in the original list of 104 series—cod and mackerel fishing, whaling, New York canal traffic, the production of non-Portland cements and mercury; several others appear in the supplementary list of 43 series—hemp raising, the production of maple sugar and walking plows. To these are added from other lists iron rails, anthra-

cite pig iron, charcoal pig iron, cut nails and fine cut tobacco. The decadent industries reveal diverse fortunes, running all the way from the complete disappearance of iron rails and anthracite pig iron to the long decline of whaling. New York canal traffic even shows a notable revival since 1918, when the elaborate improvements made by the state were completed. There are some indications of retardation in decline corresponding to retardation in advance; but the materials do not justify a generalization.

Dr. Burns concludes his analysis of retardation by hazarding the suggestion that the life histories of industries are becoming shorter. A growing share of production is assuming the form of luxuries, superfluities and style goods; the demand for such products has no such stability as the demand for staples. Hence an increase in the birth-rate of new products means an increase in the death-rate among old products and a decline in the average life-span of individual industries.

Even more general than retardation is a second characteristic of production trends as Dr. Burns measures them—the undulatory movements spoken of above, 'trend-cycles' as they are called in Chapter V. Since the rate of secular growth is unstable in all the series analyzed, each series must show trend-cycles in the sense that it has alternations of more and less rapid growth. Granted the undulations, that is a matter of course which excites no interest. But it is a highly significant fact that the trend-cycles of different series tend to concur in time with one another.

Economic life in this country since the Civil War has been pervaded not only by the short-term rhythm of business cycles but also by a long-term rhythm of accelerated and retarded secular growth. These two rhythms are interconnected. Each time the national economy has experienced an exceptionally rapid secular advance, the production trends of

different industries have diverged so widely as to suggest a partial loss of balance, and progress has been checked by a business depression of great severity.

To measure trend-cycles, Dr. Burns takes the successive rates of growth as plus or minus deviations from their primary trends. Ranking these deviations for all of his series at each of the eleven overlapping decades centered on the years 1875, 1880 and so on to 1925, he draws up a table of 'decils' which shows a high degree of concurrence among the trend cycles. (See Chart 5, p. 184). On repeating this procedure for several sub-groups of series, he gets similar results. The fact that the decil lines commonly rise and fall together indicates the prevalence of common movements among the 104 series. The parallelism of decil lines is most striking in basic nonagricultural' industries, and becomes nearly perfect when several dubious series are dropped from this group. (See Chart 8D, p. 189). The likelihood that these co-movements are due to chance is so remote that we seem bound to believe that the trend-cycles arise from common causes. But there is an important exception to the rule of similar movements of the trends. The leading crops trace out patterns of marked individuality. Few have more than a faint resemblance to the general pattern. Trend-cycles seem to be confined to nonagricultural production. These conclusions, including that concerning agriculture, reached by a study of individual series, are confirmed by a similar analysis of the leading index numbers of production.

Dr. Burns examines the trend-cycles of individual industries to see how regularly they conform to the general pattern and to find their relative amplitudes. His results for trend-cycles agree rather closely with those which the present writer is obtaining for business cycles. The erratic relationship of farm production to the fluctuations of general business activity appear as clearly in the latter investigation as in this

one. In both cases most branches of production in which output is subject to close business control have high indexes of conformity to the movements of general business. In both cases again, the precious metals behave erratically, as do various manufactures of food products. Petroleum is an outlaw. In amplitude of fluctuation both of trend-cycles and of business cycles, crops rank low and mineral products relatively high. Also, the output of producers' goods undergoes larger cyclical fluctuations than that of consumers' goods, whether we take the long cycles or the short ones.

The chronology of the standard trend-cycles may be tabulated as follows:

'General Production' Shows Exceptionally	
Rapid Growth in	Slow Growth in
1875–1885	1885 1895
1895–1905	1905–1915
1910–1920	1915–1925
1920–1929	

The overlapping of these periods since 1910 may indicate that the basic framework of eleven-year periods with centers separated by five years fits the actual tempo of change in trends less well in recent times than in the nineteenth century.

Concerning the causes of the standard trend-cycle, Dr. Burns must speak cautiously because his data cover only part of the economic system. But he brings out one highly significant fact. During the years when the increase in general production has been exceptionally rapid, the decade rates of growth shown by individual industries have drifted apart sharply. This 'dispersion' has regularly reached a maximum when the trend-cycles reached their peaks. On the other

hand, the decade rates of growth drift closer together when the increase in general production declines; dispersion falls to a minimum in the troughs of the trend-cycles. The suggestion is that exceptionally rapid growth disrupts the 'balance' of the industrial system and so causes grave business difficulties, while the ensuing retardation of growth restores the balance and so paves the way for another phase of rapid growth. But the mechanism of this process and the part which random influences play in it remain to be worked out.

Business cycles from this viewpoint are short waves superimposed upon the long waves of trend-cycles. That there is a close connection between the two phenomena is suggested by theoretical analysis and the suggestion gets some support from chronology. The first peak in the trend-cycle pattern and in the divergence of production trends occurred in 1875–85; a severe depression occurred in 1882–85. The second peak in the trend-cycle comes in 1895–1905. This period of rapid growth was followed by the severe crisis of 1907. Similarly, the third peak of 1910–20 was followed by the severe depression of 1920–21, and the fourth peak of 1920–29 by the severe depression of 1929–33. In this list the great depression of 1893–94 is conspicuous by its absence, so that we cannot say that every severe depression has been preceded by the culmination of a trend-cycle. But we can say that each of the peaks in trend-cycles within the period covered has been accompanied or followed by a severe depression. If the arbitrarily centered decades of Dr. Burns' scheme were replaced by periods chosen to fit the problem of trend-cycles, a closer relation might appear between the chronologies of the long and short waves. Dr. Burns does not profess to settle the problem in this book; but he does state it in challenging fashion. Students of business cycles as well as students of secular trends must take account of his analysis. So, for that matter, should economic historians at large and the growing

number of men who are seeking light upon the economic tendencies of today and tomorrow.

To this point Dr. Burns has dealt primarily with measurements of secular movements in individual industries. Retardation in growth and trend-cycles are found in most of the one hundred and four series with which the investigation started; also in most of the supplementary series introduced for special purposes. Both retardation and trend-cycles in individual industries indicate an orderly transformation in the pattern of national production. It remains to examine the increase in total production.

This task drives Dr. Burns back to a critique of the available statistics. Several attempts have been made to compile index numbers representing changes in the total output of American industry over considerable periods of time. How far can these indexes be trusted to show whether total production has grown at a steady, at a declining, or at an increasing rate?

Even if we waive aside the logical difficulties of interpreting an index number of 'physical' production made by applying fixed money weights to bales of cotton, ton-miles of transportation, numbers of locomotives and the like, Dr. Burns points out that the wide differences among the decade rates of growth found among industries make questionable the adequacy of any sample we can obtain for total production. Indeed, we know definitely that the best of our production indexes give inadequate representation to new industries, to services as compared with commodities, to 'secondary' production, to the utilization of by-products, and to improvements in the quality of products. All of these inadequacies tend to introduce a downward growth bias into the indexes. This bias is offset only in small part by the omission of industries which have ceased to exist and the under-

representation of decadent industries. Hence all the long-range production indexes now available, and probably the best long-range indexes which could be constructed from surviving records, are likely to understate the rate of growth in total production.

Taking the indexes as they stand, Dr. Burns finds that the least defective for his purpose are the Day-Persons and Warren-Pearson indexes. In 1870–1930 the first shows an average annual rate of growth of 3.7 per cent, while the second shows a rate of 3.8 per cent. The actual increase of total physical production has almost certainly been more rapid than these figures suggest—quite possibly a good deal more rapid.

Further, the two indexes named show rates of retardation amounting respectively to 0.5 and 0.6 per cent per decade. The higher of these rates is only half of that cited above for pig iron. Most individual industries, indeed, show higher rates of retardation than these indexes. Nor does that fact cast doubt upon either the indexes or the individual series; for declining percentage rates of growth in all industries taken one at a time would not be mathematically inconsistent with an increase in the percentage rate of growth of total production, and that quite apart from the birth of new industries. In view of the moderate retardation shown by the least defective indexes and of their inadequate representation of new industries, Dr. Burns concludes: "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."

While this general proposition must be stated in these cautious terms, two supplementary remarks can be made in bolder form. (1) Population has grown at a declining percentage rate. Hence production per capita has experienced retardation, if any, at a lower rate than total production. (2)

Despite their downward growth bias, the Day-Persons and the Warren-Pearson indexes show an increase on the average in the absolute yearly increments of total production.

A reader who grasps the import of Dr. Burns' conclusions concerning the growth of total production, concerning trend-cycles and retardation in the life histories of individual industries must ask himself whether these conclusions are really valid. If he takes this question seriously, he will read the book with the care it merits. For it is only by following Dr. Burns through his careful tests of the original data, his discussions of concepts and explanations of methods that one can appraise the results. These results contain many significant items not mentioned in this summary. While the reader will not find 'the law of increase of production' for which John Stuart Mill called, he will find the most important contribution to our knowledge of increase in production which has been made since Mill wrote.

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PRODUCTION TRENDS IN THE UNITED STATES SINCE 1870

FOREWORD

THIS inquiry into economic change is restricted to one type of change, secular trends; to one aspect of the economic system, industrial production; to one geographic division, the United States; and to a portion of the economic history of that division, the period from approximately 1870 to 1930. The first three limitations are matters of choice, the last is virtually a matter of necessity.

The theme of the work is the industrial progress of the United States, but the approach is theoretical—not historical. The production trends of a large number of industries are analyzed with a view to discovering such elements of order as have characterized the rapid development and changing content of our national production of commodities and services. The first two chapters are devoted to a description of statistical data and technique. Chapter III presents a general picture of the changes in the qualitative composition of production, and suggests certain elements of order in these changes. These elements of order are investigated in some detail in Chapters IV and V. The final chapter passes from the changes in the pattern of production to the quantitative increase in total production, the principal aim being to determine whether there has been any regularity in the secular trend of total production.

The economist need not be reminded that an inquiry confined to secular changes in industrial production can give only a partial glimpse into secular changes in the economic system as a whole; that an inquiry into secular changes in the physical volume of production can give only a partial glimpse into secular changes in industrial production; and that an

inquiry carried through largely in terms of data of the physical volume of production can give only a partial glimpse even into secular changes in the physical volume of production, since the production system does not have an independent existence. If some of our interpretations of statistical regularities in secular changes in the physical volume of production lack thoroughness, that is one of the 'costs' of a study aiming at general results, but based on a restricted range of statistical data.