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CHANGES IN THE CYCLICAL BEHAVIOR OF INDIVIDUAL PRODUCTION SERIES

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ABSTRACT

This paper uses simple time series techniques to analyze changes in the short-run behavior of 38 physical production series for 1889-1984. The main finding is that fluctuations in these output series in the periods 1889-1914 and 1947-1984 are very similar, while those in the period 1922-1939 are anomalous. Relative to the prewar era, the postwar era exhibits only a slight damping of fluctuations and no increase in the persistence of short-run movements. At the same time, the correlation between the growth rates of the 38 goods is very low in both the prewar and postwar eras and has declined slightly over time.

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INTRODUCTION

Burns and Mitchell's study Measuring Business Cycles (1947) is considered by many to be the pioneering study in the identification and measurement of economic fluctuations. Among the most outstanding and least controversial attributes of this work is its use of disaggregate data in the analysis of short-run movements in economic activity. In their analysis, Burns and Mitchell examine the short-run behavior of over 200 production series as well as a plethora of other disaggregate economic indicators. This detailed analysis of individual series allows them to both examine common elements in the behavior of all series and to pinpoint important differences in the behavior of series representing different sectors of the economy.

Though widely praised, the use of disaggregate data has been largely abandoned by modern macroeconomists. Aggregate measures such as real GNP or the index of industrial production are typically used in place of individual output series in the analysis of short-run fluctuations. While this reliance on aggregate data is characteristic of most empirical work on business cycles, it is especially prevalent in studies of changes in cyclical behavior over long time periods. Of the several studies in recent years that have analyzed changes in the nature of economic fluctuations between the prewar and postwar eras, nearly all of them have relied exclusively on aggregate measures of production (see, for example, Baily (1978), DeLong and Summers (1986), Taylor (1986), and Zarnowitz and Moore (1986)).

This paper breaks with current practice and revives the use of disaggregate production data in macroeconomic analysis. It examines the

short-run behavior of 38 individual production series for 1889-1984. The series analyzed all measure the physical production of a particular good and appear to be consistent from the earliest years to the present. The data set covers a wide variety of commodities and is equally divided among manufactured goods, the output of mines and refineries, and raw agricultural products.

The main focus of the analysis is on possible changes in the cyclical behavior of production. Two of the most important changes that are examined concern the volatility and persistence of short-run movements in real output. The disaggregate data are used to analyze whether short-run fluctuations have become less extreme or erratic over time and whether the tendency of shocks to have permanent or transitory effects has changed between the prewar and postwar eras.

Using good disaggregate data to analyze these possible changes is crucially important because traditional aggregate measures of production are not consistent over time. Romer (1986a and 1986b) shows that prewar estimates of GNP and industrial production exaggerate the size of short-run fluctuations. As a result, using such measures may lead one to mistake changes in the quality of the data for genuine changes in cyclical behavior. In contrast, the individual production series appear to be very consistent over time. Hence, they may provide an alternative way of assessing whether the volatility and persistence of fluctuations have changed between the prewar and postwar eras.

An additional change in cyclical behavior that is examined in the paper concerns the correlation of short-term changes across sectors. Does the production of various goods move together and have there been changes in the size and sign of the correlations over time? This is obviously a

change that can only be analyzed using disaggregate data.

Though the paper focuses on changes in the volatility, persistence, and correlation of short-run fluctuations in the individual production series, an important byproduct of the analysis is a description of the short-run behavior of these series within various eras. This is useful because there has been so little analysis of the behavior of disaggregate production series even within the postwar era. As a result, the analysis is able to provide new evidence on such topics as the relative importance of aggregate and industry-specific shocks in causing fluctuations in the output of individual goods, and the degree to which such fluctuations are permanent or transitory within a given period.

While the data used in the paper are similar to those used by Burns and Mitchell, the techniques used to identify changes in cyclical behavior are quite different. Burns and Mitchell use measures such as the mean cyclical amplitude and the length of cycles to identify changes in the short-run behavior of output. In contrast, I use simple time series analysis of the standard deviations, autocorrelations, and cross-correlations of the first differences of individual production series to identify possible changes in short-run fluctuations.

The data set and the time series framework used to analyze changes in the short-run behavior of output are discussed in Sections I and II. The findings concerning changes in the volatility, serial correlation, and cross-correlation of the 38 production series are analyzed in Sections III, IV, and V, respectively. The importance and implications of the changes identified are discussed in the conclusion.

I. DATA

Because much of what is unique about the analysis of cyclical changes presented in this paper stems from the use of good disaggregate production data, it is crucial to discuss the data set thoroughly. The data set consists of 38 individual production series that span the entire period 1889-1984. Most of the series reflect the physical production of individual goods such as raw steel, pig iron, coal, corn, and wheat. A few of the series, such as cotton consumed and silk imported, reflect the consumption of raw materials in the production of manufactured goods.

As the above examples indicate, the 38 series included in the data set cover a wide range of goods. Approximately one-third are conventional manufactured goods. Another third are the products of mines and refineries. Some of these goods are quite processed (such as pig iron and coke) and are conventionally included in indexes of industrial production. The remaining third are agricultural products.

With two exceptions (pig iron and cotton consumed) the individual production data are available through 1970 in Historical Statistics of the United States (1975). My contribution has been to sift through the hundreds of production series given in this volume to determine which ones are reasonably accurate and consistent over time. The series that appeared to be consistent were then checked more thoroughly and revised when necessary. They were then extended through 1984 on the basis of more recent primary and secondary publications.

Three criteria were used to choose the series to be included in the data set. The first criterion was that the series represent the physical production of a mineral, agricultural, or manufactured good. That is, the series should represent such things as the tons of steel or the bushels of

corn produced, rather than the value of this production. This requirement was designed to eliminate the measurement error that might result from trying to convert a nominal series into a real series. The second criterion was that the series exist back to at least 1889 and still be available today from standard reference publications. The desire for long time series was obviously a very restrictive requirement and eliminated at least half of the physical production series in Historical Statistics.

The third and most fundamental criterion was that the series be reasonably consistent over time. To establish consistency I looked for several characteristics in the data. One was that the production estimates were and still are based on contemporaneous annual censuses or surveys of producers. This requirement was designed to eliminate those prewar series that have been constructed in the postwar era using data that is much less complete than those underlying modern estimates. Another characteristic that I looked for was that the definition of the good being measured was the same over time. This requirement made sure that a series did not, for example, cover shipments in one period and production in another or include some by-products in one period and exclude them in another.

The application of the consistency criterion eliminated many series from Historical Statistics. For example, the commonly used wheat flour series was not used because early estimates are simply interpolated by population rather than derived from actual survey data. In some cases it was possible to improve faulty series given in Historical Statistics rather than to eliminate them altogether. For example, while the pig iron series given in Historical Statistics uses shipments and production data interchangeably, the source publications from the American Iron and Steel Institute can be used to form a series that consistently represents

production.

A complete listing of the 38 series that were eventually chosen is given in Table A1 of the data appendix. The appendix also discusses the sources of the data and any changes that were made to the series given in Historical Statistics to improve consistency.

II. FRAMEWORK OF ANALYSIS

In order to examine changes in cyclical behavior, it is useful to describe the individual production series as following a very general time series process. This time series process provides a framework for motivating and interpreting various measures of the nature of short-run fluctuations in the individual series in different time periods.

Model. The logarithm of each series can be described as following an integrated moving average process with drift. That is,

$$(1) \qquad \Delta y_{it} = B_i + u_{it},$$
$$u_{it} = A_i(L)e_{it},$$

where $A_i(L)$ is a polynomial in the lag operator and e_{it} is white noise. This representation says that the first differences of the logarithms of each production series (Δy_{it}) are equal to a series specific mean (B_i) plus a random disturbance (u_{it}). The random term of each series may be serially correlated which is represented by the size and sign of the coefficients $A_i(L)$.

This description of the data is particularly useful because it allows one to remain agnostic about whether there is indeed a deterministic trend to which the individual production series revert. For the model given in

equation (1) sufficiently large negative values for some combination of the coefficients of $A_i(L)$ would suggest that the series does tend to revert to a trend growth path when it is shocked away. Coefficients that are small or positive indicate that shocks have permanent effects.

Given this framework for describing the individual production series, it is clear that simple statistical measures can be used to describe the nature of economic fluctuations. First, an obvious measure of the volatility of each series is the standard deviation of the random component, u_{it}. This measure shows the dispersion of the first differences of a production series around the mean growth rate. Second, the autocorrelations of the u_{it}'s provide a convenient way of assessing the persistence of short-run fluctuations. Cochrane (1986) and Campbell and Mankiw (1987a,b,c) show that a weighted average of the first several sample autocorrelations can be used to indicate if movements in production are primarily transitory or permanent. Finally, the cross-correlations of the u_{it}'s provide a way of evaluating the interactions between the individual production series.

Sample Periods. These statistical measures describe the nature of cycles over whatever sample of data is used in the calculation. By dividing the last century into subperiods and estimating the standard deviations, autocorrelations, and cross-correlations for each series for each period, one can analyze whether the nature of short-run movements in output has changed over time. The particular subperiods chosen for comparison are 1889-1914, 1922-1939, and 1947-1984. In what follows these periods are referred to as the prewar, interwar, and postwar eras, respectively.

While these periods are reasonably standard (they are, for example,

similar to those used in Taylor (1986) and Schultze (1986)), it is useful to explain why they were chosen. First, the prewar sample does not begin until 1889 because of data limitations. While many of the important series exist back to 1869, several interesting series such as refined sugar, canned vegetables, cement, and refined lead are not available on a consistent basis until 1889. Second, the two World Wars and the immediate postwar depressions are excluded because it is likely that wartime expansion and the subsequent demobilization do not provide a useful indication of the typical short-run behavior of the macroeconomy.

Finally, the period before World War I is evaluated separately from the period between World War I and World War II because it is not at all clear whether the interwar period should be grouped with the prewar era or with the postwar era. For example, if one is interested in comparing a period before activist government intervention and with one after intervention, the correct break is arguably World War I.[1] A further reason for evaluating the interwar period separately is to see whether the behavior of the economy in this era is fundamentally different from that in other periods. This analysis may provide evidence about whether the Great Depression was a unique event or merely a more extreme version of earlier economic downturns.

III. VOLATILITY

Of all the changes in short-run behavior that may have occurred over time, the one that has received the most attention is the possible decline in the volatility of the economy. This possible stabilization of the postwar economy is of tremendous interest because it is perceived as being the likely effect of activist government stabilization policy. Therefore,

it is very useful to see what the sample of 38 consistent production series shows about changes in volatility between the prewar and postwar eras.

As discussed in Section II, a simple measure of the volatility of each production series in the various time periods is the square root of the variance of log first differences. In terms of the time series process described in (1), this is simply

$$\sqrt{\text{Var}(u_{it})}.$$

This measure shows the dispersion of the first differences of a production series around the mean growth rate. Since each series has been expressed in logarithms, this measure is essentially the same as the simple standard deviation of percentage changes. If this standard deviation is large, then either the deviations from trend of a series with a trend are large or the shocks to a series without a trend are large. Both of these conditions correspond to what economists mean when they describe a series as volatile.

Changes in Volatility. When this measure is calculated for each series in each period, the main finding is that the volatility of the series in the prewar and postwar eras is quite similar. This can be seen in Table 1, which reports the standard deviations of each series in each sample period. A more convenient way to examine how much stabilization has occurred in each series is to examine the ratio of the prewar standard deviation to the postwar standard deviation. Figure 1 shows histograms of the prewar to postwar stabilization ratios for agricultural goods, mineral products, manufactured commodities, and all 38 goods, respectively.

The most obvious feature evident from the histograms is that the stabilization ratios for nearly all of the goods are surprisingly close to 1.0. For the total sample, over 85% of the goods had ratios lower than

1.75 and over half had ratios lower than 1.25. The median stabilization ratio is 1.11 and the mean stabilization ratio is 1.24.[2] Of the four goods that show stabilization ratios over 2.0, three are the reasonably minor commodities of cigarettes, Irish potatoes, and hay. The only major commodity that shows an obvious stabilization is crude petroleum.

The histograms for the commodities broken down by sector reveal some interesting differences in the amount of stabilization shown by goods in each sector. Agricultural goods show by far the least stabilization. Eighty percent of these goods have stabilization ratios less than 1.25 and over 30 percent of the goods have ratios substantially below 1.0, indicating destabilization. This absence of stabilization in agriculture is particularly surprising given the technological advances of the modern era, such as pesticides and widespread irrigation, which one would have expected to counteract some of the destabilizing shocks to farm production.

The stabilization ratios for mineral products are distributed fairly evenly over the range .25 to 1.75. This indicates that there is a substantial amount of variation in the behavior of the output of mines; indeed, about as many mineral products have become less volatile as have become more volatile. Finally, for manufacturing, the stabilization ratios are clustered in the range 1.25 to 1.75. This indicates that a majority of manufactured goods have shown a small decline in volatility over time. However, it is useful to note that 40 percent of manufactured goods have stabilization ratios below 1.25.

Despite this variation across commodities, the main finding of the analysis is that most of the 38 commodities in the sample have stabilization ratios between .75 and 1.25. More importantly, nearly all of the major goods included in the sample show stabilization ratios in this

range. This can be seen if one examines the stabilization ratios for six goods that would commonly be considered among the most important goods produced in the United States: corn, wheat, bituminous coal, pig iron, cotton textiles, and raw steel.[3] Of these six goods, only pig iron and steel production show even a slight stabilization. All of the rest have ratios that are indistinguishable from 1.0. This indicates that there has been very little change in volatility between the prewar and postwar eras.

While the similarity of the standard deviations of each series in the prewar and postwar eras is one obvious feature of the data, an equally obvious characteristic is that the standard deviation of each series is substantially higher in the interwar period than in either of the other eras. Using the data in Table 1, the interwar standard deviations are typically 1-1/2 to 2-1/2 times as large as the standard deviations of the prewar or postwar eras. This indicates that economic activity was significantly more volatile in the 1920s and 1930s than in the several decades on either side of this period.

Comparison to Aggregate Findings. To put the changes in volatility shown by the individual production series into perspective, it is useful to compare the preceding results with those for various aggregate indicators of production. The standard deviations of the percentage changes for various aggregate series in different time periods are given in Table 2a. The resulting prewar to postwar stabilization ratios indicate that the traditional estimates of both GNP and industrial production (IP) show a substantial damping of cyclical fluctuations over time. However, as discussed previously, Romer (1986a and 1986b) demonstrates that the traditional prewar measures of GNP and industrial production overstate the size of short-term fluctuations and hence exaggerate the amount of

stabilization that has occurred over time. These studies find that when consistent estimates are analyzed, the ratio of prewar to postwar standard deviation is approximately 1.3 for both GNP and industrial production.

The amount of stabilization shown by the individual production series is much more similar to that shown by the consistent aggregate series than to that shown by traditional measures of GNP and industrial production. Indeed, the amount of stabilization shown by the traditional aggregate series is substantially larger than that shown by over 90 percent of the individual production series examined in this paper.[4] On the other hand, the stabilization ratios of the consistent aggregate series are roughly equal to those of the majority of individual commodities.

It is important to note that the similarity in the volatility of the individual production series and the consistent aggregate series genuinely provides new information on stabilization and is in no way present by construction. For industrial production, the consistent series is formed by continuing a prewar index of manufacturing production, which is based almost exclusively on data on inputs, with the postwar Federal Reserve Board (FRB) index of materials production. Because the FRB index contains data on many goods not present in the prewar era, a comparison of this series with the available prewar series only provides information on changes in the general behavior of materials. It does not do what this study does, which is to see if particular goods or even a particular basket of goods has stabilized over time. Furthermore, while both the prewar and postwar indexes of materials production includes some of the 13 manufactured goods analyzed in this paper (such as refined sugar and pig iron), they obviously do not include any agricultural goods and very few mineral products. Hence, the analysis of the agricultural and mineral

products included in this paper provides completely new information on how much stabilization has occurred over time.

For GNP, the consistent series is formed by extrapolating modern GNP estimates back to the prewar era using available prewar estimates of commodity output.[5] While the data on commodity output does include agricultural and mineral products, these data cover goods that are typically much more processed than those included in the sample analyzed in this paper and are derived from nominal value series that are then deflated rather than from physical production data. As a result, the data set analyzed in this paper and that used in deriving consistent estimates of GNP are very different and thus provide independent estimates of the amount of stabilization that has occurred over time.

Possible Biases. While the behavior of the individual production series certainly appears to confirm the finding that there has been little damping of business cycles over time when consistent data are compared, one might worry that the analysis of individual production series is biased toward finding little stabilization. First, because of the necessity of including only those goods for which data exist for at least 95 years, the disaggregate data set tends to include many industries that have changed from high growth to low growth industries between the prewar and postwar eras. If such industries tend to become more volatile as they decline, this could explain why the disaggregate production series have not stabilized over time.

To see if this bias in the sample of individual production series is an important source of the lack of stabilization in these series, it is useful to exploit the cross-sectional nature of the data set. Since the sample includes a fair number of goods that have continued to expand over

time as well as the many that have declined, it is possible to test explicitly whether the degree of stabilization shown by various series is systematically related to the pattern of growth in those industries. To do this one can examine the correlation between the stabilization ratios for each series and the change in the mean growth rate of each series between the prewar and postwar eras. A negative correlation would indicate that those industries that have not stabilized are precisely those industries that have shown a large decline in the rate of expansion.

The relevant correlation coefficients by sector are -.17 for agriculture, .42 for minerals, and .06 for manufacturing.[6] As can be seen, only agriculture shows the suspected negative relationship and the correlation coefficient is very small. Both manufacturing and mining show a positive correlation between the stabilization ratios and the change in the growth rates of the various commodities. This suggests that for these sectors, goods that move from a phase of high growth in the prewar era to low or negative growth in the postwar era are more likely to show stabilization than those industries that have not declined. This somewhat anomalous finding actually makes sense when one considers how volatile an industry may be in the very early phases of development. If there is lumpiness in investment, the production of a good may grow very little for several years and then grow tremendously in the year that a new plant opens.

Overall, the low and positive correlation coefficients suggest that for the economy as a whole there is not a consistent relationship between the degree of stabilization shown by a commodity and the change in the average growth rate of the commodity between the prewar and postwar eras. This indicates that the overrepresentation of declining industries in the

sample of 38 individual production series cannot account for the lack of stabilization shown by these series.

Another feature of the data that one might fear could bias the results is that the postwar sample period is 12 years longer than the prewar sample period. If one believes that the mean growth rate of a series is more likely to change over a longer sample period, then it is possible that the standard deviation around a constant mean may overstate the volatility of the postwar era relative to the prewar era. The reason for this is that a larger fraction of the deviations around the mean may be due to changes in the drift term rather than to changes in the variance of the disturbance terms in the postwar era than in the shorter prewar era.

Two pieces of evidence suggest that this possible bias is not significant. First, since several of the individual series exist back to 1869, it is possible to compare prewar and postwar eras that are of more equal length. When this is done, the ratio of prewar to postwar standard deviations are very similar to those reported in Table 1.[7] Second, one can also break the postwar sample into two equal periods and see if the mean growth rates of the individual series have changed between the first and second halves of the postwar era. The result of this test is that the mean growth rates have often changed by 1 or 2 percentage points between the early and late postwar eras. However, the standard deviations around the two different means are very similar in both periods and are consistently 10 to 15 times as large as the change in the mean growth rate. As a result, the standard deviation around a single mean in the postwar era is indistinguishable from that around two different means corresponding to the first and second halves of the period.

IV. PERSISTENCE

While a decline in the volatility of production has been the most widely analyzed change in short-run economic activity, there are many other changes that can and should be analyzed using disaggregate production data. One of these deals with the persistence of short-term fluctuations. It is useful to know if movements in real output tend to be permanent or transitory and if the persistence of shocks has changed over time. This information is crucial for determining whether there is a business cycle around a deterministic trend in either the prewar or postwar eras. This fact in turn is important for determining the nature of shocks and the appropriate model of short-term fluctuations in the prewar and postwar eras.

Measure of Persistence. To analyze whether shocks to the production of individual commodities have permanent or transitory effects, it is necessary to derive a measure of persistence. To do this it is useful to consider the simple time series representation of each series given in equation (1). Recall that the growth rate of series i can be represented as a moving average with drift. That is

$$\Delta y_{it} = B_i + A_i(L)e_{it}$$

where B_i is the industry-specific mean growth rate and $A_i(L) = 1 + A_{i1}L + A_{i2}L^2 + \ldots + A_{in}L^n$. From this representation it is clear that the sum of the coefficients of $A_i(L)$ (represented by $A_i(1)$) indicates whether a shock to the growth rate is counteracted or not in subsequent periods. If $A_i(1) = 0$, then a shock to the growth rate is completely undone in later periods. As a result, the level of output returns to its trend growth path and is

not permanently changed.[8] On the other hand, if $A_i(1) > 0$, then a shock to the growth rate is not completely undone and hence the level of output is permanently altered (even though the growth rate may eventually return to its average level.) In the extreme case that the growth rate of output is white noise (which corresponds to the level of output following a random walk), $A_i(1) = 1$.

From this description, it is clear that an estimate of $A_i(1)$ provides an obvious measure of the persistence of short-run movements in the production of individual commodities. In the recent literature on persistence, a way of estimating $A_i(1)$ that does not require specifying and estimating a particular ARMA model for each series has been developed by Cochrane (1986) and Campbell and Mankiw (1987a,b,c). Cochrane suggests that the two-sided infinite sum of the autocorrelations of a series (in log first differences) provides one indicator of persistence. If the series reverts to a deterministic trend, this sum (denoted as V_i) is 0; if the series is a random walk, this sum is 1. Cochrane shows that a consistent estimate of this two-sided infinite sum of autocorrelations is

$$(2) \qquad \hat{V}_i = 1 + 2 \sum_{j=1}^{k} \left(1 - \frac{j}{k+1}\right) \hat{\rho}_{ij}$$

where $\hat{\rho}_{ij}$ is the j^{th} sample autocorrelation of the first differences of series i, and k is large relative to the sample size.

Campbell and Mankiw show that because there is a one-to-one relationship between the coefficients of the moving average representation of a series and the autocorrelations, there is also a unique relationship between Cochrane's V_i and $A_i(1)$. In particular,

$$(3) \qquad A_i(1) = \sqrt{\frac{V_i}{(1 - R_i^2)}}$$

where R_i^2 is the fraction of the variance of a series that is predictable from a knowledge of the past history of the process. Given this relationship, Campbell and Mankiw suggest that a nonparametric estimate of $A_i(1)$ can be calculated as

$$(4) \qquad \hat{A}_i(1) = \sqrt{\frac{\hat{V}_i}{(1 - \hat{\rho}_{i1}^2)}}$$

where the square of the first sample autocorrelation of the series is used as a conservative estimate of R_i^2.

In applying this nonparametric approach I use k = 7 as the number of sample autocorrelations to include in the estimate of V_i. This level of k relative to the size of the various sample periods is approximately the level the Campbell and Mankiw (1987a and 1987c) suggest is necessary to distinguish between a deterministic and a non-deterministic process in Monte Carlo simulations. More intuitively, k = 7 should satisfy the requirement that k be fairly large in order to capture any reversion to trend that occurs only after a fairly long lag. At the same time, k = 7 is still small relative to the sample size of 25 observations in the prewar era and 37 in the postwar era. Hence, it should not introduce the downward bias in $\hat{A}_i(1)$ that results when k is very large relative to the sample size (see Campbell and Mankiw, 1987a).

Changes in Persistence. The nonparametric estimates of $A_i(1)$ are given in Table 3. The first characteristic to note about these estimates is that they indicate that for most goods there has been no change in the persistence of short-term fluctuations between the prewar and postwar eras. A simple indicator of this fact is that the average $\hat{A}_i(1)$ is .68 in the prewar era and .70 in the postwar era. A comparison of the estimates for

each good in the prewar and postwar eras shows that this similarity in the means is due to similarity in the results for individual goods, not to offsetting movements among different commodities.

The similarity in the amount of persistence shown by these individual commodities between the prewar and postwar eras suggests that the notions of cyclical fluctuations and deviations from trend are as appropriate or inappropriate for the prewar era as they are for the postwar era. More fundamentally, it suggests that the many changes that have occurred in the behavior and structure of the economy over time, have not altered the way that the production of these individual goods responds to shocks.

While the degree of persistence shown by individual commodities is very similar in the prewar and postwar eras, the level of persistence is noticeably higher in the interwar era. The average $\hat{A}_i(1)$ is .76 in the 1920s and 1930s. Furthermore, the increase in persistence in the interwar era is probably larger than that suggested by the estimates of $A_i(1)$ because for the interwar era, $k = 7$ may be fairly large relative to the sample size of 17. As a result, $\hat{A}_i(1)$ may be biased downward in a way that is not true in the longer prewar and postwar eras.

This increase in the persistence of short-term movements for the individual production series in the 1920s and 1930s is in complete accord with common perceptions of the interwar period. If there ever was a time when shocks to output are thought to have had very persistent effects it was during the boom of the 1920s and the Great Depression of the 1930s. The increased persistence of short-run movements in the interwar era is also further evidence that this period is anomalous. Whereas the prewar and postwar eras show basically the same degree of volatility and the same tendency to revert to trend, the interwar era shows much greater volatility

and much less tendency to revert to trend. This suggests that short-run fluctuations in the period between the wars should be viewed as a different phenomenon from those on either side of this era.

Level of Persistence. While changes in persistence over time is obviously an important topic, an equally important topic is the absolute level of persistence in both the prewar and postwar eras. Do the estimates of $A_i(1)$ suggest that fluctuations in the production of the individual commodities analyzed in this paper were and still are mainly transitory or mainly permanent?

To answer this question, it is first useful to note that there is a substantial difference in the level of persistence shown by agricultural and nonagricultural goods. The average $\hat{A}_i(1)$ is roughly .50 for agricultural goods in both the prewar and postwar eras and .75 for nonagricultural goods. This indicates that movements in the production of agricultural goods are substantially less persistent than those in the production of nonagricultural goods.

The average level of the estimates of $A_i(1)$ suggest that at least half of the effect of a shock to agricultural production is undone in subsequent years. This suggests that a large fraction of the short-run movements in the production of farm commodities is transitory. At the same time, there is clearly a permanent component as well; shocks to agricultural production have at least a small effect on the long-run level of production.

For mining and manufactured goods, the permanent effect of a shock is larger than that for agricultural goods. The estimates of $A_i(1)$ indicate that approximately 75 percent of a shock remains after several years. While this indicates a substantial amount of persistence, it is important

to note that this is less persistence than one would find if the production of these goods actually followed a random walk.

It is also likely that the nonparametric estimate of $A_i(1)$ overestimates the persistence of short run movements in production. Including only seven lagged autocorrelations means that the measure will miss any trend reversion that occurs after seven years. Because of this possible upward bias on $\hat{A}_i(1)$, it is reasonable to conclude that slightly less than half of the effect of a shock to the production of mineral and manufactured goods is transitory and slightly more than half of the effect is permanent in both the prewar and postwar eras.

This finding that individual production series show at least some trend reversion in both the prewar and postwar eras takes on added importance when one considers the correlation between goods. I show in Section V below that movements in different production series in the prewar and postwar eras are largely uncorrelated and thus that movements in individual series are primarily the result of industry-specific shocks. This finding combined with the results concerning trend-reversion suggests that industry-specific shocks are at least partly transitory in both the prewar and postwar eras. This in turn may suggest that either industry-specific supply shocks are partly transitory or that there exist transitory industry-specific shocks to demand.

The presence of transitory industry-specific supply shocks may also explain why agricultural production is less persistent than nonagricultural production. In addition to the many productivity and demand shocks affecting other commodities, agricultural goods are also buffeted by frequent changes in weather and disease. Since these additional shocks are likely to be transitory, a larger fraction of shocks hitting the

agricultural sector is also likely to be transitory. Hence, it is not surprising that short-run movements in agricultural production tend to be less persistent than those in other sectors.

Comparison to Aggregate Indicators. As was the case with the volatility properties, it is interesting to compare the change in the persistence characteristics of the consistent disaggregate data with that for both traditional and improved measures of aggregate production. The nonparametric estimates of $A_i(1)$ for the various aggregate series in different time periods are given in Table 2b. The first thing that one notices from Table 2b is that the traditional and consistent aggregate series yield very similar estimates of persistence. This similarity makes sense because while prewar movements are exaggerated in the traditional series, there is no reason to suspect that this exaggeration should affect the timing of short-run fluctuations.

While the traditional and consistent estimates of GNP and industrial production tell a story similar to each other, they tell a story that is slightly different from that of the individual production series. In particular, the aggregate series show slightly more change in persistence between the prewar and postwar eras than do most of the good individual production series. This is especially true of GNP which shows an increase in the estimate of persistence of 20 percent.

In addition to showing a noticeable increase in persistence between the prewar and postwar eras, all of the aggregate series show a substantial increase in persistence in the interwar era. As can be seen from Table 2b, this change is more extreme for GNP than for industrial production. In this characteristic, the aggregate series echo the behavior of the individual production series which also show an increase in the persistence

of short-run movements in the interwar era.

In terms of the actual level of persistence, industrial production shows slightly less persistence than do the individual series on average in the prewar era and about the same amount as the individual series in the postwar era. GNP shows about the same level of persistence as do the individual series in the prewar era and somewhat more persistence in the postwar era. In general, the measures of persistence for the aggregate series indicate that some of the effect of a shock is permanent and some of the effect of a shock is transitory and that the permanent component has been rising over time. However, the estimates of $A_i(1)$ do not indicate that movements in GNP or industrial production are completely permanent, even in the postwar era.

V. THE RELATIONSHIPS AMONG GOODS

A final change in cyclical behavior that can be examined using good disaggregate production data concerns the correlation between goods. It is important to discover if short-run movements in various goods are highly correlated as traditional business-cycle theory would suggest and whether the relationships among goods have changed over time. This analysis is useful in identifying what type of models are appropriate for analyzing short-run fluctuations in production in both periods. It is also important for evaluating whether the volatility and persistence characteristics of the individual production series provide information about aggregate stabilization and trend reversion.

To examine changes in the relationships between the 38 individual production series, it is useful to examine the cross-correlations of the percentage changes of each series with those of each of the other series.

In terms of the simple time series model given in (1), the measure calculated is simply

$$\frac{Cov(u_{it}, u_{jt})}{\sigma_{u_i}\sigma_{u_j}}.$$

where σ_{u_i} indicates the standard deviation of the u_{it}'s. These cross-correlations can be calculated for the prewar, interwar, and postwar sample periods to see if the size and sign of the correlations have changed over time.

Because it is difficult to analyze the resulting 38 by 38 matrix of cross-correlations, Table 4 reports the average pairwise correlation for each good with all of the other goods in the prewar, interwar, and postwar eras. These average correlations are calculated separately for agricultural, mineral, and manufactured goods. This allows one to examine whether the average correlation of a particular good with agricultural goods is different from the average correlation of that good with mineral or manufactured goods.

Level of Cross-Correlation. Several features of the cross-correlations are evident from Table 4. The most striking feature of the average cross-correlations is that they are very low in both the prewar and postwar eras.[9] For most goods the average within-sector and across-sector correlations are indistinguishable from zero. An analysis of the individual cross-correlations shows that in nearly all cases these low average correlations result from low pairwise correlations, not from large positive and negative correlations cancelling each other out.

While the average cross-correlations for most goods are very low in both the prewar and postwar eras, there are exceptions to this pattern. One of these is that the correlations between major manufactured and

mineral goods are typically quite high. This can be seen in Table 5 which shows the cross-correlations for corn, wheat, coal, pig iron, cotton consumed, and steel in the prewar, interwar, and postwar eras. Though wheat and corn are only weakly correlated with each other or with other goods, the major mineral and manufactured products have cross-correlations that range between .4 and .9 and average around .7.

Changes in Cross-Correlation. Though the low level of correlation shown by most goods is an obvious feature of the estimates, Tables 4 and 5 indicate that there have also been some changes in the pattern of cross-correlation over time. One such change is that the cross-correlations of goods within the manufacturing and mining sectors and between goods in these two sectors are much higher in the interwar era than in either the prewar or postwar eras. Average pairwise correlations of .6 or .7 are not unusual even for minor goods in these sectors during the 1920s and 1930s.

This pattern, however, does not carry over to agricultural goods. While agricultural goods are somewhat more correlated with themselves in the interwar era than in other periods, their correlation with nonagricultural goods is if anything lower in this period than in the prewar era. Indeed, beginning in the interwar era, agricultural goods switch from having a vaguely positive correlation with mineral and manufactured goods to having a small but decidedly negative correlation with these products. This change can be seen by the fact that in the prewar era only 3 of the agricultural goods have an average pairwise correlation with mining and manufactured goods that is negative, while 8 agricultural goods have a negative correlation in the interwar era. This change continues into the postwar era where 10 of the 11 agricultural goods have a negative average pairwise correlation with nonagricultural goods.

correlation between goods and the change in the correlation among goods between the prewar and postwar eras have implications for the usefulness of the individual production series for indicating aggregate behavior. First, the low level of correlation between goods in both the prewar and postwar eras suggests that the level of volatility and persistence shown by the individual series does not represent the level of volatility and persistence in the economy accurately. Because the movements in the individual series are largely independent, an aggregate series constructed using these series would certainly be less volatile than the individual series. Similarly, because aggregate shocks have so little effect on the behavior of individual commodities, the short-run movements in aggregate output could be more or less persistent than those in the individual series. The fact that aggregate series will behave differently from the individual series in any given time period is confirmed by Table 2 which shows that even good aggregate series have standard deviations and sums of autocorrelations that are quite different from those of the individual series.

On the other hand, the fact that the changes that have occurred in the correlation among goods over time have been fairly small suggests that the behavior of the individual series does provide a good indication of changes in volatility and persistence over time. If the relationship between goods has not changed significantly and if individual goods have shown little change in volatility or persistence over time, then it is unlikely that an accurate aggregate indicator could show much change either. And indeed, consistent aggregate series do not show significant changes in either volatility or persistence over time.

The small changes that good aggregate series do show between the

prewar and postwar eras can probably be explained by the decline in the correlation among major commodities and the switch from a small positive correlation to a small negative correlation shown by agricultural and nonagricultural goods between the prewar and postwar eras. As discussed in Section III, most individual commodities show little decline in volatility between the prewar and postwar eras while consistent estimates of GNP and industrial production do show a slight stabilization over time. This could be due to the fact that short-run movements in various goods may be offsetting each other more in the postwar era than they did in the prewar era.

Similarly, as discussed in Section IV, the individual production series show little change in the persistence of short-run fluctuations between the prewar and postwar eras, while GNP and industrial production shows a moderate increase in persistence over time. The changing degree of correlation between individual commodities may help to explain this finding. Because goods move together somewhat less in the postwar era, it is possible that aggregate output may stay away from trend longer in the postwar era even though the persistence of individual commodities has not changed.

CONCLUSION

To examine changes in the cyclical behavior of production, this study has eschewed the use of aggregate measures of output. Rather, it has analyzed the short-run behavior of 38 individual production series that appear to be consistent over the last century. This analysis indicates that there has been remarkably little change in the short-run behavior of these 38 commodities between the prewar and postwar eras.

First, the volatility of short-run movements does not appear to have declined noticeably over time. While short-run movements were clearly more extreme in the interwar era, the ratio of the prewar to postwar standard deviation of percentage changes is on average 1.2 for the 38 individual goods. This slight amount of stabilization is somewhat smaller than that shown by even consistent estimates of industrial production or GNP.

Second, there has been little change in the persistence of short-run fluctuations in these 38 goods between the prewar and postwar eras. Shocks to the output of these goods were approximately half temporary and half permanent in both periods. However, shocks were typically much more persistent in the interwar era. The persistence properties of the 38 goods are roughly similar to those of GNP and industrial production, though both aggregate measures show some increase in persistence over time.

Third, there has been little change in the correlation among commodities over time. The correlation between the growth rates of the various goods is very low in both the prewar and postwar eras. It is, however, somewhat higher in the interwar period. The only significant change in correlation between the prewar and postwar eras is that agricultural goods switch from having a small positive correlation with nonagricultural goods in the prewar era to having a small negative correlation in the postwar era.

The implications of the changes, or more precisely the lack of changes, in the short-run behavior of the individual production series is obviously a topic for much further research. However, it is possible to suggest some of the questions raised by the results. First, the lack of stabilization shown by the individual production series between the prewar and postwar eras raises the possibility that stabilization policy has not

been effective. Because policy was not used in the prewar era and was used in the postwar era, one might have expected to see a stabilization of production in the postwar era. That this has not happened for most of the 38 commodities examined suggests that policy has not been as obviously successful as many economists might have believed. However, in order to argue that policy has genuinely not worked at an aggregate level many additional issues such as the relative size of shocks in the two periods or the possible presence of destabilizing institutional changes in the postwar era will have to be examined.

A second question raised by the results concerns what type of model is appropriate for analyzing short-term fluctuations in output in the prewar and postwar eras. The persistence properties of the disaggregate series suggest that shocks to the production of individual goods tend to be partly transitory, but with a definite permanent component in both the prewar and postwar eras. At the same time, the correlation between the various commodities is surprisingly low in both periods. Only the major commodities tend to be highly correlated and this correlation has been declining over time.

These findings indicate that both permanent and transitory industry-specific shocks are an important source of short-term fluctuations in the production of individual commodities in both periods, and especially in the postwar era. Therefore, it is important that models of the behavior of aggregate production allow an important role for industry-specific shocks and pay careful attention to the individual variation that may be masked by aggregation.

Finally, a third issue raised by this analysis of the behavior of the individual production series involves possible explanations for the Great

more difficult to discern. In all Census Bureau documents the source of data before 1903 is given as Latham, Alexander, and Co.[16] Latham and Co. was a New York banking firm that published an extensive book annual of cotton statistics called Cotton Movement and Fluctuations. However, the data in this book appear to have been collected by correspondents of the Commercial and Financial Chronicle of New York. The Chronicle's annual report "Cotton Crop of the United States" is reprinted in each edition of the Latham book and describes Chronicle correspondents surveying all major consumers of cotton. Judging from the fact that the Chronicle reports very detailed information on such things as how many spindles came in and went out of use in each region, it appears that the survey conducted by its correspondents was indeed quite extensive and exact.

Coffee and Silk. Like cotton consumed, coffee imported and unmanufactured silk imports for consumption are input series that are used to proxy for the production of manufactured commodities. The ultimate source of the prewar data on coffee and silk imports are the monthly and annual reports from the collectors of customs duties. Customs agents, in addition to collecting revenue, received and checked reports from every ship entering the U.S. on the quantity and the value of the goods unloaded. From the tremendous amount of specific data on imports by port that are provided in early publications such as the Treasury Department's Monthly Report of the Chief of the Bureau of Statistics, it is clear that this data is based on a contemporaneous enumeration of producers, or in this case, importers. Modern data on imports are still based on the reports of customs agents and ultimately on the quantities declared by importers.

Refined Sugar. The ultimate source of early estimates of refined sugar production is the Weekly Statistical Sugar Trade Journal. This trade publication was put out by Willett and Gray whom Frickey (1947) describes as "sugar statisticians of New York." The data on both cane sugar meltings and refined beet sugar production appear to be based on a contemporaneous canvass of major producers. Modern data on refined sugar production are now compiled by the U.S. Department of Agriculture. While procedures of the USDA are no doubt different from those of Willett and Gray, modern numbers are still derived from a survey of major producers.

Canned Corn and Canned Tomatoes. Beginning in 1907 the data on canned vegetables are compiled by the National Canner's Association. The Canner's Association is a professional organization that surveys producers of canned goods about the quantity and market value of the goods they produce.[17] The canvass made by the Canner's Association from its earliest days appears to be quite complete and is still the source of modern figures on canned goods production.

According to Department of Agriculture documents, data on canned corn and canned tomatoes before 1907 are available from the trade publication The American Grocer. While it is unclear how extensive a canvass was made by The American Grocer, the data appear to be very detailed and were certainly collected contemporaneously. Furthermore, estimates made by the early trade presses were typically quite accurate because such publications often had a close relationship with producers and because accurate estimates were crucial to retaining readers.

Beer, Distilled Spirits, Tobacco, Cigars, and Cigarettes. The

ultimate source of both the prewar and postwar series on alcohol and tobacco products are the tax records of the Commissioner of Internal Revenue and later of the Internal Revenue Service. Because alcohol and tobacco products have been subject to excise taxes over the entire period 1889-1984, tax collectors have continuous records of how many goods have ben reported as being produced and hence subject to tax. Early issues of the Annual Report of the Commissioner of Internal Revenue contain very detailed information on the number of producers and the success of Treasury Department agents in enforcing the excise tax laws. This suggests that early tax data probably do provide an extensive census of the actual production of alcohol and tobacco products.

Modern data on the production of these goods are still derived from tax records. While the methods of data collection have not changed radically between the prewar and postwar eras, it seems likely that enforcement may have improved over time. However, as long as prewar tax evasion was not systematically related to the cycle, this difference should not jeopardize the accuracy of the series for analyzing changes in the representation of short-run fluctuations.

Raw Steel, Rails, and Pig Iron. The ultimate source of both prewar and postwar data on raw steel, rails, and pig iron produced is the American Iron and Steel Institute (AISI). The AISI is the research wing of the professional trade organization of producers of iron and steel.[18] From the mid-19th century on the AISI has surveyed producers of iron and steel concerning production of various products. According to the 1890 Annual Statistical Report, "all the iron and steel manufacturers in the country, with scarcely an exception, cordially respond to our calls for statistical information" (AISA, 1891, p. 8). This indicates that the data on iron and steel in both the prewar and postwar eras satisfy the requirement that the series be based on a contemporaneous survey of producers.

Updates

Continuations for the 13 manufacturing series come from a variety of sources. Modern data on coffee imported, silk imported, cotton consumed, beer, tobacco, cigars, cigarettes, and steel are available in various issues of the Statistical Abstract. Data for the most recent years for coffee imported and cotton consumed are taken from Business Statistics because series consistent with earlier estimates have been dropped from the Abstract.[19] As discussed before, the most recent numbers available are used back to 1971, but the data before 1970 given in Historical Statistics are generally not revised.

Modern data on canned corn and canned tomatoes are taken from Agricultural Statistics, 1985. The continuation for the series on distilled spirits is from Alcohol, Tobacco, and Firearms Summary Statistics, 1982 published by the Treasury Department. Modern data on shipments of steel rails are from various issues of the Annual Statistical Report of the American Iron and Steel Institute.

Notes on Individual Series

Cotton consumed. The series on cotton consumed given in Historical Statistics is inconsistent with data available for recent years because the early series includes linters (the fuzz of short fibers that adheres to

cottonseed after ginning) while recent data do not. To deal with this I put together an alternative series using data from various issues of the Statistical Abstract[20]. These data are described as being exclusive of linters.

Canned Tomatoes. The series in Historical Statistics uses different sources for 1899 and 1904 than for the rest of the prewar era. These two observations appear to come from the Census of Manufactures while those for other years come from industry trade reports. The effect of this inconsistency is that the series takes a radical jump in both 1899 and 1904 because the Census enumeration is more complete. To form a more consistent series I replace the observations for 1899 and 1904 in Historical Statistics with those from Burns (1934) which is the intermediate source for the rest of the prewar series in Historical Statistics.

Steel Rails. The series on steel rails in Historical Statistics uses production data until 1967 and shipments data thereafter. Because shipments data are all that is available, I also continue the series with shipments data. While this difference clearly yields an inconsistency, the bias should be in the direction of causing the data to show a stabilization over time. Because inventories tend to be procyclical in the postwar era, a shipments series is likely to be smoother than a production series.

FOOTNOTES

1. For example, Barro (1986, p. 376) suggests that "the process for generating deficits in the interwar period, 1920-40,. . .is broadly similar to that in the post-World War II period, 1948-82. . . ."

2. It is important to note that the mean is not a useful summary of the data because it gives more weight to a ratio of 2.0 than to a ratio of .5, even though the two are equally far from 1.0 in percentage terms.

3. Direct data on cotton textiles do not exist. However, Census Bureau estimates of raw cotton consumed is considered to be a good measure of the production of basic cotton cloth.

4. At the same time, it is useful to note that the stabilization ratios of the traditional aggregate series reported here are smaller than those found in many other studies. The reason for this is that most studies do not examine the prewar and interwar eras separately. As is true for the individual production series, the aggregate output measures are much more volatile in the 1920s and 1930s than in the preceding or proceeding three decades.

5. In the extrapolation process the postwar relationship between GNP and commodity output is used to transform the more extreme short-run movements in commodity output into reasonable movements for a GNP series.

6. For this calculation the periods compared are 1889-1914 and 1947-1984. The change in the average growth rates is calculated by subtracting the postwar figure from the prewar figure, and hence is usually positive.

7. For example, the stabilization ratio using the extended prewar sample period is 1.00 for corn, 1.20 for wheat, .84 for bituminous coal, 1.18 for pig iron, 1.06 for cotton consumed, and 1.65 for steel. The respective ratios for the shorter prewar sample from Table 1 are 1.09, 1.12, .89,

1.33, 1.08, and 1.54.

8. As written in (1), the trend level of output is defined as output that grows as the constant rate B_i per year.

9. This result is similar to that found by Long and Plosser (1987) using monthly sectoral output data for the postwar era.

10. The 1905 Yearbook of the USDA provides a good description of the crop reporting procedures.

11. For a description of current crop reporting procedures see the USDA publication Statistical Series the U.S. Department of Agriculture: How they are Constructed and Used (1971).

12. The Geological Survey actually began operations in 1879, but did not collect data systematically until 1882.

13. The descriptive notes about the pig iron series in Historical Statistics also contain some inaccuracies.

14. This series is in fact identical to that given in Historical Statistics for these two decades.

15. The thoroughness of the canvasses is evident from the 1913 Census Bureau pamphlet Instructions to Special Agents: Cotton Statistics.

16. The source before 1895 is often given as the U.S. Department of Agriculture. However, the 1899 Yearbook of the USDA says their data on cotton consumed are from Latham and Co.

17. A useful description of the Canner's Association's activities is provided in their publication The Canning Industry (1971).

18. In the mid-nineteenth century statistical reports were put out directly by the American Iron and Steel Association.

19. The cotton consumed series in Business Statistics is ratio spliced to that from the Statistical Abstract in 1978.

20. The notes to the tables in the Statistical Abstract for some years are ambiguous. It is possible that the series before 1909 includes linters. However, the data for 1889-1908 taken from the 1916 Statistical Abstract are identical to those in Historical Statistics, which are described as being exclusive of linters.

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Table 1

Standard Deviations of Percentage Changes

Series	Standard Deviations			Ratio of Prewar to Postwar
	1889-1914	1922-1939	1947-1984	
Corn	.219	.278	.201	1.09
Wheat	.157	.174	.140	1.12
Oats	.194	.311	.148	1.31
Barley	.165	.403	.151	1.09
Flaxseed	.355	.536	.340	1.04
Rye	.085	.517	.253	0.34
Irish Potatoes	.224	.137	.095	2.36
Sweetpotatoes	.075	.189	.152	0.49
Hay	.121	.173	.055	2.20
Cotton	.188	.235	.251	0.75
Tobacco	.114	.208	.121	0.94
Bituminous Coal	.086	.149	.097	0.89
Coke	.202	.270	.136	1.49
Anthracite Coal	.171	.199	.098	1.74
Petroleum	.099	.102	.044	2.25
Cement	.091	.189	.068	1.34
Pyrites	.157	.222	.188[c]	0.84
Phosphate Rock	.103	.202	.082	1.26
Iron Ore	.219	.508	.226	0.97
Pig Iron	.210	.384	.158[d]	1.33
Copper	.076	.347	.149	0.51
Lead	.081	.197	.145	0.56
Zinc	.099	.195	.097	1.02
Gold	.088	.074	.115	0.77
Silver	.072	.219	.106	0.68
Coffee Imported	.173	.089	.111	1.56
Cotton Consumed	.107	.157	.099	1.08
Silk Consumed	.321	.113	.483	0.66
Refined Sugar	.066	a	.062	1.06
Canned Corn	.339	.408	.181[d]	1.87
Canned Tomatoes	.296	.342	.179[d]	1.65
Beer	.046	.455[b]	.027	1.70
Distilled Spirits	.157	.252[b]	.123[c]	1.28
Tobacco	.052	.020	.030	1.73
Cigars	.060	.071	.109	0.55
Cigarettes	.100	.068	.036	2.78
Rails	.287	.499	.247	1.16
Raw Steel	.230	.348	.149	1.54

[a]Data on refined sugar production are not available for the interwar era.
[b]The volatility of alcohol production is clearly related to the end of Prohibition in 1933-34.
[c]Data are only available through 1982.
[d]Data are only available through 1983.

Table 2

Cyclical Characteristics of Aggregate Series

a. Standard Deviations of Percentage Changes

Series	Standard Deviations 1889-1914	1922-1939	1947-1984	Ratio of Prewar to Postwar
Traditional GNP[a]	.058	.078	.028	2.07
Consistent GNP[b]	.037	.078	.028	1.32
Traditional IP[c]	.106	.159	.063	1.68
Consistent IP[d]	.106	NA	.077	1.38

b. Measure of Persistence

Series	$\hat{A}_i(1)$[e] 1889-1914	1922-1939	1947-1984
Traditional GNP	.66	1.15	.89
Consistent GNP	.72	1.15	.89
Traditional IP	.49	.69	.62
Consistent IP	.49	NA	.63

[a]The traditional estimates of GNP are the Kendrick (1961) estimates for 1889-1928 and the Commerce Department (1986) estimates for 1929-1984. The Kendrick series in 1929 dollars is ratio spliced to the Commerce Department series in 1982 dollars in 1929.

[b]The Romer (1986b) estimates of prewar GNP are used as the consistent extension of the modern Commerce Department estimates.

[c]The traditional industrial production series is the Frickey (1947) index of manufacturing production for 1889-1914 and the Federal Reserve Board (1986) index of manufacturing production for 1919-1984.

[d]The postwar FRB materials index is used as the consistent extension of Frickey's index. See Romer (1986a) for further details on forming consistent estimates of industrial production.

[e]$\hat{A}_i(1)$ is Campbell and Mankiw's nonparametric estimate of the infinite sum of moving average coefficients.

Table 3

Measure of Persistence

Series	$\hat{A}_i(1)$[a] 1889-1914	1922-1939	1947-1984
Corn	.46	.48	.43
Wheat	.49	.50	.61
Oats	.45	.42	.54
Barley	.53	.52	.65
Flaxseed	.61	.78	.47
Rye	.80	.55	.66
Irish Potatoes	.36	.07	.42
Sweetpotatoes	.75	.67	.50
Hay	.49	.47	.44
Cotton	.38	.62	.40
Tobacco	.58	.64	.46
Bituminous Coal	.80	.72	.89
Coke	.64	.66	.77
Anthracite Coal	.43	.68	.62
Petroleum	.91	.74	1.09
Cement	1.32	1.11	.97
Pyrites	.62	.38	.49
Phosphate Rock	.80	.65	.88
Iron Ore	.67	.64	.53
Pig Iron	.58	.71	.82
Copper	.86	1.03	.53
Lead	.65	1.26	.74
Zinc	.47	.93	.88
Gold	1.06	2.13	1.18
Silver	.71	1.30	.51
Coffee Imported	.50	.48	.51
Cotton Consumed	.45	.49	.63
Silk Imported	.39	1.17	.66
Sugar	.50	NA	.74
Canned Corn	.56	.46	.38
Canned Tomatoes	.39	.41	.48
Beer	.77	1.26	1.55
Distilled Spirits	.68	.72	.61
Tobacco	.65	.93	1.21
Cigars	1.05	1.01	.96
Cigarettes	2.00	1.19	.88
Rails	.70	.66	.80
Steel	.59	.64	.67

[a] $\hat{A}_i(1)$ is Campbell and Mankiw's nonparametric estimate of the infinite sum of moving average coefficients.

Table 4

Average Pairwise Cross Correlation[a]

	1889-1914			1922-1939			1947-1984		
Series	AG[b]	MIN	MAN	AG	MIN	MAN	AG	MIN	MAN
Corn	.26	.10	.08	.46	-.10	-.05	.14	-.02	.01
Wheat	.25	.06	.11	.33	-.01	-.02	.04	-.12	.01
Oats	.34	.11	.13	.50	-.08	-.06	.27	-.07	-.14
Barley	.28	.07	.12	.46	-.13	-.11	.22	.00	-.10
Flaxseed	.16	.11	.08	.34	.07	.00	.21	-.02	-.05
Rye	.24	.09	.02	.49	-.16	-.10	.21	.06	-.04
Irish	.30	.09	.13	.13	-.15	-.17	.11	.06	-.08
Sweet	.03	-.04	-.03	.15	-.32	-.15	.05	-.01	-.10
Hay	.13	.00	-.01	.44	-.17	-.12	.18	.03	-.07
Cotton	-.12	-.25	-.09	.09	.23	.20	-.05	.03	.17
Tobacco	.21	.17	.14	.10	.45	.33	-.15	-.03	.01
Bituminous	.01	.33	.26	-.10	.71	.48	-.01	.28	.13
Coke	.07	.35	.24	-.09	.73	.50	-.06	.35	.22
Anthracite	-.21	-.03	-.04	-.10	.41	.22	-.11	.08	.12
Petroleum	-.01	-.02	.01	.05	.56	.36	-.03	.21	.16
Cement	.07	.23	.23	-.12	.57	.40	-.01	.14	.16
Pyrites	.08	.08	.07	-.06	.50	.43	-.03	.06	.08
Phosphates	-.09	-.08	.04	-.08	.61	.45	-.16	.11	.09
Iron ore	.06	.33	.21	-.05	.74	.52	.00	.33	.21
Pig iron	.09	.35	.24	-.05	.75	.52	-.02	.38	.22
Copper	.13	.10	.05	.11	.69	.49	.11	.33	.14
Lead	.14	-.02	.03	-.01	.70	.48	-.04	.06	-.11
Zinc	.20	.27	.32	-.05	.72	.51	-.13	.17	.12
Gold	-.06	-.08	-.13	.01	.26	.17	.18	.10	-.08
Silver	.10	.15	.10	.06	.66	.47	.19	.23	.00
Coffee	.15	.00	.02	.10	.13	.02	-.09	-.02	-.01
Cotton	.18	.29	.17	-.04	.53	.26	-.10	.26	.12
Silk	.11	.07	.09	.23	.05	.10	.07	.19	.11
Sugar	.17	-.01	.13	NA	NA	NA	-.08	.09	.00
Canned Corn	.09	.03	-.05	.22	.28	.25	-.05	-.09	-.05
Tomatoes	.06	-.10	.04	.03	.15	.05	.06	-.11	-.03
Beer	-.04	-.02	-.06	-.22	.31	.17	-.03	.03	.00
Spirits	-.05	.16	.02	-.01	.54	.34	-.12	.10	.04
Tobacco	.09	.11	.11	-.18	.32	.26	-.01	-.04	-.05
Cigars	-.10	.27	.16	-.04	.74	.47	.02	.07	.06
Cigarettes	.08	-.02	-.07	-.11	.70	.45	.00	.12	.08
Rails	-.02	.36	.12	-.18	.69	.43	-.11	.31	.13
Steel	.08	.36	.19	-.08	.72	.45	-.02	.42	.22

[a]Each entry shows the average cross-correlation between a particular good and all the other goods in a given sector.

[b]AG denotes agriculture; MIN denotes mining; MAN denotes manufacturing.

Table 5

Sample Cross-Correlations of Percentage Changes

a. 1889-1914

Corn	Wheat	Coal	Pig Iron	Cotton	Steel	
1.00						Corn
.08	1.00					Wheat
.14	-.10	1.00				Coal
.09	.13	.83	1.00			Pig Iron
.27	.32	.58	.74	1.00		Cotton
-.03	.18	.74	.96	.70	1.00	Steel

b. 1922-1939

Corn	Wheat	Coal	Pig Iron	Cotton	Steel	
1.00						Corn
.28	1.00					Wheat
-.11	-.21	1.00				Coal
-.07	-.16	.91	1.00			Pig Iron
.12	-.24	.73	.78	1.00		Cotton
-.10	-.24	.85	.98	.77	1.00	Steel

c. 1947-1983

Corn	Wheat	Coal	Pig Iron	Cotton	Steel	
1.00						Corn
.31	1.00					Wheat
.06	.00	1.00				Coal
-.10	-.28	.41	1.00			Pig Iron
-.23	-.24	.42	.48	1.00		Cotton
-.09	-.30	.41	.99	.51	1.00	Steel

Table A1
Individual Production Series

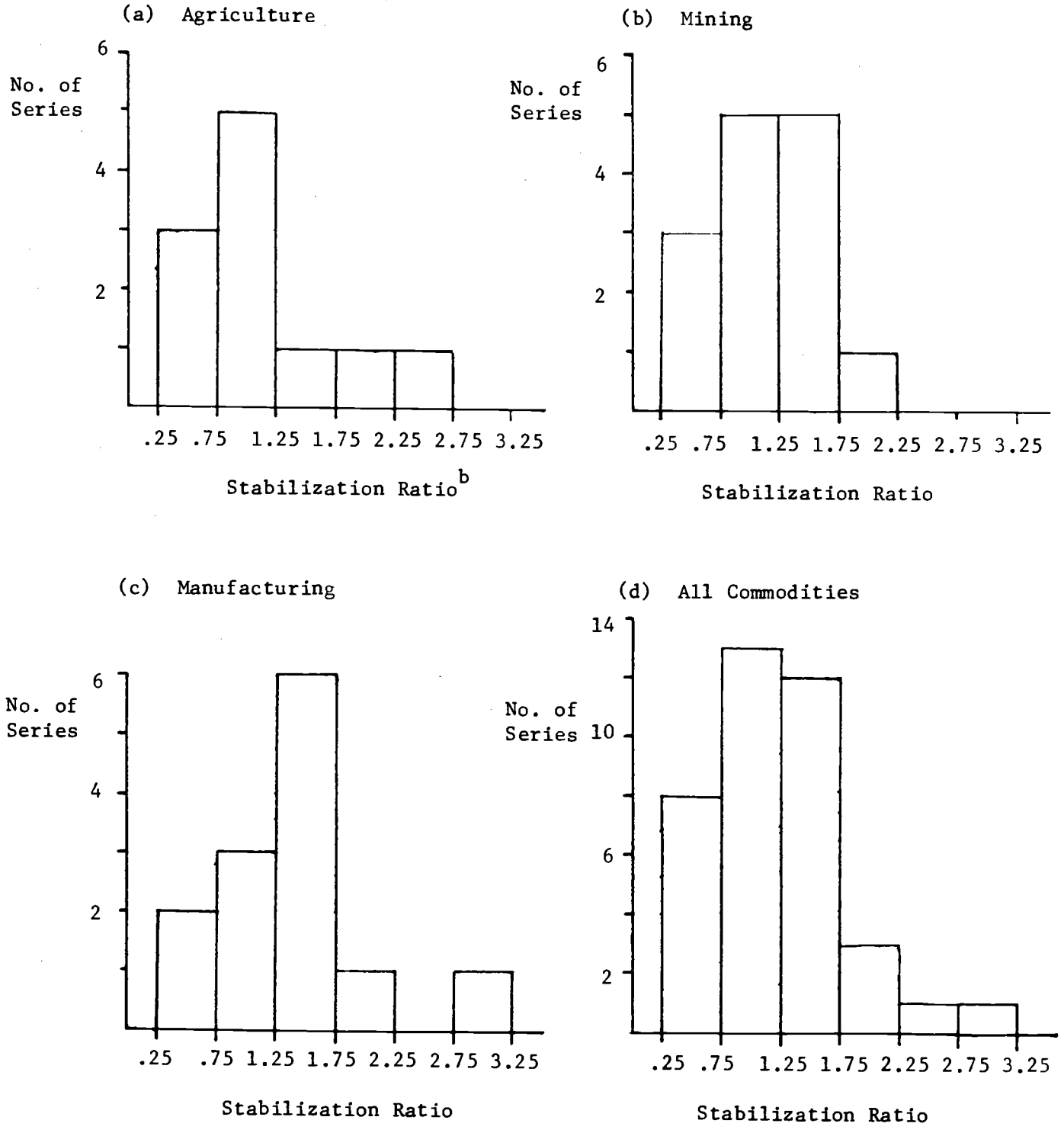
Name	Number in Historical Statistics
Corn Production	K503
Wheat Production	K507
Oats Production	K512
Barley Production	K515
Flaxseed Production	K518
Rye Production	K527
Irish Potatoes Production	K533
Sweetpotatoes Production	K536
Hay Production	K551
Cotton Production	K554
Tobacco Production	K562
Bituminous Coal Production	M93
Coke Production	M122
Pennsylvanian Anthracite Coal Production	M123
Crude Petroleum Production	M138
Cement Shipments	M188
Pyrites Production	M198
Phosphate Rock (sold or used by producers)	M203
Iron Ore Production	M205
Pig Iron Production	M217[a]
Copper Production (Mine (recoverable content))	M235
Lead Production (Primary, refined)	M243
Zinc Production (Mine (recoverable content))	M249[b]
Gold Production	M268
Silver Production	M269
Coffee Imported	P227
Cotton Consumed	P228[a]
Unmanufactured Silk Imports for Consumption	P230
Refined Sugar Produced	P232
Canned Corn Produced	P233
Canned Tomatoes Produced	P234
Beer Produced	P235
Distilled Spirits Produced (total)	P236
Manufactured Tobacco and Snuff Produced	P239
Cigars Produced	P240
Cigaretees Produced	P241
Rails Produced	P262
Raw Steel (total) Produced	P265

[a]Corresponding series in Historical Statistics abandoned in favor of other estimates. See text.

[b]Series M250 used until 1907. See text.

Figure 1

Distribution of Stabilization Ratios[a]



[a]The stabilization ratio is the ratio of the prewar standard deviation of the growth rate of each series to the postwar standard deviation.

[b]Ratios on the border are included with the lower group.