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The Prewar Business Cycle Reconsidered: New Estimates of Gross National Product, 1869–1908

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Traditional estimates of prewar GNP exaggerate the size of cycles because they are based on the assumption that GNP moves approximately one for one with commodity output valued in producer prices. This paper derives new estimates of GNP for 1869–1908 using an estimate of the actual relationship between GNP and commodity output. This estimated relationship is allowed to be time-varying and is derived from a regression covering the periods 1909–28 and 1947–85. The new estimates of GNP indicate that there has been much less stabilization between the prewar and postwar eras than is conventionally believed.

I. Introduction

The existing estimates of gross national product for the 70 years before World War II have done more to shape economists' perceptions of prewar business cycles than any other macroeconomic series. The historical GNP data have been analyzed in great detail and are frequently cited in research on prewar fluctuations in economic activity. Hence, much of what economists believe about prewar cyclical fluctuations is derived directly from the cyclical behavior of prewar GNP. As a result, the accuracy of the prewar estimates of GNP is one of the main determinants of the accuracy of our views about the prewar cycle.

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The importance of the prewar estimates of GNP has, if anything, increased in recent years. Economists interested in a variety of cyclical relationships have recently included the historical GNP series in their analyses. Much work has been done, for example, on the changing severity of cycles over time. Studies by Baily (1978) and DeLong and Summers (1986) use prewar GNP movements to argue that cycles have become less severe in the postwar era. Much current research also concerns the changing cyclical relationship of prices and output (see, e.g., Schultze 1981; Gordon 1982) and money and output (see, e.g., Friedman and Schwartz 1982). In all these studies the existing historical estimates of GNP play a key role in the analysis.

While the short-term cyclical behavior of the prewar GNP series has been analyzed in detail, the accuracy of the existing prewar estimates of GNP for such cyclical analyses has rarely been discussed. The standard estimates of GNP before 1929 are still those derived by Kuznets. Several economists have amended the Kuznets series, most notably Gallman and Kendrick, but these amendments have concentrated on improving the long-term trend of the prewar GNP series. They have not been aimed at improving the representation of cyclical movements in the Kuznets series.

This paper presents a detailed description and evaluation of the Kuznets estimates of GNP. This description suggests that while these estimates may provide a good indication of long-run trends in gross output, they may not represent cycles accurately. In particular, it is likely that the Kuznets estimates of GNP exaggerate the size of cyclical fluctuations in the prewar era. The reason for this is that the Kuznets estimates are derived almost exclusively from data on commodity output valued in producer prices. Total output valued in consumer prices, including the value added in transportation, distribution, and services, is essentially assumed to move proportionately with commodity output in producer prices. This, however, may not be true. Economic theory and modern experience suggest that GNP actually moves much less over the cycle than commodity output because the noncommodity components of GNP tend to be somewhat insulated from aggregate shocks. As a result, Kuznets's prewar series is likely to be excessively volatile.

Because the existing estimates of prewar GNP may not be accurate for the short-term cyclical analysis to which economists wish to put them, I derive an alternative GNP series for 1869–1908 that is based on more reasonable assumptions about short-run behavior. Like Kuznets, I begin with data on real commodity output. These data provide an excellent starting point because they cover all aspects of commodity production, including agriculture, construction, mining, and manufacturing, and they appear to be quite accurate as far back as 1869.

To convert these base data into estimates of GNP, I use a regression procedure. Rather than simply assuming that GNP moves one for one with commodity output as Kuznets does, I estimate the actual relationship between the two series over the interwar and postwar eras when good data are available on both these quantities. In the estimation of this relationship, the sensitivity of cyclical movements in GNP to cyclical movements in commodity output is allowed to change over time in order to deal with possible changes in the relative size of the commodity-producing sector. I then use the resulting time-varying sensitivity estimate to convert pre-1909 data on commodity output into estimates of GNP for 1869–1908.

The cyclical properties of the new estimates of GNP that I derive are very different from those of the standard GNP series. The business cycle before World War I appears to be much less severe in the new data than in the existing Kuznets series. As a result, the decline in the severity of cyclical fluctuations between the prewar and postwar eras is also much smaller than is typically believed. Indeed, the new estimates show less than half as much stabilization as the traditional estimates of GNP.

Because the derivation of new prewar estimates of GNP involves several choices about procedures and data, it is important to examine whether the findings on stabilization are robust to sensible variations in estimation procedures. For this reason I analyze various alternative choices of derivation procedures. I find that the new estimates of GNP, and hence their volatility characteristics, are indeed robust to reasonable changes in such things as the commodity output data and the time period used in estimating the controlling regression.

This reworking of the historical estimates of GNP is organized as follows. Section II describes the Kuznets estimates of GNP. Section III evaluates the accuracy of the Kuznets series. Section IV suggests a new method for deriving annual estimates of GNP for 1869–1908 and discusses the details of constructing a new series. Section V examines the volatility characteristics of the new GNP series and discusses the robustness of the new estimates and the findings on volatility to changes in estimation procedures.

II. Description of the Kuznets GNP Series

The Kuznets GNP series covers the period 1869–1938 and is published in its final form in Kuznets (1961).[1] The Kuznets series after 1929 has been superseded in common usage by the standard Com-

[1] Most of the Kuznets estimates of GNP for the early period are published only in moving average form in Kuznets (1961). However, the annual estimates are available in the widely circulated but unpublished "T" tables distributed by Kuznets.

merce Department series, which begins in 1929. However, for annual movements in GNP before 1929, the Kuznets series is still the most important series. This is true because while there have been revisions to this series for the years before 1929, these revisions have been directed mainly at the average level or long-run trend of the Kuznets GNP series, not the annual movements.

In particular, Kendrick (1961) adjusts the Kuznets series for 1869–1928 to be conceptually similar to the post-1929 Department of Commerce series. The main feature of this adjustment is that Kendrick adds in a comprehensive estimate of government spending in place of the very limited estimate included by Kuznets. Because government spending is typically quite smooth, Kendrick's adjustment significantly affects annual movements in GNP only in a few years (such as 1918). The revisions to Kuznets's GNP series prepared by Gallman (1966) that are presented in Friedman and Schwartz (1982) also have little effect on the short-run movement in GNP. The reason for this is simply that Gallman's revisions are primarily revisions of decadal averages, not of annual movements. Again, therefore, the accuracy of the representation of cyclical movements in the Kuznets series is the key determinant of the accuracy of the cyclical properties of this important revision of Kuznets's data.

The Kuznets series on which these revisions are based is in fact not one series but several series. Kuznets created different variants and used different methods to estimate GNP in different time periods. For the period after 1919, the estimates are derived using the income-payments approach. These estimates are described and presented in Kuznets (1941). While the accuracy of the GNP data after 1919 has not been thoroughly established, there is reason to believe that this series is quite reliable. For the period after 1919, Kuznets has ample income data from such sources as the Internal Revenue Service and the Bureau of Labor Statistics. He is very careful in aggregating these data and supplements national figures with industry reports and state records. As a result, it is likely that the income-side series after 1919 is not subject to important systematic biases or errors.

For the period 1869–1918, income data are less plentiful, so Kuznets uses different methods to construct data for these years. He actually forms two annual series for 1869–1918 that he identifies as the components series and the regression series. Both of these series are derived by what can best be described as the product-side approach.[2] Both use data on commodity output to estimate GNP. The

[2] There also exists a little-used Kuznets income-side series for 1909–18. Romer (1988) describes this series in detail and suggests revisions that make it roughly comparable to the later income-side series.

two series differ in how they convert these base data into estimates of GNP and at how fine a level of disaggregation the conversion is made. While the product-side approach is certainly a valid way of estimating GNP, flaws in the conversion of commodity output data into estimates of GNP could be a source of systematic errors in the prewar GNP series. As a result, this study concentrates on describing and improving the Kuznets series before 1919.

Shaw-Kuznets Commodity Output Series

Since both the Kuznets components series and regression series before 1919 are derived from data on commodity output, it is important to first describe the base data. The commodity output series comes primarily from a study by Shaw (1947). This series shows the value of finished commodities as they are leaving the producer; that is, it shows commodity output valued in producer prices. Shaw's methods of estimation are straightforward. He uses data from the *Census of Manufactures,* the *Census of Agriculture,* and the *Census of Mines,* as well as other national sources, to derive comprehensive benchmark estimates of commodity output for various census years starting in 1869. He then forms annual estimates of commodity output for 1889–1919 by interpolating between benchmark observations by numerous annual series.[3] The annual data come from a plethora of state reports and industry publications. Shaw presents commodity output data for a variety of major and minor subgroups valued in current and in 1913 producer prices.

Kuznets (1946) extends the annual Shaw series on commodity output to cover the earlier period 1869–88. He uses annual series similar to those used by Shaw to interpolate between Shaw's census year benchmarks for 1869, 1879, and 1889. Kuznets also converts Shaw's data on real commodity output from a 1913 base year to a 1929 base year. While Kuznets's contribution to the derivation of the basic commodity output data is substantial, in what follows I refer to the Shaw-Kuznets series on real finished commodity output simply as the Shaw series.

The Shaw series appears to be quite accurate. It is based on a massive array of base data, and the aggregation appears to be careful and precise. More important, there is no evidence of systematic bias in the series. For example, the series includes data on a full range of commodities, from simple nonmanufactured food products to highly

[3] Shaw also presents annual estimates of commodity output for 1919–38 that are based on a series derived by Kuznets (1938). Kuznets uses methods very similar to those used by Shaw in deriving the estimates for this later period.

fabricated machinery. As a result, it should be free of the excess volatility that has been shown to result from an overrepresentation of primary products (see Romer 1986).

While the Shaw series is quite accurate, it is nevertheless very important to be clear about what the series does and does not cover. The series represents the output of the three goods-producing sectors of the economy: agriculture, mining, and manufacturing. Also, because the series includes data on the value of construction materials, it provides a great deal of information about the behavior of the construction sector. The goods-producing sectors typically account for between a third and a half of GNP in the United States. What the Shaw series excludes is all the value added to a good after it reaches its final physical state. Because goods are valued in producer prices, the value added associated with transportation and distribution is excluded. Furthermore, the Shaw series excludes the value of the output of all types of services.

Kuznets Components Series

Given both the quality and the limitations of the commodity output series, it is clear that Kuznets's derivation of GNP estimates must center on the estimation of the noncommodity components of GNP. In estimating these components using both the components approach and the regression approach, Kuznets uses essentially no data other than the Shaw series. Rather, he uses assumptions about the relationship between the goods sector and the rest of the economy. For both series the particular assumption that he uses is that the deviations from trend of the noncommodity components of real GNP move approximately one for one with the deviations from trend of real commodity output.

To show that this assumption is the driving force behind the Kuznets estimates of GNP, it is necessary to describe the derivation of the GNP series in more detail. First, the components series is derived at a reasonably disaggregate level.[4] Kuznets uses disaggregate commodity output data to estimate the flow of perishable, semidurable, and durable goods to consumers (valued in consumer prices) and the flow of services. He also uses disaggregate commodity output data to estimate the various pieces of total capital formation, including the final value of the output of structures and producer durables, as well as the change in total inventories and the change in net claims against foreigners. For all the components of GNP, Kuznets first derives esti-

[4] The derivation of the Kuznets components series for 1869–1908 is described in detail in Kuznets (1946, pt. 2) and Kuznets (1961, app. C).

mates of real quantities and then converts them to nominal estimates by means of a price index for that component. For this reason, I discuss only the procedures he uses to derive estimates of real GNP.[5]

Kuznets's methods are quite similar for most categories. For the flow of perishable, semidurable, and durable goods to consumers, his problem is to convert the Shaw series on commodity output valued in 1929 producer prices to the value of the flow of goods to consumers at the cost to them in 1929 dollars. To do this, he begins by taking the ratio of the average flow of a category of goods to consumers to average commodity output in that category for overlapping decades. He then forms a series of the linear trend of this ratio. For the most part, the decadal averages of the flow of goods to consumers are formed by scaling up the decadal averages of commodity output. The scale factors are determined by an analysis of the trends in distributive margins and transportation charges that is described in Kuznets (1946).

To form annual estimates of the flow of a category of goods to consumers in 1929 prices, Kuznets multiplies the trend ratio of the flow of goods to consumers to commodity output in a given category by commodity output in that category. Thus he assumes that the components of the flow of goods to consumers not included in commodity output valued in producer prices, primarily the value added in transportation and distribution, move one for one with commodity output.

Kuznets's methods for other sectors use similar assumptions. The flow of gross producer durables and total construction are estimated in ways completely analogous to those for the flow of goods to consumers. For producer durables, the Shaw series on the output of producer durables valued in producer prices is multiplied by the trend ratio of the flow of producer durables to ultimate users to commodity output. For construction, the Shaw series on the output of construction materials is multiplied by the trend ratio of final construction output to the output of construction materials.

Kuznets uses a different method for measuring the components of GNP not directly involving commodities, such as the flow of services to consumers or the net change in inventories. For these series he estimates the actual sensitivity of the component in question to com-

[5] Kuznets derives three statistical variants of his components estimates of GNP. The only difference between the three variants is how the trend level of the flow of services to consumers is measured. Variant III derives the trend level of services by extrapolating the trend from the Commerce Department series after 1929 (see Kuznets 1961, p. 568). Since this series is considered to be the variant most consistent in levels with the postwar GNP series, this is the variant of the Kuznets components series used in the analysis of this paper.

modity output or to the flow of goods to consumers in the period between World War I and World War II. He then uses the estimated sensitivity to transform pre-1919 data on commodity output or consumption into estimates of the needed components. While the resulting estimates of these components of GNP for 1869–1918 move less than one for one with commodity output, they move closely enough with commodity output and are a small enough fraction of total output that the aggregate Kuznets components series on GNP still moves nearly one for one with commodity output.

Kuznets Regression Series

In contrast to the components series, Kuznets's second product-side series for 1869–1918, the regression series, is derived at the aggregate level.[6] For the regression series, he derives a measure of GNP by estimating the aggregate relationship between real GNP and real commodity output for the period 1909–38. This relationship is then used to convert Shaw's pre-1919 data on commodity output into estimates of GNP.

The actual derivation of the regression series is not complicated. Kuznets first forms estimates of trend GNP and trend commodity output. Real GNP and real commodity output for 1909–38 are then expressed as percentage deviations from trend. He then fits "a freehand regression curve" to a scatter plot of the deviations of GNP and commodity output from trend (Kuznets 1961, p. 537). This curve is used to form fitted values of real GNP for the pre-1918 era.

Though Kuznets states that the regression curve cannot be expressed as a simple mathematical function, it is actually very close to a simple linear regression. One can replicate his pre-1918 regression series very accurately using the results of a simple linear regression of the percentage deviations of GNP from trend on the percentage deviations of the Shaw series on total commodity output from trend. The actual parameter estimates are

$$\mathrm{gnp}_t - \overline{\mathrm{gnp}}_t = \underset{(.045)}{.895}(\mathrm{co}_t - \overline{\mathrm{co}}_t) + e_t,$$

where lowercase letters denote logarithms and bars over a variable denote trend values.[7]

From this representation of the derivation of the regression series,

[6] The regression series is described in Kuznets (1961, pp. 536–45).

[7] Trend values are calculated using Kuznets's methods. Kuznets first calculates the average value of GNP or commodity output for overlapping decades. He uses this value to represent trend GNP or commodity output for the midpoint of the decade. Annual trend values are derived by linearly interpolating between these midpoints.

it is clear that it has much in common with the components series. Both series are based on the premise that the cyclical movements in GNP follow those in commodity output very closely. The components series for the most part assumes that GNP moves one for one with commodity output. The regression series uses the estimated sensitivity of GNP to commodity output over the period 1909–38 to estimate GNP for 1869–1918. The assumption derived from this procedure is that cyclical movements in GNP are approximately 90 percent as large as those in commodity output.

III. Evaluation of the Kuznets Series

Trends

The reference above to the Gallman and Kendrick revisions to the trend of the Kuznets series indicates that some significant flaws in the measurement of trend movements in the Kuznets real GNP series have already been uncovered. As described previously, Kuznets derives the trend level of GNP essentially by scaling up disaggregate data on commodity output. For the most part, these scale factors are assumed to be constant over the entire period 1869–1918. Gallman argues that Kuznets's assumption of a constant scale factor for transforming data on the output of construction materials into estimates of new construction causes him to understate the level of gross capital formation in the 1870s (see Gallman 1966, pp. 25–40). Gallman finds that heavy construction such as railroad building has a larger nonmaterials component than other types of construction. Since railway construction is known to have been more important in the 1870s than in other prewar decades, Kuznets's procedure is likely to understate the level of GNP in this period.

Gallman improves the trend of the Kuznets series by adding in independent estimates of railroad production in benchmark years and then estimating nonrailroad construction by scaling up Shaw's series on construction materials (less those used in railroad construction). The resulting benchmark estimates of GNP are quite similar to Kuznets's in all census years beginning with 1879. However, Gallman's estimate of GNP in 1869 is substantially higher than Kuznets's. In general, this revision and the other more minor revisions suggested by Gallman appear to be quite sensible and have become widely accepted. Therefore, it is reasonable to conclude that the representation of trends in the Kuznets series in the late 1800s is flawed and should be amended in the way suggested by Gallman.

For measuring long-term trends, the revisions suggested by Kendrick are less important than those suggested by Gallman. Kendrick adjusts the Kuznets series to be conceptually consistent with modern

Commerce Department GNP estimates (see Kendrick 1961, pp. 238–46). The main component of this revision concerns the treatment of government expenditures. Kuznets includes government spending in his estimates of GNP in only two ways: personal tax and nontax payments are included in consumption as a measure of government services, and public construction is included in investment. Kendrick revises the Kuznets series by replacing these components with a comprehensive measure of government expenditure.

The main effect of the Kendrick revision is to raise the Kuznets estimates of GNP in all years. The reason for this is that personal tax payments account for only a part of total government revenues, and public construction accounts for only a small amount of total expenditures. However, this revision does not significantly alter the annual movements in the Kuznets series because government expenditures are quite smooth in the late nineteenth and early twentieth centuries. Because measuring GNP on a conceptually consistent basis is clearly desirable, Kendrick's revisions should be accepted and should also be applied to Gallman's series, which is similar to the Kuznets series in its treatment of government expenditures. The resulting Kendrick-Gallman prewar GNP series would probably measure long-run trends very well.

Annual Movements

For measuring annual movements in GNP the two Kuznets product-side series for 1869–1918 (and the other series derived from the Kuznets estimates) have both an important strength and an important flaw. The strength is that these series probably measure the turning points of output changes correctly. This is true because the series are derived almost exclusively from the Shaw commodity output series. Since the Shaw series is quite accurate and since GNP and commodity output are almost certainly very highly correlated in their annual movements, it is likely that the Kuznets prewar GNP series accurately captures the timing and direction of movements in GNP.

The flaw in the Kuznets estimates is that they are likely to overstate the size of cyclical movements. The source of this flaw is the fact that annual movements in real GNP are derived by assuming that deviations from trend of GNP move one for one (or nearly so) with deviations from trend of commodity output. However, there is evidence that GNP actually moves much less over the cycle than commodity output: for the postwar era it is widely accepted that the noncommodity components of GNP such as services, trade, and transportation are much less cyclically sensitive than the commodity component (see, e.g., Hall and Taylor 1986, pp. 168–69).

TABLE 1

RATIO OF COMMODITY OUTPUT TO GNP
(Selected Years)

Year	Ratio
1910	.44
1924	.40
1947	.33
1955	.33
1962	.30
1972	.29
1981	.28

SOURCE.—The commodity output series for 1910 and 1924 is the version of the Shaw series reported in Kuznets (1961, pp. 553–54, table R-21). Commodity output for 1947–81 is calculated as the sum of GNP in the commodity-producing sectors. Data are from the *National Income and Product Accounts* (NIPA) (1986, pp. 254–55, table 6.2). GNP for 1910 and 1924 is from Romer (1988, p. 104, table 5). This series has been converted into 1929 dollars so that it is compatible with the Shaw series. GNP for 1947–81 is from NIPA (1986, pp. 6–7, table 1.2).

This stylized fact that the noncommodity component of GNP is much less volatile than the commodity component is important because the noncommodity component is typically very large. Table 1 shows the ratio of commodity output to GNP in selected years. This table indicates that the noncommodity sector accounts for over 50 percent of total output in all years for which we have data. This suggests that there is a substantial part of total output that is smoother than commodity output. Hence, assuming that GNP moves one for one with commodity output could lead to a serious exaggeration of short-run movements.

The ratios in table 1 also indicate that there has been a noticeable decline in the size of the commodity sector between 1910 and 1981. If this trend continued back into the late 1800s, it could be that the cyclical exaggeration resulting from the assumption of a one-to-one relationship between GNP and commodity output was smaller in the prewar era than it would be if the same method were used to estimate GNP today. However, available evidence suggests that the decline in the relative size of the commodity-producing sector is a modern phenomenon. For example, the classic study by Barger (1955, p. 63) concludes that the distributive margins on goods "scarcely rose at all" between the Civil War and the Great Depression. As a result, it is likely that the noncommodity sector of the economy was large enough even in the late 1800s that the assumption of a one-to-one correlation between GNP and commodity output causes large errors in annual estimates of GNP for this period.

Since the argument that the Kuznets prewar GNP estimates are excessively volatile is based largely on the stylized fact that such components of GNP as services and distribution are quite smooth, it is important to note that economic theory also suggests that the noncommodity components of GNP should be less cyclically sensitive than the commodity components. First, in the case of consumer expenditures on services, it is likely that the demand for many services is nearly invariant to the state of the cycle. Except under extreme circumstances, one would not expect expenditures on haircuts or physicians' services to fluctuate dramatically. The same is not true of expenditures on commodities (especially durable goods), for which demand may not have a strong time-specific character. Hence, one would not expect expenditures on services to be as cyclically sensitive as commodity output.

Second, in the case of distributive margins, fixed costs may provide an explanation of why the trade and transportation component of consumer expenditures on goods does not move one for one with commodity output valued in producer prices. It is certainly possible that fixed costs for trade and transportation firms are relatively larger compared with variable costs than they are for manufacturing firms. This could be due, for example, to the fact that retail firms are typically quite small. As a result, overhead expenses may be very large relative to labor costs.

If this is true, then one would expect the value added in transportation and distribution to be less cyclically volatile than commodity output. In a cyclical downturn, a retail distributor or a transportation firm may be unable to cut costs proportionately with the decline in volume simply because variable cost is a small fraction of total cost. In this case, the distributive margin on each good will rise. As a result, the final gross value to consumers of the commodity in question will not have fallen by as much as the value of the commodity to producers. Hence consumer expenditures on commodities will tend to be less cyclically volatile than commodity output valued in producer prices.

This discussion of theoretical arguments for expecting the noncommodity components of GNP to be quite smooth also suggests an exception to this pattern: that in very severe depressions, services and distribution may collapse as much as commodity output. For example, while consumers will typically smooth their expenditures on services, in a very severe depression they are likely to reduce those expenditures, perhaps because of revisions in estimates of permanent income or increasingly binding liquidity constraints. Similarly, while distributive margins typically rise in a recession, they may not do so in a long and severe depression. This could be caused by bankruptcies among transportation and retail establishments that allow remaining firms to have sufficient volume to cover fixed costs. If these kinds of responses do indeed occur in severe depressions, GNP and commodity output could genuinely move together one for one in such periods.

This exception to the general rule that GNP should be less cyclically sensitive than commodity output is important because it may explain why Kuznets in the derivation of his regression series estimates the actual sensitivity of GNP to commodity output to be very near to one. The sample period over which he runs the regression is 1909–38, a period that is certainly dominated by the Great Depression. Hence it is not surprising that the estimated sensitivity is very high. At the same time, it is almost surely the case that such a high coefficient is not appropriate for creating new prewar estimates. If one judges from the behavior of commodity output, the percentage deviation of production from trend at the trough of the Great Depression was approximately two and a half times as large as the percentage deviation of production from trend in the worst depression of the 1869–1908 period.[8] As a result, it is very unlikely that true GNP should move as closely with commodity output in these more moderate prewar cycles as it did in the 1930s.[9]

Both casual empiricism and theoretical analysis suggest that the assumption of a nearly one-to-one correlation between real GNP and real commodity output used in the derivation of both the Kuznets components series and regression series is not correct. As a result, it is likely that the two Kuznets product-side series for 1869–1918 exaggerate the size of short-term fluctuations. Kuznets himself believed that his annual series did not represent cyclical movements accurately. He states in *Capital in the American Economy* (1961, p. 546) that his product-side estimates of prewar GNP "would not be acceptable measures of the amplitude of short-term changes." He repeatedly warns readers not to use his data for short-term cyclical comparisons and urges them to use the data in 5-year moving average form. Thus one is on firm ground in challenging the Kuznets estimates and seeking to

[8] The Shaw series was 47.4 percent below trend in 1932; the next-largest deviation from trend was 19.5 percent, which occurred in 1871. The Shaw series is detrended using the piecewise linear trend described in Sec. IV.

[9] The same reasoning suggests that the components of GNP (most notably the flow of services to consumers) that Kuznets estimates for the components series using a regression procedure will also be excessively volatile. For example, because he estimates the sensitivity of the flow of services to consumers to the flow of commodities to consumers over the 1919–41 period, which is dominated by the Depression, the estimated sensitivity is likely to be too high. In addition, because he uses his prewar estimates of the flow of goods to consumers and the estimated sensitivity of services to goods to form the pre-1919 estimates of the flow of services, any excess volatility in the estimates of the flow of goods to consumers will be translated into excess volatility in the estimates of the flow of services to consumers.

form a new prewar GNP series that may reflect cyclical movements more accurately.

IV. New Estimates of Prewar GNP

Overview

While there is reason to believe that the Kuznets estimates before 1919 are excessively volatile, it is necessary to derive new estimates only for the period 1869–1908. The reason for this is that in a previous paper (Romer 1988), I have already derived a revised series for the 1910s. This revised series is based on little-used estimates of national income included in an appendix to Kuznets (1961). Because, as discussed previously, the income-payments methodology does not tend to systematically misrepresent cycles, this series should represent annual movements accurately (see Romer [1988, pp. 102–5] for a more thorough discussion of the accuracy of the new estimates). The revised income-side series for 1909–18 is combined with the standard Kuznets income-side series for 1919–28, and the GNP estimates for both decades are adjusted using the Kendrick correction factors. This yields a series for 1909–28 that is conceptually consistent with the standard Commerce Department series, which begins in 1929.

For the period before 1909, such a straightforward revision of the Kuznets series is not possible because estimates of national income are not available. However, the description of the Kuznets series given in the previous section does suggest that we possess two major pieces of information that will be useful in deriving new product-side estimates of GNP for 1869–1908. First, the Kuznets series with the Gallman and Kendrick revisions provides a good measure of the trend of real GNP. Second, the Shaw series provides a good measure of the size and direction of annual movements in real commodity output.

To derive a new prewar GNP series that represents cyclical movements accurately, I replace Kuznets's assumption that deviations from trend of real GNP and real commodity output move together essentially one for one with a more reasonable assumption. Specifically, I estimate the relationship between the percentage deviations from trend of GNP and commodity output in a period when good data exist for both these series and then use this estimated relationship to form estimates of prewar GNP. This approach corresponds very closely to the technique Kuznets used in deriving his regression series. However, unlike Kuznets, I exclude the 1930s from the sample period of estimation because economic theory and empirical evidence suggest that the relationship between GNP and commodity output may be much different in a severe depression than during more stable periods.

I also modify Kuznets's procedure by allowing the measured sensitivity of aggregate GNP to aggregate commodity output to change over time. As shown in Section III, there has been a noticeable decline in the ratio of commodity output to GNP between 1909 and 1981. If this trend continued back into the pre-1909 period as well, it is possible that GNP should move more closely with commodity output in the late nineteenth century than it does today. To deal with this, I allow the estimated sensitivity of GNP to commodity output to be a function of time. This time-varying coefficient will, in fact, reflect the net effect of all the long-run structural changes that may have caused the relationship between GNP and commodity output to be different in 1869 from what it is in 1985. This is useful because there are no doubt many changes in addition to the decline in the commodity sector, such as the rise of government regulation and changes in the composition of the commodity sector itself, that could also affect the relationship between GNP and commodity output. By including a time-varying coefficient, it should be possible to derive an estimate of the sensitivity of GNP to commodity output that is appropriate for the period for which I am creating new data.

Specifics of the Derivation

While the basic procedure that I use to create new estimates of prewar GNP is conceptually quite simple, there are many specific issues concerning the actual derivation of new GNP estimates that need to be discussed.

Specification

The most important issue involves the specification of the relationship between aggregate real GNP and aggregate real commodity output. As mentioned earlier, it is desirable to allow the estimated relationship to vary over time. A straightforward way to do this is to make the coefficient estimate a linear function of a time trend. That is, I specify the relationship as

$$\text{gnp}_t - \overline{\text{gnp}}_t = (\alpha + \beta \cdot \text{trend})(\text{co}_t - \overline{\text{co}}_t) + \epsilon_t, \qquad (1)$$

where gnp_t is the logarithm of real gross national product, co_t is the logarithm of real commodity output, trend is a simple linear trend, and bars over a variable denote trend values (also in logarithms). The specification allows the data to decide whether the relationship between GNP and commodity output has indeed changed over the time period of estimation.

Time Period

I choose to estimate equation (1) over the combined prewar and postwar sample period 1909–28 and 1947–85. The particular dates in the sample period are determined partly by the availability of data: 1909 is the earliest date for which independent income-side estimates of GNP exist; 1947 is the earliest date for which the Commerce Department estimates of commodity output are available.

The primary benefit of this combined prewar and postwar sample period is that it is long enough to allow noticeable changes in the ratio of commodity output to GNP. Hence, this period should capture any trend in the relationship between the two series. Furthermore, the combined sample represents a good compromise between wanting to use a period for estimation that is close to the period for which we are creating data and wanting to use the best data possible. The period 1909–28 is clearly very close to the period for which we are creating data. However, it is likely that the GNP data for these two decades (and especially for 1909–18) have more measurement error than those for the more distant postwar era. By including both periods and a time-varying coefficient, the good postwar data can help provide more precise estimates of the necessary coefficients without imposing the postwar composition of output on the prewar economy.

The other noticeable feature of this sample is that the 1930s and early 1940s are excluded. As discussed in Section III, the reason for doing this is that it is very likely that GNP and commodity output move together more closely during extreme cyclical fluctuations than during more ordinary times. Since both the depression of the 1930s and the boom of the early 1940s are clearly of unprecedented amplitude, it is best not to let the experience of these decades determine the relationship between GNP and commodity output in the early prewar era. It is useful to note that if theory is wrong and GNP and commodity output do not move together more closely in severe fluctuations, then leaving out the observations for the 1930s and 1940s will not affect the parameter estimates. On the other hand, if theory is right, then it will be important to have left them out. Hence, it is clearly prudent not to include these potentially misleading observations.

Data

Another issue in the derivation of new estimates of GNP concerns the data used to estimate the controlling regression and to form fitted values for the period 1869–1908. First, for real commodity output, good data exist for the periods 1869–1938 and 1947–85. For the early period the series is the Shaw-Kuznets series in 1929 dollars given in Kuznets (1961, pp. 553–54, table R-21) and described in Section II. Because this series is consistently good over time, it can be used as the interpolating variable for prewar GNP.

For the post–World War II era a good measure of commodity output can be derived as the sum of real GNP in the three commodity-producing sectors of the economy: agriculture, forestry, and fisheries; mining; and manufacturing. The Commerce Department routinely publishes these data in its tables on GNP by industry. While the resulting series is not identical to Shaw's in its conceptual base, it is nevertheless reasonably consistent with the prewar Shaw series. Real GNP by sector is calculated by summing income accruing to the factors employed in each sector. To the extent that all that these three sectors produce is commodities, this income will equal the value of the finished commodities, valued in producer prices. If these sectors also produce some services, then GNP in these sectors will be larger than a true measure of commodity output and probably smoother. That this postwar commodity output series is, if anything, too smooth suggests that the measured sensitivity of GNP to commodity output in the postwar era may be closer to one than is in fact true. It is also useful to note that, as in the Shaw series, the sum of GNP in agriculture, mining, and manufacturing includes the output of construction materials. This is true because construction materials such as plate glass, structural steel, and millwork are included in manufacturing output.

For real GNP, data that represent annual movements correctly do not become available until 1909. Hence, the controlling regression can be estimated only starting in 1909. For 1909–28 the GNP series used is from Romer (1988, table 5). For 1929–85 the GNP series is the standard Commerce Department series in 1982 dollars.

While the existing estimates of GNP before 1909 do not represent annual movements correctly, they do appear to measure the trends of GNP well. Hence it is appropriate to use this trend in the derivation of the new prewar estimates of GNP. The version of the pre-1909 series that I use to calculate trend GNP is the Kuznets series with both the Kendrick and Gallman revisions included. This series is derived by taking the Gallman-Kuznets estimates of net national product in 1929 dollars from Friedman and Schwartz (1982, pp. 122–29, table 4.8) and adding in Kuznets's unpublished estimates of real capital consumption.[10] This series is then adjusted to be consistent with modern Commerce Department estimates by adding in the net adjustment factors derived by Kendrick (1961). These adjustment factors are calculated as the difference between the final Kendrick series and the

[10] These numbers are from table T-8 of the unpublished tables underlying Kuznets (1961).

underlying Kuznets series, both in 1929 dollars.[11] Finally, the resulting series is converted from a 1929 base to a 1982 base by multiplying by the ratio of the Commerce series to the Kendrick series in 1929.[12]

Trend Values

To estimate equation (1) and to form new estimates of GNP for 1869–1908, one must specify trend values for both GNP and commodity output for the entire period 1869–1985. The method I use for calculating trend values involves interpolating linearly between benchmark estimates of the logarithms of GNP and commodity output. Provided that benchmarks are reasonably close together, this method allows the trend of each series to change frequently over the period in question.

In using piecewise linear trends, the key step is deciding which years to use as benchmarks. Often, researchers choose to connect peak years and thus form an estimate of potential rather than trend GNP or commodity output (see, e.g., Gordon 1982). For this study, I specifically choose years that correspond only to trend output or unemployment at the natural rate rather than to peak output. This was a necessary change because the Gallman-Kendrick prewar GNP series used to estimate trend GNP for the pre-1909 era accentuates the size of cyclical fluctuations. As a result, the years for which the traditional pre-1909 GNP estimates are most accurate are years in which the economy is neither below nor above trend.

Deciding during which years the economy was on trend involves an admittedly arbitrary and imperfect procedure. In choosing benchmark dates, I use a mixture of an examination of a plot of the data in logarithms and a qualitative knowledge of which prewar and postwar years are typically considered to correspond to periods of boom and recession. From the plot of the data I try to choose years that correspond to points of midexpansion in the business cycle. When possible, I also use data on the unemployment rate to confirm that the years chosen do correspond to conventional estimates of full, rather than overfull, employment.

The actual years chosen as benchmark estimates for both GNP and

[11] The Kendrick series is given in Kendrick (1961, pp. 293–95, table A-IIa). For 1869–78 and 1879–88, Kendrick reports only a decadal average for his revised series. To derive annual correction factors for these decades, I use the decadal averages to calculate the adjustment factor for the midpoint of each decade and then interpolate linearly between 1873.5, 1883.5, and 1889. This procedure is valid because Kendrick calculates the correction factors incorporated in the decadal averages largely by similar interpolation.

[12] The standard Kendrick series is used in this ratio splice because the Gallman revisions stop in 1909.

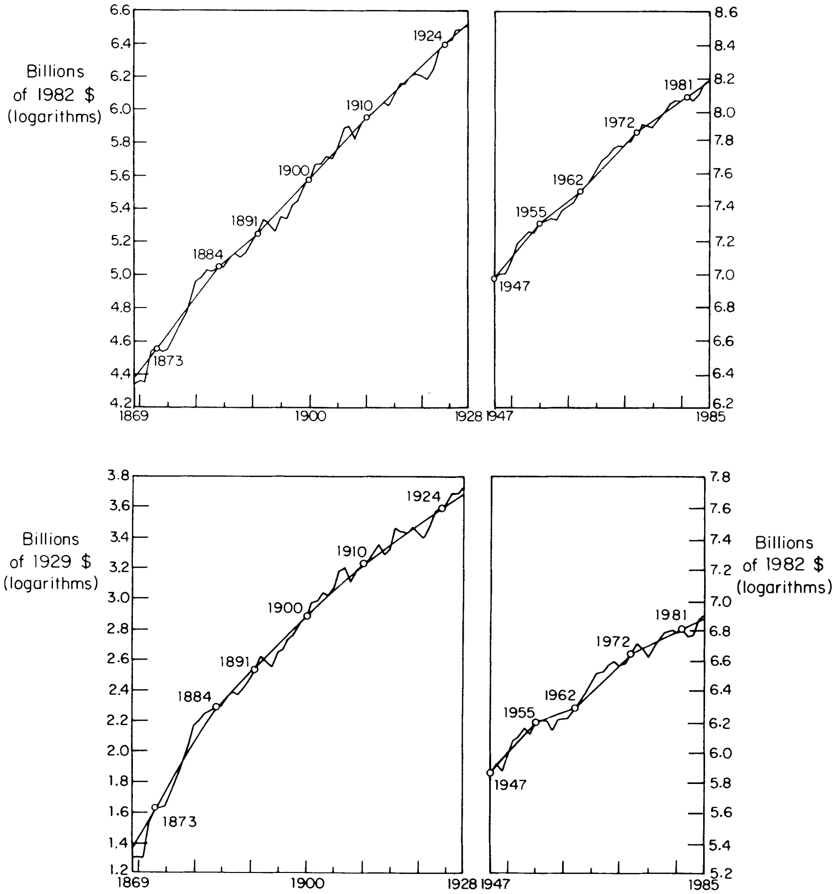

FIG. 1.—*a*, Trend and actual gross national product. Source: For 1869–1908, the GNP series used is the Gallman-Kendrick series described in the text. For 1909–28, the GNP series is from Romer (1988, p. 104, table 5). For 1947–85, the GNP series is from the Commerce Department. *b*, Trend and actual commodity output. Source: For 1869–1928, the series used is the Shaw commodity output series given in Kuznets (1961, pp. 553–54, table R-21). For 1947–85, the series used is from the Commerce Department. See the text for a description of this series.

commodity output are 1873, 1884, 1891, 1900, 1910, 1924, 1947, 1955, 1962, 1972, and 1981.[13] Figure 1*a* and *b* shows the resulting trend values of GNP and commodity output and the underlying data. From these graphs, it should be clear that the years chosen as benchmarks do correspond reasonably well to points of midexpansion in the cycle.

[13] To calculate trend values for years not between two benchmarks, the trend from the nearest two benchmarks is continued either forward or backward.

Estimation

Having dealt with these various issues, I can now estimate equation (1). The results using ordinary least squares indicate that there is substantial serial correlation in the residuals (the Durbin-Watson statistic is .66). This serial correlation is not surprising because movements in GNP that are not correlated with commodity output may be quite persistent.

To derive more efficient parameter estimates, I estimate equation (1) using the Cochrane-Orcutt correction for first-order autocorrelation. The resulting parameter values for the combined prewar and postwar sample period of 1909–28 and 1947–85 are

$$\begin{aligned} \text{gnp}_t - \overline{\text{gnp}}_t &= \underset{(.0775)}{(.5830} - \underset{(.0017)}{.0007} \cdot \text{trend})(\text{co}_t - \overline{\text{co}}_t) + e_t, \\ \text{SEE} &= .0132,\ \text{D-W} = 1.89,\ \text{rho} = \underset{(.0921)}{.7184}, \end{aligned} \tag{1'}$$

where standard errors are in parentheses.[14]

Two important characteristics of these estimates should be noted. First, the standard error of the regression is quite low, suggesting that the movements in GNP that are uncorrelated with commodity output are fairly small. Furthermore, the residuals are even smaller in the postwar era than a standard error of the estimate of .013 would suggest. This may indicate that there is measurement error in the GNP estimates for 1909–28 that accounts for some of the residual movement in GNP. Hence, it is likely that movements in commodity output account for the vast majority of movements in GNP.

The second important characteristic to note is that the estimated sensitivity of GNP to commodity output is substantially below one and is not a strong function of time. (Indeed, the time-varying part of the coefficient is not significantly different from zero.) According to the estimates, the time-varying coefficient measuring the sensitivity of GNP to commodity output fell from .583 in 1909 to .527 in 1985. This indicates that Kuznets's assumption that the deviations of real GNP from trend move essentially one for one with the deviations of real commodity output from trend is not borne out by a regression based on good data and a sample period that excludes the Great Depression. Furthermore, the fact that the coefficient is only a very weak

[14] In this estimation, "trend" is equal to zero in 1909. Equation (1) is estimated without a constant because it is reasonable to expect the deviation from trend of GNP to be zero when the deviation from trend of commodity output is zero. When a constant is included, it is small (−.008) and insignificant, and the other coefficients are nearly identical to those from the regression excluding the constant.

function of time suggests that the various structural changes that one might have expected to affect the relationship between GNP and commodity output have had little impact. This may indicate either that these changes were unimportant or that the various changes had different effects and tended to cancel each other out.

New Estimates of GNP for 1869–1908

With these coefficient estimates it is relatively straightforward to create new estimates of real prewar GNP. First, I calculate the implied estimate of the sensitivity of GNP to commodity output for each year in the period 1869–1908 by projecting the linear time trend backward. The resulting coefficient ranges between .613 in 1869 and .584 in 1908.

Next, I estimate the deviations of GNP from trend for the pre-1909 era by multiplying the deviations of the Shaw commodity output series from trend by the estimated time-varying coefficient.[15] Finally, to create new point estimates of real GNP for 1869–1908, these estimates of the percentage deviations of GNP from trend are added on to a series on the trend of real GNP. As discussed previously, this trend series is calculated by linearly interpolating between benchmarks. The series used for benchmarks is the Gallman-Kendrick series. This series in 1929 dollars was also ratio-spliced to the Commerce Department series in 1982 dollars in 1929 so that the resulting trend series would be comparable in levels to modern Commerce Department estimates of real GNP.

The resulting new estimates of real GNP for 1869–1908 are given in table 2. (The estimates for 1909–29 also shown in table 2 are discussed below.) The new estimates of prewar GNP are also graphed in figure 2. For comparison, the Gallman-Kendrick series (in 1982 dollars) is also presented in figure 2. Two characteristics of the new series are apparent from the figure. First, by construction, the new estimates of prewar GNP are identical to the Gallman-Kendrick estimates in the years chosen as benchmarks. Second, cyclical movements in the new series are noticeably smaller than cyclical movements in the Gallman-Kendrick series. This difference between the two series is analyzed in detail in Section V.

[15] In forming these forecasted (or, more properly, "backcasted") values, I set all the error terms equal to their mean (which is zero). Because eq. (1) is estimated with a correction for first-order autocorrelation, an alternative procedure for backcasting would be to include the error for 1909 and set all earlier errors to zero. This alternative was not followed because the estimated residual for the backcasting regression in 1909 was .001 and hence would have essentially no impact on the backcasted values.

TABLE 2

NEW ESTIMATES OF GNP, 1869–1929

Year	GNP (Billions of 1982 Dollars)	GNP (Billions of Current Dollars)	Implicit Price Deflator* (1982 = 100)
1869	75.609	7.745	10.244
1870	76.464	7.387	9.661
1871	76.952	7.517	9.769
1872	89.605	8.444	9.423
1873	94.863	8.849	9.329
1874	96.205	8.821	9.169
1875	97.684	8.738	8.945
1876	104.628	8.934	8.539
1877	110.797	9.093	8.207
1878	118.906	9.069	7.627
1879	127.675	9.420	7.378
1880	139.990	11.431	8.166
1881	143.580	11.483	7.998
1882	149.307	12.343	8.267
1883	152.097	12.382	8.141
1884	155.684	12.035	7.730
1885	157.789	11.455	7.260
1886	164.375	11.791	7.173
1887	169.453	12.269	7.240
1888	168.940	12.420	7.352
1889	175.030	12.955	7.402
1890	182.964	13.276	7.256
1891	191.757	13.742	7.166
1892	204.279	14.081	6.893
1893	202.616	14.257	7.036
1894	200.819	13.260	6.603
1895	215.668	14.046	6.513
1896	221.438	14.044	6.342
1897	233.655	14.914	6.383
1898	241.459	15.869	6.572
1899	254.728	17.319	6.799
1900	264.540	18.879	7.136
1901	284.908	20.187	7.086
1902	291.572	21.386	7.335
1903	306.239	22.724	7.420
1904	307.127	23.041	7.502
1905	323.162	24.807	7.676
1906	351.499	27.674	7.873
1907	361.920	29.701	8.206
1908	346.800	28.247	8.145
1909	368.872	31.066	8.422
1910	383.888	33.187	8.645
1911	391.858	33.712	8.603
1912	407.112	36.412	8.944
1913	424.492	38.242	9.009

TABLE 2 (*Continued*)

Year	GNP (Billions of 1982 Dollars)	GNP (Billions of Current Dollars)	Implicit Price Deflator* (1982 = 100)
1914	414.599	37.741	9.103
1915	443.048	41.655	9.402
1916	476.498	50.442	10.586
1917	473.896	61.896	13.061
1918	498.458	75.786	15.204
1919	503.873	78.503	15.580
1920	498.132	88.399	17.746
1921	486.377	73.560	15.124
1922	514.949	73.612	14.295
1923	583.105	85.676	14.693
1924	600.377	87.115	14.510
1925	615.108	90.839	14.768
1926	655.033	97.194	14.838
1927	661.365	95.785	14.483
1928	669.288	97.663	14.592
1929	709.600	103.900	14.600

SOURCE.—For 1869–1908, see the text for a description of the new estimates. For 1909–28, the estimates are from Romer (1988, p. 104, table 5). For 1929, the estimates are from NIPA (1986, p. 6, table 1.2).
* The relationship between columns may not be exact because of rounding.

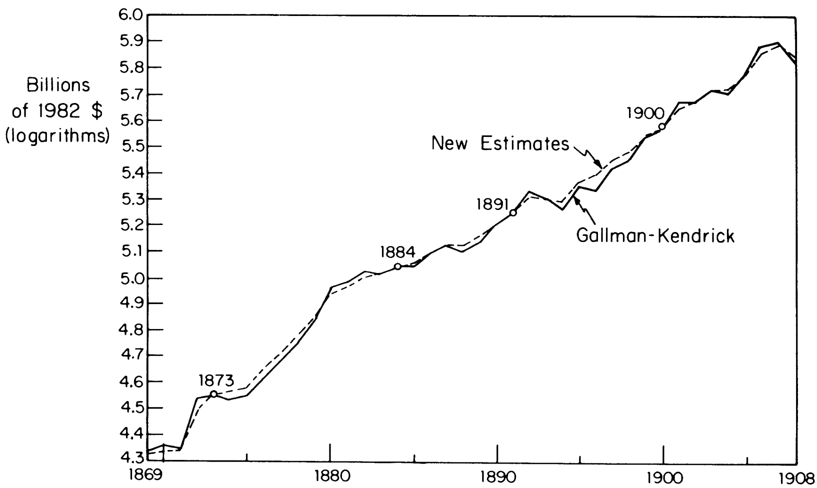

FIG. 2.—Traditional and new GNP estimates, 1869–1908. Source: See the text for a description of both the new estimates and the traditional Gallman-Kendrick series.

Nominal Estimates

In estimating the relationship between GNP and commodity output, I used constant-dollar data. As a result, the new estimates that are derived using this estimated relationship are also in constant dollars.[16] However, for many applications it would be useful to have nominal estimates as well. While the derivation of a thoroughly new nominal series is outside the scope of this study, it is possible to create a nominal version of the new estimates that is based on a conventional deflator series.

The resulting nominal series should be better than conventional nominal estimates because the real series being reflated measures cycles more accurately than the traditional estimates. However, the absolute accuracy of the new nominal series depends crucially on the quality of the conventional deflator series. While the existing deflator series appear to be derived using good data and reasonable assumptions, it is possible that they are flawed in some systematic way.[17] If this is true, then the new nominal estimates would also be flawed. Nevertheless, pending further study, it seems useful to create a nominal version of the new estimates using the best deflator series currently available.

As described above, the real GNP series that I use to derive the trend of the new estimates is a hybrid version of the Kuznets series that incorporates the revisions suggested by both Gallman and Kendrick. Thus one needs a deflator that is also based on this hybrid series. Because both Gallman and Kendrick present nominal versions of their revisions to Kuznets as well as real estimates, one can use methods identical to those described above to create a nominal Gallman-Kendrick series.[18] This series can then be divided by the real estimates to yield a Gallman-Kendrick implicit price deflator series. Because the real Gallman-Kendrick series was ratio-spliced to the

[16] While the new estimates are listed in table 2 as being denominated in 1982 dollars, this is true only in a limited sense. The Gallman-Kendrick series used to calculate trends was originally expressed in 1929 dollars. I ratio-spliced it to the Commerce Department series in 1982 dollars in 1929. Because this splice is done at the aggregate level, all that it does is to make the two series roughly comparable in levels; it does not genuinely use 1982 prices to weight the components of GNP. Hence, in a more fundamental sense, the new estimates still use 1929 relative prices to weight the components of GNP.

[17] For example, it is possible that the deflators are too cyclically sensitive because they are based very heavily on wholesale price data. If this is true, then the new nominal series will also be excessively volatile, even though the real series is not.

[18] In particular, the nominal net national product series incorporating the Gallman revisions from Friedman and Schwartz (1982, pp. 122–29, table 4.8) is combined with estimates of nominal capital consumption from the unpublished tables underlying Kuznets (1961). The nominal Kendrick correction factors are calculated by subtracting the nominal Kuznets components series from the nominal Kendrick series given in Kendrick (1961, pp. 296–97, table A-IIb).

Commerce Department series in 1929, the resulting deflator series is on a 1982 base.[19] This deflator series and the nominal version of the new GNP estimates (calculated by multiplying the real estimates by the deflator) are given in table 2 along with the new real GNP series for 1869–1908.

Characteristics of the New Real Estimates

For those interested in using the new constant-dollar estimates, certain facts are relevant. First, the new estimates are conceptually consistent with modern Commerce Department estimates in their treatment of government expenditures. Because the trend of the new prewar estimates includes Kendrick's revision of the Kuznets series, the new estimates should take into account important changes in the trend level of government spending just as modern estimates do. Furthermore, because the controlling regression uses GNP data that include total government expenditures, the estimated coefficient should capture the typical cyclical behavior of government spending. Thus the new GNP series formed using these coefficients should also incorporate the typical behavior of the public sector.

A second characteristic of the new estimates is that they can be continued very easily with the available GNP series for later years. Because the estimates have been put on a 1982 base and include the Kendrick corrections, they can be continued with the standard Commerce Department estimates that begin in 1929. For the period 1909–28 the new estimates can be continued with those given in Romer (1988), which are also on a 1982 base and which treat government expenditures in the same way that modern estimates do. For reference, these estimates for 1909–28 as well as the Commerce Department observations for 1929 (in both constant and current dollars) are included along with the new estimates for 1869–1908 in table 2.

A final characteristic of the new estimates that must be stressed is the fact that they are just estimates. In deriving these estimates, I have taken care to ensure that the resulting prewar GNP series is as consistent as possible with modern estimates both in the representation of trends and especially in the representation of cyclical movements. Nevertheless, it is still the case that the new prewar series is based on less information and is derived using methods that are very different from those used to construct modern data. As a result, the prewar estimates must be presumed to be subject to a much wider margin of error than modern estimates.

[19] The nominal Gallman-Kendrick series is also ratio-spliced to the nominal Commerce series in 1929 to remove the trivial difference in the level of the two series in this year.

V. Volatility Properties of the GNP Series

Now that new estimates of GNP have been derived, it is natural to ask how these estimates change one's perception of the prewar business cycle. This section considers the basic volatility properties of the new prewar GNP series. Two common measures of the severity of cycles are used to compare the traditional prewar GNP estimates, the new estimates, and actual postwar data on GNP.

The two common measures of volatility that are used to compare the various GNP series are the standard deviation of percentage changes and the standard deviation of deviations from trend. The standard deviation of percentage changes is essentially a measure of general variability. It measures the range of typical annual movements and hence is affected by both the choppiness and the amplitude of short-run movements. The standard deviation of deviations from trend is more a measure of the severity of cycles. It measures the range of cyclical movements and therefore is primarily affected by the amplitude of cycles.

Comparison of Old and New Prewar Estimates

Table 3 shows these measures of volatility for two prewar GNP series: the new estimates and the Kuznets series with both the Gallman and

TABLE 3

Measures of Volatility

Series	Standard Deviation of Percentage Changes*		
	1870–1908	1870–1928	1948–85
Gallman-Kendrick GNP	.052	.052	NA
New GNP estimates	.034	.034	NA
Commerce GNP	NA	NA	.027
Commodity output	.057	.055	.047

Series	Standard Deviation of Deviations from Trend		
	1869–1908	1869–1928	1947–85
Gallman-Kendrick GNP	.053	.050	NA
New GNP estimates	.039	.038	NA
Commerce GNP	NA	NA	.029
Commodity output	.065	.059	.045

Source.—See the text for a description of the derivation of the Gallman-Kendrick GNP series and the new prewar GNP estimates. For 1909–28, the new GNP series is from Romer (1988, p. 104, table 5). The Commerce GNP series is from NIPA (1986, pp. 6–7, table 1.2). The commodity output series for 1869–1938 is the Shaw series from Kuznets (1961, pp. 553–54, table R-21). For 1947–85, commodity output is calculated as the sum of GNP in the three commodity-producing sectors; data are from NIPA (1986, pp. 254–55, table 6.2).

* Percentage changes are calculated as the difference in logarithms. Standard deviations are calculated as the square root of the maximum likelihood estimate of the variance.

the Kendrick revisions. It is useful to limit the prewar comparison to the Gallman-Kendrick series because this is the series used to derive the trend of the new series. Hence, any differences between this series and the new series will be due solely to the representation of annual movements. For reference, however, a brief Appendix discusses the volatility behavior of the other permutations of the prewar Kuznets series.

I examine two prewar time periods. The first is the period 1869–1928. This period corresponds to the "pre-Depression era" and reflects the behavior of the economy after the Civil War but before the cataclysm of the 1930s. To be able to analyze the volatility of the entire pre-Depression era, I continue the new estimates derived in this paper with those for 1909–28 given in Romer (1988). To isolate the impact of just the new estimates derived in this paper, I also examine the volatility of the prewar series only through 1908.

The basic result that is evident from table 3 is that the new prewar estimates are much less volatile than the traditional prewar GNP series. The standard deviation of percentage changes is 42 percent smaller for the new estimates for 1869–1928 than for the traditional estimates. The standard deviation of deviations from trend is 27 percent smaller for the new estimates than for the traditional series. The same results also hold if one examines the two prewar series only through 1908.[20]

This finding indicates that the suspicion that the traditional estimates are excessively volatile is indeed true; prewar estimates derived using more reasonable assumptions about key relationships are noticeably smoother than the traditional estimates. This suggests that business cycles in the pre-Depression era are much less severe than the traditional GNP estimates for the prewar era have led us to believe.

Stabilization of the Postwar Economy

This difference in the volatility of the old and new prewar series also has important implications for the amount of stabilization shown by GNP between the prewar and postwar eras. To analyze stabilization, table 3 reports measures of volatility for the standard Commerce

[20] As this comparison suggests, the new estimates for 1909–28 given in Romer (1988) are also smoother than the traditional Gallman-Kendrick series. For example, the standard deviation of percentage changes for these two decades is .036 for the Romer series and .049 for the Gallman-Kendrick series. It is useful to note that the Romer series is also much less volatile than the undocumented but widely used Commerce Department GNP series for 1909–28 (see NIPA 1986, p. 87, table 1.25). The standard deviation of percentage changes for this series is .066.

Department GNP series for 1947–85. The amount of stabilization shown by the old and the new series can be measured by calculating the ratio of the standard deviation for 1869–1928 for each of the two prewar series to the standard deviation of the conventional Commerce Department GNP series for 1947–85. For percentage changes, this ratio is 1.93 for the Gallman-Kendrick series and 1.26 for the new series. For deviations from trend, this ratio is 1.72 for the Gallman-Kendrick series and 1.31 for the new series.

These numbers indicate that there is much less evidence of stabilization over time when the new GNP estimates are used than when the traditional prewar GNP series is considered. Indeed, between one-half and two-thirds of the stabilization between the pre-Depression and post–World War II eras shown by traditional prewar series disappears when the new estimates are used. This suggests that much of the often-noted stabilization of GNP over time is the result of comparing excessively volatile prewar data with good postwar data.

While these ratios suggest that the old estimates show a great deal of stabilization and the new estimates show very little, there are two issues that should be considered. First, it is useful to see if the difference in volatility between the pre-Depression and postwar eras is statistically significant using either the old or the new prewar GNP series. This can indicate the degree of certainty that one can have regarding either the old or new stylized fact about stabilization.

To test whether the standard deviations or, more precisely, the variances of the percentage changes or the deviations from trend of GNP are significantly different in one period than in another, one cannot use the usual ratio test because the observations are serially correlated. However, it is possible to derive an appropriate test by viewing the variance as the mean of the squared differences of a given series from its mean. Then one can use the standard test for the difference in two means, provided that the serial correlation of the observations is accounted for in the estimation of the standard errors.

To implement this test, I calculate the necessary standard errors using the procedure described in Newey and West (1987). To calculate the standard error of a mean, this procedure simply involves taking a weighted average of the first several autocovariances of the series under consideration.[21] The resulting estimate of the standard

[21] The actual formula that I use for estimating the standard error of the mean of a series is

$$SE = \sqrt{R_0 + 2\sum_{k=1}^{J} w_k R_k},$$

where R_k is the kth autocovariance of the series (divided by the sample size) and $w_k = 1 - [k/(J + 1)]$. In this application I use $J = 3$.

error is consistent even in the presence of serial correlation and heteroscedasticity. Given these standard errors, I then construct a test statistic by taking the difference between the two means (which in this case is in fact the difference between the two variances) and dividing by the square root of the sum of the squared standard errors. This statistic has a standard normal distribution in large samples.

The resulting test statistic for the difference in the variances of the traditional pre-1929 GNP series and the postwar series is 3.77 for percentage changes and 3.56 for deviations from trend. These statistics indicate that the differences between the prewar and postwar variances when the traditional prewar series is used are significant at the 99 percent confidence level. On the other hand, the same test statistic comparing the new prewar GNP series with postwar data is 1.55 for percentage changes and 1.44 for deviations from trend. These statistics indicate that the decline in the variances between the prewar and postwar eras is not significant at even the 90 percent confidence level. This suggests that the modest stabilization shown by a comparison of the new prewar GNP estimates with good postwar data is not statistically significant.

The second issue that arises in comparing the standard deviations of either percentage changes or deviations from trend of the new prewar GNP series with those of actual postwar data involves the fact that the new GNP estimates are derived as the forecasted values of a regression. As a result, one would expect the new prewar estimates to have lower standard deviations than a true GNP series would have just simply because the variance of the residual has been suppressed.[22] One way to gauge the importance of this effect is to construct a GNP series for the postwar era using the same methods as those used to create the new prewar estimates. Since this constructed postwar series will also be the fitted values of a regression, it too should have standard deviations that are biased downward. By comparing the standard deviations of the new prewar estimates with those of the constructed postwar series, one can make more accurate comparisons over time.

When this constructed series is compared with the new prewar estimates of GNP, the results are very similar to those obtained with actual postwar data. For percentage changes, using constructed postwar data in place of actual postwar data raises the ratio of prewar to

[22] It is important to note that comparisons of the standard deviations of the traditional GNP series with those for actual postwar data suffer from a similar problem. Both the Kuznets components series and regression series are created by interpolating GNP solely by commodity output. Hence, none of the movements in true GNP that are uncorrelated with commodity output are included in the traditional prewar estimates either.

postwar standard deviations from 1.26 to 1.31. For deviations from trend, this change raises the stabilization ratio from 1.31 to 1.58. The reason that using the constructed postwar series raises the ratios only modestly is that the within-sample predictive power of the regression used to form new prewar estimates is very high in the postwar era. While it is possible that the true residual variance is larger prewar, this is unlikely given that commodity output was, if anything, a larger fraction of GNP in the past than it is today. Therefore, it is reasonable to conclude that the fact that the new prewar estimates are the forecasted values of a regression does not bias the volatility calculations significantly.

Given that the new prewar estimates of GNP show much less stabilization over time than the traditional estimates, it is useful to point out that this finding is by no means present by construction. The new prewar series is derived by using the estimated relationship between GNP and commodity output in the interwar and postwar eras to convert prewar commodity output data into estimates of GNP. Because this procedure imposes no restrictions on the behavior of the prewar commodity output series, if the commodity output series had stabilized greatly between the prewar and postwar eras, then GNP would have stabilized greatly as well. Furthermore, in the estimation of the crucial relationship, the sensitivity of GNP to commodity output is allowed to be larger in the earlier period than in later years. As a result, if the estimated coefficient used for extrapolating were a strong function of time, GNP could have stabilized significantly even if commodity output had not.

The reason that the comparisons of the new prewar GNP estimates and the standard postwar series do not show a dramatic stabilization is precisely that neither of these conditions holds. First, as can be seen in table 3, commodity output has not shown a dramatic stabilization. The ratio of the pre-Depression (1869–1928) to postwar standard deviations of commodity output is 1.17 for percentage changes and 1.31 for deviations from trend. Second, the estimated sensitivity of GNP to commodity output over the period 1909–28 and 1947–85 is only a very weak function of time. As a result, the coefficient used to transform commodity output data into new prewar estimates of GNP is only slightly larger in 1869 than it is in 1908 or 1985. Thus there is nothing in the behavior of either the base data or the time-varying sensitivity coefficient that could cause GNP to show a dramatic stabilization.

The analysis of why the new prewar estimates show little stabilization when compared with the actual postwar GNP series also provides insight into why the traditional estimates show a dramatic decline in volatility. Since the original Kuznets series that forms the basis for all the traditional prewar series is also derived from the Shaw commodity output series, it is clear that the base data are not the source of the greater volatility of the prewar data. Rather, the dramatic stabilization shown by the Kuznets series is due almost entirely to Kuznets's assumption that GNP moves nearly one for one with commodity output in the period 1869–1908, while GNP moves only about 0.6 for one with commodity output in the postwar era. Since the available evidence suggests that the relationship between GNP and commodity output did not change this dramatically over time, these estimates of the degree of stabilization are almost surely incorrect.

Robustness

From the discussion in Section IV, it is clear that the derivation of the new estimates involves several choices about such things as the specification of the relationship between GNP and commodity output, the time period and data used in the estimation, and the method for calculating trends. While I have tried to argue that all the choices I made were appropriate, it is useful to see if alternative choices that are also reasonable yield a series that has very different volatility properties.

Multiple Regressors

One important choice that I made in deriving the new prewar estimates of GNP is to use only the Shaw commodity output series to interpolate between benchmark observations on GNP. An alternative procedure would be to run a multiple regression and then use several series besides commodity output to form prewar estimates of GNP.[23]

This alternative, however, is likely to matter only if the additional regressors are poor series. If the additional regressors are good series that are consistent over time, adopting multiple regressors should not alter the prewar GNP estimates significantly. The reason for this is that commodity output is an excellent predictor of GNP. Because the commodity output series covers much of the agricultural, mining, manufacturing, and construction sectors of the economy, the explanatory power of the regression of the deviations from trend of GNP on the deviations from trend of commodity output is very high. Furthermore, available evidence suggests that, if anything, the relationship between GNP and commodity output was closer in the prewar era than today because commodities were a larger fraction of total out-

[23] This procedure is done in a limited way in Berry (1978) and directly in Balke and Gordon (this issue).

put. As a result, it is unlikely that even good data on the noncommodity sector of the economy would provide much additional information on the behavior of GNP. Hence including these regressors should not noticeably alter the point estimates or the volatility of the new prewar GNP series.

On the other hand, including poor regressors could alter the new estimates of prewar GNP. The Shaw series is a particularly good interpolating series because it is very consistent over time and because it almost surely bears a stable (though perhaps slightly time-varying) relationship to GNP. Many other series that are available for both the prewar and postwar eras are not truly consistent over time and would therefore be inappropriate to use. For example, using a series that is excessively volatile prewar but accurate postwar would lead to excessively volatile estimates of prewar GNP. Other series—for example, money or the output of a small sector of the economy—do not bear structural relationships to GNP and thus may not have relationships with GNP that are stable over time. If these additional regressors are nevertheless included, the resulting prewar series could be quite different from the new series presented here, and almost surely much less accurate.

Time Periods

If one accepts that it is appropriate to use commodity output as the only predictor of GNP, then all the other derivation issues affect the new estimates of GNP only if they affect the coefficient used to convert prewar commodity output data into estimates of GNP. Therefore, the significance of various changes can be evaluated by seeing whether they alter this crucial coefficient noticeably. Because I allow the relationship between GNP and commodity output to be a function of time, it is necessary to evaluate the effect of various changes on both parts of this coefficient. A convenient way to do this is to discuss the size of the average time-varying coefficient over the period 1869–1908. If a change raises this average coefficient, then the resulting GNP series would be more volatile than the one presented in this paper; if a change lowers this coefficient, the resulting series would be less volatile.

For the new estimates presented in Section IV, the crucial coefficient is derived from a time-varying regression covering the periods 1909–28 and 1947–85.[24] However, small changes in the sample pe-

[24] The relationship is also estimated using a correction for first-order autocorrelation. All the coefficients reported in the section on robustness are also estimated using this correction. When a specific sample period is not mentioned, the period used is 1909–28 and 1947–85.

riod do not affect the parameter estimates noticeably. For example, extending the prewar sample to 1929 yields an average coefficient for 1869–1908 that differs from the standard coefficient by less than .001.

However, altering the sample period to include the 1930s raises the estimated average coefficient from the standard value of .60 to .81. This confirms the suspicion that GNP and commodity output move together much more closely in severe depressions than in other periods. While this change alters the results significantly, I have argued previously that this is not a reasonable change: the fall in commodity output in the 1930s was dramatically larger than any fall in the prewar era, and there are good reasons to suspect that the relationship between commodity output and GNP in such extreme circumstances would not be a good guide to their relationship in normal times.

Time Trends

In the derivation of the new prewar estimates of GNP, the calculation of trend values is also important. Because the specification of the relationship between GNP and commodity output is expressed in deviations from trend, the choice of trend values could affect the coefficient used to construct new prewar estimates. Since the basic method that I use is to construct a piecewise linear trend between years that appear to be points of midexpansion, it is clear that one could argue that other benchmarks are as legitimate as the ones I choose.

As a general rule, specifying alternative benchmarks matters very little, provided that the benchmarks chosen still correspond to years of full but not overfull employment. For example, if the benchmarks are 1910, 1925, 1948, 1956, 1963, 1972, and 1984 instead of 1910, 1924, 1947, 1955, 1962, 1972, and 1981, the estimated average coefficient for 1869–1908 is .63 rather than the standard value of .60. This change would not significantly alter the volatility properties of the new prewar GNP series. Hence, the new estimates appear to be quite robust to the particular years chosen as benchmarks in the calculation of piecewise linear trends.

Data

In the estimation of the relationship between GNP and commodity output, it was also necessary to choose which data to use. First, because the Shaw series stops in 1938, it was necessary to choose a postwar continuation of the commodity output series. For reasons described in Section IV, I measured postwar commodity output as the sum of real GNP in agriculture, mining, and manufacturing. Another series that one might consider using as the postwar extension of Shaw is the Federal Reserve Board (FRB) index of industrial production.[25] The FRB index is an undesirable extension of the prewar Shaw series because it does not include the nonmanufactured agricultural goods that figure prominently in the Shaw series. If one nevertheless uses this flawed series in the backcasting regression, the average coefficient over the period 1869–1908 rises only slightly: it moves from the standard value of .60 to a new value of .63. Thus the new GNP estimates are quite robust even to this undesirable change in the commodity output series used.

For GNP data, I use the series from Romer (1988) for 1909–28. An alternative series that could be used is the official Commerce Department series for these two decades. This series, however, is a very poor series that is completely undocumented and behaves in a way that is contrary to other reliable indicators for this period. (See Romer [1988, pp. 94–102] for a thorough discussion of the flaws in this series.) If one nevertheless uses the Commerce Department GNP series for 1909–28 in the controlling regression, the estimated average coefficient for 1869–1908 is .93. This suggests that in this case the new estimates of prewar GNP are not robust to an unreasonable change in the derivation procedures.

Specification

In estimating the relationship between GNP and commodity output, I allow the coefficient to be a linear function of a time trend. An obvious alternative would be not to include this trend term and to use a constant coefficient to create new prewar GNP estimates. This procedure would be particularly sensible if one wanted to estimate the coefficient using only a short sample of data such as the interwar era.

If one used a non-time-varying regression over the period 1909–28 and 1947–85, the coefficient used to form new prewar estimates would be .55, which is noticeably lower than the average time-varying coefficient of .60 used to form the estimates presented in this paper. If one used a non-time-varying regression over just the period 1909–28, the coefficient would be .59, which is also lower than the coefficient used in this paper. Hence, altering the specification and perhaps the time period in this way would lower the volatility of the resulting prewar estimates of GNP.

While there are clearly many other changes that one could make in

[25] The FRB industrial production index is available in the *Economic Report of the President, 1987* (p. 296, table B-45).

the derivation procedures, the examples discussed here suggest that the new estimates are quite robust to sensible changes in the estimation procedures. Using slightly different data, trends, time periods, or specifications would not alter the coefficient used to convert data on commodity output into estimates of GNP and hence would not alter the volatility properties of the new prewar GNP series.

Given that the new prewar estimates derived in this paper are robust to sensible changes in estimation procedures, it is reasonable to conclude that the new estimates provide an accurate representation of the prewar business cycle. As a result, the finding that the new prewar GNP estimates are only slightly more volatile than the actual postwar data can be viewed as a genuine fact that needs to be analyzed and explained in greater depth.

Appendix

As discussed in the text, there are several existing variants of the basic Kuznets prewar GNP series. First, Kuznets created both the components series and the regression series. Second, Gallman and Kendrick each revised the trend of the Kuznets components series. Third, I combined both the Gallman and Kendrick revisions to yield an additional revision. This last revision (referred to as the Gallman-Kendrick series) is the series that I take to be the best traditional prewar GNP series and hence is the one I use to derive the trend underlying the new estimates.

In Section V, I compare the volatility of the new estimates with the volatility of the Gallman-Kendrick series. In this Appendix I discuss the volatility properties of the other prewar GNP series. The basic finding is that while all these variants have slightly different annual movements, the measures of volatility for the series are roughly similar. More important, even the least volatile of the traditional prewar series is much more volatile than the new GNP series given in table 2 of this paper.

Table A1 shows the standard deviations of both percentage changes and deviations from trend for all five traditional prewar variants of GNP and my new estimates for the period 1869–1908. For all series, trend values are calculated using the methods described in Section IV above. From this table it is clear that the Kuznets components series is the most volatile of all the series. The various revisions to this basic series have all had the effect of reducing volatility at least slightly. First, depending on the measure used, the Kuznets regression series is either slightly or moderately smoother than the components series. This finding is not surprising because, as noted in Section III, this series is derived by assuming that GNP moves 0.9 for one with commodity output rather than essentially one for one, as is assumed in the derivation of the components series. Hence, it should be smoother than the components series.

Second, the Gallman revision is also slightly smoother than the Kuznets components series. However, this difference is due almost entirely to the fact that Gallman's revisions raise the level of GNP in 1869 and hence remove some of the very high growth rates shown by the Kuznets series in the 1870s. In later years the annual movements in the Gallman series and the Kuznets components series are almost identical.

TABLE A1

MEASURES OF VOLATILITY

Real GNP Series	Standard Deviation of Percentage Changes (1870–1908)	Standard Deviation of Deviations from Trend (1869–1908)
Kuznets components	.061	.062
Kuznets regression	.051	.060
Gallman	.055	.056
Kendrick	.057	.058
Gallman-Kendrick	.052	.053
New estimates	.034	.039

SOURCE.—The Kuznets components series and the Kuznets regression series (both in 1929 dollars) are from tables T-5 and T-2, respectively, of the unpublished tables underlying Kuznets (1961). The Gallman series is from Friedman and Schwartz (1982, pp. 122–29, table 4.8) with the unpublished Kuznets capital consumption figures added on. The Kendrick series is from Kendrick (1961, pp. 293–95, table A-IIa). The derivation and sources of the Gallman-Kendrick series and the new series are given in the text.

Third, the Kendrick series is again smoother than the Kuznets components series, though only marginally so. This difference appears to be due to the fact that government spending was slightly countercyclical on occasion in the prewar era. For example, government expenditures rose at more than their trend rate in the recession of 1908, and as a result the fall in real GNP between 1907 and 1908 is 8.6 percent in the Kendrick series while it is 10.1 percent in the Kuznets components series. This kind of government response, however, appears to be limited to just a few years in the prewar era.

Finally, the series that includes both the Gallman and Kendrick revisions is the smoothest of all the traditional prewar GNP series. This finding should not be surprising given that both of the revisions taken separately reduce the volatility of the Kuznets components series slightly and that the two revisions are fairly independent. However, it does indicate that these two revisions, which mainly change the trend of GNP, had some effect on conventional measures of volatility.

While the best traditional prewar estimates of GNP are somewhat less volatile than the standard Kuznets components series, table A1 shows that the Gallman-Kendrick series is still much more volatile than the new estimates derived in this paper. Furthermore, the effect of the Gallman and Kendrick revisions on volatility is substantially smaller than the effect of using more sensible assumptions about the relationship between the deviations from trend of GNP and commodity output.

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