Spurious Volatility in Historical Unemployment Data

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This paper shows that the stabilization of the unemployment rate between the pre-1930 and post-1948 eras is an artifact of improvements in data collection procedures. Prewar methods are used to construct postwar unemployment data that are consistent with the historical data. The constructed postwar series is nearly as volatile as the pre-1930 unemployment data. The constructed postwar data are systematically more volatile than the actual postwar data because the cyclical behavior of the labor force and productivity are misspecified in the construction procedures. The relationship between the actual and constructed postwar unemployment series is used to construct new historical data.

I. Introduction

A. *Problem*

The unemployment rate series for 1900–1980 is not one but several series. Like nearly all aggregate macroeconomic series, it is a combination of modern survey data and less accurate historical series. The modern unemployment series is based on the Current Population Survey, which began in 1940. The pre-1940 data, on the other hand, are pieced together from census data, industry records, and various state reports. With decadal census data as benchmark estimates, annual unemployment is calculated by various forms of interpolation.

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While such inconsistencies between the modern and historical unemployment data may not matter when this series is used to examine long-term trends, they may be very important when the series is used for cyclical comparisons. This paper shows that the methods used to construct the historical data yield an unemployment series that is systematically too volatile. The interpolation methods exaggerate cyclical movements in the historical unemployment series. As a result, comparisons of short-term cyclical movements in the historical and modern unemployment data are fundamentally flawed.

The finding that the prewar data are excessively volatile challenges the belief that the postwar economy is more stable than the prewar economy. In its inconsistent form, unemployment, like most other macroeconomic variables, is dramatically less volatile in the postwar era than in the prewar era. This can be seen in table 1, which shows the mean, standard deviation, and average cyclical amplitude of the unemployment series over various time periods. Even during the most stable prewar period, 1900–1930, the historical unemployment rate is much more variable than the postwar rate. However, if the prewar data are artificially volatile, this apparent stabilization may actually be a figment of the data.

B. *Methodology*

To analyze the effects of the inconsistencies in the unemployment data I rely on unconventional methods. Typical studies of data problems often begin by correcting the historical data and then explain on theoretical grounds why the correction is appropriate. The problem with this approach is that there are many data problems for which solutions do not exist. Furthermore, even if one can form a prewar series that is conceptually similar to the postwar data, the quality and availability of base data in the prewar period are so poor that the prewar series is certainly less accurate than the postwar series. Because of the inaccuracies in the prewar data, comparisons between the prewar and postwar data are flawed.

The fundamental approach of my research is to do just the opposite of what is typically done. Because it is impossible to form prewar data that are as good as the postwar data, I begin by creating postwar data that are as bad as the prewar series. From a description of the historical data, it is possible to construct a series for the postwar years using the same procedures that are used to create the prewar series. For example, if the historical unemployment rate is calculated by interpolating between census years, a postwar series can be created by interpolation as well. Doing this yields a postwar series that is truly consistent with the historical data.

TABLE 1

SUMMARY STATISTICS OF THE UNEMPLOYMENT RATE SERIES

Period	Mean	Standard Deviation	Average Amplitude*
1890–1940	8.71	6.48	6.79
1890–1930	6.20	4.05	5.10
1900–1930	4.84	2.38	4.16
1948–82	5.41	1.58	2.65
1948–73	4.77	1.10	2.23

* Amplitude is measured as the peak to trough change in the level of the unemployment rate. Cycles with a peak to trough change of less than one percentage point are excluded from the calculation of the mean.

This constructed postwar series is very useful. First, it permits valid comparisons of various time periods. It makes it possible to disentangle true economic changes from improvements in our data collection procedures. Second, it allows one to see what errors the construction process adds to the data. By comparing the good (actual) postwar data with the bad (constructed) postwar data, it is possible to analyze and quantify the systematic differences between the two. One can estimate the size and other characteristics of the errors and evaluate their significance.

While turning good data into bad is useful for pointing out possible errors in the constructed data, the process is most fruitful if it leads to the ability to turn bad data into good. There is one obvious way in which the constructed data may be useful for such corrections. If the constructed postwar data bear a systematic relationship to the actual postwar data, it may be possible to derive a simple filter that can be used to correct the prewar constructed data. While one must be very careful in imposing a postwar relationship on prewar data, such an unabashedly ad hoc correction may improve the historical data greatly.

C. *Overview*

The organization of this paper follows the description of the methodology very closely. Section II discusses the construction of a postwar series that is consistent with the historical unemployment rate series. Section III uses the constructed data to make accurate comparisons between the pre-1930 and the post-1948 periods. Section IV analyzes the behavior of the postwar constructed series and compares it with the actual unemployment rate series. It includes a simple model of the relationship between the two postwar series. Section V uses this model to create a potentially more accurate historical unemployment rate series.

II. Constructing Consistent Postwar Data

A. *The Historical Unemployment Series*

The first step in explaining my procedures for turning good data into bad is to describe the historical unemployment data. The now-standard unemployment series for 1890–1940 is that created by Lebergott and described in his book *Manpower in Economic Growth* (1964). Though Lebergott is extremely careful and detailed in his construction of the historical data, his prewar series is less accurate than modern data because of a lack of data and a narrowness of method.

The methods that Lebergott uses to piece together the available base data vary across the prewar era. I concentrate on the period 1900–1930 because the methods that he uses throughout this time period are roughly similar. These methods are described in detail in part 3 of *Manpower in Economic Growth.* In general, Lebergott begins with decadal census data on the labor force, unemployment, and employment. He does some adjusting of the census data, which, for the purposes of this study, I assume to be correct. He then calculates intercensal estimates of the labor force and employment. Unemployment in intercensal years is calculated as a residual.

Labor Force

To construct annual estimates of the labor force, Lebergott first calculates labor force participation rates for various demographic groups in census years and interpolates linearly between these observations. He then multiplies the estimated participation rates by annual population numbers to derive estimates of the labor force. Though taken as fact by this study, the annual population numbers are themselves estimates, based on more exotic interpolation procedures.

It is clear that Lebergott's labor force numbers miss cyclical movements in the labor force. Specifically, they do not take into account the countercyclical fluctuations in the number of discouraged workers that typically dominate the movements in the labor force. Other authors have noticed this problem. For example, Coen (1973) uses the postwar behavior of the labor force to estimate the cyclical movements in the labor force in the interwar period. He finds that movements in the labor force are strongly procyclical in the postwar period. The application of this relationship to the interwar period substantially changes Lebergott's estimates of the labor force and unemployment.

If the labor force were also procyclical in the 1900–1930 period, then it is clear that Lebergott's labor force numbers are too high in recessions and too low in booms. This implies that the unemployment rate calculated as a residual is artificially high in recessions and artificially low in booms. Thus the historical unemployment rate is, by construction, more volatile than the truth.

Employment

To estimate annual employment, Lebergott uses more complicated procedures. He estimates it as the sum of several component series on employment in various sectors and among various classes of workers. To form these component series he begins with basic data on employment in each sector in whatever base years are available. He then interpolates each employment series using some annual variable he believes to be related to employment in that sector. The most common interpolating variables are measures of output, fragments of employment data, and indexes of labor demand.

While interpolating by some fragment of employment data probably yields reasonably accurate estimates of sectoral employment, interpolating by output may lead to systematic errors in the sectoral employment estimates. Usual interpolation procedures assume that the percentage deviations from trend of a given employment series are equal to the percentage deviations from trend of output in the corresponding sector. The typical formula for interpolating between years $t = 0$ and $t = 10$ is

$$\begin{aligned} \text{emp}_t = {} & .1[(10 - t)\text{emp}_0 + t\text{emp}_{10}] + y_t \\ & - .1[(10 - t)y_0 + ty_{10}], \end{aligned} \tag{1}$$

where emp_t is the logarithm of employment, the series to be estimated, and y_t is the logarithm of output, the interpolating variable.[1] Lebergott correctly notes that with frequent benchmarkings, this type of procedure captures most long-run changes in hours and productivity.[2]

However, productivity and hours have strong cyclical movements as well as trend movements. Productivity and hours, at least in the

[1] Friedman (1962) discusses this typical formula in detail. He demonstrates the statistical complexity of interpolation and suggests more accurate correlation procedures.

[2] In discussing the effects of interpolating by output, Lebergott states: "Individual employment series for key industries will in turn tend to reflect changes in production because of the method of estimate. However, the frequency of benchmark counts . . . means fairly frequent checks of the combined productivity and hours factor interpolated between these dates" (Lebergott 1957, pp. 222–23).

postwar period, are significantly procyclical. Firms tend to be slow to fire workers in bad years and slow to hire workers in good years. Typical interpolation procedures miss this effect entirely. They assume that deviations of employment from trend move one for one with deviations of output from trend. The cyclical movements of productivity and hours suggest that the true relationship is much smaller. Thus using the basic interpolation methods leads to a systematic overstating of the cyclical movements of those series for which output is the interpolating variable.

This systematic overstating of cyclical movements in employment has important implications for the unemployment rate. If Lebergott's annual total employment series includes some components that ignore procyclical movements in productivity and hours, then employment is overestimated in boom years and underestimated in slump years. This suggests that the employment effect will exacerbate rather than counteract the labor force effect. The unemployment series is even more biased downward in booms and upward in recessions. Because of this, it is also biased toward having a larger variance and cyclical amplitude than a true unemployment series would have.

It is important to note that the errors I have pointed out in Lebergott's methods for estimating employment are due only to the misspecification of the relationship between employment and output. I have assumed that the base output data that Lebergott uses are correct. Thus one way of summarizing the errors I have identified in Lebergott's estimates of both employment and the labor force is to say that the Okun's law relationship between unemployment and output is misspecified. By assuming that employment in some sectors moves one for one with output and that the labor force has no cyclical component, Lebergott's methods impose that the Okun's law coefficient for the historical unemployment series is biased toward one and away from its actual value of 2.5 or 3.

While this analysis in terms of Okun's law provides a useful framework for considering the errors in Lebergott's methods, it is not strictly correct. Okun's law refers specifically to the aggregate relationship between unemployment and gross national product (Okun 1962). The errors in Lebergott's series are due to the misspecification of the relationship between employment and various measures of output at the sectoral level and to the misspecification of the cyclical behavior of the labor force. To express these errors in terms of Okun's law may lead one to forget that Lebergott's unemployment figures are not the result of imposing a simple aggregate relationship but of careful calculations of the labor force and employment in many sectors.

B. *Applying Old Methods to Current Data*

Changing good postwar data into bad data is a somewhat tedious process. However, because what I do is only an approximation to Lebergott's procedures, it is important to describe my methods in detail. This is especially true because one must believe that these procedures are similar to Lebergott's to believe that the postwar unemployment rate series I construct is more consistent with the historical data than is the actual unemployment series.

Labor Force

As mentioned earlier, Lebergott's procedures for constructing annual estimates of the labor force are relatively straightforward. He merely interpolates participation rates for various demographic groups between census years and then multiplies them by annual population estimates. The only difficulty in replicating Lebergott's procedures is to match his age, sex, and race classifications. Lebergott uses 36 classifications that divide people according to whether they are native white, foreign-born white, or black; male or female; and ages 10–13, 14–19, 20–24, 25–44, 45–64, or 65 and over.

For modern benchmark estimates of the labor force for these groups I use information from the Current Population Survey (CPS) rather than from the *Census of Population.* I do this because the CPS is generally thought to be the more accurate source of data on population, employment, and the labor force.[3] Also, the CPS is the source of the standard annual population and unemployment data. For purposes of comparison later, it is very helpful to have the constructed and actual data based on the same source.

The fact that the CPS provides annual data has another important benefit. If one were to construct a single postwar series by interpolating between actual census years, one might discover biases not present in Lebergott's series. The particular census years might be odd, and this would be causing most of the errors. But with consistent annual data, it is possible to get a rough estimate of the sampling properties of such errors. Rather than construct just one series, one can construct several series by imagining that censuses fell in various years. That is, in addition to creating a series by interpolating between 1950, 1960, 1970, and 1980, one can create other series by interpolating

[3] A Bureau of the Census publication states (1960, p. 3): "It is generally agreed after extensive analysis that the CPS results, which are obtained through a repetitive sample survey with the opportunity for developing a well-trained and controlled field organization, provide more accurate measures of labor force items than a census does."

between 1951, 1961, 1971, 1981; 1952, 1962, 1972, 1982; and so on. The existence of these several series enables one to distinguish between the effects of particular census years and the general effects of the interpolation procedures.

Because the CPS data on the labor force by race do not begin until 1954, it is impossible to replicate Lebergott's procedures for the labor force exactly for the entire postwar period. However, since the CPS data on the labor force by sex and age, but not race, begin in 1948, I can approximate Lebergott's procedures using a finer age-sex breakdown without the race distinction. I classify people according to whether they are male or female and ages 16–17, 18–19, 20–24, 25–34, 35–44, 45–54, 55–64, or 65 and over.[4] Using these classifications I create five series of 30 observations each by imagining that census decades begin in 1948, 1949, 1950, 1951, and 1952, respectively.

Employment

Replicating Lebergott's procedures for estimating employment is much more difficult. To do exactly what Lebergott does for every employment series that he estimates would be nearly impossible. However, it is possible to capture some of the most important errors of his approach. To do this, I construct employment series only for those sectors in which I can replicate Lebergott's procedures fairly well. For the other series I assume that Lebergott manages to estimate employment exactly. That is, in the aggregate employment measure I include the actual employment number for those sectors. Thus the errors in the total employment measure are only ones I am reasonably certain exist in the historical data.

Replicating Lebergott's procedures when he interpolates using some fragment of employment data is very difficult. It is hard to guess what modern fragment might correspond to the fragment that Lebergott actually uses. However, when he interpolates using a measure of output, it is more straightforward to replicate his methods. Fortunately, from the perspective of this study, Lebergott uses output to interpolate three of the largest and traditionally most important employment series: construction, manufacturing, and trade. He does this because, as he notes, "the soundest procedure was to take advantage of the major advances in our knowledge of this period which are associated with the names of Shaw, Fabricant, Kuznets and others

[4] This approximation to Lebergott's procedures is quite accurate. When one compares the constructed labor force numbers for the 1958, 1968, 1978 series using both Lebergott's methods and my approximation to them, the difference between the two series is almost always less than 0.1 percent of the actual labor force number and usually less than 0.025 percent.

who have laboriously developed basic production series" (Lebergott 1957, p. 222).

The actual activity series that Lebergott uses for each of these sectors are described in detail in the Appendix. I describe them only briefly here. For 1900–1920, Lebergott interpolates employment in construction by Shaw's (1947) series on the output of construction materials. For 1920–30, he uses the Commerce Department's series on the value of new construction, deflated by the price of input materials as the interpolating series.

For the period 1909–19, Lebergott interpolates employment in manufacturing by Shaw's estimates of the output of finished goods plus construction materials. For 1899–1909, Lebergott interpolates total employment in manufacturing by manufacturing employment in a sample of states. The Appendix discusses this procedure and shows that the results of this method are similar to those using output.

Finally, Lebergott interpolates the number of employees in retail and wholesale trade for 1900–1929 by the number of goods sold. He uses disaggregated data on employees in a particular line of trade and interpolates by the real output of finished goods in the same category. For example, he interpolates the number of employees in food stores by Shaw's series on the real output of food.

While there are other sectors, such as transportation and banking, in which Lebergott uses a measure of output as the interpolating variable, the three sectors I consider are clearly the most important. Employment in construction, manufacturing, and trade accounts for 47 percent of total employment in 1972. Employment in these same sectors accounts for approximately 37 percent of total employment in 1910.[5] While their share is somewhat smaller in the pre-1930 era, the construction, manufacturing, and trade sectors clearly account for a substantial fraction of total employment in both the prewar and postwar eras. For this reason, these are the only three employment series that I attempt to construct. All the others are set equal to their actual values.

It is useful to note that the Shaw series that Lebergott uses to interpolate employment in these three sectors appears to provide a fairly accurate measure of industrial production. Shaw's data are based on data from various volumes of the *Census of Manufactures* and numerous annual state records. Because his series relies on a larger sample of base data than most of the other prewar indexes of produc-

[5] For 1972 this calculation is based on the ratio of wage and salary workers in construction, manufacturing, and trade to total employment. Data on these quantities are from the CPS. For 1910 the calculation is based on the ratio of employees in construction, manufacturing, and trade establishments to total employment. The data are from Lebergott (1964, tables A-3, A-5).

tion, it is probably more accurate than most other output measures. Another characteristic of the Shaw series is that it is somewhat less volatile than most of the other output measures. As a result, it is likely that most of the excess volatility of the prewar employment numbers comes from the misspecification of the employment-output link, not from the underlying output data.

To approximate Lebergott's procedures for the postwar period, I use series that are conceptually similar to Shaw's data. In general, because the various Shaw series are essentially measures of industrial production, I use industrial production data from the Federal Reserve Board to construct postwar data. For employment in construction I interpolate by the Federal Reserve Board index of the output of construction materials. For employment in manufacturing I use the Federal Reserve Board index of the production of final products, adjusted to include construction materials, as the interpolating variable. For trade, I interpolate by the Federal Reserve Board index of final products destined for consumers. This is an aggregate approximation to Lebergott's procedure of estimating employment in various lines of trade separately.

The Appendix contains a detailed study of the effects of using these particular activity variables. I try a wide variety of variables for each sector and find that the results described in the rest of the paper do not depend on the choice of the activity variable.

The actual construction of the employment series for construction, manufacturing, and trade is relatively straightforward. I use the formula given in equation (1). Following Lebergott, I interpolate between 10-year benchmarks for trade and construction. For manufacturing I interpolate between 5-year benchmarks because for 1899–1919 Lebergott has quinquennial data from the *Census of Manufactures.* The benchmark estimates I use are simply the actual data on wage and salary workers in construction, manufacturing, and trade from the CPS. As in the replication of Lebergott's procedures for estimating the labor force, I form five possible constructed series for employment in each sector by supposing that benchmark intervals begin in 1948, 1949, 1950, 1951, and 1952.

The resulting constructed series on employment in the various sectors for each base year are combined with data on actual employment for all remaining sectors and classes of workers to form constructed series on total employment for each base year. These estimates of total employment are combined with the constructed labor force numbers to form estimates of postwar unemployment that are roughly consistent with Lebergott's prewar series.[6] I construct five

[6] The actual combination of the two series is very simple because the CPS data on the labor force, employment, and unemployment are mutually consistent and exhaustive. Because Lebergott's base data are often not exhaustive, he uses a more complicated

postwar unemployment series corresponding to the five possible combinations of benchmark estimates. These constructed unemployment series, as well as the actual postwar unemployment rate series, are shown in table 2. The prefix *UI* denotes that the unemployment series is formed using both constructed labor force and employment series. The numerical suffix denotes the first base year.

III. Accurate Comparisons of Various Time Periods

The most obvious use of the constructed data is to make accurate comparisons of the prewar and postwar unemployment rate data. Because the two series are now roughly consistent, any change in the behavior of the two series reflects true economic changes rather than improvements in data collection procedures. Another way to view it is that these comparisons show what the stylized facts would have been had we used the same data collection procedures throughout both periods.

In forming the consistent postwar series, I have replicated the methods Lebergott uses for the period 1900–1930. Thus the only valid comparison is between the pre-1930 data and the post-1948 data. While this comparison clearly excludes the very important decade of the 1930s, it is still useful. The notion that the prewar unemployment rate was substantially more volatile than the postwar unemployment rate does not stem from the fact that the Great Depression occurred in the prewar rather than the postwar era. As table 1 showed, Lebergott's unemployment series for 1900–1930 is approximately 50 percent more volatile than the actual postwar series. Thus a comparison of consistent unemployment data over these same periods can provide useful information about whether this apparent stabilization actually occurred or is an artifact of data inconsistencies.

A. *Severity of the Cycle*

Figure 1 shows Lebergott's unemployment series for 1900–1930 and the constructed series for the postwar period (based in 1950, 1960, 1970, and 1980) for 1950–80. In terms of the overall picture, I could use any one of the five constructed postwar series since their basic movements are similar. One thing is apparent from the figure: relative to the period 1900–1930, there is no stabilization of the postwar

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two-step procedure. He forms a preliminary unemployment series by subtracting a preliminary estimate of total employment from his series on the annual labor force. He then uses this series to interpolate between census observations on unemployment.

TABLE 2

ACTUAL AND CONSTRUCTED UNEMPLOYMENT RATES FOR THE POSTWAR PERIOD

Year	*UA**	*UI*48[†]	*UI*49	*UI*50	*UI*51	*UI*52
1948	3.76	3.76	...	...	...	...
1949	5.94	7.17	5.94	...	...	...
1950	5.29	3.40	1.98	5.29	...	...
1951	3.31	2.65	1.14	4.13	3.31	...
1952	3.04	2.40	.79	3.42	2.78	3.04
1953	2.91	2.55	.84	3.13	2.64	2.73
1954	5.55	6.72	5.45	7.24	6.93	6.84
1955	4.38	2.96	2.16	3.50	3.32	3.04
1956	4.14	1.93	1.65	2.50	2.44	1.99
1957	4.27	3.09	3.32	3.66	3.55	3.11
1958	6.80	6.80	7.48	7.37	7.21	6.95
1959	5.47	4.41	5.47	4.89	4.67	4.57
1960	5.53	5.20	6.10	5.53	5.26	5.33
1961	6.68	6.80	7.56	7.11	6.68	6.91
1962	5.54	5.44	6.10	5.75	5.25	5.54
1963	5.67	5.86	6.40	6.16	5.59	5.76
1964	5.18	5.53	5.80	5.66	5.02	5.07
1965	4.52	4.51	4.68	4.47	3.75	3.70
1966	3.79	3.41	3.47	2.84	2.40	2.22
1967	3.85	4.25	4.21	3.16	2.81	2.70
1968	3.58	3.58	3.43	1.92	1.67	1.89
1969	3.51	3.37	3.51	1.56	1.40	1.95
1970	4.95	6.76	6.80	4.95	4.84	5.66
1971	5.95	7.91	7.84	6.08	5.95	7.06
1972	5.60	6.23	6.03	4.28	4.09	5.60
1973	4.88	5.26	4.92	3.20	2.94	4.12
1974	5.61	7.03	6.87	5.29	4.97	5.70
1975	8.45	11.53	11.36	10.15	9.77	10.08
1976	7.70	9.00	8.78	7.39	7.30	7.26
1977	7.06	7.38	7.11	5.58	5.52	5.37
1978	6.07	6.07	5.74	4.09	4.07	3.57
1979	5.85	...	5.85	4.11	4.12	3.29
1980	7.14	...	...	7.14	7.15	6.07
1981	7.61	...	...	...	7.61	6.23
1982	9.69	...	...	...	...	9.69

* *UA* denotes the actual unemployment rate.

[†] *UI*48 denotes the constructed unemployment rate based on 1948, 1958, 1968, 1978; *UI*49 denotes the unemployment rate based on 1949, 1959, 1969, 1979, etc.

unemployment rate. The severity of cyclical swings is nearly identical in both periods.

Cyclical Amplitude

This fact is easily quantified. The most common measure of the severity of the cycle is the average peak to trough change in the unemployment rate. Thus a simple test of the hypothesis that the pre-Depression and the postwar cycles are equally severe is to

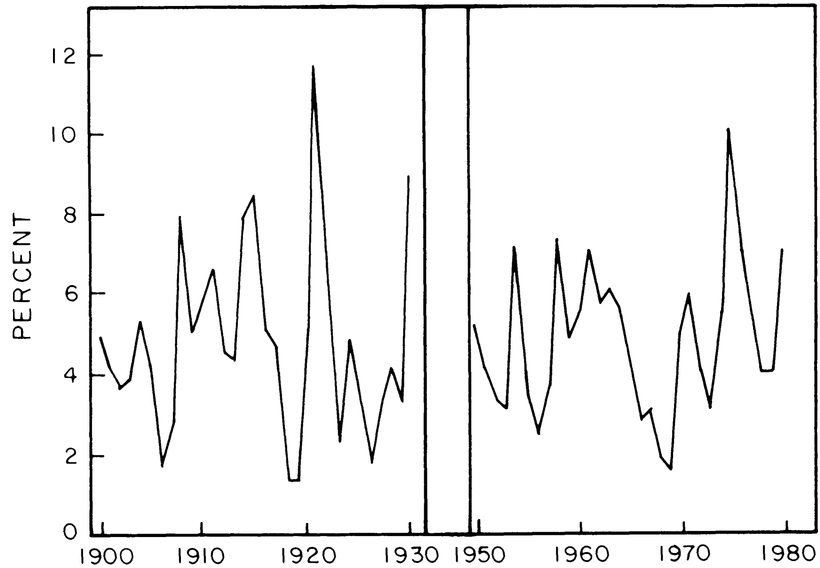

FIG. 1.—Consistent unemployment rate series. The series for 1900–1930 is Lebergott's unemployment rate series. The series for 1950–80 is the constructed unemployment series *UI*50.

compare the peak to trough movements in the pre-1930 Lebergott series and the post-1948 constructed series. This is done in table 3, which shows the average cyclical amplitude for Lebergott's series and all five of the constructed series. To calculate these cyclical amplitudes, peaks and troughs are defined as the actual turning points in the various unemployment series. Cycles with a peak to trough increase in unemployment of less than one percentage point are excluded from the calculation of the mean.

The similarity between all the constructed series is very strong. When consistent data are used, there is no damping of the amplitude of the business cycle. In fact, the amplitudes of the constructed postwar unemployment rate series are slightly greater than the amplitude of Lebergott's series for 1900–1930. This is certainly a contrast to the comparison of Lebergott's prewar series with the actual postwar unemployment rate. When inconsistent data are used, the postwar period looks markedly more stable.

Standard Deviation

While the amplitude of the cycle is a common measure of the severity of cyclical swings, it is in some sense an arbitrary measure. The definition of a cycle is imprecise, and the cyclical amplitude may be

TABLE 3

AVERAGE CYCLICAL AMPLITUDES

Period	Series	Average Amplitude*
1900–1930	*U*LEB	4.16
1948–78	*UI*48	4.30
1949–79	*UI*49	4.69
1950–80	*UI*50	4.53
1951–81	*UI*51	4.49
1952–82	*UI*52	4.82
1948–82	*UA*	2.65

* Amplitude is measured as the peak to trough change in the level of the unemployment rate.

affected by the particular definition chosen. The standard deviation of the constructed unemployment series is a more straightforward measure of volatility. The standard deviations for the prewar and postwar constructed series are shown in table 4.

The results are very similar to those for the cyclical amplitudes. Whereas a comparison of Lebergott's pre-1930 series with the actual postwar unemployment rate shows an obvious stabilization, a comparison of Lebergott's series with the constructed postwar series shows little stabilization. On average, the standard deviation of the constructed postwar series is only approximately 10 percent less than that of Lebergott's series for 1900–1930. Furthermore, table A1 of the Appendix shows that this result holds regardless of what output variables are used to interpolate employment in the various sectors.

TABLE 4

STANDARD DEVIATIONS

Period	Series	Standard Deviation*
1900–1930	*U*LEB	2.38
1948–78	*UI*48	2.19
1949–79	*UI*49	2.48
1950–80	*UI*50	1.90
1951–81	*UI*51	1.98
1952–82	*UI*52	2.14
1948–82	*UA*	1.58

* The standard deviation of the level of the unemployment rate around its mean.

The noticeable absence of stabilization is also robust to the choice of time period. Keynesians might argue that the supply shocks of the 1970s were a unique destabilizing force and that it is only the period 1948–73 that is more stable than the pre-1930 era. Even this assertion fails when consistent data are compared. The standard deviations and amplitudes of the constructed postwar unemployment series before 1974 are shown in table 5. The amplitudes of the pre-1974 series are still very similar to the amplitude of Lebergott's pre-1930 series. The standard deviations of the pre-1974 series are somewhat smaller than that of the pre-1930 Lebergott unemployment data but still substantially larger than the standard deviation of the actual postwar series before 1974. Thus a comparison of consistent unemployment data still shows little stabilization of the postwar economy, even if one excludes the years after the first oil shock.

B. *Time-Series Properties*

In addition to the severity of the cycle, a second aspect of the volatility of the cycle is the choppiness of cyclical movements. A common perception is that prewar cycles are much shorter and much less protracted than postwar cycles. In terms of the time-series properties of the various unemployment series, this translates into the perception that a given shock has greater persistence in the postwar era than in the prewar era.

Standard Deviation of the Change in Unemployment

The standard deviation of the change in the unemployment rate is a simple measure of the choppiness of the cycle. This measure shows

TABLE 5

STANDARD DEVIATIONS AND AVERAGE AMPLITUDES BEFORE 1974

Period	Series	Standard Deviation	Average Amplitude
1900–1930	*U*LEB	2.38	4.16
1948–73	*UI*48	1.72	3.91
1949–73	*UI*49	2.19	4.25
1950–73	*UI*50	1.66	3.93
1951–73	*UI*51	1.68	3.91
1952–73	*UI*52	1.80	4.15
1948–73	*UA*	1.10	2.23

the average size of yearly fluctuations in unemployment. It indicates whether unemployment moves gradually through the cycle or shifts rapidly from peak to trough. The standard deviations of the change in the actual and constructed unemployment series for various time periods are shown in table 6.

The results show that the year-to-year volatility of the constructed postwar unemployment series is much larger than that of the actual postwar series. At the same time, it is also noticeably smaller than that of the historical unemployment series. On average, the standard deviation of the change in the constructed unemployment rate series is approximately 30 percent smaller than the standard deviation of the change in the historical series.[7] This finding suggests that even when consistent data are compared, yearly fluctuations are smaller in the postwar era than in the prewar era. However, the decline in the choppiness of the cycle in the consistent data is only half as large as the apparent decline in the inconsistent data.

Sample Autocorrelations

The time-series properties of the various unemployment series can be analyzed more generally by examining the sample autocorrelations of each series. The sample autocorrelations show the correlation of a given series with itself at various lags. The pattern of these autocorrelations can suggest the nature of the serial correlation in the various

TABLE 6

STANDARD DEVIATIONS OF THE CHANGE IN UNEMPLOYMENT

Period	Series	Standard Deviation*
1900–1930	*U*LEB	2.86
1948–78	*UI*48	2.19
1949–79	*UI*49	2.15
1950–80	*UI*50	2.15
1951–81	*UI*51	2.11
1952–82	*UI*52	2.19
1948–82	*UA*	1.22

* The standard deviation of the change in the unemployment rate around its mean.

[7] This result also holds when the sample is stopped in 1973. In this case the average standard deviation of the change in the constructed unemployment rate series is 35 percent smaller than the standard deviation of the change in the pre-1930 Lebergott series.

unemployment series. The sample autocorrelations for the first 10 lags of the prewar and postwar unemployment series under consideration are given in table 7.

The degree of first-order serial correlation is of particular interest. It is a simple measure of the persistence of shocks in the various unemployment series. The figures in table 7 show that the degree of first-order autocorrelation is much lower in the Lebergott unemployment series for 1900–1930 than it is in the actual postwar unemployment series. This is certainly consistent with the usual belief that cycles are much more protracted in the postwar era than in the prewar era.

The first-order sample autocorrelations of the constructed postwar series are, in general, substantially smaller than that of the actual postwar unemployment rate series. Only one of the five constructed postwar series (*UI*49) shows persistence as large as that of the actual postwar series. On the other hand, the first-order autocorrelations of the constructed postwar series are also substantially larger than that of the prewar Lebergott series. In fact, on average the first-order serial correlation of the constructed postwar series is approximately halfway between that of the prewar Lebergott series and that of the postwar actual series.

These findings suggest that prewar and postwar cycles look much more similar when consistent data are compared than when inconsistent data are analyzed. The increased persistence of shocks between the prewar and postwar eras apparent in the inconsistent data is much less pronounced in the consistent data. While even consistent data reveal somewhat more protracted and persistent cycles in the postwar era than in the pre-1930 era, the actual change in this series has been slight rather than dramatic.

The overall pattern of the first several sample autocorrelations provides some additional information about the various unemployment series. The figures in table 7 show that the prewar Lebergott series and the actual postwar unemployment series have very different autocorrelation patterns. The prewar unemployment series has sample autocorrelations that die out very quickly; in fact, the second autocorrelation is negative. A given shock has very little persistence in the prewar era. The actual postwar series, on the other hand, has sample autocorrelations that die off gradually; the first five autocorrelations are positive and progressively smaller. A given shock continues to have a positive effect for several subsequent years.

The autocorrelation patterns of the five constructed postwar unemployment series are very different from one another. The patterns for *UI*50, *UI*51, and *UI*52 are very similar to that for Lebergott's prewar unemployment series. The patterns for *UI*48 and *UI*49 are

TABLE 7

Sample Autocorrelations

	Series						
Lags	*U*LEB (1900–1930)	*UA* (1948–82)	*UI*48 (1948–78)	*UI*49 (1949–79)	*UI*50 (1950–80)	*UI*51 (1951–81)	*UI*52 (1952–82)
1	.254	.579	.506	.633	.357	.409	.395
2	−.255	.344	.223	.334	−.084	−.060	−.001
3	−.198	.244	.202	.254	−.042	−.024	−.080
4	−.214	.274	.241	.234	.150	.199	.009
5	−.169	.229	.156	.096	−.001	.114	−.044
6	.207	.046	−.072	−.094	−.280	−.098	−.123
7	.140	−.046	−.116	−.200	−.364	−.319	−.084
8	−.133	−.214	−.178	−.266	−.366	−.376	−.255
9	.028	−.173	−.060	−.158	−.178	−.188	−.114
10	.024	−.156	−.076	−.112	−.055	−.065	−.096

equally similar to the autocorrelation pattern of the actual postwar unemployment data. The large difference between the five constructed postwar series suggests that the benchmark estimates used in the construction process may be an important determinant of the pattern of autocorrelation. Since the five series differ only in which years are used to determine trends, these different trends are the most plausible source of the difference in the serial correlation properties.

The fact that the five postwar constructed unemployment series differ substantially in their autocorrelation patterns makes it difficult to assess how much change has actually occurred over time. It is possible to conclude that there has been little change or much change in the serial correlation properties of the unemployment series over time, depending on which of the five possible extensions of Lebergott's pre-1930 series one considers. Since it is very difficult to decide which of the constructed postwar series has benchmark years most similar to those Lebergott uses to construct the prewar data, it is best to leave the degree of change in the overall pattern of serial correlation as an unresolved issue.

Despite this particular ambiguity, it is possible to draw two conclusions about what the stylized facts concerning the unemployment rate series over time would be if economists used consistent rather than inconsistent data. One new stylized fact would be that the business cycle from 1900 to 1930 is no more severe than the cycle from 1948 to 1982. The second new stylized fact would be that while even consistent data show more protracted cyclical movements in the postwar era than in the prewar era, the change over time has been only about half as large as the analysis of inconsistent data has led economists to believe.

IV. The Behavior of the Constructed Postwar Series

The preceding section showed what the stylized facts about the pre-1930 and the post-1948 unemployment rates would have been had the United States not revamped its data collection procedures. This section analyzes the behavior of the constructed series in the postwar period. It examines the difference between the actual and constructed postwar unemployment rates. It derives and tests a model of the relationship between the two series and uses the results to suggest the source of the systematic errors in the constructed series. This section also uses a series of counterfactual experiments to decompose the source of the errors into those due to estimating the labor force and those due to estimating employment.

A. The Relationship between the Actual and Constructed Series

As discussed in Section II, certain facts about the cyclical behavior of the labor force and employment suggest possible errors in the constructed unemployment data. The fact that Lebergott's estimation techniques neglect procyclical movements in the labor force, productivity, and hours implies that the cyclical movements in the constructed unemployment rate may be exaggerated. Figure 2 suggests that this is indeed the case. It graphs the actual unemployment rate (*UA*) and the constructed unemployment rate (*UI*50) and shows that *UI*50 is consistently more volatile. Given this qualitative evidence, it is useful to test whether the suspected errors in the constructed series actually do account for the systematic differences between the actual and constructed series.

Model

To do this I derive a model of the relationship between the two series. The derivation centers on the difference between the interpolation formulas for the constructed series and the more likely regression formulas for the true series. For the labor force the construction formula is

$$\mathrm{lf}_I = \overline{\mathrm{lf}_A} + e_0, \qquad (2)$$

where lf_I is the logarithm of the constructed (interpolated) labor force and $\overline{\mathrm{lf}_A}$ is the trend of the logarithm of the actual labor force. The error term, e_0, is included to account for the fact that this interpolation formula is a simplification of Lebergott's procedures.

We suspect that the regression formula for the true labor force should be more complicated than this simple interpolation formula. Specifically, we suspect that the true labor force depends on the business cycle. Thus a likely representation of the true labor force is

$$\mathrm{lf}_A = \overline{\mathrm{lf}_A} + a(y - \bar{y}) + e_1, \qquad (3)$$

where lf_A is the logarithm of the actual labor force, y is the logarithm of any conventional measure of output, and a is presumably positive. The deviation of output from its trend is used as a measure of the cycle.

For employment, the construction procedures imply that

$$\mathrm{emp}_I = \overline{\mathrm{emp}_A} + c(y - \bar{y}) + e_2, \qquad (4)$$

where emp_I is the logarithm of the constructed total employment series and $\overline{\mathrm{emp}_A}$ is the trend of the logarithm of the actual total

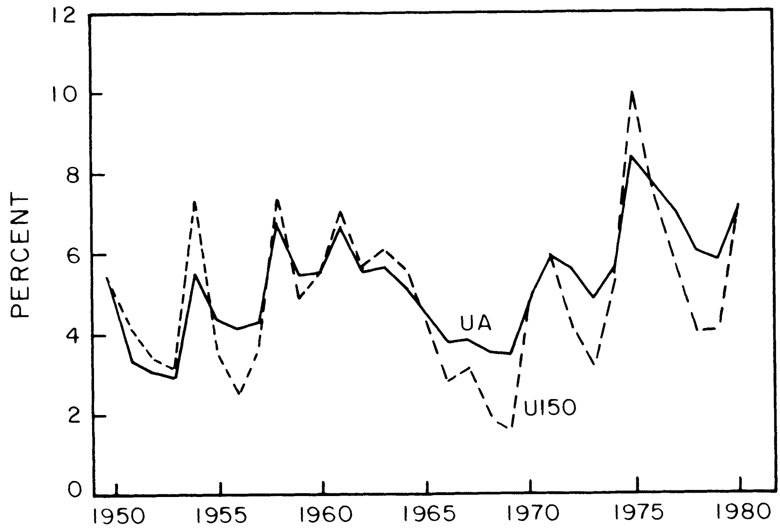

FIG. 2.—Actual and constructed employment rates. *UA* is the actual unemployment rate series and *UI50* is the constructed unemployment rate series based in 1950.

employment series. The coefficient on $(y - \bar{y})$ enters not because of the interpolation procedures but because the total constructed employment series includes some actual and some interpolated series for individual sectors. If all sectors were interpolated, c would equal one by construction and there would be no error e_2.

We suspect that this interpolation formula differs from the true regression relationship in two ways. First, true employment is probably less responsive to current output than the construction formula implies. Second, actual employment may depend on lagged output. Thus actual employment may be more correctly modeled as

$$\text{emp}_A = \overline{\text{emp}_A} + b_0(y - \bar{y}) + b_1(y - \bar{y})_{-1} + e_3, \tag{5}$$

where b_0 is positive but less than c. The coefficient on lagged output (b_1) is also likely to be positive because it is capturing the fact that employment is a lagging indicator.

From these relationships one can derive a model of the difference between the level of the constructed unemployment rate (*UI*) and the level of the actual unemployment rate (*UA*). Using the approximation $\ln(1 - x) \doteq -x$ yields the following expression for *UI*:

$$\begin{aligned} UI &\doteq -\ln(1 - UI) \\ &= -\ln\left[1 - \left(1 - \frac{\text{EMP}_I}{\text{LF}_I}\right)\right] \\ &= \ln \text{LF}_I - \ln \text{EMP}_I. \end{aligned} \tag{6}$$

Here capital letters denote variables in levels rather than logarithms. A similar relationship holds between UA and LF_A and EMP_A. Substituting these relationships and adding an error term (e_4) to account for the approximation yields

$$\begin{aligned} UI - UA &= (\mathrm{lf}_I - \mathrm{emp}_I) - (\mathrm{lf}_A - \mathrm{emp}_A) + e_4 \\ &= -(a + c - b_0)(y - \bar{y}) + b_1(y - \bar{y})_{-1} \\ &\quad + e_0 - e_1 - e_2 + e_3 + e_4. \end{aligned} \tag{7}$$

Using the same approximation as above one can show that

$$\overline{UI} \doteq \overline{\mathrm{lf}_I} - \overline{\mathrm{emp}_I} = \overline{\mathrm{lf}_A} - \overline{\mathrm{emp}_A}. \tag{8}$$

Substituting this relationship yields

$$\begin{aligned} UI - \overline{UI} &= (\mathrm{lf}_I - \mathrm{emp}_I) - (\overline{\mathrm{lf}_A} - \overline{\mathrm{emp}_A}) \\ &= (\mathrm{lf}_I - \overline{\mathrm{lf}_A}) - (\mathrm{emp}_I - \overline{\mathrm{emp}_A}) \\ &= 0 - c(y - \bar{y}) + e_0 - e_2. \end{aligned} \tag{9}$$

This implies that

$$\begin{aligned} UI - UA = {} & \left(\frac{a + c - b_0}{c}\right)(UI - \overline{UI}) \\ & - \left(\frac{b_1}{c}\right)(UI - \overline{UI})_{-1} + e, \end{aligned} \tag{10}$$

where $(a + c - b_0)/c$ is positive, $-(b_1/c)$ is negative, and e is the combined error term. Equation (10) shows the relationship between UI and UA that one might expect knowing the interpolation formulas and some stylized facts about the postwar economy.

Estimation

To test whether this is indeed the relationship between UI and UA, equation (10) can be rewritten as the following estimating equation:

$$UI - UA = g_0(UI - \overline{UI}) + g_1(UI - \overline{UI})_{-1} + e. \tag{11}$$

If the explanatory power of this model is high, then it is likely that the suspected sources of the errors in UI do explain the systematic deviations of the constructed unemployment series from the truth.

This model can be estimated in two ways. One is to run the regression for each of the five constructed postwar series. The other is to pool all five series and constrain the response to be similar. Since the results from the two procedures are very similar, I report only the results from the pooled regression. In both cases I exclude some observations to take into account the fact that, by construction, $UI = UA$ in census years. This model is designed to explain how intercensal estimates of the constructed unemployment rate (UI) differ from the actual unemployment rate (UA), and thus it is run on data excluding census years.

The basic results are

$$UI - UA = \underset{(.029)}{.528}(UI - \overline{UI}) - \underset{(.029)}{.136}(UI - \overline{UI})_{-1} + e; \qquad (12)$$

$$\text{S.E.} = .615,$$

where the standard errors are in parentheses. For reference, when a constant is included, it is not significantly different from zero, and the R^2 is .77. While the explanatory power of the regression is very high, the Durbin-Watson statistic is .63. This suggests that there is serial correlation. To correct for this I include a lagged dependent variable.[8] The expanded results are

$$UI - UA = \underset{(.023)}{.484}(UI - \overline{UI}) - \underset{(.042)}{.458}(UI - \overline{UI})_{-1} \qquad (13)$$

$$+ \underset{(.084)}{.749}(UI - UA)_{-1} + e; \ \text{S.E.} = .476.$$

Again, when a constant is included it is not significant, and the R^2 is .86.

Despite the presence of serial correlation, the key finding is that the basic model of the systematic errors in the constructed unemployment series does fit the data quite well. The errors predicted on the basis of a knowledge of certain facts about the postwar labor market are indeed the main errors present in the constructed data. This suggests that most of the errors in the constructed unemployment series are due to the misspecification of the output-employment link and the failure to take into account procyclical movements in the labor force.

The fact that the specification including a lagged endogenous variable fits the data slightly better than the simple specification in equation (11) suggests that there are some explanatory variables that are

[8] Alternatively, one can use the Cochrane-Orcutt correction for first-order serial correlation. The results are very similar to those in eq. (13). The estimated equation is

$$UI - UA = \underset{(.024)}{.501}(UI - \overline{UI}) - \underset{(.024)}{.087}(UI - \overline{UI})_{-1} + e;$$

$$\rho = \underset{(.056)}{.819}, \ \text{S.E.} = .498,$$

where standard errors are in parentheses.

excluded from the model. One example of an excluded variable that might give rise to serial correlation is a more complicated trend term. It is very likely that the 10-year linear trend used to describe the trend of the actual employment and labor force series is too simple. While the slight difference in fit of the two specifications suggests that the excluded variables are not particularly important, their existence does indicate that some of the systematic differences between the actual and constructed series may not be related to the business cycle.

B. *Decomposing the Source of Systematic Errors*

The results of the model show that the main source of the systematic errors in the constructed unemployment rate is the misspecification of the cyclical behavior of unemployment. However, the results do not show whether it is understating the cyclical response of the labor force or overstating the cyclical response of employment that is the more important mistake. Counterfactual techniques, however, do provide a way to separate and evaluate the importance of both errors.

To do this one can consider two experiments. Instead of estimating both the labor force and employment to calculate unemployment, suppose that one knew the true level of employment. Then the unemployment rate (designated *UL*) is calculated as

$$UL = \frac{\mathrm{LF}_I - \mathrm{EMP}_A}{\mathrm{LF}_I},$$

where *I* denotes an estimated series and *A* denotes an actual series. A comparison of *UL* with the actual unemployment rate, *UA*, shows the effect of having to estimate only the labor force.

One can also suppose that the true labor force is known but that total employment must be estimated. The resulting unemployment rate (designated *UE*) is

$$UE = \frac{\mathrm{LF}_A - \mathrm{EMP}_I}{\mathrm{LF}_A}.$$

One can compare *UE* with *UA* to see the pure effect of estimating employment. Furthermore, one can also compare *UE* with *UL* to see the relative size of the labor force and employment effects.

An obvious characteristic on which to compare these series is the average cyclical amplitude. Table 8 shows the average peak to trough change of the true unemployment rate (*UA*), the completely constructed unemployment rate (*UI*), and the two new hypothetical unemployment rates (*UL* and *UE*) for all five base years. The results are quite straightforward. First, both *UL* and *UE* have substantially higher cyclical amplitudes than does the actual unemployment series.

TABLE 8

AVERAGE CYCLICAL AMPLITUDES

	SERIES				
BASE YEAR	*UA**	*UI*†	*UL*‡	*UE*§	*UEM*‖
1948	2.45	4.30	3.03	3.78	3.37
1949	2.50	4.69	3.20	4.24	3.49
1950	2.50	4.53	3.09	4.04	3.38
1951	2.50	4.49	2.97	4.18	3.64
1952	2.65	4.82	3.32	4.36	3.90

* *UA* denotes the actual unemployment rate. The amplitude of *UA* is calculated for the 30-year period beginning in the base year listed.
† *UI* denotes the constructed unemployment rate based on estimated labor force and employment.
‡ *UL* denotes the hypothetical unemployment rate based on estimated labor force and actual employment.
§ *UE* denotes the hypothetical unemployment rate based on actual labor force and estimated employment.
‖ *UEM* denotes the hypothetical unemployment rate based on actual labor force, actual employment in manufacturing, and estimated employment in trade and construction.

This shows that estimating either the labor force or employment using Lebergott's methods raises the cyclical amplitude of the resulting unemployment rate series.

Second, the two effects compound rather than counteract each other. The difference between the amplitude of the totally constructed unemployment rate *UI* and the actual unemployment rate *UA* is approximately equal to the sum of the differences between the amplitudes of *UL* and *UA* and the amplitudes of *UE* and *UA*. That is,

$$\mathrm{AMP}(UI) - \mathrm{AMP}(UA) \doteq [\mathrm{AMP}(UL) - \mathrm{AMP}(UA)] + [\mathrm{AMP}(UE) - \mathrm{AMP}(UA)],$$

where AMP denotes amplitude. This fact makes the decomposition of the source of the excessive volatility of the totally constructed series very easy. The ratio

$$\frac{\mathrm{AMP}(UE) - \mathrm{AMP}(UA)}{[\mathrm{AMP}(UE) - \mathrm{AMP}(UA)] + [\mathrm{AMP}(UL) - \mathrm{AMP}(UA)]}$$

is a measure of the amount of the exaggeration of the amplitude of the constructed unemployment series that is due to estimating employment. For each of the five base years, this ratio is at least .70. This shows that estimating employment accounts for 70 percent of the cyclical exaggeration of *UI*, while estimating the labor force accounts for the remaining 30 percent of this exaggeration.

This finding is very important for two reasons. First, it shows that authors who have concentrated on the problems with Lebergott's estimates of the labor force have missed the more fundamental problem in the historical unemployment estimates. Estimating employment is a source of much larger errors.[9] Second, for those who believe that the unemployment rate is a poor measure of the cycle, perhaps because the labor force is an inherently nebulous quantity, this finding implies that more direct cyclical variables will show the same cyclical exaggeration. Measures such as the deviation of employment from trend or the employment to population ratio, when based on the constructed employment series, will show much greater cyclical movements than similar measures using actual employment data.

The counterfactual experiments can be taken a step further. If most of the errors in the constructed unemployment rate are due to estimating employment, it is useful to discover if the total employment effect is due to estimating employment in a particular sector. Specifically, this analysis has only replicated Lebergott's procedures for estimating employment in trade, construction, and manufacturing. Because the replication is roughest in manufacturing, it is important to see if the total employment error is due to the estimates of manufacturing employment.

To check this, I run the following experiment. As in the experiment for *UE*, I suppose that the true labor force is known. I suppose also that employment in manufacturing is known, while employment in the rest of the economy is estimated as before. The resulting unemployment rate (denoted *UEM*) can be compared with the *UE* series from before to see how much of the employment effect is due to estimating employment in manufacturing.

The average cyclical amplitudes for *UEM* for all base years are also shown in table 8. When employment in manufacturing and the labor force are set equal to their actual values, the resulting unemployment series (*UEM*) is still much more variable than the actual unemployment rate. Furthermore, *UEM* is nearly as variable as *UE*, which sets only the labor force equal to its actual value. This suggests that the employment effect is not driven by estimates of employment in manufacturing. If one compares the difference in the amplitudes of *UA* and *UE* with the amplitudes of *UA* and *UEM*, only about a third of the total employment effect is due to manufacturing.

V. Creating Better Historical Data

Now that I have derived a model of the relationship between the actual and constructed series in the postwar period, it is natural to consider using this model to create a better historical series. Trans-

[9] Darby (1976) also points out the importance of possible errors in the employment series. He shows that the estimates of unemployment during the Great Depression are very sensitive to whether workers on public works jobs are counted as employed.

forming the constructed prewar data by the estimated filter may yield a series that is closer to the true prewar unemployment rate. However, imposing a relationship identified using postwar data on the prewar period is a risky step. To do so assumes that the effects of the construction procedures are the same in the two time periods. This is an assumption whose validity must be tested before it is imposed.

A. *Historical Evidence*

The analysis of Section IV showed that the main errors in the constructed postwar data stem from the fact that employment in some sectors is assumed to move one for one with output in those sectors and that the labor force is assumed not to vary with the cycle. Both these assumptions are false in the postwar era, and because of this an unemployment series derived using these assumptions is excessively volatile. If both these assumptions are also false in the prewar era, then it is likely that Lebergott's unemployment series is excessively volatile as well. In this case, the relationship between the constructed and actual postwar unemployment series can legitimately be used to filter the historical constructed data to form a more accurate series.

In order for Lebergott's prewar unemployment series to be excessively volatile, prewar employment in manufacturing, trade, and construction must move less than one for one with output. That is, productivity and hours must be procyclical in these sectors in the prewar era. Direct empirical evidence on whether this is true is obviously limited because the necessary data are scarce. However, there are fragments of employment and output data that others have used to examine the cyclical movements in productivity and hours.

The most recent analysis of the cyclical behavior of productivity and hours is done by Bernanke and Powell (1984). Their study uses employment and hours data from a monthly survey conducted by the National Industrial Conference Board over the period 1923–39. Bernanke and Powell use various time-series techniques to compare the cyclical movements of productivity and hours in manufacturing over time. Their primary measure is the coherence between movements in productivity and hours and output. They find that for both productivity and hours the coherence with output is positive and significant in both the prewar and postwar periods. They conclude that "the interrelationship of productivity, hours, output, and employment is essentially stable between the prewar and postwar [eras]" (Bernanke and Powell 1984, p. 17).

There exist other studies with the same conclusion, provided that one defines the prewar era very loosely. The classic study by Hultgren (1960), for example, uses data that begin in 1932. Hultgren concludes that output per hour usually rises when production rises. This shows that for a period that is at least contiguous to the pre-1930 period, productivity is procyclical as it is in the postwar period.

Both these studies apply only to manufacturing. Whether productivity and hours in construction and trade are procyclical in the prewar era as they are in the postwar era is still an open question. Unfortunately, there are essentially no data that can be used to answer this question directly. However, on a theoretical level it seems unlikely that labor hoarding in these sectors has increased over time. For example, the increase in the extent of unionism in the construction industry between the prewar and postwar eras is believed to have served mainly to raise and regulate wages (see Mills 1972, p. 120). Such stabilization of wages may have actually made productivity in construction less procyclical in the postwar era than in the prewar era. Similarly, the large expansion of employment in wholesale and retail trade and the increasing reliance on secondary workers may have weakened the ties between workers and firms in this sector. As a result, employment in trade may move more closely with output in the postwar period than it did in the prewar era. Both these observations suggest that the assumption that employment in construction and trade moves one for one with output is at least as bad in the prewar era as in the postwar era.

Though far less crucial than the output-employment link, the relationship between the labor force and output is another determinant of whether Lebergott's prewar unemployment series is excessively volatile. For the prewar series to have the same errors as the constructed postwar series, fluctuations of the labor force should be procyclical in the prewar period as they are in the postwar period. Evidence on whether this is true, however, is very hard to find. For the pre-1930 period there does not exist even a fragment of time-series data on the labor force.

However, it is possible to use cross-section data to estimate the cyclical behavior of the labor force. For example, several modern studies have tested how the labor force participation rates of various cities are related to the unemployment rates of those cities (see, e.g., Bowen and Finegan 1965). While Mincer (1966) has suggested several reasons why such studies may overstate the procyclical movements in the labor force,[10] this type of study is one of the few that can be done on both prewar and postwar data. Furthermore, since this test is

[10] Mincer (1966) suggests several possible problems with cross-section studies. One of the main problems is that because the labor force enters both the dependent and independent variable, but in opposite directions, the two variables could be negatively correlated by construction.

designed to gauge the stability of the cyclical movement of the labor force rather than estimate the actual sensitivity, such problems should not affect the basic results.

For cross-section data on the prewar labor force, I use figures from U.S. Bureau of the Census (1932). In a special volume on unemployment, the census lists the number of gainful workers and the number unemployed by city.[11] The gainful worker numbers are only an approximation to the labor force in each city because seasonal and other workers are treated differently in the gainful worker figures than in the modern labor force estimates. However, Lebergott suggests that on average the difference between the two numbers is probably small (Lebergott 1964, p. 402). Therefore, I use the gainful worker numbers to calculate the labor force participation rates and the unemployment rates of each city.

To see how the labor force participation rate varies with unemployment, I regress the participation rate by city (LF/POP) on a constant and the unemployment rate by city (U/LF). I use data on the 33 cities that had more than 200,000 inhabitants in 1930. The estimated relationship is

$$\frac{\mathrm{LF}}{\mathrm{POP}} = \underset{(.013)}{.482} - \underset{(.149)}{.330}\frac{U}{\mathrm{LF}} + e; \quad R^2 = .136, \text{ S.E.} = .018, \quad (14)$$

where standard errors are in parentheses. The negative coefficient estimate on U/LF suggests that the labor force was significantly procyclical in 1930.

To see if the size of procyclical movements in the labor force is the same pre- and postwar, I run a similar regression for 1975. I choose 1975 because it is one of the few years for which data are available that corresponds to approximately the same point in a business cycle as 1930. When the same sample of cities as before is used, the estimated relationship is

$$\frac{\mathrm{LF}}{\mathrm{POP}} = \underset{(.025)}{.473} - \underset{(.248)}{.298}\frac{U}{\mathrm{LF}} + e; \quad R^2 = .049, \text{ S.E.} = .027. \quad (15)$$

While the similarity in parameter estimates for the 1930 and 1975 regressions provides some evidence that the cyclical behavior of the labor force has indeed been stable, it is far from conclusive. The estimated coefficient on U/LF is very unstable in the postwar period.

[11] Volume 1 of the 1930 *Census of Unemployment* classifies the unemployed into eight classes. To be consistent with modern unemployment data, I estimate the number unemployed in each city as the sum of the class A unemployed (persons out of a job, able to work, and looking for a job) and the class B unemployed (persons having jobs but on layoff without pay).

While the sign is always negative, the coefficient varies with whether the year is one of boom or bust.[12]

Nevertheless, the results on the cyclical behavior of the prewar labor force and employment do support the notion that the construction procedures have the same effects in the pre-1930 period as they do in the postwar period. The fact that productivity, hours, and the labor force are procyclical in the prewar period suggests that the historical unemployment series has errors that are similar to those in the postwar constructed series. Thus imposing the postwar model of the relationship between the actual and constructed series may yield a more accurate estimate of the prewar unemployment rate.

B. New Historical Data

To impose the postwar relationship is straightforward. In rearranged form, the model of the relationship between the actual unemployment rate and the constructed rate estimated in equation (13) is

$$UA = UI - .484(UI - \overline{UI}) + .458(UI - \overline{UI})_{-1} - .749(UI - UA)_{-1} + e. \quad (16)$$

Constructing fitted values for the historical period is slightly complicated because of the lagged *UA* term in the model of the relationship between *UI* and *UA*. To deal with this complication I use a dynamic simulation to get fitted values. This process assumes that for the first observation the error is equal to zero. While this procedure is technically correct, it is of little consequence. As noted earlier, the inclusion of a lagged endogenous variable expands the explanatory power of the model of the relationship between *UI* and *UA* very little. As a result, the fitted values from the dynamic simulation are nearly identical to those from the simpler model that excludes the lagged endogenous variable.

Constructing fitted values for the historical period is also complicated because it is necessary to take into account the fact that Lebergott's series is correct in census years. To deal with this second complication, I impose that $UI = UA$ in each census year and then start the dynamic simulation over in the first year of each decade.

The results of applying these procedures are shown in table 9. The first column shows Lebergott's series; the second shows the filtered

[12] For boom years the coefficient is typically lower. For 1977, e.g., the coefficient is −.70. This may show that a given change in the unemployment rate has a greater impact when the unemployment rate is low. This finding also explains why the coefficient found for 1975 is lower than that found by Bowen and Finegan (1965) for 1960.

TABLE 9

OLD AND NEW HISTORICAL DATA

Year	ULEB*	$\widehat{UA}$†	Year	ULEB*	$\widehat{UA}$†
1890	3.97	3.97	1911	6.72	6.27
1891	5.42	4.77	1912	4.64	5.25
1892	3.04	3.72	1913	4.32	4.93
1893	11.68	8.09	1914	7.92	6.63
1894	18.41	12.33	1915	8.53	7.18
1895	13.70	11.11	1916	5.10	5.63
1896	14.45	11.96	1917	4.62	5.23
1897	14.54	12.43	1918	1.37	3.38
1898	12.35	11.62	1919	1.38	2.95
1899	6.54	8.66	1920	5.16	5.16
1900	5.00	5.00	1921	11.72	8.73
1901	4.13	4.59	1922	6.73	6.93
1902	3.67	4.30	1923	2.41	4.80
1903	3.92	4.35	1924	4.95	5.80
1904	5.38	5.08	1925	3.22	4.92
1905	4.28	4.62	1926	1.76	4.02
1906	1.73	3.29	1927	3.28	4.57
1907	2.76	3.57	1928	4.21	5.02
1908	7.96	6.17	1929	3.25	4.61
1909	5.11	5.13	1930	8.94	8.94
1910	5.86	5.86			

* ULEB denotes Lebergott's original series. These unemployment rates are calculated by dividing Lebergott's series on total unemployment by his series on the civilian labor force. The series are from Lebergott (1964, table A-3 [for 1900–1930] and table A-15 [for 1890–99]).

† $\widehat{UA}$ denotes the new filtered version.

series $\widehat{UA}$. In addition to filtering the 1900–1930 data, I also apply the correction filter to Lebergott's series for 1890–1900. This application is much more dubious than that for the later period both because I am less certain that the necessary relationships hold in this period and because the procedures Lebergott uses to construct data for this decade are slightly different from those he uses for the later period.

Nevertheless, it is interesting to see how the new data change our perception of the pre-Depression economy. For example, the downswing of the 1890s now appears to be a much milder cycle. Rather than assuming near–Great Depression severity, the depression of the 1890s looks more like the 1982 recession. The 1920s also look much different. Rather than being a roaring boom, the twenties actually look no more prosperous than the rest of the early 1900s and less prosperous than the roaring sixties. This smoothing out of the business cycle fluctuations of the early 1900s has the effect of making the Great Depression stand out as a great anomaly. Instead of being the largest of several very severe prewar recessions, the Great Depression appears to be a complete collapse of what had previously been a reasonably stable economy.

VI. Conclusion

While I have tried to suggest that the methods used to create the new prewar unemployment rate series are valid, it is important to note that the new series presented in table 9 is still very rough. It is provided mainly to suggest how different the prewar business cycle would look if the systematic biases were removed from Lebergott's series. Although the new estimates may be useful for certain cyclical comparisons over time, their accuracy is questionable enough that they should not be used in any applications where the actual point estimates of unemployment are crucial.

While the construction of more accurate prewar unemployment data is an important task, this activity is to some degree peripheral to the main point of this study. I view this work much more as putting Lebergott's own footnotes back on the historical unemployment series. By demonstrating the direction and magnitude of the systematic errors imposed by the data construction procedures, I have shown the dangers of making cyclical comparisons between the constructed prewar unemployment data and the more nearly accurate postwar data.

The main danger of making such comparisons may be to overestimate how much the economy has changed. This is especially true of the issue of the stabilization of the postwar economy. Whereas the inconsistent unemployment data show a marked decline in the amplitude of the business cycle between the pre-1930 and the post-1948 periods, the consistent data show no such decline. By naively assuming that the first comparison was valid, economists may have misjudged both the effectiveness of stabilization policy and the long-run changes in the economy.

It is natural to ask whether the results I have identified for the unemployment data also hold for the other macroeconomic series as well. Because the excess volatility of the unemployment series comes primarily from particular errors in the specification of the output-unemployment link, it seems unlikely that other series have identical errors. However, the types of assumptions and interpolations that Lebergott had to make are not unique to the unemployment series. The builders of various output and industrial production series had to make similar assumptions about the behavior of many variables in order to piece together the available fragments of data. While the exact effect of these assumptions is still an open area of research, it is possible that critical analysis of these data will also resurrect the footnotes of Simon Kuznets and the Federal Reserve Board on the limitations of the historical output series.

Appendix

This Appendix tests the robustness of the results in the text to the choice of the variables used to interpolate employment. For each sector I describe the series and methods Lebergott uses to construct annual employment estimates. I then suggest various postwar extensions of the series Lebergott uses and test to see if the choice of series affects the employment estimates.

The test that I use is to construct several employment series and the corresponding constructed unemployment rates and compare them. For the sample period 1960–80 I construct nine estimates of total employment based on nine combinations of interpolating variables. Combining these estimates of total employment with the constructed labor force numbers for 1960–80, I create nine constructed unemployment series. The 1960–80 sample period is chosen because this is the earliest time period for which all the interpolating series exist.

1. *Series and Methods Used for Various Sectors*

Construction

Pre-1930.—For employment in construction, Lebergott (1964) has data on total employment and activity in 1899 and 1929. The interpolating series for 1899–1920 is Shaw's (1947) series on the output of construction materials, deflated by the related price series. The interpolating series for 1920–38 is the Commerce Department series on the nominal value of new construction. Lebergott creates a price series that he uses to deflate this series.

The method Lebergott uses reduces to the usual interpolation formula. He describes forming the ratio of employment to activity for 1899 and 1929 and interpolating linearly. He then multiplies the resulting fitted values by the annual activity series. In logarithms this procedure is identical to the formula $\text{emp}_t = \overline{\text{emp}} + y_t - \bar{y}$.

Post-1948.—There are several possible activity series for the postwar period that are similar to those chosen by Lebergott. The most obvious is that chosen for the main text: the Federal Reserve Board index of the output of construction materials (abbreviated CM). A second candidate is the Commerce Department series on the value of new construction. Using the gross national product (GNP) deflator for structures, one can construct a series very similar to that used by Lebergott for the 1920s. This series is designated in what follows as CONST. A third candidate is real GNP in construction (designated GNPC). While conceptually different from Lebergott's series, real GNP is arguably the most natural output series to use.

Trade

Pre-1930.—Lebergott's method for estimating employment in trade is complicated. He begins by constructing benchmarks for employment in trade in 1900, 1910, 1920, and 1930. He also constructs benchmarks for a sample of component series for the same years. That is, he forms benchmarks for the number of employees in the food trade, the furniture trade, and so on. He then interpolates each of these component series by Shaw's series for the real output of finished commodities in the corresponding sector. For example, he interpolates the number of employees in drugstores by Shaw's series on the output of drugs. These constructed component series are combined and used to interpolate the total employment series.

Post-1948.—The most obvious postwar series to use is one similar to the one Lebergott uses. For 1960–80, I construct a preliminary employment series by summing seven constructed employment series. Following Lebergott, I form the component series by taking employment in a particular line of trade and interpolating by the corresponding Federal Reserve Board index of the output of finished goods in that line of trade. The resulting interpolating series is designated ETRADE.

This series is not a viable interpolating series for the entire postwar period because annual data on employment in various types of stores are not available from the CPS for most lines of trade before 1958. An aggregate approximation to Lebergott's procedure is to interpolate total employment in trade by the Federal Reserve Board series on the output of final goods destined for consumers. This series, which is used in the main text, is designated as CG in table A1.

Two other interpolating series are of interest. Conceptually, real retail sales might be the activity series most closely related to employment in trade. For this reason I include the Commerce Department series on retail sales deflated by the personal consumption deflator (designated RSALES) as an interpolating series. I also try real GNP in trade (GNPT) as an interpolating series.

Manufacturing

Pre-1930.—For 1899–1909 Lebergott interpolates employment in manufacturing by an index of manufacturing employment in a sample of states. The index is based on the five largest manufacturing states, which in 1904 accounted for 50 percent of all manufacturing employment.

For 1909–19 the interpolating series is Shaw's estimates of the output of finished goods in constant dollars. Lebergott adjusts this series to include construction materials and to exclude nonmanufactured foods.

For 1919–29 Lebergott adopts Fabricant's series on employment in manufacturing. For this period the *Census of Manufactures* was biennial. Fabricant estimates intercensal employment using a sample of state data very similar to what Lebergott uses for the early decade (Fabricant 1940, p. 332).

The method Lebergott uses is again equivalent to the usual formula. To be sure of this fact, I have replicated his results for manufacturing between 1909 and 1919 using both the iterative process he describes and the formula given in equation (1). The resulting employment series differ by at most 0.2 percent and are generally much closer.

Post-1948.—There are again several possible postwar series to use. The one chosen for the main text is the Federal Reserve Board index of the output of final goods (designated as FG). I adjust this to include construction materials by combining the final goods series and the construction material series using 1967 value-added weights.

Because Lebergott uses state data for much of the prewar period, it is important to try a similar series for interpolating the postwar employment data. To create an index of state employment I use a sample of the seven largest manufacturing states in 1967. I use seven rather than five so that this sample accounts for 50 percent of manufacturing employment. I combine the state employment series into an index by weighting each series by its share of total manufacturing employment in 1967. This series is referred to as STATE in table A1.

The third manufacturing activity series I use for interpolating employment is real GNP in manufacturing (GNPM). Again, this is included primarily as a reference case.

TABLE A1

STANDARD DEVIATIONS

Combination of Interpolating Variables*	Standard Deviation of Resulting Unemployment Series†
Base case of main text	
1. CM, CG, FG	2.01‡
Experimenting with construction	
2. CONST, CG, FG	2.08
3. GNPC, CG, FG	2.04
Experimenting with trade	
4. CM, ETRADE, FG	2.00
5. CM, RSALES, FG	1.87
6. CM, GNPT, FG	1.91
Experimenting with manufacturing	
7. CM, CG, STATE	1.94
8. CM, CG, GNPM	2.09
Experimenting with all	
9. GNPC, GNPT, GNPM	2.02

* CM = Federal Reserve index of construction materials; CG = Federal Reserve index of consumption goods; FG = Federal Reserve index of final goods; CONST = real value of new construction; GNPC = real GNP in construction; ETRADE = preliminary employment series for trade; RSALES = retail sales/PCE deflator; GNPT = real GNP in trade; STATE = index of state employment in manufacturing; and GNPM = real GNP in manufacturing.

† Based on the constructed labor force series for 1960–80 and constructed employment series using the variables listed in col. 1.

‡ For reference, the standard deviation of the actual unemployment rate series for 1960–80 is 1.34.

2. *Comparison*

The primary subject of the paper is the effect of the interpolating procedures on the variability of the constructed unemployment rate series. Thus one important characteristic on which to compare the various unemployment series is the standard deviation of the series. Table A1 reports the standard deviations for several constructed unemployment series for the period 1960–80. Column 1 shows the combination of interpolating variables used in forming the estimates of total employment. For each combination the first series is that used to interpolate construction, the second is that used to interpolate trade, and the third is that used to interpolate manufacturing.

The most important result is that it does not matter which activity series are used for interpolation. The standard deviations of all the constructed series are very similar and much larger than that of the true unemployment rate. A second result is that the combination of interpolating variables used and analyzed in the main text is approximately in the middle of the field in terms of its standard deviation. Half of the combinations yield unemployment rates that are more variable and half yield unemployment rates that are less variable.

For brevity, table A1 shows the effects of changing only one of the interpolating series from the combination used in the text. For example, it shows the effects of various construction series, keeping the series used for trade and manufacturing unchanged. The results do not change when all combinations are tried. As an example, I include the reference case that interpolates each sector by real GNP in that sector. Even in this instance the results are very similar to the basic case.

The individual results are straightforward. For construction, using either of the alternative series increases the standard deviations. For trade, the most important result is that my aggregate approximation to Lebergott's procedure is very good. The standard deviation of the series that interpolates employment in each line of trade is nearly identical to the standard deviation of the series that interpolates total employment in trade.

For manufacturing, interpolating by the index of state employment yields results very similar to interpolating by an activity series. The reason for this is that the sample bias of this particular fragment of employment data causes the interpolation procedure to have the same effects as interpolating by output. By using employment in manufacturing in the large states, one gets a sample that overrepresents heavy industry and heavy unionization. Because of this, employment in these states typically moves more with output than does manufacturing employment in general. Thus interpolating by this sample of states yields a total series for manufacturing employment that is excessively volatile.

Together these three findings show that the results of the paper are indeed robust to the choice of the interpolating variables for employment. No reasonable combination of interpolating series yields a constructed unemployment rate that is substantially less volatile than the constructed series presented in the text. Thus the similarity between Lebergott's historical series and the constructed postwar series cannot be dismissed as the result of using different types of activity data as the interpolating series for sectoral employment.

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