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SHIFTS IN THE NINETEENTH-CENTURY
PHILLIPS CURVE RELATIONSHIP

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ABSTRACT

This paper examines shifts in the output effects of unanticipated
inflation in the nineteenth-century United States by estimating a Lucas-type
aggregate supply function over the 1840-1900 period. It is shown that, in
contrast to the twentieth-century experience in which there has been a
pronounced movement toward greater cyclical price rigidity, the nineteenth-
century output response to unanticipated price changes was roughly stable over
the period. Such stability is also particularly interesting in view of the
dramatic changes in communications and transportation technology, particularly
the telegraph and the railroad, which greatly facilitated information flows
and thereby should have forced the price-surprise coefficient downward. Other
factors which may have offset the influence of these improvements in
information technology on the price-surprise coefficient include the reduced
general price level variability due to the gold standard in the postbellum
period and the possibility that the net effects of such improvements may in
fact have been small because shocks were able to spread more rapidly as
well. Finally, the perceived increase in cyclical price rigidity over the
nineteenth century in the raw data is shown to have resulted not from a change
in price-surprise coefficient but rather from an increased degree of
persistence or inertia in the economy.

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An important issue in macroeconomics has been whether the Phillips curve relationship has been changing over time toward greater price rigidity over the business cycle. It has often been argued that a given increase in the level of unemployment is now associated with a smaller reduction in inflation than had been true in the past. In other words, the suggestion is that the output costs of lowering inflation has increased over time. Studies based essentially on twentieth-century U.S. data (e.g., Cagan, 1975; Sachs, 1980) in general confirm that the cyclical rigidity of prices has been increasing.[1] In his Phillips curve estimates Sachs (p. 83) finds, for example, a dramatic shift in the inflation-unemployment relationship between the pre-1929 and the post-World War II period - the estimated coefficients fall by more than 70 percent.

Greater historical perspective would be useful in assessing long-term shifts in the degree of price rigidity over the business cycle. Although original studies of the Phillips curve (Phillips, 1958; Lipsey, 1960) were based on historical data, relatively little attention has been devoted to studying long-term changes since then.[2] This paper therefore will consider the American case between 1840 and 1900. The nineteenth-century experience should be especially interesting in terms of informational theories of the Phillips curve or aggregate supply (Phelps, 1970, pp. 6-7; Lucas, 1973). The theory suggests that if the economy were composed of a large number of scattered, competitive markets, or "islands", and information flows among them are costly, suppliers of labor and goods would have difficulty in distinguishing relative price changes from general movements in the price level. The presence of imperfect information leads to a positive association of price and output changes in the short run as suppliers misinterpret general price level changes for relative price changes. In the nineteenth century

when transportation and communication were significantly more difficult and costly than today, this "island" characterization of markets should be particularly appropriate. In view of some difficulties in estimating positive price-surprise terms in aggregate supply curves with contemporary data (Fair, 1979), the results for the nineteenth century in measuring the output response to inflationary surprises should be of some interest.

The basic historical evidence for the period 1835-1975 is summarized in Tables I and II, and also in Tables IA and IIA. Tables I and II report the total change in wholesale prices from peak to trough of the business cycle to give an idea of the magnitude of decline, while Tables IA and IIA present the change in inflation rates resulting from the cycle. The change in inflation is measured as the difference between the inflation rate in the year prior to the peak of the cycle and the average rate of price change during the downturn (following Sachs). The change in the gap between actual real output and potential output from peak to trough of the cycle (a widening of the GNP gap carries a minus sign) is used as a measure of the magnitude of the cycle and the cycles are grouped in terms of severity.[3] Such a classification scheme allows contractions of a similar degree of severity to be compared directly. Note first of all however that three nineteenth-century periods, 1847-48, 1873-79, 1890-91, which had been previously classified as contractions on the basis of movements of NBER business cycle indicators, were in fact expansionary periods marked by a narrowing GNP gap. These, as a result, will be omitted in the period comparisons which follow.

The increase in cyclical rigidity in the post-World War II period is readily apparent. For mild contractions, downward price flexibility appears to have ended with the post-World War II period and the size of the reduction in the inflation rate declines significantly as well (the same is true for

moderate contractions, but there is only one postwar observation here).
Longer term trends are more difficult to discern from the tables however, so
price and output gap changes over cyclical downturns with the trend line for
the nineteenth and twentieth centuries respectively are plotted in Figures I
and II. Comparing the nineteenth and twentieth century experience directly is
a rather dangerous enterprise because the figures are based on different data
sources and output variability in the nineteenth century may be
understated.[4] Nevertheless, increased price rigidity (flatter slope) in the
twentieth century is certainly supported by the figures. Moreover, this trend
remains even when the data are divided into shorter periods. Regressions of
price change on output gap change with the observations grouped into three
periods--pre-Civil War, Civil War to World War II, and post-World War II--show
a progressively smaller coefficient in each period with the shifts being
statistically significant in a likelihood ratio test.[5] This suggestion of a
very long term trend toward increased price rigidity from the raw data (from
the antebellum period on) however is primarily for a bit of (perhaps
questionable) historical perspective. Problems of possibly incomparable data
will be avoided by focusing on the nineteenth century.

Rather than such casual empiricism, as above, this paper will examine the
issue of changing price rigidity, or in the context of an aggregate supply
curve shifts in the output effects of unanticipated inflation, over the mid
and late nineteenth century more formally. Distinguishing between anticipated
and unanticipated inflation, I estimate an expectational aggregate supply
curve over the period 1840-60, 1870-1900. This period is particularly
interesting as well because it encompasses the diffusion of two of the most
important improvements in communications and transportation, the telegraph and
the railroad. It will be shown however that, notwithstanding the apparent

trend toward greater cyclical price rigidity and the dramatic improvements in communications and transportation over the period, the output response to inflationary surprises was remarkably stable over the last sixty years of the nineteenth century. The sharp decline in the slope of the twentieth-century Phillips curve therefore was not characteristic of the nineteenth century.

The estimation of the aggregate supply curve is described in Section I, while the results are analyzed in Section II. The conclusions appear in Section III, and the data are discussed in the Appendix.

II.

It is assumed that the aggregate supply function is the familiar expectational form with lagged adjustment, as in Lucas (1973).

$$(y_t - y_t^*) = \alpha_1 (y_{t-1} - y_{t-1}^*) + \alpha_2 (p_t - E_{t-1} p_t) + \alpha_0 + u_t \tag{1}$$

where y_t, y_t^*, and p_t, are logarithms of real output, real potential output, and the price level respectively at time t. The variable $E_{t-1} p_t$ represents the public's expectation of the log of the price level in period t as of the end of period t-1 based on information available at that point.

The gap between actual and potential output is a function of last period's gap and the difference between the actual price level and the public's expectation of it. Unanticipated price increases lead to increases in real output, a result consistent with a negatively sloped short-run Phillips curve, but a vertical long-run one. Gordon (1980, 1981, 1982) has criticized such a specification for assuming complete rather than gradual

price adjustment. Nevertheless, with annual data, as we have here, this does not seem to be an unreasonable characterization.[6]

Potential output is taken to be a simple constant returns to scale Cobb-Douglas function of exogenous factor inputs:

$$y_t^* = \phi_{kt}k_t + \phi_{Lt}\ell_t + \phi_{Tt}t_t + A_t \tag{2}$$

$$\text{with } \phi_{Kt} + \phi_{Lt} + \phi_{Tt} = 1$$

where k, ℓ, and t are the logs of capital, labor, and land respectively; ϕ_{Kt}, ϕ_{Lt}, and ϕ_{Tt} are the factor shares; and A_t is the efficiency parameter at time t.

Substituting (2) into (1), we may rewrite the supply curve as:

$$y_t = \phi_{Kt}k_t + \phi_{Lt}\ell_t + \phi_{Tt}t_t$$

$$+ \alpha_1(y_{t-1} - \phi_{Kt-1}k_{t-1} - \phi_{Lt-1}\ell_t - \phi_{Tt-1}t_{t-1}) \tag{3}$$

$$+ \alpha_2(p_t - E_{t-1}p_t) + \alpha_3\text{time}_t + \alpha_0 + u_t$$

where changes in the efficiency parameter A_t are captured by a time trend.

Price expectations are taken to have been formed based on two lagged values of the price level. They are "economically rational" in the sense that given available information at the time the public did not make systematic errors in forming expectations of future price levels (Feige and Pearce, 1976). Such a specification seems particularly appropriate for the nineteenth

century when information on exogenous variables must have been quite difficult and costly to obtain.[7]

Equation (3) therefore was estimated concurrently with the price forecasting equation by instrumental variables. The instruments used included the exogenous and predetermined variables in the model plus the logs of the money supply, government expenditures, and exports.[8] The hypothesis of no first-order autocorrelation is not rejected using Godfrey's π test (1976). The results for the equation estimated over the period 1841-1900 with a gap in the 1860's appear in the first line of Table III. The coefficient of the price surprise variable, $p_t - E_{t-1} p_t$, is positive and statistically significant, so that unanticipated increases in the price level elicits an increased supply of output, as in the traditional expectational Phillips curve.[9] This result contrasts with the inability of Friedman and Schwartz (1982, p. 461) to identify a statistically significant Phillips curve relationship in the United States after 1867. With the exception of the interwar period, they find that the relation between price change and output change, if anything, was negative rather than positive.[10] The influence of the lagged output gap is significantly positive and the time trend is as well, consistent with technical progress. The positive constant term might indicate some error in the measurement of potential output.

Deviations from full employment in the aggregate supply function of equation (1) are caused by aggregate demand shocks. Recent experience however has shown that supply-side shocks, where price and output movements are negatively rather than positively related, can also be important influences on the output gap and hence on the observed Phillips-curve tradeoff (Gordon, 1982; Froyen and Waud, 1984). Supply shocks in agriculture (bad harvests, etc.) may have been particularly important in nineteenth-century America, when

agriculture constituted a much larger proportion of total output than today. To allow for the influence of supply perturbations a supply-shock variable, z_t, measured here as the relative price of food products,[11] is included in the aggregate supply equation. The results of the estimation are presented in the second line of Table III. The coefficient of the supply-shock measure, z_t, is not significantly different from zero, and the estimates of the other coefficients are essentially unchanged from their values in line 1. Allowing for agricultural supply shocks does not therefore affect our estimate of the tradeoff.

Gordon (1982, pp. 1090-1091) derives another formulation of the aggregate supply function in which the unanticipated component of nominal GNP change, $U\hat{Y}_t$, appears on the right-hand side of the equation rather than the price surprise.

$$y_t - y_t^* = \frac{\alpha}{1+\alpha} U\hat{Y}_t + \lambda(y_{t-1} - y_{t-1}^*) + \frac{1}{1+\alpha} \varepsilon_t \qquad (4)$$

To separate the nominal GNP change into anticipated and unanticipated components, the nominal change is regressed on two lagged values each of changes in nominal GNP, the money stock, the rate of wholesale price change, and the interest rate on government bonds, as well as the other right-hand side variables in the supply equation - the lagged output gap and time. The fitted values from the estimated equation are taken to represent expected income change, and the residuals, unanticipated changes in nominal income.[12] This proxy for $U\hat{Y}_t$ was then used in the estimation of equation (4). The results are reported in the third line of Table III. The estimated tradeoff coefficient, α, is again significantly positive and also of a similar magnitude (.6463) to those of the first two equations in Table III. The

estimate of the Phillips curve parameter seems to be quite robust with respect to alternate specifications of the aggregate supply function. On average 39 percent ($\frac{\alpha}{(1+\alpha)}$) of the unanticipated nominal change showed up as output change and 61 percent ($\frac{1}{1+\alpha}$) as price change.

Did the Phillips curve relationship, that is, the output response to unanticipated inflation as given by α_2, shift over the nineteenth century? The regression results from estimating equation (3) over two subperiods, divided by the Civil War decade, which appear in the first two lines of Table IV show an upward movement in the price-surprise coefficient α_2.[13] This is supported as well by the set of regression results at the bottom of Table IV in which the sample size is increased by five year increments. The pattern is generally one of a steadily increasing α_2 over the postbellum period, indicating a shift toward a flatter Phillips curve (a smaller unanticipated price change associated with a given output change over the business cycle) which Sachs argues is characteristic of the twentieth century. However, a likelihood ratio test for a shift in α_2 after the Civil War decade produces a test statistic $\chi^2(1) = 6.07$, significant at the 5 percent level (3.84), but not at the 1 percent level (6.63).[14] Although there may have been a bit of trend toward larger output responses to a given unanticipated price change in the late nineteenth century, the shift does not appear nearly as pronounced as that in the following century. In contrast to the twentieth-century experience the output-unanticipated inflation tradeoff appears to have been roughly stable over the 1840-1900 period.

II.

The relative stability of the price-surprise coefficient α_2 after 1840 is remarkable in view of the dramatic improvements in technology, particularly the telegraph and the railroad, which greatly facilitated information flows over the period. Commercial telegraphy beginning with Samuel F. B. Morse's famous cable in 1844 spread rapidly across the United States, so that within a decade more than 20,000 miles of telegraph line had been put in place. From its inception it was used primarily for business purposes, and its "market perfecting" impact in reducing information and transactions costs soon became apparent (Du Boff, 1983, pp. 255-258). The railroad network in the United States began to develop in the late antebellum period as well. From its beginnings in the 1830's, it tripled in size over the decade of the 1850's to a total of over 30,000 miles by 1860. Growth in track mileage continued in the postbellum period, although at slower rates. The railroad was also an important force in promoting the integration of dispersed local markets (Chandler, 1977).

Some crude evidence of increased local market integration may be offered in the form of a significant decrease in the degree of geographical price dispersion over the early part of our period. Consider the variance of averaged first differences of logarithms of regional price indices as a measure of how closely prices move together (Hercowitz, 1981, p. 337).

$$\Delta p_t = \frac{1}{N} \left(\sum_i \Delta p_{it} \right)$$

$$\sigma_t^2 = \frac{1}{N} \sum_i (\Delta p_{it})^2 - (\Delta p_t)^2$$

where p_{it} is the logarithm of the price index of region i at time t. Using the Coelho and Shepherd (1974) indices of regional retail prices based on the Weeks Report (they exclude the South Atlantic and Western regions) as the price data, we see that the variance of regional price changes decreased by about 30 percent between the decade of the 1850's and that of the 1870's.[15]

In the Lucas supply function (1973, p. 328) α_2 may be written as:

$$\alpha_2 = (\frac{\tau^2}{\sigma^2 + \tau^2})\gamma , \tag{5}$$

where σ^2 represents the variance of the "prior" distribution of the log of the general price level for the traders, τ^2 is the variance of the distribution of the deviation of prices in individual markets from the average, and γ is the supply elasticity with respect to price surprises. The term in parentheses then is the fraction of total individual price variance which is due to relative price variation.

Cukierman (1979) in turn generalized a price-surprise aggregate supply model to the case in which individuals may have access to price information from other markets rather than just observing the current price in her own market. In such a case the "Lucas type effect" becomes $\tau^2/(n\sigma^2 + \tau^2)$, where n is the number of other markets from which the individual has access to information. Information about general price movements is reinforced as the individual samples more and more markets, so the ratio $n\sigma^2/\tau^2$ is an increasing function of n. As n increases, $\tau^2/(n\sigma^2 + \tau^2)$ and hence α_2 should decrease. As the number of other markets observed grows larger, the output effect grows weaker. Or, in other words, as price information becomes more widely diffused in the economy, the slope of the Phillips curve should become steeper.

Moreover, improvements in communication and transportation should make local market prices less subject to peculiarly local shocks. As a result, the degree of local price variability τ^2 should decline, which also decreases α_2. Both of these effects of improved communication and transportation technology, access to price information from other markets and reduced local price variability, therefore should work in the same direction, toward a fall in α_2.[16] Suppliers of labor and goods would have been less likely to think that general price increases represented relative price changes in their favor and to increase output in response.

However, the price-surprise coefficient α_2 (from Table IV) in fact remained roughly stable, or increased slightly, rather than falling. What forces offset the effects of improvements in information technology? First of all, the net effects of such changes are less clear because even though information is propagated more swiftly and efficiently throughout the economy, shocks are spread more rapidly as well. The relative position of individuals in local markets may have been largely unchanged if at the same time information from other markets were available more rapidly, shocks from the outside world impinged more quickly as well. For example, in the (pre-telegraph) Panic of 1837 the wave of suspension of specie payments in local banks radiating outward from New York reached Boston in two days, Pittsburgh in five days, Detroit in seven days, and St. Louis in twelve days (Pred, 1973, pp. 250-252). In contrast, during the Panic of 1873 suspension in other financial centers followed that in New York almost immediately (Sprague, 1910, p. 62).

In addition, the variance of the general price level, σ^2, which also affects α_2, may have changed over the nineteenth century as well. The period before the Civil War was marked by a bimetallic monetary standard, while from

the Civil War until Resumption in 1879 the United States was on a fiat standard with floating exchange rates (the Greenback Era). In 1879 the monetary regime was switched to the gold standard. Even though the mean of the distribution of the log of the price level changed little between the antebellum and postbellum periods, the degree of unpredictability decreased substantially - the variance of residuals from the price forecasting equation (log of prices regressed on two lagged values) declined from .278 for the 1841-60 period to .011 for 1871-1900, a shift that is significant at the 1 percent level.[17] The price level variance σ^2 should be inversely related to α_2 from (5) - the higher the variance in the general price level, the less favorable the tradeoff will be.[18] Thus, a decrease in price level variability or unpredictability resulting from the transition to convertibility (over the 1870's) and the adoption of the gold standard (after 1879) would have pushed the α_2 coefficient upward, contrary to the influences of improved transportation and communications.

The econometric evidence indicates that the price-surprise coefficient is roughly stable over the 1840-1900 period, but at the same time the cyclical price and output gap change data (Tables I and II) indicate a trend toward increased cyclical price rigidity (or a smaller output response to price changes) in the nineteenth as well as in the twentieth century. Such a trend was not due to a change in α_2 but rather in the lagged output gap coefficient α_1.

In Table IV the shift in α_1 is clear. The estimated coefficient which had been relatively small in magnitude and not statistically significantly different from zero in the period before the Civil War became much larger and statistically significant in the period after the Civil War. The regressions at the bottom of Table IV confirm this change, showing increases in the

magnitude of the estimated α_1 coefficients and their associated t statistics as the sample period is extended into the postbellum era. The influence of the lagged output gap on the current gap appeared to be growing between 1840 and 1900. During a downturn, for example, the lagged effect of actual output falling below potential output would pull current output farther below potential than would have been predicted earlier, ceteris paribus. In other words, increased inertia in the economy or increased persistence effects of the deviation of output from its potential level was responsible for the apparent increase in cyclical rigidity.[19]

Explanations for this rise in the importance of lagged effects must remain primarily speculative here, but some possibilities may be identified. The first is based on the dramatic increase in the rates of savings and investment in the nineteenth-century United States. Over the middle third of the century the share of capital formation in gross national product approximately doubled.[20] This sharp rise in the investment rate by itself could have played an important role in magnifying persistence effects over time periods if it takes some time to build new capital goods (Kydland and Prescott, 1982). Also, multiplier effects could amplify and draw out the influence of changes in the higher level of investment.

Another possible explanation is based on the increased specialization in the U.S. economy and within manufacturing in particular. With the growth of the manufacturing sector both capital and labor were applied to increasingly specialized tasks. Over the nineteenth century, the use of skilled as opposed to unskilled labor increased dramatically (Williamson and Lindert, 1980). While unskilled workers may have found it relatively easy to move from one industry to another, skilled workers were probably much less mobile across industries at least in the short term. Much of the accumulated human capital

may have been relatively task specific and hence not readily transferable into other industries. Similarly, machines came to be designed for increasingly specialized purposes as well. Rosenberg (1976, pp. 9-31) describes the trend toward greater specialization in the machine tool industry, for example, and observes that "by 1880 the proliferation of new machine tools in American industry had begun to reach torrential proportions" (p. 24). If both labor and capital had been becoming more "fixed" or industry-specific over time, the economy would have adjusted more slowly to demand shocks. The growth of the railroad expanded geographical markets and facilitated interregional factor mobility, but at the same time increased human capital accumulation and specialization may have raised the barriers to intersectoral or interindustry mobility. As a result, the degree of inertia or persistence in the economy may also have increased.

III.

Even though the direction of the long-term trend in the Phillips curve relationship has remained unchanged in the United States from at least 1840 onward--toward larger output changes in response to a given change in unanticipated inflation--there appears to be a distinct difference between the nineteenth and twentieth century experience. While the twentieth century shows a pronounced trend toward greater cyclical price rigidity, in the sense that a given rise in unemployment is associated with smaller and smaller reductions in inflation than in the past, in the period between 1840 and 1900 the change in the expectational Phillips curve tradeoff was so small that the relationship could be judged to have been a roughly stable one.[21] This

relatively stable relationship persists even after taking possible changes in the nature of shocks to the economy into account. The inclusion of a supply-shock variable, relative agricultural prices, does not significantly affect the estimated coefficients in the aggregate supply function.[22]

This essential stability of the price-surprise coefficient is particularly noteworthy in view of the rapid expansion of the telegraph and railroad after 1840, which by improving information flows should have led to a steeper Phillips curve. Suppliers were less likely to be "fooled" into changing output in response to a change in the aggregate price level. Since α_2 did not fall, other factors must have offset the influences of improved information flows. It is possible that the net effects of such improvements may have been small because shocks as well as new information were able to spread more rapidly. Another counteracting effect on α_2 may have been the decreased variability of the general price level resulting from the move to the gold standard. Sufficient information on the functioning of nineteenth-century labor markets is not available to assess whether there were substantial changes in the nature and extent of implicit contracting (in turn affecting α_2), but it is a possibility in view of the dramatic changes in labor force composition over the period.

The trend toward greater cyclical price rigidity over the nineteenth century observed in the pattern of price and output gap changes over successive business cycles therefore were not so much the result of a shift in the output response to unanticipated inflation but rather of the increased influence of the lagged output gap on current output. The degree of inertia or persistence in the economy increased markedly over the period due perhaps to the sharp rise in the investment share of GNP or increased specialization

in the economy which made adjustment to shocks and intersectoral mobility more difficult.

The movement toward a substantially flatter Phillips curve relationship (larger α_2) which appears characteristic of recent experience therefore does not seem to have been true for the earlier period. It in fact then is essentially a twentieth century phenomenon. Sachs (1980, pp. 87-88) emphasizes the influence of countercyclical macroeconomic policy and the spread of long-term wage contracts particularly after World War II in reducing cyclical flexibility. However, Spencer (1977) finds a significant decrease in downward cyclical flexibility of individual prices from industries experiencing increases in concentration over the late nineteenth and early twentieth century. Perhaps the merger wave and attendent increases in industrial concentration should be accorded more attention in studies of increases in cyclical rigidity.

Data Appendix

The annual real output series used here developed by Robert Gallman is unpublished but well known.[23] Beginning in the mid 1830's, there is a gap over the decade of the 1860's. The years before 1859, which were Census years in the original series, have been interpolated into calendar years. A potential difficulty with this series for measuring cyclical fluctuations is that it omits changes in inventories. Evidence for the post-World War I period suggests that inventory fluctuations are very significant in business cycles (Abramovitz, 1950; Blinder and Holtz-Eakin, 1984). Neglecting inventory shifts then would understate the degree of output variability in the nineteenth century. Data are not available to measure these inventory shifts directly, while contradictory influences make it difficult to puzzle out the relative degree of nineteenth-century inventory fluctuations. On the one hand, improvements in communications and transportation, particularly the railroad, have been widely argued to have reduced the level of inventory holdings substantially, and thus the ratio of inventories to GNP (Du Boff, 1983). On the other hand, the shift in inventory composition away from farm to more manufacturing over the period may have increased total variability.

Kuznets' solution to this problem involved simply projecting a regression line between annual inventory change on annual commodity output change for the interwar period back to the nineteenth century and calculating fitted values (1961, p. 601; also Kendrick, 1961, p. 277). This method, of course, does not capture any effects from structural change that may have been occurring. This measure of inventory change in turn was incorporated into Friedman and Schwartz's income estimates which begin in 1869 (1982, p. 100). However, estimating the aggregate supply curve (3) over the postbellum period with the

Friedman and Schwartz real income figures produced results very similar to those from the regressions based on the Gallman series. For example, the Friedman and Schwartz price-surprise coefficient, α_2, differed from the reported one by only +.045, or less than 10 percent, with comparable t statistics. The degree to which α_2 is underestimated because the omission of inventory shifts understates output variability appears quite small, at least based on the Kuznets estimate of inventory changes. The Kuznets adjustment for inventory changes therefore would not appear to imply a different pattern of results or conclusions from those in the paper based on the Gallman series.

Alternative series do not appear to be superior to the Gallman one in measuring output fluctuations. In particular, Romer (1984) has argued that the Frickey index of industrial production (1947) exaggerates the volatility of the pre-World War I economy. Such a measure may not be an accurate reflection of changes in aggregate output in any case in view of the substantial sectoral shift in the distribution of output that was taking place over the period, with the share of agriculture in national income falling from 26 to 15 percent, and that of manufacturing and mining was rising from 14 to 25 percent over the second half of the nineteenth century. Furthermore, the Gallman measure has the advantage of extending back into the antebellum period, which is especially interesting because of the spread of the telegraph and the railroad, while neither the Friedman and Schwartz income series nor the Frickey industrial production index go back before the Civil War.

There was considerable variation in the rate of growth of real output across subperiods between 1840 and 1900 (Abramovitz and David, 1973, p. 431), so a simple time trend is not a satisfactory measure of the growth of potential output over the period. The potential output series used in the

regressions is built up from constructed annual series for capital, labor, and land.

Annual real capital stock figures were based on Davis and Gallman's Census year capital-output ratios (1973, p. 457) and Gallman's annual gross capital formation series. Using Census year capital stock figures as benchmarks, one may solve for average decadal depreciation rates and thus for an annual capital stock series. Davis and Gallman (1973, pp. 463-466) show that capital stock figures calculated from investment flows are quite close to those from Census year benchmarks so that the capital stock and flow data, even though they come from different sources, are reasonably consistent and combining them, as is done here, is basically legitimate.[24] The Davis and Gallman capital-output ratio estimates run from 1840 to 1900, which limits the time period for the regressions to those dates. In any case, the Gallman real output series extends only a few years earlier, into the mid 1830's.

Estimates of land inputs are calculated from Davis and Gallman's estimates of capital plus land-output ratios for Census years (p. 457) and then interpolated. Labor force figures are constructed from annual population estimates (U.S. Bureau of the Census, 1975, p. 8) and Lebergott's estimates of the labor force by Census years (Lebergott, 1964, p. 510). There were dramatic changes in the size of relative factor shares over this period, with the capital share rising from .27 to .37 between the 1834/36-1853/57 and the 1888/92-1903/07 periods, while the labor share fell from .62 to .54, so clearly constant factor shares can not be assumed. Instead, time series for the factor shares--ϕ_{Lt}, ϕ_{Kt}, and ϕ_{Tt}--are constructed by interpolating between midpoints of David's 15 year periods (1977, p. 189). Technical progress, the change in the efficiency parameter A_t, is captured by a time trend in the regressions.[25]

An alternative measure of potential output derived from projecting from a benchmark year of full employment along a trend rate of growth may also be constructed. In this case, estimates of y_t^* are projected forward from the base year of 1834 using growth rates interpolated from David's period estimates of growth in real product (1977, p. 189). This estimate is used in calculating the output gap changes in Tables I and II, and IA and IIA, because we don't know the values of A_t in our first measure of potential output. The same pattern of regression results remain if the trend growth rate projected measure is used as y_t^*, with α_2 increasing somewhat from .5977 to .8411 between the antebellum and postbellum periods.

The price level is measured by the Warren-Pearson index of wholesale prices (1933, pp. 25-27). The underlying data for the series are primarily price quotations from New York markets. Changes in the degree of local price variability across regions therefore are not captured directly in the price series. While changes in price variability across products may be reflected in the index, the influence of increasing integration of geographical markets is reflected only in so far as it affects local price variability in New York. However, the alternative price index spanning the period, the David and Solar cost-of-living index of retail prices (1977, p. 21) is based on retail price quotations from only Massachusetts and Pennsylvania and thus its geographical coverage is only slightly greater than the Warren-Pearson.

The degree of variability in the wholesale price index is significantly greater than in the David and Solar consumer price index (David and Solar, 1977, pp. 20-21). For one thing, rent enters the index with a fairly large weight (17.7 percent for 1851-1880), and such prices are likely to be rather sticky in the short run (p. 55). Moreover, if the retail price markup adjusts only slowly with a lag to changes in the wholesale market (pp. 52-55), the

degree of variability in retail prices will be reduced for that reason as well. It would seem that the wholesale price index would be the one more relevant to suppliers in making output decisions, so we shall choose the Warren-Pearson index for this paper.[26] Ideally, we might prefer a GNP deflator series as the measure of p_t, but one is not available for this period.

As for the other instrumental variables, government expenditures are taken as the sum of federal outlays (U.S. Bureau of the Census, 1975, p. 1114) and total state and local government expenditures (Davis and Legler, 1966), which constituted a substantial part of the total in the nineteenth century. Estimates of the money and specie stocks for the antebellum period are from Stevens (1971); for the postbellum period they are taken from Friedman and Schwartz (1970). Finally, exports are taken from (U.S. Bureau of the Census, 1975, pp. 864-865).

Notes

1.   Gordon (1980), who finds a stable relation over the period, is one
exception to this generalization, but his estimates are not based on the
expectational Phillips curve specification. Wachter (1976) finds _au contraire_
increasing cyclical responsiveness in wages in the postwar period, but Sachs
(pp. 82-84) argues that his equations were misestimated.

2.   Lipsey (1960, p. 27) also identifies a shift in the relationship in the
U.K. in the first part of the twentieth-century, around World War I - "The
post-1922 experience was of less flexibility of wages in response to excess
demand, whether positive or negative, than occurred in the pre-1914 period."

3.   This classification scheme follows Sachs (1980, p. 81). However, the
classifications of the cycles themselves may differ because his criterion is
the change in the gap between actual and the trend level of industrial
production rather than between actual and potential real output. For example,
the contraction of 1902-1904 which Sachs classes as moderate is identified
here as mild; the downturn of 1918-19, labeled as strong by Sachs, is moderate
here. The measure of potential output used here is described in the Data
Appendix.

4.   The Gallman GNP figures for the nineteenth century omit inventories.
Since inventory fluctuations may have been significant over business cycles,
output fluctuations will be understated (see the discussion in the
Appendix). Also, to the extent that the derivation of the annual series
involved some interpolation some high frequency variability will be lost and
annual output variability understated.

5. $\chi^2(2) = 8.88$, which is significant at the 5 percent level. The estimated
coefficients for the time periods are 2.37, .73, and -2.31 respectively. A

similar grouping for inflation rate changes as the dependent variable shows
the same pattern of decreasing coefficients, but is not statistically
significant by the likelihood ratio test.

6.   Moreover, in Gordon's gradual price adjustment equation estimated on
quarterly data for the 1892-1929 period, the closest we can come to the
nineteenth century, the mean lag of past inflation variables was less than a
year and the coefficient of the lagged difference between actual and potential
output was quite small (.02).   (Gordon, 1982, p. 1104)

7.   In addition, adding lagged fiscal and monetary variables, such as
government expenditures or the money supply, to the price forecasting equation
makes very little difference to the reported results.

8.   Minor variations in the list of instruments, such as replacing the money
stock by the specie stock or adding some international variables (see James,
1984, pp. 198-199) made no essential difference in the results.

9.   Perhaps it should be reiterated here that because the dependent variable
may understate the true level of output variability, the estimate of α_2 here
may be a bit too low.   See note 4.

10.   Their specification however differs from the one used here.   They use
unanticipated price change as the dependent variable and unanticipated money
stock change and the output gap as independent variables.   On the other hand,
in this aggregate supply function and also in the relationship studied by
Irving Fisher (1926) on early twentieth-century data the output gap is taken
as the dependent variable.

11.   Using relative agricultural prices as a measure of supply shocks would be
appropriate in a closed economy, but the nineteenth-century United States was
a significant exporter of agricultural products.   In that case, high foreign
demand could lead to high relative farm prices, but it would be caused by a

demand rather than supply shock. Therefore exports as a percentage of GNP can be included in our supply shock variable with a negative sign, $zz_t = z_t - x_t/y_t$, to reduce foreign demand influences. The new variable should respond primarily to domestic supply shocks. However, when such a variable was included in the aggregate supply curve, its coefficient also was not significantly different from zero, and the estimates of the other coefficients were not significantly different from those reported in Table II. The conclusion reached in the text still appears to stand and is consistent with Temin's argument that the antebellum business cycle was driven by demand shocks (1974).

Alternative measures, the relative price of farm products or the rate of change of food prices, relative to the wholesale price index, (Warren and Pearson, 1933, pp. 25-27), made no significant difference to the reported results.

12. This procedure is described in more detail in Gordon (1982, pp. 1096-1097, 1099).

13. In his estimates of the output-inflation tradeoff for the nineteenth-century United States, Easton (1984, p. 526) finds a similar upward shift in the price-surprise coefficient.

14. A test for a shift in the pattern of price forecasting over the two subperiods cannot reject the null hypothesis of stability. The test statistic $F(2, 53) = 1.03$ was much less than the critical value of 4.08 at the 5 percent level.

15. The decadal variance in the 1860's however actually increased, presumably due to the Civil War.

16. It should perhaps be noted that the influence of the spread of the telegraph in lowering the cost of obtaining price information from other

markets is not captured explicitly in the specification of the price

forecasting equation based on lagged general price level changes, and it is

not clear how it should be modeled. One possibility is adding a time trend to

the equation to represent improvements in the forecast over time due to

increased information availability. In that case, the level, patterns of

shift, and t statistics of the price-surprise coefficients in equation (3)

remain essentially the same as those reported in the text. Rather

interestingly the time trend coefficient in the forecasting equation is

significantly different from zero in the antebellum period when telegraph and

rail systems were expanding rapidly, but not in the postbellum period under

the gold standard. The coefficient was also not significant when the equation

was estimated over the whole period.

17. The test statistic $F(20,30) = 25.49$ is much larger than the 1 percent

significance level, 2.77. Comparing the entire antebellum period, 1801-60,

with the 1871-1900 produces an even greater decline in variance, and omitting

the years during and after the War of 1812 does not alter the results.

Similarly, adding a time trend to the regression (in order to allow for a

change in the mean over time) does not affect the results either.

18. The larger the shocks to the economy as evidenced in the degree of price

level variability, the more incentive there is to distinguish between the

nominal and real components of any nominal income change (Alberro, 1981, p.

248). Cukierman (1979) suggests that as σ^2 falls, individuals need to sample

price information in fewer other markets, so changes in n reinforce the effect

of changes in σ^2 on α_2 for a given technology.

19. This increased lag implies that the total effect of a price surprise on

output would have risen significantly over the nineteenth century even though

the contemporaneous effect remained roughly stable. The total multiplier of

the price surprise, $\alpha_2/(1 - \alpha_1)$, increased by 300 percent between the antebellum and postbellum periods.

20. In the 1839-1848 decade capital formation constituted an 11-12 percent share of GNP, while by 1879-1888 it had increased to 19 percent, and to 20-22 percent by 1889-1898. (Davis and Gallman, 1973, p. 439)

21. Data limitations unfortunately prevent the period from being extended earlier than 1840, but the early part of the century is a very interesting period as well. Even without technological changes as dramatic as the telegraph and the railroad, there appear to have been significant improvements in information flows. Rothenberg, for example, in her study of Massachusetts farmers (1981, pp. 300-305) finds pronounced declines in the coefficient of variation over time for many crops, even early in the century when no important transport innovations had yet occurred. Pred (1973, pp. 20-77) finds a substantial decline in time lag of public information dissemination among cities before 1840 based on examinations of local newspapers. In addition if observations before 1840 had been available, we would have been able to observe the effects on the aggregate supply function of a dramatic change in information technology. Quite suggestively, David and Solar (1977, p. 30) find a marked dampening in the amplitude of short-term cycles in their change in labor-cost of living series. While many of the peak and trough rates of change were greater than +10 or -10 percent per annum before 1840, the fluctuations in subsequent years were significantly smaller.

22. Structural change in the economy may affect the nature of the shocks. As the economy moved over time from an emphasis on agriculture to relatively more emphasis on manufacturing, the nature of shocks to the economy may have changed also - from supply shocks, where price and output changes are inversely related, associated with agriculture (bad harvests), to demand

shocks, where price and output changes are positively related, more associated with manufacturing. If this had been the case and price and output changes were becoming more and more positively associated, then α_2 would have been forced up over time due to structural change. We may reject this possibility however because including a variable to capture the influence of supply shocks explicitly left the other coefficients essentially unaffected.

23. Obtained through private correspondence from Robert E. Gallman.

24. A bit more evidence and detail on this point is available in James (1984, p. 211).

25. However, the changes in relative factor shares in fact suggest that technical change may have actually been more complex than the neutral specification postulated here. See David (1977).

26. However, the David and Solar consumer price index produces roughly the same pattern of regression results. Since the variance of the index is smaller than that of the Warren-Pearson series the estimated α_2 coefficients are larger.

Table I

Price and Real Output Gap Changes During Business Cycles:
Mild Contractions, 1835-1975

Peak to Trough	Change in Wholesale Prices	Change in GAP
1836-38	- 3.57	-1.7
1845-46	0	- .97
1847-48	- 9.31	+ .71
1853-55	12.58	-4.44
1873-79	-39.05	+1.86
1890-91	0	+1.01
1895-97	- 4.32	-2.63
1899-1900	+ 6.29	- .77
1902-04	+ 1.2	-3.32
1910-11	- 3.6	- .92
1923-24	- 2.7	-3.81
1926-27	- 4.5	-3.73
1948-49	- 5.1	-2.08
1953-54	+ .2	-4.52
1957-58	+ 1.4	-3.81
1960-61	- .4	-1.29
1969-70	+ 3.5	-3.63

Sources: The timing of nineteenth-century business cycles is taken from the NBER reference cycles (Hughes and Rosenberg, p. 485; Burns and Mitchell, pp. 102-103). Nineteenth-century price movements are based on the Warren-Pearson wholesale price index (Warren and Pearson, pp. 25-27) and the twentieth century on the BLS wholesale price index (U.S. Historical Statistics, p. 200). Nineteenth-century real output movements are based on the Gallman series, while the twentieth-century figures are taken from Gordon (1981, pp. xv-xvii).

Notes: The change in prices is calculated as the percentage change in the log of the price index from peak to trough.
     GAP is measured as the difference in the logarithms of actual real output and full employment output. The change in GAP therefore is the difference between its values at the peak and trough of the cycle, $\Delta GAP = GAP^p - GAP^t$. This procedure follows Sachs (1980, p. 81), although he measures deviations in industrial production rather than in real output. As a result, the two measures of cyclical severity are not strictly comparable. The cycles are grouped according to degrees of cyclical severity here as well, but the criteria are somewhat different: Mild contactions $-5 \leq \Delta GAPx100$; Moderate contractions, $-10 \leq \Delta GAPx100 \leq -5$; Severe contractions, $\Delta GAPx100 < -10$.

Table IA

Inflation and Real Output Gap Changes During Business Cycles:
Mild Contractions, 1835-1975

Price Changes

Peak to Trough	Year Before Peak to Peak (1)	Peak to Trough, Annual Rate (2)	Change in Price Inflation (2) - (1)	Change in GAP
1836-38	13.10	-1.79	-14.89	-1.7
1845-46	7.50	0	- 7.50	- .97
1847-48	8.10	-9.31	-17.41	+ .17
1853-55	9.73	6.29	- 3.44	-4.44
1873-79	-2.23	-6.51	- 4.28	+1.86
1890-91	1.23	0	- 1.23	+1.01
1895-97	1.42	-2.16	- 3.58	-2.63
1899-1900	8.11	6.29	- 1.82	- .77
1902-04	6.4	.6	- 5.8	-3.32
1910-11	4.2	-8.3	-12.5	- .92
1923-24	3.9	-2.7	- 6.6	-3.81
1926-27	-3.2	-4.5	- 1.3	-3.73
1948-49	7.9	-5.1	-13.0	-2.08
1953-54	-1.3	.2	1.5	-4.52
1957-58	2.8	1.4	- 1.4	-3.81
1960-61	.1	- .4	- .6	-1.29
1969-70	3.8	3.5	- .3	-3.63

Table II

Price and Real Output Gap Changes During Business Cycles:
Moderate and Severe Contractions, 1835-1975

Peak to Trough	Change in Wholesale Prices	Change in GAP
Moderate Contractions		
1839-43	-40.10	- 6.2
1856-58	-12.14	- 5.09
1882-85	-23.95	- 8.82
1887-88	+ 1.17	- 5.41
1913-14	- 2.2	- 6.69
1918-19	+ 5.72	- 5.72
1937-38	- 8.90	- 6.94
1973-75	+26.2	- 8.97
Severe Contractions		
1893-94	-10.82	-11.09
1907-08	- 3.6	-12.07
1920-21	-46.0	-11.29
1929-33	-30.71	-45.68

Table IIA

Inflation and Real Output Gap Changes During Business Cycles:
Moderate and Severe Contractions, 1835-1975

Price Changes

Peak to Trough	Year Before Peak to Peak (1)	Peak to Trough, Annual Rate (2)	Change in Price Inflation (2) - (1)	Change in GAP
Moderate Contractions				
1839-43	1.80	-10.03	-11.83	- 6.2
1856-58	-4.64	- 6.07	- 1.42	- 5.09
1882-85	4.74	- 7.98	-12.72	- 8.82
1887-88	3.59	+ 1.17	- 2.42	- 5.41
1913-14	1.1	- 2.2	- 3.3	- 6.69
1918-19	10.9	- 5.5	-16.4	- 5.72
1937-38	6.8	- 8.9	-15.7	- 6.94
1973-75	12.3	13.1	.8	- 8.97
Severe Contractions				
1893-94	2.60	-10.82	-13.42	-11.09
1907-08	4.8	- 3.6	- 8.4	-12.07
1920-21	10.8	-46.0	-56.8	-11.29
1929-33	- 1.7	- 7.68	- 5.98	-45.68

Table III

Estimates of the Aggregate Supply Function, 1841-1858, 1871-1900

(t statistics in parentheses)

$$y_t = y_t^* + \underset{(4.69)}{.5236} (y_{t-1} - y_{t-1}^*) + \underset{(4.46)}{.5495} (p_t - E_{t-1}p_t) + \underset{(3.48)}{.00168} \text{ time}_t$$

$$- \underset{(-4.16)}{.4881}$$

$$y_t = y_t^* + \underset{(4.60)}{.5214} (y_{t-1} - y_{t-1}^*) + \underset{(3.75)}{.5703} (p_t - E_{t-1}p_t) + \underset{(3.44)}{.00167} \text{ time}_t$$

$$+ \underset{(.57)}{.0768} z_t - \underset{(-4.12)}{.4893}$$

$$y_t = y_t^* + \underset{(3.80)}{\frac{.6463}{(1 + .6463)}} U\hat{Y}_t + \underset{(7.78)}{.6334} (y_{t-1} - y_{t-1}^*) + \underset{(3.45)}{.0012} \text{ time}_t - \underset{(-4.31)}{.3675}$$

Table IV

Aggregate Supply Function Estimated Over Subperiods

(t statistics in parentheses)

Time Period	$(y_{t-1} - y^*_{t-1})$ α_1	$(p_t - E_{t-1} - p_t)$ α_2	$time_t$ α_3	α_0
1841-58	.1989 (.81)	.3516 (2.07)	.0050 (2.31)	-.9511 (-3.24)
1871-1900	.6370 (4.93)	.4774 (3.13)	.0010 (1.03)	-.3450 (-2.39)
1841-58, 71-75	.2446 (1.15)	.4349 (2.43)	.00206 (1.81)	-.7386 (-3.32)
1841-58, 71-80	.1522 (.72)	.6416 (4.00)	.00313 (3.45)	-.8822 (-4.09)
1841-58, 71-85	.4189 (2.88)	.4902 (3.75)	.00271 (3.26)	-.6399 (-3.86)
1841-58, 71-90	.4333 (3.20)	.5160 (4.06)	.00240 (3.45)	-.6077 (-4.04)
1841-58, 71-95	.4435 (3.46)	.5662 (4.24)	.00241 (3.46)	-.5823 (-4.16)
1841-58, 71-1900	.5236 (4.69)	.5495 (4.46)	.00168 (3.48)	-.4881 (-4.16)

FIGURE I
PRICE LEVEL AND OUTPUT GAP CHANGES
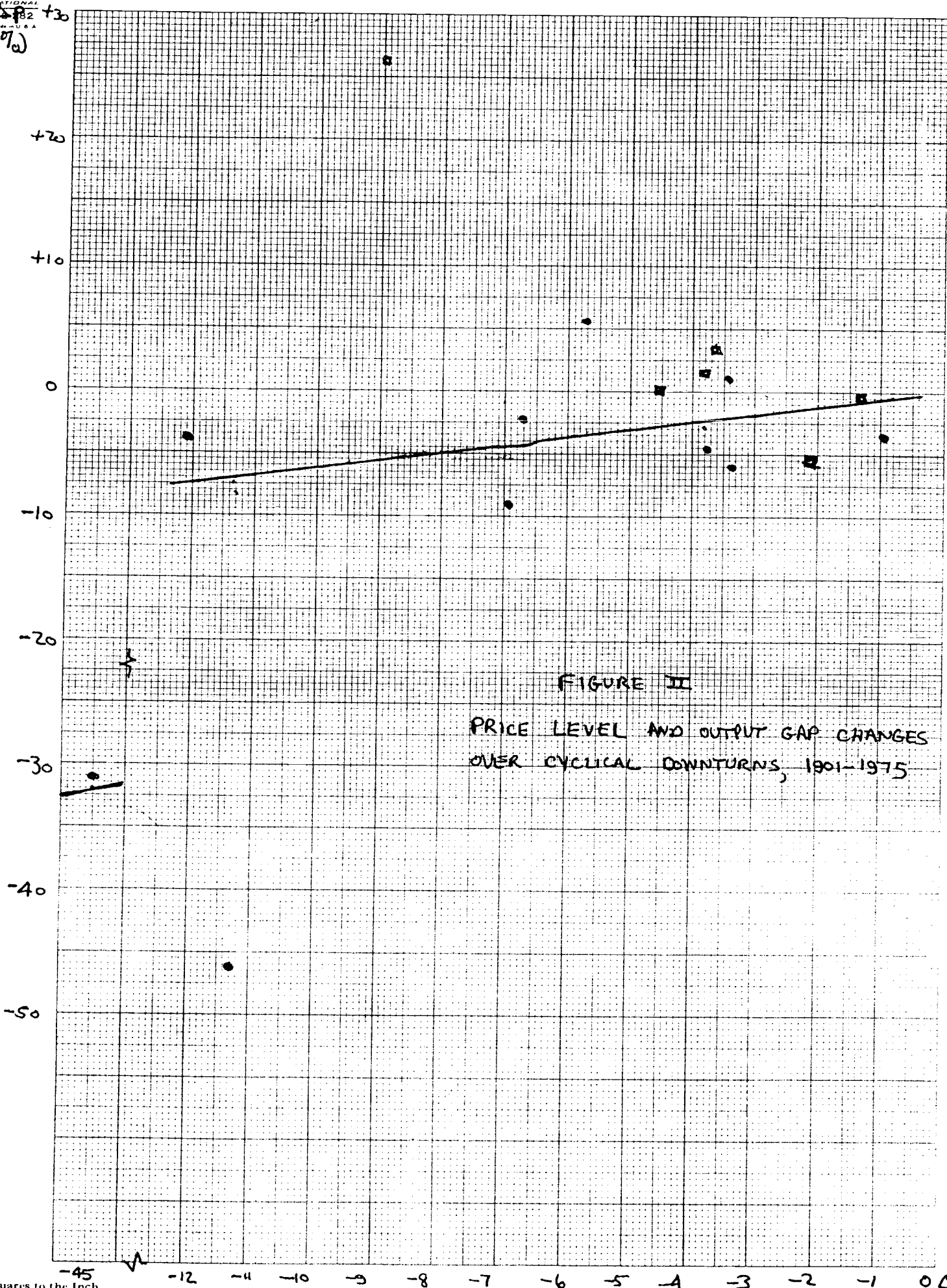OVER CYCLICAL DOWNTURNS, 1835-1900
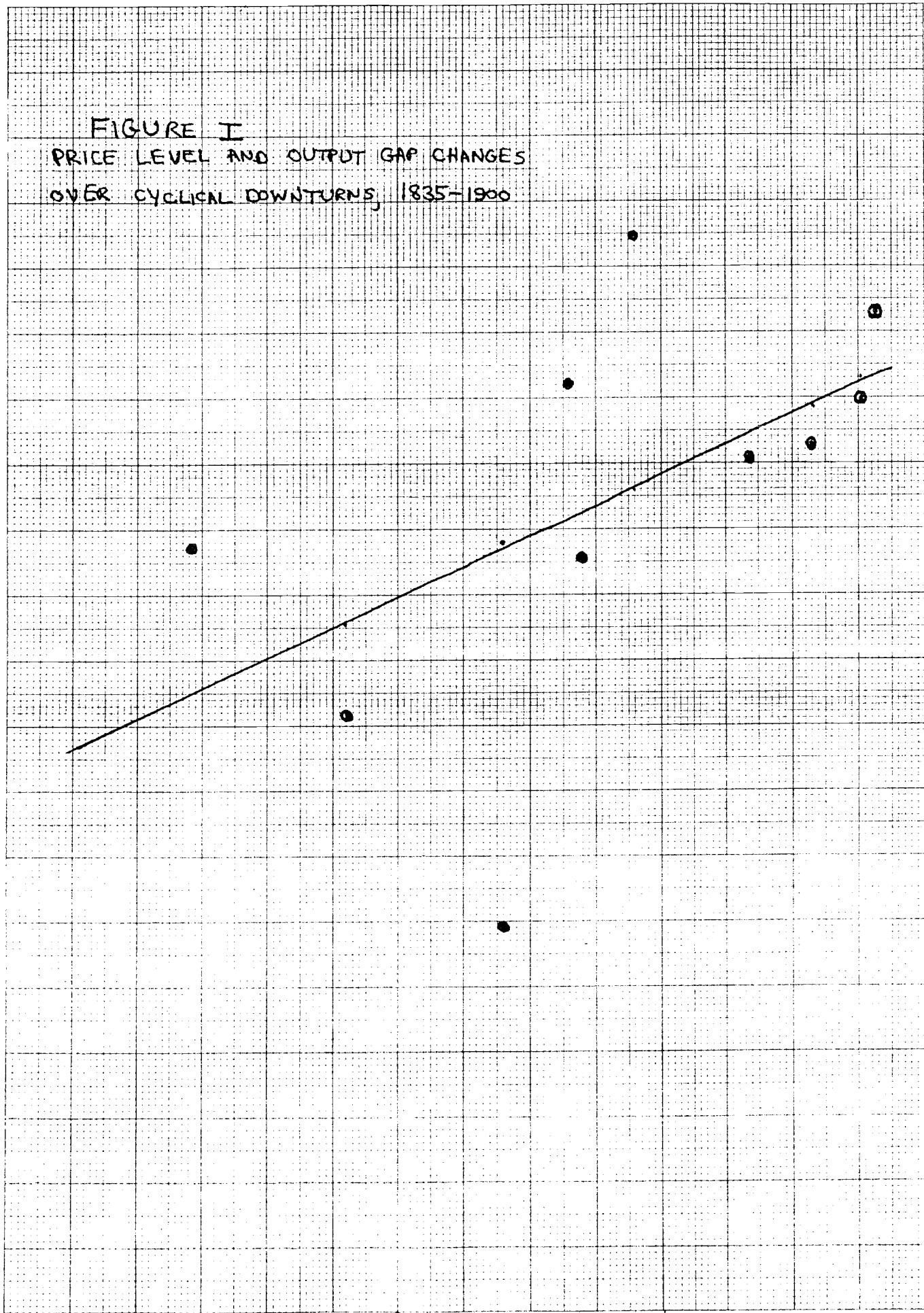
FIGURE II

PRICE LEVEL AND OUTPUT GAP CHANGES
OVER CYCLICAL DOWNTURNS, 1901-1975

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