INFLATION, PRODUCTIVITY, AND THE NAIRU DURING THE GREAT DEPRESSION

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ABSTRACT:

This paper argues that inflation during the low-output years of the early recovery from the Great Depression was consistent with the standard Phillips Curve relationship between inflation and deviations from trend output. The measure of trend output used is the time-varying NAIRU. I provide estimates of the path of the NAIRU during the interwar period, and find that prices rose during periods when actual unemployment, though high, fell below the NAIRU. Shifts in the NAIRU are interpreted as deviations from a long-run trend shared by three cointegrated variables (whose relationship I document): inflation, wage growth, and productivity growth. I argue that the NAIRU rose due to a steep decline in productivity during the Depression, which in turn was the result of a rise in the cost of credit intermediation in the nation’s financial markets.
1. Introduction

Inflation is not typically associated with economic downturns. The current climate is evidence of this; as the world economy continues to falter, the twin ‘D’ words of depression and deflation are seen with increasing frequency in business publications and academic writings. Nevertheless, the price level rose throughout much of the Great Depression, the world’s last severe economic slump.

Prices rose between 1933 and 1937, and again after 1939 (which was followed by ten years of year-to-year inflation encompassing the Second World War). At its peak between 1933 and 1934, the growth rate of the price level was 7.1 percent. These data are presented in Table 1, alongside those representing what Christina Romer (1999) terms ‘a puzzle in need of explanation’: real GNP, real GNP growth, and real GNP relative to trend. Trend GNP, in this case, is constructed by extending forward real GNP growth for the period 1910 to 1924; deviations from trend are calculated as log differences. Immediately apparent is the US economy’s significant shortfall relative to trend until 1942. This deficit is reflected as well in the unemployment data for the period; average unemployment for 1933-42 was 16.3%, peaking at 24.9% in 1933.

Any conventional model of price adjustment would suggest that given such a deep economic slump, disinflation or even deflation should have been observed during the 1930s; how, then, can prices have risen during the period? Temin and Wigmore (1990) have argued that the devaluation of 1933 resulting from the United States’ suspension of the gold standard put upward pressure on both tradables prices and expectations of the general price level; Friedman and Schwartz (1963) and Eichengreen and Sachs (1985) agree
that this devaluation was likely to act as a one-time supply shock, contributing to
inflation during the recovery. But Romer points out that this inflation was a general
phenomenon throughout most of the Depression; thus, one-time supply shocks such as
the devaluation of 1933 or the National Industrial Recovery Act (NIRA) in 1933-5
explain only short pieces of 1930s inflation, leaving unexplained the more persistent rise
in the price level throughout the period.

Romer offers two primary explanations for the anomaly. First, she argues that
even with output so far below trend, the rapid growth rate of the economy during the
recovery period led to inflation, working partially through the channel of raw materials
prices. She also points out that the NIRA, which set minimum wages and encouraged
firms to base their prices on observable costs, and thus led to prices being set as
something approaching a simple mark-up over wages, caused a persistent decoupling of
inflation from the deviation of output relative to its trend level.

This paper will not dispute the importance of either of these factors for the price
rise of the 1930s; indeed, the unprecedented growth rate of the economy during the
recovery and early years of WWI, as well as New Deal regulations boosting wages, each
played a role in generating the observed inflation. However, I will argue that the inflation
was not, after all, anomalous; though output was certainly depressed, the economy was
not so far beneath its potential as to rule out any expectation of inflation. To this end, I
will argue for a different measure of trend output: rather than extend earlier growth rates
forward into the time of the Great Depression, various estimates of the natural rate of
unemployment will be utilized to measure the economy’s position relative to trend. I will
propose a richer specification of the wage and price Phillips curve processes governing inflation, which takes account of time variation in the natural rate of unemployment. Crucial to this argument will be the role that productivity plays in determining the level of unemployment consistent with stable prices, and the fact that productivity growth fell precipitously through the early years of the depression. This fall, I will claim, was largely the result of the destruction of financial intermediary infrastructure, which raised the cost of credit intermediation in the United States and around the world. I will conclude, then, that this destruction and its devastating effect on productivity contributed to a rise in the natural rate of unemployment (i.e., a fall in trend output), such that inflation during the recovery was not anomalous – rather, it was to be expected.

The remainder of the paper is structured as follows. In Section 2 I review the fact that prices rose during the 1930s while the economy stagnated, as well as existing explanations for this phenomenon. Section 3 briefly explains why alternative measures of trend output might be appropriate. I then discuss in more detail one such measure, the natural rate of unemployment, including its time-varying nature. In Section 4 this variation is characterized as fluctuation about a long-run relationship between price inflation, wage inflation, and productivity growth, which leads to a presentation of the model used in this paper – a specification of the wage- and price-Phillips curve which incorporates the notion of a time-varying natural rate of unemployment. Section 5 presents the results obtained from applying this model to the Great Depression, noting the implications for the natural rate of unemployment, and thus for inflation, of the sizeable decrease in productivity observed during the period. In Section 6 I present an
explanation for this decrease, focusing on the role of financial intermediation in the economy. Section 7 concludes and suggests avenues for future research.

2. Explaining the Price Rises of the 1930s

As noted above, Romer (1999) identifies the anomaly of inflation during the recovery from the Depression, concurrent with output significantly below trend. She offers two explanations for this phenomenon: growth rate effects and the weakening of the deviation-from-trend effect resulting from the NIRA and other New Deal regulations.

2.1 Anomalous Inflation

The model Romer (1999) uses to examine the behavior of prices during the Great Depression is a Phillips curve similar to that employed by Hanes (1996):

\[ \pi_t = \pi_t(y_t - y_t^*) + \pi_{t-1} + \pi_2 + \pi_3t + \epsilon_t \]  

(1)

where \( \pi \) is the rate of inflation, \( (y_t - y_t^*) \) is the percentage deviation of output from trend, and \( \epsilon \) captures supply shocks. Inflation is calculated as the log difference of the implicit GNP deflator\(^1\). Output is measured as real GNP, while trend output is calculated using a piecewise linear trend, using 1873, 1884, 1891, 1900, 1910, and 1924 as benchmark dates. Trend GNP after 1924 is constructed by extending forward the trend for 1910-24.

Forecasts of inflation for the period 1933 to 1942 generated by this estimated relationship (using a dynamic simulation to capture the effects of the lagged dependent variable) are presented in Table 2, column 2. What is apparent is that rising prices

\(^1\) Note: Data and sources are described in fuller detail in the Data Appendix.
between 1933 and 1937, and again from 1939 to 1942, is not explained by this base specification of the Phillips curve.

2.2 The Effect of the Growth Rate

In order to allow for a more complicated price adjustment mechanism than that implied by the base Phillips curve, Romer augments her model as follows:

\[ p_t = b_1(y_t - y_t^*) + b_2 \Delta y_t + b_3 \Delta y_{t-1} + \Delta_2 + \Delta_3 t + \epsilon_t \]  

(2)

where \( \Delta y_t \) is the annual percentage change in real output. The growth rate effect is found to be significant and substantially larger than the deviation from trend effect. Forecasts generated by this model appear in column 3 of Table 2; while the model continues to predict deflation for much of the period, the forecasts are much closer to actual inflation than those produced by the base Phillips curve model (as illustrated in Figure 1).

Romer proposes that the source of the growth rate effect is feedthrough from raw material prices into the GNP deflator. Growth rates reached very high levels during the recovery (Table 1, column 5), and as they did so, demand outstripped supply for many commodities. As depicted in columns 7 and 8 of Table 1, wholesale prices rose throughout the period, which can be thought of as an adverse supply shock, contributing to the general rise in prices. Indeed, Romer estimates nearly a one-to-one relationship between the growth rate of real GNP and commodity price inflation.

2.3 The Effect of the NIRA

A final contributor to the inflation of the recovery period considered by Romer is the National Industrial Recovery Act (NIRA), enacted in July of 1933. The NIRA could have contributed to inflation through two channels. First, it enacted minimum wages for
industry. Assuming that these minima were binding, this could have led to inflation through the traditional Phillips curve wage channel – especially because the NIRA also encouraged firms to base their prices on observable costs, of which wages constitute a major portion. Second, even if these minimum wages directly caused only a one-time jump in prices, the NIRA could have engendered a persistent decoupling of prices from the deviation of output from trend. Under ordinary circumstances, a drop below trend output, associated with rising unemployment, allows employers to set lower wages (or at least to slow their growth), as there are more unemployed workers competing for jobs. To the extent that the NIRA prevented them from doing so, it may have prevented deflation that would ordinarily result from output’s fall below trend.

To test the effects of the NIRA empirically, the Phillips curve is augmented with a variable constructed by interacting deviation from trend with a dummy taking the value 0.5 in 1933, 1.0 in 1934, and 0.5 in 1935 (the NIRA was struck down as unconstitutional in June of 1935). Romer’s evidence suggests that the NIRA did indeed reduce the deviation-from-trend effect. Fitted values from this regression are presented in Table 2, column 4. They are compared to fitted values from an estimation through 1942 of the model including growth rate effects but excluding the NIRA, presented in column 5. It is clear that the inclusion of the NIRA interactive term greatly improves the fit of the Phillips curve model to actual inflation during the recovery; the model predicts nearly all episodes of inflation, excepting only the price rise of 1936-7.
3. The NAIRU – An Alternative Measure of Trend Output

The arguments of the previous section were posited as an explanation for the puzzle of inflation during the 1930s, while output languished far below trend. But this puzzle is based on the assumption that trend output equals that which would have obtained had the economy’s 1910-24 growth rate prevailed through 1942. This assumption is questionable, for two reasons.

First, the average growth rate in a given economic cycle rarely seems to carry over to the next. Table 3 presents the mean growth rate between each of Romer’s benchmark dates and between the later benchmark dates of 1942, 1953, 1965, 1978, 1986, and 1996 (chosen to be in mid-expansion, when the economy is likeliest to be at its trend level). Clearly, the mean does not stay constant from cycle to cycle; it therefore seems erroneous to identify one cycle’s mean growth rate as the trend rate of growth for another cycle.

Suggestively, Romer’s measure of deviation from trend output follows very closely a measure of deviation from trend unemployment, calculated as actual unemployment less a four-year moving average of unemployment, until 1924 (when Romer begins using a past mean growth rate to construct trend output), after which the two differ significantly. The two are plotted in Figure 2; Table 4 presents the results of Chow Tests for a break in a model relating the two measures of trend output, which fail to reject a break in the relationship in 1924.

Secondly, the years 1925-1942 were among the most turbulent in our nation’s history, both economically and otherwise. The last years of the Roaring Twenties, the subsequent crash of the financial markets, innumerable bankruptcies, defaults, and bank
panics, the introduction of the socialist-flavored policies of the New Deal, and the outbreak of war could not have left the economy’s structural capacity untouched. Even if the Depression did not necessarily destroy sufficient physical capital to explain completely the fall in output, I will argue below in greater detail that the destruction of much of the nation’s (and world’s) financial capital severely damaged the economy’s productive capacity. Surely there were years during the Depression in which output fell below its potential, but, just as surely, potential itself fell as well.

A concept that has been used to capture the idea of time variation in trend output in Phillips curve models is the nonaccelerating inflation rate of unemployment, or NAIRU. The NAIRU is the rate of unemployment consistent with stable prices (or, in its original specification, with stable wages); in the long run, unemployment cannot deviate from the NAIRU. It has a long history as a building block of macroeconomic theory, reflecting the tradeoff between unemployment and inflation implicit in the Phillips curve. Many theories have been proposed to explain exactly why prices should have real effects on employment, including information asymmetries (Friedman (1968), Lucas (1973), Mankiw and Reis (2001a)), long-term labor contracts (Fischer (1977), Gray (1976), Taylor (1980)), the costs of price adjustment (Rotemberg (1982), Mankiw (1985), Blanchard and Kiyotaki (1987), Ball and Romer (1990)), and departures from full rationality (Akerlof and Yellen (1985)). A common thread in all of these arguments is

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2 Ball and Mankiw (2002) write, ‘It is beyond dispute that this acronym is an ugly addition to the English language.’

3 A similar concept is the natural rate of unemployment, which is the rate at which inflation expectations are fulfilled. The two terms are treated as synonyms in this paper.
that some market imperfection not included in the classical model means that in the short run, money is not neutral, and acts in opposite ways on inflation and unemployment.

Another idea common to the recent NAIRU literature is that the relationship between unemployment and inflation is not stable, as has been proven by data since the stagflation episodes of the 1970s. Rather, we observe a NAIRU that varies over time (referred to as the TV-NAIRU), so that different levels of unemployment are consistent with rising, stable, or falling prices in different periods. The reasons for this shifting pattern are a matter of some debate. Blanchard and Summers (1986) suggest that the labor market is subject to hysteresis, the phenomenon of a variable failing to return to its original value after being acted on by some force, even after the force has been removed. In other words, deviations of unemployment from its natural rate may be closed by an adjustment of the NAIRU. Alternatively, the NAIRU is thought to reflect how well the economy matches workers and jobs, and so slow-moving shifts can result from changes in demography or labor-market institutions. Rich and Rissmiller (2001), who reject the hypothesis of such changes for the period 1967-2000, focus on the relationship between productivity and the TV-NAIRU. Trends in productivity growth are also identified by Staiger, Stock and Watson (2001) as driving changes in the natural rate of unemployment.

Why should shifts in productivity affect the NAIRU? Neoclassical theory and empirical evidence both suggest that with constant productivity growth, real wages move in step with productivity over time. Workers come to expect this rate of wage growth; if productivity falls, they resist wage cuts or slower wage growth. To the extent that such resistance influences the wage-setting process (i.e., if workers have sufficient bargaining
power), the resultant mismatch between productivity growth and real wage growth worsens the inflation-unemployment tradeoff: the NAIRU rises\(^4\).

The U.S. economy suffered such a productivity shock in the Great Depression. As depicted by figure 3, productivity growth trended downward through most of the 1920s and early 1930s, turning negative in 1932-3.\(^5\) This suggests a possible rise in the NAIRU, as does figure 4, which presents a scatterplot of inflation and unemployment for the years 1890-1942. Two trendlines are plotted; the trend for 1930-1942 intersects the x-axis to the right of that for 1890-1929, suggesting that the level of unemployment consistent with stable prices had risen by the 1930s. This, in turn, gives rise to the possibility that actual unemployment, though high, may have been below the natural rate of unemployment at times during the Depression and recovery period. If this were the case, inflation during these times would not be a puzzle at all, but would merely be what the standard Phillips curve predicts.

4. A TV-NA IRU Phillips Curve Model

To examine this question empirically, I turn to a Phillips curve model that allows for time variation in the NAIRU. In particular, following Staiger, Stock and Watson (2001), I generate forecasts of inflation from a model that explicitly captures the long-run

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\(^4\) See Mankiw and Reis (2001b) for an interesting interpretation of the role of the slow dissemination of information in driving this process.

\(^5\) Note that here and elsewhere, productivity is measured as trend productivity – calculated as a four-year moving average of Kendrick’s output per manhour in the nonfarm business sector – to avoid low frequency measurement error and cyclicality in the data.
The price equation in our model relates the deviation of inflation from its expectation to a gap in economic activity and supply shocks. That is,

$$\pi_{t+1} - \pi_{t+1}^e = a_p + b_p X_t + g_p Z_t + \varepsilon_{p,t+1}$$  \hspace{1cm} (3)$$

where $\pi_{t+1}$ is expected inflation in period $t+1$ as of period $t$, $X_t$ is a vector of activity gap variables (in our case we will use the difference between actual and trend unemployment), $Z_t$ is a vector of supply shocks (research on recent data typically uses oil prices and the Nixon price and wage controls; our system will use dummies for the NIRA, FDIC insurance, and money growth), and $\varepsilon_{p,t+1}$ is an error term. Following the usual convention (see Gordon (1990, 1998), Fuhrer (1995), and Staiger, Stock and Watson (2001)), we proxy $\pi_{t+1}$ by $\pi_t$, so that $\pi_{t+1} - \pi_{t+1}^e = \varepsilon_{\pi,t+1}$. This gives us

$$\pi_{t+1} = a_p + b_p X_t + g_p Z_t + \varepsilon_{\pi,t+1}$$  \hspace{1cm} (4)$$

Making the same assumptions, we obtain a similar equation for nominal wages:

$$\pi_{t+1} = a_w + b_w X_t + g_w Z_t + \varepsilon_{\pi,t+1}$$  \hspace{1cm} (5)$$

In practice, because prices and wages are codetermined, we allow for correlation between the error terms in the two equations by estimating (4) and (5) as a system, using seemingly unrelated regressions.

Equations (4) and (5) omit both lag dynamics and the long-run relationship between real wage growth and productivity growth, to which we now turn.
4.2 The Markup as a Cointegrating Error Term

In his book Lessons from the Great Depression (1989), Peter Temin notes the differing experiences of the United States and Germany during the Great Depression with respect to wages and productivity. While German wages were allowed to fall, U.S. wages were maintained at a high level (in part by the NIRA) – simultaneously, the United States enjoyed a more rapid return to high productivity during the 1930s. Temin observes that the US experience may be explained by efficiency wage models, postulating a relationship between wages and productivity in which employers take advantage of high wages to hire more productive workers and encourage higher work effort and job commitment.

Temin’s book does not explore this relationship further, and it is beyond the scope of this paper to do so as well. Nevertheless, this paper takes advantage of an empirical relationship between real wage growth and productivity growth, which is depicted in figure 5. As predicted by theory, the series appear to follow a common trend. This suggests that wage inflation, price inflation, and productivity growth may be cointegrated – i.e., that deviations by any one of the three from the common trend they share cannot persist in the long run.

In fact, theory says that

$$\omega_{t+1} = \omega_{t+1}^{e} + \omega_{t+1}^{p}$$

where $\omega_{t+1}$ is wage inflation, $\omega_{t+1}^{e}$ is expected price inflation, and $\omega_{t+1}^{p}$ is expected productivity growth, all at time $t+1$. Continuing to follow the conventional random walk assumptions, we proxy $\omega_{t+1}^{e}$ by $\omega_{t}$, and $\omega_{t+1}^{p}$ by $\omega_{t}$, where again productivity growth is
measured as a four-year moving average. This leads to a specification of the cointegrating relationship as

$$\Delta_{t+1} = \Delta_{t} + \Delta$$

(7)

In other words, if price inflation, wage inflation, and productivity growth are integrated of order one (I(1)), then $\Delta_{t} - \Delta_{t+1} + \Delta$, sometimes referred to as the *markup*, should be stationary over time (integrated of order zero, or I(0)). Support for such an empirical relationship can be found for the U.S. from 1960-2000 in Staiger, Stock and Watson (2001) and Banerjee, Cockerell and Russell (2001) in Australian data from 1972 to 1995.

Tables 5.1 and 5.2 presents empirical tests of the univariate and multivariate trends in the data. Inflation is calculated as the log difference of the implicit GNP deflator; wage inflation is measured as the log difference in average hourly earnings in the nonfarm business sector, which is in turn calculated as Lebergott’s average annual nonfarm earnings series divided by Kendrick’s annual nonfarm manhour series. I use the interwar (1919-1942) sample, and test current wage inflation, lagged price inflation, and lagged productivity growth for unit roots, and the trivariate system for a cointegrating relationship.

Augmented Dickey-Fuller unit root tests, assuming trends in the data, do not reject the hypothesis of a unit root for any of the three series at the 10% significance level. Using the same set of assumptions, a Johansen cointegration test finds evidence of a single cointegrating relationship between the three. This evidence supports the hypothesis that real wages, adjusted for productivity growth, are stationary: deviations
from the long-run trend shared by the three are not persistent; the markup, therefore, can be used as an error-correction term in the sense of Granger (1983).

To make this clear, we augment our earlier wage-price system as follows:

\[
(Dp)_{t+1} = \alpha_0 + \alpha_1(L)(Dp) + \alpha_2(L)(Dw - Dw_{t+1} + \lambda) + \alpha_3Y + \alpha_4Z + \epsilon_{t+1} \tag{8.1}
\]

\[
(Dw)_{t+1} = \beta_0 + \beta_1(L)(Dp) + \beta_2(L)(Dw - Dw_{t+1} + \lambda) + \beta_3Y + \beta_4Z + \epsilon_{t+1} \tag{8.2}
\]

System (8) is referred to as the triangular representation of a system with cointegrated variables. \((Dw - Dw_{t+1} + \lambda)\) is referred to as an error-correction term because deviations from its mean forecast adjustments in the cointegrated variables to reestablish the long-run cointegrating trend. Assuming that the slope coefficients on the other variables in system (8) are stable, the sum of the error-correction term and the constant intercept term can be interpreted as a time-varying intercept for the system, any drift in which reflects shifts in the NAIRU (cf. Staiger, Stock, and Watson (2001)).

The actual series values for the markup are constructed using the dynamic OLS procedure of Stock and Watson (1999), in which lagged price inflation is regressed on wage inflation and lagged productivity growth, as well as two leads and lags each of the change in wage inflation and the change in lagged productivity growth. The coefficients on wage inflation \((\lambda'w)\) and lagged productivity growth \((\lambda'q)\) are then used to construct the markup: \(markup_t = \lambda'w - \lambda'q - \lambda_1Markup_{t-1}\).\(^6\) Table 5.3 presents an ADF unit root test for the markup, which rejects the hypothesis of a unit root at the 1% significance level; a plot of the markup (Figure 6) further supports the hypothesis that the markup is stationary.

\(^6\) Note that \(\lambda'q\) is negative, preserving the proper signs in the markup.
5. Results

Before presenting the results of estimating system (8), I describe two different ways of estimating trend unemployment for the ‘activity gap’ variable $X_t$: a simple moving average of unemployment, and a straight-forward way of estimating the natural rate of unemployment.

5.1 Estimates of trend output

One simple way of estimating trend unemployment is to simply use a four-year moving average of the raw data (which are taken from Lebergott (1964)). The ‘gap’ is then the difference between actual unemployment and the moving average. The disadvantage of using a backward-looking moving average is that any structural aspects of the economy captured by this method refer to past characteristics of the labor market; on the other hand, given the role of expectations (often based on past experience) in the wage-setting process, this may be appropriate. In any case, using a forward-looking moving average, or an average using two leads and lags, does not substantially change the results that follow, which use the backward-looking moving average.

Another way to measure trend unemployment would be to actually attempt to estimate the NAIRU. A straight-forward method of doing so, which I follow here, is presented by Ball and Mankiw (2002).

A simple rewriting of our price Phillips curve is

$$\pi_{t+1} = \beta (U_t - U_t^*) + \gamma Z_t$$

(9)
where we have explicitly written our gap variable as unemployment \((U_t)\) less the natural rate of unemployment \((U_t^*)\). If it is assumed that the supply shocks are uncorrelated with contemporaneous values of \(U_t\), then this equation can be estimated by OLS. This, of course, is a rather strong assumption: many supply shocks will, in fact, be correlated with unemployment. While this problem could be handled by use of instrumental variables which are correlated with the supply shocks but not with unemployment, in practice finding such instruments is very difficult and rarely done.

Another econometric issue with estimating the NAIRU is that of standard errors. Only recently has the literature attempted to put standard errors on estimates of the NAIRU. Stock, Staiger and Watson (1997) estimated a NAIRU of 6.2 percent in 1990, with a 95 percent confidence interval of 5.1 to 7.7 percent. Using a Kalman smoother (which requires more data than is available for the Depression period), the same authors narrow their error bands to \(\pm 0.4\) percentage points in their 2001 paper, but in any case it appears that given existing specifications, the NAIRU is not estimated precisely. In what follows I present only point estimates.

A first pass at estimating the NAIRU might be undertaken by assuming that \(U^*\) is not a function of time, but is constant through the sample. Then we can rewrite (9) as

\[
\Delta P_{t+1} = \Delta_0 U_t - \Delta_1 U^* + \Delta_2 Z_t
\]  

(10)

Now, if we regress the change in inflation on a constant, unemployment, and a vector of supply shocks (I use the NIRA dummy, the FDIC dummy, and the growth rates of the currency-deposit ratio, the loan-deposit ratio, and the level of bank loans), then the ratio
of the absolute value of the constant term ($\bar{U}$) to that of the coefficient on unemployment ($\bar{b}$) gives an estimate of $U^*$. When we do this using data from 1919 to 1942, we estimate a constant of –3.36, and a coefficient of -0.25 on unemployment, leading to an estimate of 13.7 percent for the natural rate of unemployment.

Of course, as has already been emphasized, the NAIRU is not constant over time. To estimate the path of a TV-NAIRU, rewrite equation (10) as

$$ U^* - \frac{\partial U}{\partial \bar{b}} \bar{Z} = U_t - \frac{\partial U}{\partial \bar{b}} \bar{D}_t $$

(11)

The right-hand side of this equation can be calculated from the data, where we use the same $\bar{b}$ (-0.25) as that estimated in equation (10). The left hand side, on the other hand, is the difference between the NAIRU and a term proportional to the supply shocks. It is often assumed in the literature that movements in the natural rate of unemployment are long-term movements, reflecting relatively slow changes in the unemployment-inflation tradeoff; higher frequency fluctuations in the right hand side of (11) can therefore be attributed to the shorter-term supply shocks. This leads to the estimation of the NAIRU as the trend component of the right-hand side of equation (11).

I use the Hodrick-Prescott Filter to attain the trend component of the data (Hodrick and Prescott (1997)). The HP Filter minimizes the sum of squared deviations between a linear time trend and the actual data, with a penalty for curvature to smooth the trend. The higher the penalty, the smoother the estimated trend; I use a penalty parameter value of 100, which is the most common value used with annual data.
Figure 7 presents the estimate for the path of the NAIRU during the interwar period, along with the actual unemployment data and the constant estimate of the NAIRU (13.7 percent) given above. It is interesting to note that as productivity fell, the NAIRU rose such that actual unemployment fell beneath the estimated natural rate of unemployment between the years 1925 and 1931, and again between 1935 and the end of the sample. Recalling that inflation was positive during 1933-7 and again after 1939, we see that this simple pass at estimating the natural rate of unemployment suggests that price movements during the recovery were not anomalous, but would have been predicted by the naïve specification of the Phillips curve offered in equation (9) – as depicted in Figure 8.

One potentially unattractive feature of the TV-NAIRU presented in Figures 7 and 8 is that its ends are pulled to somewhat implausible extremes by the HP Filter. That is, the early and late parts of the estimated NAIRU are strongly influenced by the actual level of unemployment, and may therefore not be good estimates of the natural rate. To deal with this, I repeat the exercise described above for a sample running from 1897 to 1970 (which brings us through the post-war period prior to the oil shocks of the 1970s). Following the same methodology, a constant NAIRU of 16.1% is estimated; the path of the TV-NAIRU from 1919 to 1942 is plotted with actual unemployment in Figure 9. Figure 10 reveals that, as with the earlier estimate, this estimate of the natural rate was higher than actual unemployment in the mid-to-late 1930s, when prices were rising.

It should be noted that, as mentioned earlier, these are point estimates only, with potentially large standard errors. We cannot, therefore, say with a great deal of precision
that actual unemployment was below the NAIRU. We do, nevertheless, observe that the path of the NAIRU appears to have been trending upwards into the mid-1930s, when prices began to rise, such that the gap between unemployment and its trend was surely shrinking, lessening the mystery surrounding recovery-period inflation.

I turn now to the results of estimating system (8), using each of our three measures of trend unemployment in turn.

5.2 Results from the Price-Wage Phillips Curve System

I estimate system (8) using three measures of trend output to construct my ‘gap’ variable: the simple four-year moving average of unemployment, and the two estimated paths of the TV-NAIRU discussed in the previous section. Estimation output for the two specifications is presented in Table 6. There is a noticeable improvement in fit (as measured by adjusted R-squared) in the model using the TV-NAIRU estimated over 1919-42, although the effect is less using the TV-NAIRU estimated over 1897-1970. However, it is interesting to note the differences between the coefficients on the gap variable and on the error-correction term in the two models. Using the difference between actual unemployment and the 1919-42 TV-NAIRU as the gap, the error-correction term becomes much more significant and takes on the correct signs (recall that the markup is calculated as $\frac{q_{t-1} - q_t}{\frac{w_{t-1} - q_{t-1}}{w_t - q_t}}$; if it is high, then inflation is above trend, which implies that inflation should fall to adjust back to trend in the next period), while the coefficients on the gap variable become less significant. This is consistent with the hypothesis that deviations from the long-run trend shared by real wage growth and productivity growth
are associated with changes in the NAIRU; information contained in the gap between
unemployment and the TV-NAIRU is captured by the markup.7

Fitted values for inflation generated by the estimation are provided for the years
1933-42 in Figure 11. The models fit the data quite well; the root mean square error of
the fitted values using the four-year moving average as trend unemployment is 0.0413;
using the TV-NAIRU estimated over 1919-42, the RMSE is 0.0205; using the TV-
NAIRU estimated over 1897-1970, the RMSE is 0.0416. The models correctly predict
the direction of movements in the price level for nearly all years, without explicitly
incorporating growth rate effects into the model (I do, of course, include a dummy for the
NIRA as one of my supply shock controls).

To sum up the findings of the previous two sections: price inflation, wage
inflation, and productivity growth follow a common trend; deviations from this trend
constitute a time-varying intercept term closely related to the TV-NAIRU in a price-wage
Phillips curve system (it is interesting to note the coincidence of the peak in the estimated
NAIRUs and the trough of trend productivity growth, depicted in Figures 12 and 13).
Estimates of the path of the TV-NAIRU during the Depression and recovery period
suggest that the drop in productivity pushed the TV-NAIRU up such that actual
unemployment fell below its natural rate at roughly the same time that prices rose, just as
predicted by the standard Phillips curve model of the inflation-unemployment tradeoff.

7 Staiger, Stock and Watson (2001) actually use the markup to estimate the TV-NAIRU as a
time-varying intercept term in the Phillips curve system. However, doing so requires
implementation of the Kalman filter, for which more observations are required than are
available for the interwar period.
Using a model of this tradeoff which explicitly takes account of the role of the long-run relationship between productivity growth and real wage growth, the direction of price movements during the recovery period is correctly predicted for nearly all years from 1933-42.

Thus, the fall in productivity of the late 1920s and early 1930s implied a rise in the NAIRU which all but removes the puzzle of inflation during the 1930s: price rises were simply a consequence of the usual Phillips-curve relationship, albeit one in which the rate of unemployment consistent with stable prices had risen to levels much higher than in past years. What remains to be explained is the source of that fall in productivity. One possibility is that the period coincided with large-scale destruction of productivity-enhancing technology. This does not seem to be the case, however; not only were technologies not lost, but Field (1999) finds evidence that the period from 1929-1941 was the most technologically **progressive** in U.S. history. Indeed, the late 1930s saw productivity growth return to positive territory as new technologies were implemented. It must be, then, that during the Depression and in the early recovery years, something was preventing new and existing technologies from being applied, projects which could have benefited from them being undertaken, investments from being made. In what follows, I argue that the tightening of financial conditions and the destruction of financial intermediary capacity, in both the U.S. and global economy, were significant factors in explaining the productivity decline.
6. The Effects of the Financial Crisis on Productivity During the Depression

In their classic work *A Monetary History of the United States, 1867-1960* (1963), Milton Friedman and Anna Schwartz portray the Great Depression as a time of numerous bank failures, bank runs, a rise in the currency-deposit and reserve-deposit ratio, and falls in the level of bank loans, the ratio of loans to securities in bank portfolios, and the loan-deposit ratio (some of these data are plotted in Figures 14-16). In other words, it was a time of severe financial tightening, caused by catastrophic turmoil in the capital markets (the specific reasons for this chaos, ranging from the bursting of a stock market bubble in 1929 to international politics to dogmatic adherence to the gold standard, are beyond the scope of this paper; see Bernanke (1995), Bordo (1997), Calomiris and Hubbard (1996), Field (1992), Friedman and Schwartz (1963), Hart (1938), Obstfeld and Taylor (2002), and Temin (1989) for various explanations). Numerous authors have emphasized a link from financial conditions to macroeconomic performance. Fisher (1933) and Hart (1938) speak of the role of inside debt; Mishkin (1978) and Hubbard (1995) focus on household balance sheets, liquidity, and the so-called ‘credit channel’. Friedman (1981) writes of the link between credit and aggregate activity. The classical story told of the link from the financial sector to the macroeconomy is that offered by Friedman and Schwartz (1963), who stressed the effects of the banking crisis on the money supply.

In theory, however, money can only impact the real economy in the short run, as mentioned earlier. Due to the lack of theoretical grounding for persistent nonneutrality of money, which would have to be present to support a purely monetary link from capital
markets to the real economy, a different story has been told by Bernanke (1983) and Bernanke and Gertler (1989, 1990). Here the focus is on agency costs and market imperfections, especially asymmetric information between lenders and borrowers, which give rise to a demand for financial intermediation. The *cost of credit intermediation* is particularly emphasized; the CCI is defined as being ‘the cost of channeling funds from the ultimate savers/lenders into the hands of good borrowers… (including) screening, monitoring, and accounting costs, as well as the expected losses inflicted by bad borrowers.’ (Bernanke (1983), p. 263) While no direct measure or the CCI exists, Bernanke (1983) presents data similar to that plotted in Figures 14-16, illustrative of a rise in the CCI caused by the financial crisis. A vicious feedback loop from the CCI to defaults and bankruptcies developed (the financial crisis pushed many firms into bankruptcy, which made banks more hesitant to extend credit, which forced more borrowers to default or declare bankruptcy, etc.), greatly reducing the efficacy of the financial intermediation infrastructure.

A useful survey of the literature on the link between financial intermediation and the macroeconomy is provided by Hubbard (1997). A point of consensus through this literature is the importance of financial intermediation for productivity in the complex U.S. economy, bringing together borrowers and investors in a deep, relatively anonymous market for capital. Cooper and Ejarque (1995) point out the possibility of multiple investment and productivity equilibria, depending on the efficiency of financial intermediation. As capital markets grow less efficient, they argue, individuals substitute from future to current consumption to avoid investing in a period of high costs and low
expected returns. A similar argument is common to much of the literature. Gertler (1988) shows that beliefs regarding future economic conditions can affect the CCI (because, for instance, borrowers may offer claims on future earnings as collateral); higher CCI, in turn, can adversely affect current capacity utilization. Calomiris, Himmelberg, and Wachtel (1994), Kashyap, Stein and Lamont (1994), and Kashyap, Stein and Wilcox (1993) all argue that in times of inefficient financial intermediation, firms with poor balance sheets will choose to build up ‘buffer stocks’ of capital and cash to improve their net asset position, resulting in a drop in investment and activity. According to Greenwald and Stiglitz (1989), failures in equity markets curtail the abilities of firms to diversify the risks of their investments and operations.

What all of these arguments point to (and as is explicitly argued by Gertler (1988) and Greenwald and Stiglitz (1989)) is that financial crisis, by raising the CCI, can severely limit investment, activity, on-the-job training, learning-by-doing, information spillovers, and research and development: all crucial components of productivity growth. Given the severity of the financial crisis and the fall in productivity leading into the Depression, it seems likely that this is precisely what drove the rise in the natural rate of unemployment in the late 1920s and early 1930s. The crucial point is that trend output is not merely a multiple of the stocks of capital and labor in the economy. Intangible capital, such as financial intermediation, plays an important role in determining the productive capacity of the U.S. economy (cf. Williamson (1989)), and of the international economy as well (see Bernanke (1995), Bernanke and James (1991) and Obstfeld and Taylor (2002)). It was not lack of physical capital, but lack of confidence in the system of financial
intermediation so necessary to put that capital to use, that curtailed productivity growth and drove potential output down during the Great Depression. This, in turn, translated into a rise in the natural rate of unemployment, making the price rises of the 1930s possible.

7. **Conclusion**

This paper has argued that financial crisis during the Great Depression raised the costs of credit intermediation and severely hindered the growth of productivity in the United States economy. The fall in productivity worsened the unemployment-inflation tradeoff, causing the natural rate of unemployment to rise to the point that actual unemployment, though high throughout much of the recovery, may actually have fallen below the NAIRU in certain years (crucial to this finding was the identification of the long-run trend shared by real wage growth and productivity growth, and the role that deviations from this trend play in shifting the TV-NAIRU). Inflation followed: in effect, though the physical capital stock had not fallen greatly, sufficient intangible (i.e., financial) capital had been destroyed that the economy was straining against the bounds of its potential. It is beyond doubt that the rapid growth rate of the economy played a significant role in this process; nevertheless, the growth rate need not be invoked to explain inflation in the 1930s. That prices rose was not a puzzle: it was simply the ordinary workings of the relationship between unemployment and inflation described by the standard Phillips curve.
The exact link between financial crisis and productivity has only been sketched here. This paper did not attempt a formal modeling of this relationship beyond those provided by the past literature cited above. However, none of these papers attempts such a model specifically for the events of the Great Depression: this, then, is an area for future research. An additional question not addressed in this paper is the causality, if any, which characterizes the relationship between real wage growth and productivity growth. As noted above, the US and Germany followed essentially opposite paths in both these areas during the recovery: the US set high wages and enjoyed high productivity, while Germany restricted wage growth and stagnated. It is an unsettled question whether there is a direct link between wages and productivity, beyond the merely empirical relationship used in this paper. Productivity is arguably the most important variable for any economy; this question, then, is one that deserves great attention.
Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflation Rate (Implicit GNP Deflator)</th>
<th>Real GNP (Millions of 1996$)</th>
<th>Trend GNP (Millions of 1996$)</th>
<th>Deviation from Trend GNP</th>
<th>Real GNP Growth</th>
<th>Unemployment Rate</th>
<th>Inflation Rate (Raw Materials Prices)</th>
<th>Inflation Rate (All Commodities Prices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933</td>
<td>-2.6%</td>
<td>606.42</td>
<td>927.71</td>
<td>-42.5%</td>
<td>-1.7%</td>
<td>24.9%</td>
<td>2.5%</td>
<td>1.7%</td>
</tr>
<tr>
<td>1934</td>
<td>5.4%</td>
<td>671.73</td>
<td>957.84</td>
<td>-35.5%</td>
<td>10.2%</td>
<td>21.7%</td>
<td>19.4%</td>
<td>12.8%</td>
</tr>
<tr>
<td>1935</td>
<td>1.9%</td>
<td>732.60</td>
<td>988.95</td>
<td>-30.0%</td>
<td>8.7%</td>
<td>20.1%</td>
<td>11.7%</td>
<td>6.6%</td>
</tr>
<tr>
<td>1936</td>
<td>1.2%</td>
<td>825.15</td>
<td>1021.06</td>
<td>-21.3%</td>
<td>11.9%</td>
<td>16.9%</td>
<td>3.6%</td>
<td>1.0%</td>
</tr>
<tr>
<td>1937</td>
<td>4.1%</td>
<td>869.93</td>
<td>1054.22</td>
<td>-19.2%</td>
<td>5.3%</td>
<td>14.3%</td>
<td>6.0%</td>
<td>6.6%</td>
</tr>
<tr>
<td>1938</td>
<td>-3.1%</td>
<td>840.62</td>
<td>1088.46</td>
<td>-25.8%</td>
<td>-3.4%</td>
<td>19.0%</td>
<td>-16.4%</td>
<td>-9.3%</td>
</tr>
<tr>
<td>1939</td>
<td>-1.1%</td>
<td>908.64</td>
<td>1123.81</td>
<td>-21.3%</td>
<td>7.8%</td>
<td>17.2%</td>
<td>-2.5%</td>
<td>-1.9%</td>
</tr>
<tr>
<td>1940</td>
<td>1.5%</td>
<td>984.51</td>
<td>1160.30</td>
<td>-16.4%</td>
<td>8.0%</td>
<td>14.6%</td>
<td>2.4%</td>
<td>1.9%</td>
</tr>
<tr>
<td>1941</td>
<td>6.5%</td>
<td>1154.26</td>
<td>1197.98</td>
<td>-3.7%</td>
<td>15.9%</td>
<td>9.9%</td>
<td>15.0%</td>
<td>10.5%</td>
</tr>
<tr>
<td>1942</td>
<td>7.6%</td>
<td>1364.17</td>
<td>1326.89</td>
<td>9.8%</td>
<td>16.7%</td>
<td>4.7%</td>
<td>18.0%</td>
<td>12.4%</td>
</tr>
</tbody>
</table>

Mean: 2.1%
Standard Deviation: 3.7%

Notes: Trend GNP is calculated by extending forward the average growth rate of real GNP from 1910-24. Inflation rates are calculated as log differences, as is the deviation of real GNP from trend GNP. Sources are in the Data Appendix.

Table 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Inflation</th>
<th>Forecast Using Base Phillips Curve</th>
<th>Forecast Including Growth Rate Effects</th>
<th>Fitted Values Including Growth Rate Effects and NIRA</th>
<th>Fitted Values Including Growth Rate Effects but not NIRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933</td>
<td>-2.6%</td>
<td>-14.1%</td>
<td>-11.9%</td>
<td>-0.4%</td>
<td>-7.7%</td>
</tr>
<tr>
<td>1934</td>
<td>5.4%</td>
<td>-13.0%</td>
<td>-5.4%</td>
<td>8.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>1935</td>
<td>1.9%</td>
<td>-11.4%</td>
<td>-3.2%</td>
<td>4.3%</td>
<td>1.9%</td>
</tr>
<tr>
<td>1936</td>
<td>1.2%</td>
<td>-8.1%</td>
<td>2.3%</td>
<td>3.4%</td>
<td>5.0%</td>
</tr>
<tr>
<td>1937</td>
<td>4.1%</td>
<td>-7.2%</td>
<td>-1.3%</td>
<td>-0.7%</td>
<td>1.2%</td>
</tr>
<tr>
<td>1938</td>
<td>-3.1%</td>
<td>-9.5%</td>
<td>-8.8%</td>
<td>-7.4%</td>
<td>-5.0%</td>
</tr>
<tr>
<td>1939</td>
<td>-1.1%</td>
<td>-8.3%</td>
<td>-1.9%</td>
<td>-1.0%</td>
<td>1.5%</td>
</tr>
<tr>
<td>1940</td>
<td>1.5%</td>
<td>-6.8%</td>
<td>0.0%</td>
<td>0.5%</td>
<td>2.9%</td>
</tr>
<tr>
<td>1941</td>
<td>6.5%</td>
<td>-2.6%</td>
<td>8.1%</td>
<td>7.4%</td>
<td>9.5%</td>
</tr>
<tr>
<td>1942</td>
<td>7.6%</td>
<td>2.1%</td>
<td>12.7%</td>
<td>11.1%</td>
<td>12.1%</td>
</tr>
</tbody>
</table>

Notes: All inflation rates refer to the implicit GNP deflator. Forecasts are reproduced from Romer (1999), with the exception of column 5, which are the author's calculations. Other sources are in the Data Appendix.

Table 3

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Real GNP Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1873-1883</td>
<td>4.81%</td>
</tr>
<tr>
<td>1884-1889</td>
<td>2.64%</td>
</tr>
<tr>
<td>1890-1899</td>
<td>3.68%</td>
</tr>
<tr>
<td>1900-1909</td>
<td>3.70%</td>
</tr>
<tr>
<td>1910-1923</td>
<td>3.25%</td>
</tr>
<tr>
<td>1924-1941</td>
<td>2.98%</td>
</tr>
<tr>
<td>1942-1952</td>
<td>4.53%</td>
</tr>
<tr>
<td>1953-1964</td>
<td>3.43%</td>
</tr>
<tr>
<td>1965-1977</td>
<td>3.56%</td>
</tr>
<tr>
<td>1978-1985</td>
<td>2.91%</td>
</tr>
<tr>
<td>1986-1995</td>
<td>2.74%</td>
</tr>
<tr>
<td>1996-2001</td>
<td>3.33%</td>
</tr>
</tbody>
</table>
Table 4
Model Stability Tests
(Unemployment - Four-year Moving Average) = \[ \] + \[Deviation from Trend GNP]\]

<table>
<thead>
<tr>
<th></th>
<th>Chow Breakpoint Test: 1924</th>
<th>Chow Forecast Test: Forecast from 1924 to 1942</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
<td>4.207</td>
<td>2.594</td>
</tr>
<tr>
<td>Log Likelihood Ratio</td>
<td>8.398</td>
<td>49.652</td>
</tr>
<tr>
<td>Probability</td>
<td>0.021</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Notes: The Model is estimated over the sample period 1893 to 1942. Sources are in the Data Appendix.

Table 5
Unit Root and Cointegration Tests

Table 5.1 - Unit Root Tests for Price Inflation, Wage Inflation, and Trend Productivity Growth

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF Test Statistic</th>
<th>10% Critical Value</th>
<th>5% Critical Value</th>
<th>1% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p_{t-1})</td>
<td>-2.802695</td>
<td>-3.2418</td>
<td>-3.6118</td>
<td>-4.3942</td>
</tr>
<tr>
<td>(w_t)</td>
<td>-3.134428</td>
<td>-3.2418</td>
<td>-3.6118</td>
<td>-4.3942</td>
</tr>
<tr>
<td>(q_{t-1})</td>
<td>-2.671466</td>
<td>-3.2418</td>
<td>-3.6118</td>
<td>-4.3942</td>
</tr>
</tbody>
</table>

Table 5.2 - Johansen Cointegration Test for the Trivariate System

<table>
<thead>
<tr>
<th>Hypothesized Number of Cointegrating Relationships</th>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5% Critical Value</th>
<th>1% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None**</td>
<td>0.755305</td>
<td>54.54354</td>
<td>42.44</td>
<td>48.45</td>
</tr>
<tr>
<td>At Most One</td>
<td>0.526688</td>
<td>20.7577</td>
<td>25.32</td>
<td>30.45</td>
</tr>
<tr>
<td>At Most Two</td>
<td>0.110328</td>
<td>2.805669</td>
<td>12.25</td>
<td>16.26</td>
</tr>
</tbody>
</table>

Table 5.3 - Unit Root Test for the Markup

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF Test Statistic</th>
<th>10% Critical Value</th>
<th>5% Critical Value</th>
<th>1% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p_{t-1}) - (w_t) - (q_{t-1})</td>
<td>-4.52**</td>
<td>-3.2535</td>
<td>-3.633</td>
<td>-4.4418</td>
</tr>
</tbody>
</table>

Notes: All tests are performed over the sample 1919 to 1942. The tests allow for a linear deterministic trend in the data. *(**) indicates rejection of the given hypothesis at the 5%(1%) significance level. Price inflation and trend productivity growth are lagged values to conform with theory, which says that wage inflation should equal expected price inflation plus expected productivity growth. Sources are in the Data Appendix.
Table 6
Estimation Output for Price-Wage Phillips Curve Systems

<table>
<thead>
<tr>
<th>Using Four-Year Moving Average as Trend Unemployment</th>
<th>Using NAIRU Estimated over 1919-42 as Trend Unemployment</th>
<th>Using NAIRU Estimated over 1897-1970 as Trend Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Price Inflation</td>
<td>Change in Price Inflation</td>
<td>Change in Price Inflation</td>
</tr>
<tr>
<td>Constant</td>
<td>0.02 (0.03)</td>
<td>Constant</td>
</tr>
<tr>
<td>Markup(-1)</td>
<td>0.21 (0.35)</td>
<td>Markup(-1)</td>
</tr>
<tr>
<td>Markup(-2)</td>
<td>-0.33 (0.25)</td>
<td>Markup(-2)</td>
</tr>
<tr>
<td>(U-U*)(-1)</td>
<td>-2.55** (0.71)</td>
<td>(U-U*)(-1)</td>
</tr>
<tr>
<td>(U-U*)(-2)</td>
<td>0.68 (0.60)</td>
<td>(U-U*)(-2)</td>
</tr>
<tr>
<td>M2 Growth Rate(-1)</td>
<td>-0.50 (0.33)</td>
<td>M2 Growth Rate(-1)</td>
</tr>
<tr>
<td>M2 Growth Rate(-2)</td>
<td>-0.51 (0.28)</td>
<td>M2 Growth Rate(-2)</td>
</tr>
<tr>
<td>NIRA</td>
<td>0.08 (0.11)</td>
<td>NIRA</td>
</tr>
<tr>
<td>FDIC</td>
<td>0.02 (0.03)</td>
<td>FDIC</td>
</tr>
<tr>
<td>Change in Price Inflation(-1)</td>
<td>-0.99* (0.40)</td>
<td>Change in Price Inflation(-1)</td>
</tr>
<tr>
<td>Change in Price Inflation(-2)</td>
<td>-0.61* (0.22)</td>
<td>Change in Price Inflation(-2)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.733</td>
<td>R-squared</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.490</td>
<td>Adjusted R-squared</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change in Wage Inflation</th>
<th>Change in Wage Inflation</th>
<th>Change in Wage Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.04* (0.02)</td>
<td>Constant</td>
</tr>
<tr>
<td>Markup(-1)</td>
<td>1.89** (0.60)</td>
<td>Markup(-1)</td>
</tr>
<tr>
<td>Markup(-2)</td>
<td>-0.81 (0.60)</td>
<td>Markup(-2)</td>
</tr>
<tr>
<td>(U-U*)(-1)</td>
<td>-0.36 (0.75)</td>
<td>(U-U*)(-1)</td>
</tr>
<tr>
<td>(U-U*)(-2)</td>
<td>-0.06 (0.60)</td>
<td>(U-U*)(-2)</td>
</tr>
<tr>
<td>NIRA</td>
<td>0.05 (0.07)</td>
<td>NIRA</td>
</tr>
<tr>
<td>Change in Price Inflation(-1)</td>
<td>0.39 (0.35)</td>
<td>Change in Price Inflation(-1)</td>
</tr>
<tr>
<td>Change in Price Inflation(-2)</td>
<td>-1.46 (0.81)</td>
<td>Change in Price Inflation(-2)</td>
</tr>
<tr>
<td>Change in Wage Inflation(-1)</td>
<td>0.97 (0.68)</td>
<td>Change in Wage Inflation(-1)</td>
</tr>
<tr>
<td>Change in Wage Inflation(-2)</td>
<td>-0.18 (0.23)</td>
<td>Change in Wage Inflation(-2)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.734</td>
<td>R-squared</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.534</td>
<td>Adjusted R-squared</td>
</tr>
</tbody>
</table>

Notes: Estimation is by seemingly unrelated regressions of the price-wage Phillips curve system (System (8) in the text). *(***) indicates significance at the 5%(1%) level. Sources are in the Data Appendix.
Figure 1
Forecasts of Inflation from Romer (1999)

![Chart showing forecasts of inflation from 1933 to 1942.](chart1.png)

Notes: See Notes for Table 2
Figure 2
Two Measures Of Trend Output

Notes: Deviation from Trend Output is from Romer (1999); Unemployment – Four-Year Moving Average is actual unemployment minus a backward-looking four-year moving average of unemployment, and is plotted on an inverse scale. Sources are in the Data Appendix.
Notes: Trend Productivity Growth is calculated as a four-year backward-looking moving average of the log difference of productivity. Sources are in the Data Appendix.
Figure 4
Unemployment and Inflation, 1890-1942

Notes: Sources are in the Data Appendix.
Figure 5
Real Wage Growth and Trend Productivity Growth

Notes: Trend Productivity Growth is calculated as a four-year backward-looking moving average of the log difference of productivity. Real Wage Growth is calculated as wage inflation less price inflation. Sources are in the Data Appendix.
Figure 6
The Markup

Notes: The markup is calculated as $\frac{q_{t-1} - q_t - q_{t-1}}{q_{t-1}}$. See text for details. Sources are in the Data Appendix.
Figure 7
The NAIRU: Estimation Sample 1919-1942

Actual Unemployment

Constant NAIRU = 13.7%

Time-Varying NAIRU

Figure 8
The NAIRU (Estimation Sample 1919-1942) and Inflation

Actual Unemployment

Time-Varying NAIRU

Inflation

Notes: See text for estimation methods. Sources are in the Data Appendix.
Figure 9
The NAIRU: Estimation Sample 1897-1970

Figure 10
The NAIRU (Estimation Sample 1897-1970) and Inflation

Notes: See text for estimation methods. Sources are in the Data Appendix.
Figure 11
Fitted Values for Inflation from the Price-Wage Phillips Curve System

Notes: ‘4-yr MA’ depicts the fitted values generated by the price-wage Phillips curve system using the four-year moving average of unemployment as trend unemployment. ‘NAIRU(1919-1942)’ uses the NAIRU estimated over 1919-1942 as trend unemployment. ‘NAIRU(1897-1970)’ uses the NAIRU estimated over 1897-1970 as trend unemployment. Sources are in the Data Appendix.
Notes: See text for estimation methods. Trend Productivity Growth is calculated as a four-year backward-looking moving average of the log difference of productivity. Sources are in the Data Appendix.
40 Notes: Sources are in the Data Appendix.
Data Appendix

BANK LOANS: Loans are for all banks, excluding those unincorporated or ‘private’ banks not reporting to State banking authorities. Banks in US possessions are excluded except one national bank in Alaska, which was a member of the Federal Reserve System from the time it opened for business in April 1915 until it was placed in voluntary liquidation in April 1921 and which in June 1919 had total deposits of $351,000.

Source: Banking and Monetary Statistics, Board of Governors of the Federal Reserve System (1943)

COMMODITY PRICE INFLATION: Commodity Price Inflation is the growth rate of the wholesale price index for all commodities.

Source: Romer (1999)

CURRENCY: Currency is calculated as annual averages of estimates of currency held by the public by Milton Friedman and Anna Schwartz.

Source: Friedman and Schwartz (1963)

CONSUMER PRICE INFLATION: Inflation is calculated as the log difference of the implicit GNP deflator.

Source: Romer (1999), Bureau of Economic Analysis

DEPOSITS: Deposits are total deposits at all banks, as defined in the note for bank loans above.

Source: Banking and Monetary Statistics, Board of Governors of the Federal Reserve System (1943)

PRODUCTIVITY: Productivity is output per manhour in the nonfarm business sector. Trend Productivity is calculated as a four-year backward-looking moving average of actual productivity. Trend Productivity Growth is calculated as \( \log(\text{productivity}_t) - \log(\text{productivity}_{t-4}) \).

Source: Kendrick (1961)

RAW MATERIALS INFLATION: Raw Materials Inflation is the growth rate of the wholesale price index for raw materials.

Source: Romer (1999)

REAL GNP: Real GNP is calculated as nominal GNP, divided by the implicit GNP deflator, in $1996. Real GNP growth is the log difference of Real GNP.

UNEMPLOYMENT: Unemployment data are measured as annual averages of monthly figures for the nonfarm business labor force. Trend unemployment is calculated as a four-year backward-looking moving average of actual unemployment, as well as two estimates for the path of the time-varying NAIRU (see text for estimation methods).

WAGE INFLATION: Wages are calculated as Lebergott’s average annual nonfarm earnings series divided by Kendrick’s annual nonfarm manhour series. Wage inflation is the log difference of wages.

Source: Romer (1999), Bureau of Economic Analysis

Source: Lebergott (1964), Bureau of Labor Statistics

Source: Lebergott (1964), Kendrick (1961)
References


