Wage Rigidity in the Great Depression

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Abstract: It is often claimed that nominal wages were unusually rigid in the downturn of the Great Depression. We compare the behavior of wages in the Great Depression with cyclical patterns in postwar and pre-1914 periods. We find no evidence that wages were unusually rigid over 1929-32. Given the path of output and unemployment, wage inflation over 1929-32 was remarkably close to forecasts from coefficients of Phillips curves estimated on data from the post-World War II era, or years before the First World War. Growth in real product wages was not greater than one would expect based on postwar and pre-1914 patterns.

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Economists continue to study the American Great Depression of the 1930s, using new models to re-examine old explanations of historical events (e.g. Bordo, Erceg and Evans, 2000; Christiano, Motto and Rostagno, 2003; Eggertsson, 2008), applying new theories to propose radically different explanations (e.g. Ebell and Ritschl, 2008; Ohanian, 2009), and using 1930s experience to guess at possible future outcomes of current events (e.g. Reinhart and Rogoff, 2009).

Work is framed around perceived stylized facts about the Depression. One influential notion is that nominal wages were unusually rigid in the Depression's downturn: that is, the decrease in nominal wages over 1929-32 was unusually small relative to the decline in real activity and/or prices. To match this purported unusual behavior of wages, some who argue that the Great Depression was caused by monetary factors (the fundamental instability of the gold exchange standard, Federal Reserve policy errors) posit a special flexible-price, "sticky wage" aggregate supply mechanism for 1929-32, not meant to apply outside the 1930s (e.g. Bernanke and Carey, 1996, p. 854; Bordo, Erceg and Evans, 2000). Others (Ebell and Ritschl [2008], Ohanian [2009]) claim the peculiar behavior of wages over 1929-32 supports a radically different explanation of the Great Depression in which monetary factors were unimportant: they argue the 1929-32 downturn (not just the persistence of low activity into the later 1930s) was proximately *caused* by extraordinary wage rigidity, which reflected a sudden increase in unions' potential bargaining power and Hoover administration policy that forced employers to pay higher real wages.

Two facts are cited as evidence that nominal wages were unusually rigid over 1929-32. First, nominal wages fell more slowly over 1929-32 than they had in the preceding large cyclical downturn of 1920-21 (O'Brien, 1989, p. 721; Dighe, 1997; Ohanian, 2009, p. 2317; Rose, 2010). Second, over 1929-32 manufacturing wage series fell less than price indexes for consumer goods and services, manufactured goods or GDP: real product wages and real consumption wages were countercyclical (O'Brien, p. 719; Dighe, 1997; Ohanian, 2009; Ebell and Ritschl, 2008, p. 35). In postwar data, real wages generally appear acyclical or procyclical.

But these facts do not make the case. For wage inflation, 1920-21 is a bad benchmark. Studies that compare inflation across business cycles of the pre-1914, postwar and interwar eras generally find that inflation fell more rapidly in 1920-21 than in *any* other cyclical downturn, in any era. Schultze (1981, p. 562), Gordon (1983, p. 105) and Vernon (1991) argue that this was because the 1920 recession signalled a change in policy regime, creating expectations that future prices would revert toward the pre-1914 gold standard level, which had a rapid effect on inflation consistent with an expectations-augmented Phillips curve. Whatever the explanation of 1920-21, it is important to compare 1929-32 with other business cycles.

On real wages, Dighe (1997) presents evidence that real product wages were countercyclical in *all* downturns of the interwar era, not only 1929-32 but also 1920-21, 1937-38 and the mild downturns of the mid-1920s. Hanes (1996) shows that real consumption wages were countercyclical before 1914, as well as in the interwar era. He argues that the long-term historical trend toward procyclicality in in real wages could have resulted from an unchanging degree of nominal wage rigidity, interacting with a secular increase in the number of stages of production and sale embodied in final output. Huang, Liu and Phaneuf (2004) make a similar argument. Whether or not Hanes and Huang *et. al.* are right about the reasons for it, it is important to see whether 1929-32 was out of line with the historical trend.

In this paper we compare the behavior of wages in the Great Depression with cyclical behavior in postwar and pre-1914 periods. As in most exercises of this type, the devil is in the details of historical data. It is important to keep in mind their limitations. Statistics from different eras were not constructed in exactly the same ways. One must keep in mind which way the possible biasses run. The number of observations is small, so formal statistical tests are hardly convincing. We rely on graphical representations instead.

We find no evidence nominal wages were unusually rigid or real wages unusually countercyclical over 1929-32. Given the path of real activity over 1929-32, wage inflation traced out the path forecast by empirical relationships in pre-1914 or post-World War II data. Relative to a consistent measure of the price level, real product wages were no more countercyclical over 1929-32 than in the other eras. We cannot rule out the possibility that in *some* specification wages would appear unusually rigid over 1929-32. But our specifications make reasonable demands on the quality of the data and are consistent with current theoretical models of nominal wage rigidity. The available data may not be enough to convince someone with a strong prior belief that wages were unusually rigid in the Great Depression. But the data *per se* do not justify such a belief.

To begin, we detail common claims about wage rigidity over the Great Depression. Then we lay out the specifications we use to describe cyclical wage behavior, and relate those specifications to economic theory. Next we catalogue available data. Finally we make our comparisons between the Great Depression and other eras. Data sources are detailed in Appendix 1.

1) Claims about wages in the Great Depression

It is important to distinguish claims about wage rigidity in the downturn of the Great Depression from more generally-accepted beliefs about the later years 1933-40. There can be little doubt that after 1932 American wage inflation deviated from its usual Phillips curve relation to real activity. In the first application of the Phillips curve to American data, Samuelson and Solow (1960) found that "the years from 1933 to 1941 appear to be *sui generis:* money wages rose or failed to fall in the face of massive unemployment" (p. 188). Wage inflation accelerated over 1933-34 and again in 1937. Samuelson and Solow attributed this to "the workings of the New Deal" (p. 188), as have most others (e.g. Friedman and Schwartz, 1960, p. 498; Weinstein 1980; Gordon, 1983; Mitchell 1986). (An exception is Akerlof, Dickens and Perry (1996), who explain the wage-inflation anomalies after 1932 as the result of downward nominal wage rigidity, a special constraint against nominal wage cuts, interacting with another social norm linking wages to employers' profits.) The National Recovery Administration (NRA), established in 1933, not only promoted product-market cartels: it also fixed minimum wages by industry, banned wage cuts, encouraged union formation, and strengthened union bargaining power. When the NRA was declared unconstitutional in 1935, most of its employment policies were revived in other forms. The Fair Labor Standards Act of 1938 introduced a national minimum wage and required premium pay for overtime. The National Labor Relations Act of 1935 re-established and strengthened the NRA's pro-union institutional structure (Mills and Brown 1950). After 1935 many firms and industries became unionized for the first time.

The potential effects on wages of the first wave of New Deal policies can be dated quite precisely. In the summer of 1933 government officials, employers and labor unions began to negotiate over wage and employment policies to be followed under the NRA. The act establishing the NRA was passed in July 1933. In that month some employers gave across-the-board raises to "improve their bargaining power in code negotiations" (Fine 1963, 125). In August, 1933 the first round of across-the-board NRA wage rules (the "President's Re-Employment Agreement", or "blanket code") came into effect, fixing minimum wage rates and required "equitable" maintenance of differentials above the minimums for higher-paid workers (Sachs 1934, 131). The effects of unionization can also be dated, though not quite as precisely. "The overwhelming Roosevelt victory" in the election of November 1936 "led employers to expect aggressive organizing drives by trade unions" and "wage rates were influenced by the large number of industrial disputes and by the efforts of employers to forestall unions by making concessions" (Slichter 1938, pp. 98, 99). Judging from unionization rates, the increase in union power was most rapid over 1937, as the proportion of nonagricultural workers belonging to unions surged from 14 percent in 1936 to 28 percent in 1938 (U.S. Bureau of the Census 1975, 178, series D951).

Our concern is the span of time between the 1929 downturn and July 1933. O'Brien (1989) claims that there was "extraordinary rigidity of aggregate money wages during the first two years of the Depression" (p. 720), through late 1931. He argues large employers refrained from wage cuts because they believed a general maintenance of wage levels would keep up sales. Others have blamed extraordinary wage rigidity in this period on President Hoover, who urged employers to hold wages fixed and held conferences where executives of large firms and trade associations pledged to do so. Ohanian (2009) claims employers gave in to Hoover's jawboning, "either raising nominal wages or keeping nominal wages fixed at their 1929 levels" (p. 2311), because Hoover promised protection from unions. Ebell and Ritschl (2008) claim a sharp hike in union's bargaining power promoted by Hoover boosted real wages and depressed output beginning in 1929, which appeared as extraordinary nominal wage rigidity in the face of a cyclical downturn (p. 5). Rose (2010) tests whether firms and industries that sent representatives to Hoover’s conferences were especially slow to cut wages. Rose’s evidence is ambiguous: conference attendees were slower to cut wages on average but “the statistical significance of these results are not robust to the inclusion of controls for industry characteristics [such as product-market concentration] or the exclusion of a small number of non-attending firms that cut wages particularly quickly” (p. 845).

2) Our specifications

To test whether cyclical wage behavior was unusual in the downturn of the Great Depression, we look at the relationship between measures of real activity and wage inflation, and the relationship between real activity and growth in real wages, comparing 1929-1932 and the later 1930s with pre-1914 and post-World War II eras.

For real wages, we look at the relation between the year-to-year growth in the real wage and the change in output or unemployment, following Solon, Barsky and Parker (1994) and many others. To see whether the 1930s were out of line with the long-term transition from countercyclical to procyclical real wages, we project relations from other eras on matching measures of real activity from the interwar era, and compare the "forecasts" with the actual 1930s real-wage data.

For wage inflation, we use versions of the Phillips curve, allowing for a well-known historical shift in its nature. In the pre-1914 era American wage inflation followed the original Phillips curve: wage inflation was negatively related to unemployment, positively related to deviation from trend in nonagricultural output. A similar pattern can be seen in data from the early postwar era through the early 1960s (Samuelson and Solow, 1960), and perhaps in data from the late 1980s-2000s (Gali, 2011). Samples that span the 1970s and 1980s are better described by a relation between real activity and the *change* in wage inflation - the "accelerationist" curve. The shift in the nature of the Phillips curve has been observed in a number of studies that compare the cyclical behavior of wage inflation across eras by regressing wage inflation on a real activity indicator and lagged wage or price inflation. In pre-1914 samples, estimated coefficients on lagged inflation are small and usually not significantly different from zero at conventional levels. In postwar samples including the 1970s and 1980s, lagged-inflation coefficients are positive, statistically significant and of a magnitude that indicates a nearly one-to-one relation between recently-experienced inflation and current inflation (e.g. Gordon, 1990; Alogoskoufis and Smith, 1991; Allen, 1992; Hanes, 1993). The same transition appears in price-inflation Phillips curves.[1]

To see whether 1930s wage inflation was out of line with pre-1914 experience, we look at scatterplots of pre-1914 wage inflation against measures of real activity. Then we add points corresponding to data from the 1920s and 1930s. We will conclude there is evidence for extraordinary wage rigidity in 1929-1932 if the points from those years are above the scatter of the pre-1914 points. We adopt this method because there are there are very few observations in the pre-1914 data that can be compared with interwar data. In effect, however, we are projecting

[1]Some studies add to the right-hand side the change in real activity from the previous period to the right-hand side, finding a positive coefficient on this variable (Gordon's "rate of change effect"). This is equivalent to adding lagged real activity and finding a positive coefficient on current real activity along with a smaller-magnitude negative coefficient on lagged real activity. But this effect of the rate of change, or a negative coefficient on lagged real activity, fails to appear in many studies (e.g. Hanes, 1993).

the pre-1914 Phillips curve on matching measures of real activity from the interwar era and comparing the "forecasts" with the actual 1930s data.

To compare with postwar experience, we take postwar samples and regress wage inflation on real activity and lagged wage inflation. Applying the estimated postwar coefficients to the interwar path of real activity, we project a "forecast" path for wages over 1929-1940, in two different ways. In one variant we apply both the real-activity and lagged-inflation coefficients. In the other we apply the postwar real-activity coefficient but set the interwar coefficients on lagged inflation to zero. We will conclude there is evidence for extraordinary wage rigidity in 1929-1932 if the actual path of wages or wage inflation is above the forecast path. Before we apply the postwar coefficients to project a path for interwar wage inflation, we check to make sure that a projection on the postwar path of real activity would give an unbiassed "forecast" of postwar wage inflation.

3) Does our exercise make sense in terms of theory?

Our method is transparent, but does it make sense in terms of economic theory? In this section, we argue that it is easy to interpret in terms of two current models: the standard "New Keynesian Phillips curve," and the "sticky-information" Phillips curve. We focus on these models because, unlike some others, they can account for the historical transition from the pre-1914 Phillips curve to the postwar accelerationist Phillips curve. For each model, our exercise amounts to testing a null hypothesis that the model applied in both 1929-1932 and the comparison era, with about the same structural coefficients: that is, no special model is needed for 1929-32.

We review each model briefly, describe how it can account for the historical transition, and how it corresponds to our exercise.

3.1) A general condition

An element of both models is that a wagesetter's behavior is equivalent to minimizing a loss function that increases with the difference between his wage w_i and a "desired wage" w_i^*:

$$L_t = \sum_{j=0}^{\infty} \psi^j \; {}_t\left[(w_i - w_i^*)^2_{t+j}\right]^e \quad where \; w_{it}^* = w_t + \gamma(x - x^n)_t \tag{1}$$

ψ is a discount factor. ${}_tX^e_{t+j}$ is a wagesetter's expectation as of time t - not necessarily a rational expectation - for the value a variable X will take at time *(t+j)*. The desired wage increases with the economy-wide average wage w_t and with a variable x related to real activity (if x is unemployment γ is negative). x^n , which can vary from period to period, is the "natural rate" of x. In the absence of constraints on wagesetting or information (a "flexible-wage equilibrium) x must equal the natural rate every period, because every wagesetter would equate w_{it} to w_{it}^*. We refer to $(x - x^n)$ as the "real activity gap."

Existing new-Keynesian models with nominal wage rigidity (such as Erceg, Henderson and Levin, 2000; Gali 2011) derive (1) in ways that fit into the representative-agent DSGE setting. In these models (1) is an approximation that holds as long as inflation remains close to zero and real variables do not deviate too much from their long-run trend values. In appendix 2 we give an example of such a derivation. In our view, the mechanism of wagesetting in those models is too unrealistic to be taken seriously. But (1) is plausible as a general condition. It is consistent with many models of efficiency wages and union bargaining, which imply that a wagesetters' desired wage increases with the level of real activity, relative to other wages (Summers, 1988).

3.2) Imperfect-information or Friedman-Phelps Phillips curve

In imperfect-information models (described by Mankiw and Reis, 2010) a wagesetter is free to adjust his wage every period. Expectations are rational but a wagesetters' information may be stale, not updated every period. The sequence of wages he chooses period-by-period, using information from the last time his information was updated, is equivalent to the path he would have pre-planned at that time, given his expectations at that time of future real activity and inflation. In a simple case wagesetters' information is updated every two periods on a staggered schedule: half the wagesetters receive new information in each period; the other half use information that is one period out of date. Then wage inflation is:

$$w_t - w_{t-1} = \pi_t = \beta(x - x^n)_t + {}_{t-1}\pi_t^e \quad \textbf{(2)}$$

(See appendix 3.) This is equivalent to the "expectations-augmented" Phillips curve of Friedman (1968), Phelps (1970) and Lucas (1972). (2) is obviously unrealistic as it implies that wagesetters' expected value for the upcoming period's real-activity gap is always zero - that is, no one ever expects a recession to persist more than one wagesetting period. To avoid this one must assume a wagesetters' information may be more than a period out of date, e.g. because a wagesetter's information is updated randomly with a fixed probability each period as in Mankiw and Reis (2002), or because there is a it is costly to update information as in Reis (2006). In these more complicated cases the expected-inflation term in (2) is replaced with a term that still represents past expectations of time-*t* economic conditions. But it is a weighted average of expectations for the path of real activity as well as π_t, and expectations formed in periods prior to *(t-1)* as well as time-(t-1) expectations. We focus on (2) in our discussion here because, interpreted as a Friedman-Phelps Phillips curve, it has been the framework for much historical research.

How it accounts for the historical transition

Presumably, measures of unemployment and output gaps used to estimate Phillips curves are imperfect indicators of the true real activity gap. Consider an imperfect measure $\hat{x}$ of the real-activity gap $(x - x^n)$, such as an unemployment rate or the deviation of an aggregate output measure from its long-run trend. Then wage inflation is:

$$\pi_t = \beta\hat{x}_t + {}_{t-1}\pi_t^e + s_t \quad where \ s_t = \gamma\left((x - x^n)_t - \hat{x}_t\right) \quad \textbf{(3)}$$

where *s*, a "supply shock,"is the effect of unobservable fluctuations in the natural rate.

Suppose an observer regresses wage inflation on lagged wage inflation and $\hat{x}$. The estimated coefficient on real activity will be close to β if period-to-period changes in $\hat{x}$ are sufficiently uncorrelated with *s* and $_{t-1}\pi_t^e$. Coefficients on lagged inflation will reflect their correlation with $_{t-1}\pi_t^e$: they will be close to zero if lagged inflation is uncorrelated with $_{t-1}\pi_t^e$. They; positive if lagged inflation is positively correlated with $_{t-1}\pi_t^e$.

The historical transition in the empirical Phillips curve has often been explained in this way. (e.g. Alogoskoufis and Smith, 1991; Ball and Mankiw, 2002): it is argued that lagged inflation was uncorrelated with $_{t-1}\pi_t^e$ before 1914 but positively correlated with $_{t-1}\pi_t^e$ postwar. This argument is plausible as there is independent evidence for such a historical change in the relation between experienced and expected inflation. Barsky (1987) shows that, in postwar samples including the 1970s-1980s, serial correlation in inflation is so strong that inflation is statistically indistinguishable from a random walk. In pre-1914 data, by contrast, monthly or annual inflation shows little or no serial correlation - using standard tests, one cannot reject the hypothesis that the price *level* was a random walk. Any past expectation of current inflation would be strongly correlated with past inflation in the postwar years but uncorrelated with past inflation in the pre-1914 era. Barsky also shows that interest rates behave as if short-horizon inflation expectations were correlated with experienced inflation in postwar years, but not pre-1914. Assuming the Fisher relation holds, a nominal interest rate reflects expectations of inflation (on the part of financial-market participants, if not wagesetters) over the horizon of the instrument's maturity. Short-term interest rates and current or past inflation are highly correlated in postwar samples, uncorrelated in pre-1914 samples. Importantly, the obvious explanation of the historical change in inflation persistence lies *outside* the mechanism of aggregate supply. It is a difference in the monetary regime. The postwar regime, but not the pre-1914 gold standard, allowed aggregate demand growth to drive or accommodate persistent inflation (Klein, 1975).

What were inflation expectations like in the Great Depression? For times when people experienced policy changes such as the abandonment of the gold standard, the NRA and the

NLRB, the only honest answer can be "who knows?" But our focus is 1929-32. For these years, there is evidence that most of the realized deflation was a surprise (Hamilton, 1992; Evans and Wachtel, 1993). But there is also evidence that the onset of deflation in the early 1930s was associated with expectations of future deflation (Cecchetti, 1992). Thus, one could argue that ${}_{t-1}\pi_t^e$ was as stable over 1929-32 as in pre-1914 downturn. One could also argue ${}_{t-1}\pi_t^e$ was correlated with lagged inflation, as in the postwar era.

What our exercise means

When we use the prewar Phillips curve graph to "project" wage inflation after 1929, our null hypothesis has two parts: first, the nature of wagesetting was the same in both eras; second, ${}_{t-1}\pi_t^e$ was as stable over 1929-1931 as it was in pre-1914 downturns.

When we use postwar coefficients to project wage inflation after 1929, we are setting up a null with three parts. First, the nature of wagesetting was the same in both eras. Second, in the postwar era period-to-period changes in $\hat{x}$ were sufficiently uncorrelated with ${}_{t-1}\pi_t^e$ (and s) that the postwar coefficient on real activity is close to β. In the variant where we turn off the lagged-inflation coefficients, the third part of the null is that ${}_{t-1}\pi_t^e$ was stable (until 1933). In the variant where we apply the lagged-inflation coefficients, the third part is the opposite assumption that ${}_{t-1}\pi_t^e$ was as strongly correlated with lagged inflation as in postwar samples.

3.2) New Keynesian Phillips curve

A "new-Keynesian" Phillips curve for wage inflation, of the same form as the well-known new-Keynesian Phillips curve for price inflation, follows from two assumptions in addition to (1). First, the Calvo (1983) constraint applies to wages: with a fixed probability an agent *i* that sets a wage - e.g. an employer or union - can adjust his nominal wage w_{it} in a period; otherwise he must leave it fixed. Second, wagesetters believe (as common knowledge) that the economy tends to revert to a long-run steady state with real activity at the natural rate and price inflation equal to a particular value $\bar{\pi}_P^e$. Such a steady state exists in new Keynesian models of the postwar American economy where a central bank controls interest rates to follow a "Taylor rule" or to minimize a loss function of real activity and inflation. It also exists in reasonable models of the pre-1914 international gold standard (Taylor, 1999). Given a long-run trend rate of real wage growth g, $\bar{\pi}_P$ implies a corresponding long-horizon expectation for wage inflation $\bar{\pi}^e = \bar{\pi}^e_P - g$. Due to changes in the long-run price inflation rate and/or real wage growth, $\bar{\pi}^e$ can evolve over time. (g need not correspond to growth in labor productivity. Since the 1970s, labor productivity has grown smartly while real wage growth has been practically zero for most jobs and types of workers.) Let ${}_t\bar{\pi}^e$ denote wagesetters' time-t expectation of long-run wage (not price) inflation.

Under these assumptions, as long as the discount rate in the wagesetters' loss function is small enough, wage inflation is approximately:

$$\pi_t \approx \beta(x - x^n)_t + {}_t\pi^e_{t+1} \tag{4}$$

where ${}_t\pi^e_{t+1}$ is wagesetters' expectation of the upcoming period's wage inflation rate. The value of β is determined by the frequency of price adjustment and γ in (1). Iterating back from the long run, wage inflation can also be described in terms of expected long-run wage inflation and the path of the output gap to that horizon:

$$\pi_t \approx \beta \sum_{j=0}^{\infty} {}_t(x - x^n)^e_{t+j} + {}_t\bar{\pi}^e \tag{5}$$

Suppose the relation between the current real-activity gap and wagesetters' expected future real-activity gaps can be approximated by an AR(1):

$${}_t(x - x^n)^e_{t+q} \approx \rho^q (x - x^n)_t \quad \textit{where} \;\; 0 < \rho < 1 \tag{6}$$

In fact, for real GDP in the postwar era, a simple autoregressive univariate forecast like this is hard to beat (Faust and Wright, 2007). Then (5) becomes:

$$\pi_t \approx (\beta/(1-\rho))(x - x^n)_t + {}_t\bar{\pi}^e \tag{7}$$

The current wage-inflation rate increases with the current real-activity gap, and with expected long-run wage inflation.

How it accounts for historical patterns

With an imperfect measure $\hat{x}$ of the real-activity gap $(x - x^n)$, wage inflation is:

$$\pi_t \approx (\beta/(1-\rho))\hat{x}_t + {}_t\bar{\pi}^e + s_t \quad where\ s_t = (\beta/(1-\rho))\left((x - x^n)_t - \hat{x}_t\right) \qquad \textbf{(8)}$$

Again suppose an observer regresses wage inflation on $\hat{x}$ and lagged wage inflation, in a sample where s is uncorrelated with period-to-period changes in the real activity measure $\hat{x}$. Results will depend on the correlations between lagged inflation and $\hat{x}$ and long-horizon expected inflation ${}_t\bar{\pi}^e$.

We know of no evidence on long-horizon expected wage inflation. But changes in long-horizon expected wage inflation should be related to changes in long-horizon expected price inflation. There is a lot of evidence about the latter. In the postwar era, professional economic forecasters have reported long-run price inflation expectations in surveys. From the late 1960s through the early 1990s reported long-run expected inflation varied from year to year and was positively correlated with recently experienced inflation. Long-horizon inflation expectations in surveys declined sharply, along with actual inflation,in the recessions of 1973, 1981 and 1991 (see Clark and Nakata, figure 20). Estimates of long-term expected inflation extracted from long-term interest rates have been unstable and strongly affected by news about inflation and economic activity (Gurkaynak, Sack and Swanson, 2005). Erceg and Levin (2003) show that a New Keynesian DSGE model reproduces postwar price-inflation movements fairly well assuming long-term inflation expectations responded to experienced macroeconomic conditions with magnitudes calibrated to the survey data.

It is a matter of debate whether these long-horizon inflation expectations were rational. Many observers (e.g. Rudd and Whelan, 2007) have noted that postwar data are clearly inconsistent with a joint hypothesis that (4) holds, ${}_t\pi^e_{t+1}$ is a rational expectation, and the distribution of realized inflation is the same as the *ex ante* distribution behind ${}_t\pi^e_{t+1}$. For example, under this joint hypothesis changes in inflation would be negatively correlated with lagged real activity. In fact changes in inflation have been positively correlated or uncorrelated with lagged real activity. But which of the three elements of the joint hypothesis is wrong? Some researchers (e.g. Fuhrer and Moore, 1995; Smets and Wouters, 2007) have presented models in which expectations are rational and realized inflation reflects the *ex ante* distribution, but the nature or wage- or pricesetting differs from (4), in a way that creates a structural effect of lagged inflation on current inflation. We do not consider these models because, as Ball (2000) points out, they cannot account for the *absence* of a positive coefficient on lagged inflation in pre-1914 Phillips curves. Ball proposes that (4) held but expectations are not rational. Erceg and Levin (2003) argue that expectations were rational and (4) holds but, especially over the 1980s, realized inflation did not reflected the *ex ante* distribution. Wage- and price-setters accounted for a possible future in which monetary policy would accommodate high, persistent inflation. This future that was not realized but it was perfectly reasonable to consider after the 1970s. In other words, there was a "peso problem."

We know of no survey data on inflation expectations from the interwar or pre-1914 eras. For the pre-1914 era, however, the behavior of long-term interest rates can be taken to indicate that long-term price inflation expectations were stable, remarkably unresponsive to experienced macroeconomic events (Bordo and Dewald, 2001). Barsky and DeLong (1991) find evidence that the long-term inflation expectations indicated by pre-1914 interest rates were perhaps too stable to be rational expectations: they failed to respond to data on gold production, available at the time, which turned out to predict realized inflation. But they also point out - like Erceg and Levin (2003) for the postwar era - that one cannot judge the rationality of expectations on the basis of distributions of observed outcomes. From a late-nineteenth century point of view, there were many possible relations between gold discoveries and inflation; the "theory" that turned out to be correct *ex post* was just one of many *ex ante* possibilities.

We do not want to take a position on whether wagesetters' expectations were strictly rational in any era. Assuming expectations were at least *roughly* rational (8) can account for the historical transition in the empirical Phillips curve. Before 1914, long-horizon wage inflation was stable. Thus, estimated coefficients on lagged inflation from pre-1914 data are about zero, and estimated coefficients on real activity measures are about equal to $(\beta/(1-\rho))$. In postwar samples including the 1970s and early 1980s, ${}_t\bar{\pi}^e$ is strongly correlated with lagged inflation, and perhaps also positively correlated with real activity. Thus, estimated coefficients on lagged inflation are positive. Estimated coefficients on real activity may be biassed - too large in absolute value - relative to $(\beta/(1-\rho))$.

What were long-horizon inflation expectations like in the early 1930s? One can hardly infer them from long-term interest rates, given that it was a period of financial crisis - what was happening to term and liquidity premia? But we think it most reasonable to believe that $\bar{\pi}^e$ either remained stable or increased. It should have remained stable until the time U.S. adherence to the gold standard came into question. That time was, at the earliest, September 1931, when Britain left the gold standard and at least some financial-market participants came to perceive at least some chance that the U.S. would leave the gold standard as well (Friedman and Schwartz, 1963, p. 316). After that - if wagesetters' expectations were as sophisticated as financial-market participants' - $\bar{\pi}^e$ may have increased.

What our exercise means

When we use the prewar Phillips curve to project post-1929 wage inflation our null is that, first, the nature of wagesetting was the same in both eras; second, ${}_t\bar{\pi}^e$ was as stable over 1929-1931 as it was in pre-1914 downturns. If ${}_t\bar{\pi}^e$ was actually increasing at some point after 1929, due to fears for the gold standard, then realized post-1929 wage inflation would be higher than projected *even if the first condition holds*. Recall that we will judge there is evidence for extraordinary wage rigidity if post-1929 inflation is higher than projected. Thus, we are biassed *toward* a conclusion that the nature of wagesetting was different in the the 1930s.

When we use postwar coefficients, our null has three parts. First, the nature of wagesetting was the same in both eras. Second, in the postwar era period-to-period changes in $\hat{x}$ were sufficiently uncorrelated with $_t\bar{\pi}^e$ (and s) that the postwar coefficient on real activity is close to $(\beta/(1-\rho))$. In the variant where we turn off (on) the lagged-inflation coefficients, the third part of the null is that $_t\bar{\pi}^e$ was stable (that $_t\bar{\pi}^e$ was as strongly correlated with lagged inflation as in postwar samples). Again we are biassed toward a conclusion that the nature of wagesetting was different in the the 1930s. This is not only because $_t\bar{\pi}^e$ may have been increasing due to fears for the gold standard. Recall that in the postwar era $_t\bar{\pi}^e$ may have been correlated with real activity, perhaps magnifying the estimated Phillips-curve coefficient on real activity. That will tend to pull the projection for the 1930s down, even if the nature of wagesetting was the same in both eras.

4) Available data

4.1) Wages

The "wage" in some theoretical models corresponds to the pay earned by a given person - the “person-wage” - which is affected by a person’s movements across jobs, as well as by changes in pay on a given job. Nowadays time-series data on person-wages can be constructed from household surveys (such as the Panel Survey of Income Dynamics [PSID]).

In other models the wage corresponds to the “job-wage,” that is the wage paid for a given job with a given employer - the straight-time wage or salary for a position in an employers' pay structure. Nowadays job-wages are measured by the BLS Employment Cost Index program, which repeat-surveys firms on wages and salaries paid for narrowly-defined job categories. Wages in new-Keynesian models correspond to job wages. When the wage received by a person changes because the person moved from one job to another, that is not a change in the “wage” depicted by a new Keynesian model.

Unfortunately, there are no time-series data on job-wages *or* person-wages from the early 1930s.[2] The only data we have that indicate the path over time of wages for large numbers of workers or establishments, and are comparable with data from other eras, are monthly series of industry-level average hourly earnings (AHE) in manufacturing.[3] These run continuously from June 1920, except for an unfortunate break from January-June 1922 when no data were collected. Hanes (1996) used these data to construct an aggregate manufacturing AHE series that is as comparable and consistent as possible from the 1920s through 1990, by applying a fixed set of industry weights to these data and postwar data for matching industries. A number of recent studies including Ohanian (2009) use this series, so we will too.

Any series derived from AHE is an imperfect measure of job wages, and the measurement errors may be correlated with the state of the business cycle. Dunlop (1944, pp. 19-27) discusses the possible cyclical biasses in AHE as a measure of given employers' wages. AHE series are also imperfect measures of person-wages. Solon, Barsky and Parker (1994) present evidence that within the postwar era AHE series have a countercyclical bias as a measure of person-wages. For our purposes, the direction of the biasses do not matter much, as long as it remained stable between the interwar and postwar eras. We know of no evidence on this one way or the other.

The most comprehensive wage data from the pre-1914 era are job wages: rates paid for given jobs in given firms. Series constructed from these data match the postwar ECI but incomparable with the interwar AHE series. Fortunately, starting in the 1890s a few state labor bureaus conducted annual surveys of manufacturing firms' employment and payrolls. Using the results of these surveys and U.S. census data, Albert Rees (1960) created estimates of average hourly earnings by industry from 1890-1914. The estimates could only be created on an annual average basis - no monthly estimates could be made. The particular Rees series that is most comparable

[2] In the early 1930s there were at least two survey programs that asked firms to report changes in their overall pay structures. The resulting data (used in a number of studies including Dunlop, 1944 and Hanes, 2000) indicate when firms began to institute general wage cuts in the post-1929 downturn, but have no counterparts from other eras close enough to allow comparisons of wage rigidity between 1929 and other downturns.

[3] They are from surveys carried out by the National Industrial Conference Board beginning in 1920, and by the Bureau of Labor Statistics beginning in 1934, as described by Dighe (1997).

to the interwar-postwar AHE series is his "Nine-industries" index, which overlaps the industry coverage of the interwar-postwar series and uses effectively fixed weights to aggregate across industries.

The Rees series may have a cyclical bias, but the possible bias is *procyclical*, which would tend to make wages look more rigid in 1929-32, in comparison. The possible bias results from a deficit in the historical data. Pre-1914 surveys collected annual data on total payrolls, number of workers and days in operation, but not hours per day. Rees had to estimate the last by straight-line interpolation between information from scattered years. In the postwar era, hours per day is strongly procyclical, so dividing daily earnings by a fixed estimate of hours per day, following Rees' methods, would give a procyclically biassed estimate of actual AHE (Allen, 1992). Were hours per day also procyclical before 1914? There is some evidence that in the pre-1914 era manufacturing establishments cut days in operation but not hours per day in cyclical downturns (Carter and Sutch, 1992).[4] In that case, the Rees series may not have this procyclical bias. In any case there is no reason to believe the Rees series has a *countercyclical* bias.

4.2) Real Activity

We use series on industrial production (IP), real GDP and unemployment rates. To compare the Great Depression with the postwar era, we have all three of these measures. The Federal Reserve Board Index of Industrial Production starts with 1919, is on a monthly frequency and is quite uncontroversial. Real GDP estimates are also uncontroversial: the BEA's National Income and Product Accounts begin with 1929. But within the 1930s they are only on an annual frequency. We use the index for real gross output of nonfarm private business.[5]

[4] This is not surprising. In the pre-1914 era there was a large fixed cost of starting up a manufacturing plant in the morning. Most plants had a central power source - steam engine, waterwheels or turbines - with power carried to individual workstations by a complicated apparatus of wheels and belts. It is hard to turn such a system on and off - it certainly takes time and extra fuel to fire up a steam engine. In the postwar era, manufacturing plants used electric power with small motors at individual workstations, which can be started and stopped instantly.

[5] Real GDP including housing services is obviously wrong. In our judgement it is also inappropriate to include agricultural and government output, but the index for output including those sectors gave results similar to those reported here.

For IP and real GDP, we define real activity to be the deviation of the log of the measure from a long-term trend. It is tricky to define trends for the Great Depression era. It is clearly inappropriate to use a Hodrick-Prescott trend with conventional parameters, or a loglinear trend estimated within the interwar era alone. Either of those definitions would imply output was close to trend or even above trend in the mid-1930s, which is inconsistent with anyone's view of the Great Depression and with all unemployment estimates. We follow Romer (1989) and Balke and Gordon (1989) and define trends by loglinear interpolation between benchmark "normal" years. The benchmark years they use are 1884, 1891, 1900, 1910, 1924, 1947, 1955, 1962, 1972, and 1981. We add two more benchmarks: 1941 and 1990. Using these benchmarks, output was far below "potential" throughout the 1930s. Cole and Ohanian (1999, footnote 5) define trends by estimating one loglinear trend spanning both 1919-1929 and postwar years, and assuming 1929 was on trend, so that the trend level for 1930 is the 1929 level *plus* the trend growth rate. We try that, too.

Unemployment estimates for the 1930s are only on an annual frequency. They are tricky for a number of reasons. First, standard postwar unemployment estimates are based on household surveys, which allow people to classify themselves as in or out of the labor force (on BLS definitions). For years before 1940 no such surveys are available: unemployment must be estimated as the difference between employment and the long-term trend "usual labor force" (indicated by population censuses). Second, there is no reliable way to estimate short-term variations in agricultural employment absent household survey data, since so much farm labor is family labor. Finally, there is no consensus on whether the large numbers of Federal relief workers in the 1930s should be classified as employed or unemployed (see Darby, 1976 *versus* Lebergott, 1964). We use David Weir's (1992) estimate of the "private nonfarm unemployment rate," which sidesteps these problems. It is on an annual frequency, covering years from 1890 through 1990. Its denominator is the "usual labor force," estimated the same way, for both postwar and earlier years. It excludes agriculture, government and relief workers from both the employment and labor force figures. Within the interwar era, its underlying estimates for private nonagricultural employment are not significantly different from those underlying the alternative unemployment series of Lebergott (1964) and Romer (1986).

For pre-1914 comparisons we use industrial production and unemployment rates. The industrial production index of Miron and Romer (1990) covers 1884-1940 and is consistent (same component series, same aggregation formula) across the pre-1914 and interwar eras. For unemployment, we again use Weir's private nonfarm unemployment rate. We do not use prewar real GDP series, for three reasons. First, there is no consensus on a series (Romer's (1989) series is significantly different from Balke and Gordon's (1989)). Second, it is not clear that agricultural output should be included in "output" for an exercise of this type (agricultural output is unstable but acyclical). Third, the portion of historical GNP series meant to indicate nonagricultural output is based mainly on IP indices. Better to use IP indices explicitly.

4.3) Prices

Prices of less-finished goods such as raw materials (e.g. cotton) and intermediate products used mainly as inputs to further production (e.g. cotton thread) are procyclical relative to prices of more-finished goods. In postwar data, real wages appear acyclical or procyclical when the price index is heavily weighted toward finished goods, but countercyclical when the price index is weighted toward less-finished goods (Hanes, 1996).

Most price data that have survived from the pre-1914 era are for relatively unfinished goods. There are no surviving price records for most of the more-finished goods of the era. 1930s price data are more abundant, but still unrepresentative of more-finished goods. Apart from the lack of historical data on more-finished goods' prices, there is reason to believe that real GDP and aggregate consumption have become more finished over time. Hanes (1996) and Huang, Liu and Phaneuf (2004) show that a secular increase in the number of intermediate stages of sale preceding the final purchaser could tend to make real wages more procyclical, holding fixed the degree of nominal wage rigidity. In Hanes' model, more stages make real wages procyclical because firms' desired price markups over marginal cost are countercyclical. In the model of Huang, Liu and Phaneuf (2004), it is because pricesetting is subject to Calvo-type constraints and more stages make production more roundabout in the sense of Basu (1995).

We want to compare the cyclical behavior of real product wages across eras controlling for this phenomenon. To do that, we use a peculiar price index (see Appendix 1). This is an index of prices of the same goods that are in pre-1914 WPIs, or closely matched goods, carried through the interwar and postwar eras to 1990. This "fixed-bundle" index is not the best measure of producer prices in *any* era, but it allows comparisons across eras to be relatively unaffected by the degree-of-processing problem.

5) Comparing the Great Depression with other eras

Figure 1 shows wage inflation from 1891 through 1990 as indicated by the change in the log of the Rees series and the interwar-postwar AHE series on an annual frequency, with 1929-32 indicated by vertical lines. The figure shows that AHE inflation was close to zero in the years just before 1929, and also over much of the 1891-1914 period. AHE inflation was generally higher in the postwar era. Figure 2 focuses on the interwar era, at monthly frequency. Vertical lines mark the August 1929 NBER cyclical peak that marks the beginning of the Great Depression, and July 1933, the first month wages were affected by the NRA. The cyclical peak preceding the 1920-21 depression was in January 1920. The difference between 1920-21 and 1929-30 is obvious. So are the wage increases coincident with the inception of the NRA in 1933, and with the unionization wave of 1936-38.

5.1) Comparisons with the pre-1914 era

Wage inflation

To compare the Great Depression with the thirteen available pre-1914 observations, we scatter annual wage inflation against real activity and see whether the 1929-1940 observations are out of line with the 1891-1914 slope. Figures 3-6 are these scatterplots. For 3 the real activity variable is the unemployment rate. Along with observations from 1891-1914, the figure includes observations from 1924 through 1932. The figure includes a regression line from the 1891-1914 observations only, and another regression line from the 1924-32 observations only. If nominal wages were unusually rigid after 1929, then the observations from 1930, 1931 and 1932 would be *higher* than one would expect given the 1891-1914 pattern. In fact, they are remarkably close to the 1891-1914 regression line. Figure 4 adds the observations from 1933 through 1940. These observations are a striking contrast to 1929-32: they are very obviously above the 1891-1914 regression line.

For Figures 5 and 6, the real activity variable is the deviation from trend in the log IP index, using the benchmark-year trends. Again, the 1930-32 observations are remarkably close to the 1891-1914 regression line; the post-1933 observations are above it.

Real wages

Figures 7-10 show scatterplots with the change in real product wages on the vertical axis and the change in the real activity variable on the horizontal axis. This measure of real product wages, using a consistent price index, is procyclical in both the pre-1914 and interwar eras, because it is heavily weighted toward less-finished goods. Are the 1930-32 observations are out of line with the 1891-1914 pattern? No, except for 1932 when the change in the real wage was *lower* than one would expect. In Figures 9 and 10, with the change in the log of the IP index on the horizontal axis, 1930 is above the 1891-1914 regression line but not outside the pre-1914 experience: the 1930 observation is very close to a pre-1914 observation.

5.2) Comparisons with the postwar era

Wage inflation

Using postwar data, we run OLS regressions of wage inflation on real activity and lagged wage inflation. We apply the estimated coefficients to the interwar path of real activity to project the corresponding path of wage inflation over 1929-1940 and compare this with the actual path, on both an annual and monthly frequency. The monthly frequency is useful to indicate whether the response of wage inflation to the 1929 downturn was unusually *delayed*.

Annual data

To begin, we regress wage inflation on current real activity and two lags of wage inflation, following Akerlof, Dickens and Perry (1996). We tried adding lagged real activity and further lags of inflation to the right-hand side, but coefficients on these variables were never significantly different from zero at the ten percent level. For the results presented here, we exclude years before 1956 and 1972-77 from the postwar sample, because results for a sample including these years would be affected by wage and price controls.[6] These are also the years around the 1973-74 oil-price shock. Excluding these years tended to *increase* estimated coefficients on real activity, so we are thus biassing our results *toward* a conclusion that wages were relatively rigid in 1929-32.

Table 1 shows results for the various combinations of real-activity variables and trends. "Constrained" trends are the ones defined as in Cole and Ohanian, with the trend growth rate for the interwar era constrained to be the same as in the postwar era. Coefficients on the second lag of inflation are not significantly different from zero at conventional levels. Judging from the R-squareds, all give about the same fit to wage inflation.

Before we apply these coefficients to 1930s data, we must rule out one possible problem. They could generally underpredict the degree of deceleration in downturns, because of measurement error in the real-activity series, nonlinearities and so on. To check this, we used the coefficients from Table 1 to project wage inflation in *postwar* downturns, and compare projected deceleration with the actual change in wage inflation. Table 2 shows these comparisons. The upper portion of the table shows projected and actual wage inflation rates, expressed as change in log, at cyclical peaks and the following years. The first columns show projections from the various real-activity

[6] Inexcusably, many empirical studies testing New Keynesian Phillips curves include price-control years in samples even though Gordon (1983, 1990) shows that controls had statistically and economically significant effects on wage and price inflation. The Korean War wage and price controls were lifted in February 1953, plausibly affecting the rate of wage inflation from 1953 to 1954. With two years' lagged inflation in our specifications, we begin with 1956. We also exclude 1972 through 1977, as the Nixon price controls held in one form or another from August 1971 through April 1974 (affecting inflation from 1974 to 1975). Rockoff (1984) gives chronologies of the Korean War and Nixon controls. An alternative approach would be to account for the Nixon wage and price controls with a set of dummy variables constrained to take pre-specified relative values over the different periods covered by the controls. Following that approach gave results similar to those presented here, but we prefer to simply exclude the price-control years because we have no prior information about the relative year-by-year effects of the controls on earnings.

variables and trend definitions. The projections jump off from *actual* wage inflation in the years *preceding* the peak. The lagged inflation rate used to determine projected wage inflation in the year following the peak is the projection for the peak year. The next-to-last column is an average of the projections. The last column shows actual wage inflation. In the year following the peak, is projected wage inflation generally too high? No: the projections are sometimes, higher, sometimes lower than actual wage inflation. The lower portion of the table shows the change in wage inflation from the peak to the following year. Is projected deceleration generally too small? No: it is sometimes stronger, sometimes weaker than actual. Thus, applied to postwar data the coefficients do *not* underpredict the degree of deceleration in downturns.

Now we apply the estimated postwar coefficients to project wage inflation starting with 1929. The projections using lagged inflation jump off from *actual* wage inflation in 1927 and 1928; the lagged inflation rates used to determine projected wage inflation after 1929 are lagged projections.

The upper portion of Table 3 gives the projections from 1929 through 1932, along with actual inflation. The table's lower portion gives projected and actual 1930-32 wage inflation rates *minus* 1929 wage inflation. The projections are quite close to actual deceleration. Figures 11 and 12 plot the projections and actual inflation over 1929-32. (We do not plot the projections from the constrained trends.) The figures show an obvous divergence starting with 1933. From 1933-40, wage inflation is always higher than projected. But over 1929-32, the projections are very close to actual inflation. In 1930, actual inflation is a bit higher than the projections with no lagged-inflation effect, but extremely close to the projections that do have a lagged-inflation effect.

Monthly data

Recall there are no monthly unemployment or real GDP estimates, so monthly projections are based on IP only. To make monthly projections, we ran this regression on postwar data:

$$w_t - w_{t-12} = c - a\ IP_t^{GAP} + + \alpha_1 (w_{t-12} - w_{t-24}) + \alpha_2 (w_{t-24} - w_{t-36}) \qquad \textbf{(9)}$$

where t is a month.[7] Using benchmark-year trends, estimated coefficient values are:

$$w_t - w_{t-12} = 0.0044 + 0.1368\ IP_t^{GAP} + + 0.5627\ (w_{t-12} - w_{t-24}) + 0.3007\ (w_{t-24} - w_{t-36}) \qquad R^2 = 0.73 \tag{10}$$

We apply these coefficients to interwar data to generate projections starting with January 1929.[8] (As before, the lagged values of wage inflation used to generate simulated values were actual rates in 1927 and 1928; for later years they were lagged values of simulated inflation.) We generate one simulated interwar path with coefficients on lagged inflation equal to the estimated postwar values, and another path with coefficients on lagged inflation set to zero. Figure 13 plots the results. Again, there is no evidence of extraordinary wage rigidity until 1933.

Real wages

Figures 14-16 show scatterplots with the change in real product wages on the vertical axis and the change in the real activity variable on the horizontal axis. As in the corresponding plots with pre-1914 data, the only observation that is grossly out of line with the usual relationship is 1932, when real wage growth was extraordinarily *low*.

6) Conclusion

The notion that wages were unusually rigid over 1929-32 should be removed from economists' list of stylized facts. Of course, we cannot rule out the possibility that in some specification, nominal wages would appear unusually rigid over 1929-32. There is an infinite supply of theoretical models and, for each model, many justifiable statistical representations. But we have shown that data from 1929-32 were in line with specifications that make reasonable demands on available data, are consistent with current models of wage rigidity, and allow comparison with other historical studies of wage flexibility.

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[7] Again to avoid periods most obviously affected by wage and price controls, the sample for the monthly data runs from March 1955 through July 1971 and from May 1976 through December 1990.

[8] We used the Census X-11 method to seasonally adjust the actual and simulated monthly earnings series.

We do not mean that nominal wages were "flexible" in the Great Depression. Rather, the evidence is that wages were subject to the same type of nominal rigidity in 1929-32 as in postwar or pre-1914 periods. The early years of the Great Depression should be analysed with the same models of aggregate supply that an economist would apply to other eras.

Appendix 1. Data sources

Real GDP: Gross value added by nonfarm business, index number. 1929 on from U.S. Bureau of Economic Analysis website (accessed January 2010). Linked to Real GDP. "Millenial Edition Series," from Historical Statistics (2006), series Ca9.
Unemployment rates from Weir (1992).
Industrial production. Interwar-postwar is Federal Reserve Board Index of Industrial production from Federal Reserve Board of Governors website (accessed January 2010). Pre-1914-interwar from Miron and Romer (1990). The Miron-Romer series lacks an observation for March 1902. We define a log value for this month as the average of the logs of the series in the two adjacent months.
Average hourly earnings. 1923-1990 from Hanes (1996). 1890-1914 from Rees, 1961, "Nine industries," Table 21 p. 72.
Wholesale price index. Group indexes from Historical Statistics Millenial Edition, Cc125-137. Composite excluding farm products and foods is calculated from other components using weights from Warren and Pearson (1932, p. 184, 1889 weights).

Appendix 2. Derivation of (1) in New-Keynesian models

This appendix is of no interest to a reader familiar with New Keynesian literature. We include it on the off chance that a reader unfamiliar with that literature, but interested in the economic history literature on empirical Phillips curves, is bothered by (1).

In a typical New-Keynesian model that allows for noninal wage rigidity, the wagesetter is a household that is the monopoly seller of a differentiated type of labor. A household's desired wage w_i^* for its labor type is a fixed markup over the opportunity cost of providing labor at this wage. The next-best alternative to employment at w_i is "leisure," a component of the household's utility function. As the household maximizes its lifetime utility function, the real opportunity cost of supplying a labor type is the ratio of the marginal disutility of labor to the marginal utility of consumption. A household's marginal disutility of supplying a labor type increases with the quantity of the labor supplied by the household, while the marginal utility of consumption decreases with household consumption. To allow for unemployment, as distinct from variations in hours per worker, one can follow Gali (2011) and assume that labor is "indivisible" (each worker must work full time or not at all) and each household contains many members of a given labor type with varying disutilities of labor. Under that interpretation, one unit of labor supplied by a household is equivalent to one *worker*. The unemployment rate is the fraction of household members not currently employed. This definition of an unemployment rate may not match BLS survey data (where the size of the labor force is strongly procyclical) but it corresponds very well to the historical unemployment estimates we use (based on the "usual labor force").

Let h_{it} denote the quantity of a labor type supplied by household *i*. . Each household's consumption is equal to *average* consumption per household c_t , on the assumption that some mechanism (such as insurance or complete financial markets) transfers income across households to maximize net social benefit. Consumption can be described as the sum of steady-state path consumption c_t^{SS} and the deviation from steady state $(c - c^{SS})_t$. The markup of the desired real wage over the opportunity cost is μ^W. Thus the desired *real* wage can be described as:

$$w_{it}^* - p_t = \kappa_3 + gt + \mu^W + (c - c^{SS})_t + \eta\ h_{it} \qquad \textbf{(11)}$$

The coefficient on log consumption must be one in this expression so that employment per household can be stable in a long run steady state.)

Each firm *f* uses an aggregate of *all* labor types as an input to production. Thus, each firm's cost of labor is the average wage *w* across all labor types, rather than any particular wagesetter's w_i . The production function is:

$$y_{ft} = \alpha k_{ft} + (1 - \alpha)(a_t + l_{ft}) \qquad \textbf{(12)}$$

where l_f is the input of labor aggregate and a_t grows at the rate *g*. Assuming the aggregate capital stock does not deviate significantly from the steady-state path, aggregate output per firm is approximately:

$$y_t \approx \kappa_4 + gt + (1 - \alpha) l_t \qquad \textbf{(13)}$$

where l_t is average employment per firm. As each employer (or the "labor aggregator") can substitute across workers' labor types, employment of an individual labor type h_{it} depends on its relative wage $(w_i - w)$ and on l_t:

$$h_{it} = \kappa_5 + l_t - \lambda(w_i - w)_t \qquad \textbf{(14)}$$

An individual firm's capital stock can be adjusted every period - there are no short-run fixed factors - so a firm has constant returns to scale in the short run as well as the long run. Each firm's marginal cost (really long run marginal cost, in ordinary terms) is determined entirely by labor cost w and the rental rate for capital; the individual firm's production level does not affect its marginal cost. But the market-clearing capital rental rate depends on total output. So each firm's marginal cost is the same, and it is determined by the wage and *aggregate* output. Each firm is a monopolist with a fixed elasticity of demand for its product, so its desired price p_t^* is a fixed markup μ^P over this common marginal cost:

$$p_t^* = \kappa_6 + \mu^P + w - gt + \alpha l_t \tag{15}$$

To define ooutput and employment per firm on the steady-state path, set $c = c^{SS}$, $w_i = w$, and $p = p_i^*$:

$$y_t^{SS} = \kappa_7 + gt + \frac{1-\alpha}{\eta+\alpha}\left(-\mu^P - \mu^W\right) \tag{16}$$

Output deviations from the steady-state path are positively correlated with consumption deviations. Describe the relation by:

$$(c - c^{SS})_t = \omega(y - y^{SS})_t + \varepsilon_t^c \tag{17}$$

ε_t^c represents disturbances to the "normal" relation between consumption and output. The desired relative wage is thus:

$$(w_i^* - w)_t = \kappa_1 + \frac{1}{1+\eta\lambda}\left[gt - (w-p)_t + \varepsilon_t^c + \left(\omega + \frac{\eta}{1-\alpha}\right)(y - y^{SS})_t \right] \tag{18}$$

A firm sets its price as a markup over marginal cost, so the cyclical behavior of real wages depends on the cyclical behavior of the markup. In nearly all new-Keynesian DGSE models, a firm's desired price markup is *fixed*. Thus the real wage is:

$$(w - p)_t = \kappa_2 + gt - \frac{\alpha}{1-\alpha}(y - y^{SS})_t \tag{19}$$

Substituting (19) into (18) gives:

$$(w_i^* - w)_t = \frac{1}{1+\eta\lambda}\left(\omega + \frac{\alpha+\eta}{1-\alpha}\right)(y - y^{SS})_t + \frac{1}{1+\eta\lambda}\varepsilon_t^c \tag{20}$$

This expression is (1) in the text. It can be put in terms of unemployment by making the substitution $(y - y^{SS})_t = (1-\alpha)(u - u^{SS})_t$.

If φ is the probability that a wagesetter will be able to adjust his wage in a period, then under the conditions described in the text a wagesetter who has the opportunity to reset his wage at time t will choose a wage approximately equal to:

$$z_t \approx \varphi \sum_{j=0}^{\infty} (1-\varphi)^j \; {}_t w^{*e}_{t+j} = \varphi \sum_{j=0}^{\infty} (1-\varphi)^j \; {}_t[w + \gamma(x - x^n)]^e_{t+j} \tag{21}$$

and the rate of wage inflation is:

$$\pi_t = \varphi(z_t - p_{t-1}) \approx \beta(x - x^n)_t + \frac{\varphi^2}{1-\varphi} \sum_{j=1}^{\infty} (1-\varphi)^j \left(\gamma \; {}_t(x - x^n)^e_{t+j} + \sum_{\tau=t+1}^{j} {}_t\pi^e_\tau \right) \quad where \;\; \beta = \varphi^2\gamma/(1-\varphi) \tag{22}$$

which is (4).

Things are more complicated if the Calvo constraint is applied to pricesetting as well as wagesetting. The desired relative wage is still positively related to real activity but it is also related to the lagged real wage. The resulting wage-inflation dynamics are more complicated. To allow for nominal price rigidity, suppose a firm must hold its nominal price fixed unless, with probability φ^P, it can adjust the price to a reset value:

$$z_t^P \approx \varphi^P \sum_{j=0}^{\infty} (1-\varphi^P)^j \; {}_t p^{*e}_{t+j} = \varphi^P \sum_{j=0}^{\infty} (1-\varphi^P)^j \; {}_t[\kappa + gt + w + \tfrac{\alpha}{1-\alpha}(y - y^{SS})]^e_{t+j} \tag{23}$$

Price inflation is $\pi^P = \varphi^P(z^P - p_{t-1})$. The price level thus depends on pricesetters' expectations of future wages and real activity. We point out some patterns that must hold as long as there is a long-run steady state. The reset price can be generally described as a function of last period's wage level, current wage inflation and current output, with positive derivatives with respect to these variables:

$$z_t^P = Z(\pi_t, y_t, w_{t-1}) \quad where \;\; Z_\pi > 0, Z_y > 0, Z_w > 0 \tag{24}$$

In order for a steady state to be possible, it must be true that:

$$\bar{\pi}_t^P = \bar{\pi}_t + g = \varphi^P \left[Z(\bar{\pi}, y^{SS}, w_{t-1}) - w_{t-1} + (w-p)^{SS}_{t-1} \right] \tag{25}$$

which means:

$$Z(\bar{\pi}, y^{SS}, w_{t-1}) = \frac{1}{\varphi^P} (\bar{\pi}_t - g) - (w-p)_{t-1}^{SS} + w_{t-1} \tag{26}$$

Around the steady state,

$$Z(\pi, y, w_{t-1}) = \frac{1}{\varphi^P} (\bar{\pi}_t - g) - (w-p)_{t-1}^{SS} + w_{t-1} + Z_y (y - y^{SS})_t + Z_\pi (\pi - \bar{\pi}_t) \tag{27}$$

For $\varphi^P = 1$, it must be true that $z_t = p_t^*$, and:

$$p_{it}^* = w_t + (w-p)_t^{SS} + \frac{\alpha}{1-\alpha} (y - y^{SS})_t = = w_{t-1} + \pi + (w-p)_{t-1}^{SS} + g + \frac{\alpha}{1-\alpha} (y - y^{SS})_t \tag{28}$$

These expressions setting $\varphi^P = 1$ give $Z_y = \alpha/(1-\alpha)$ and $Z_\pi = 1$. Those values in turn give z_t^P, hence p_t and the real wage is:

$$(w-p)_t = \kappa_3 + gt - \varphi^P \frac{\alpha}{1-\alpha} (y - y^{SS})_t + (1-\varphi^P)(\pi_t - \bar{\pi}_t) + (1-\varphi^P)[(w-p)_{t-1} - (w-p)_{t-1}^{SS}] \tag{29}$$

so:

$$(w_i^* - w)_t = \tag{30}$$

$$\frac{1}{1+\eta\lambda} \left(\omega + \frac{\varphi^P \alpha + \eta}{1-\alpha} \right) (y - y^{SS})_t + \frac{1}{1+\eta\lambda} \left[\varepsilon_t^c + (1-\varphi^P)(\pi_t - \bar{\pi}_t) + (1-\varphi^P)[(w-p)_{t-1} - (w-p)_{t-1}^{SS}] \right]$$

which is different from (1).

Appendix 3 Simple sticky-information Phillips curve

Suppose wagesetters minimize (1) in the text using information about *w* and *x* that is updated every two periods. In each period, half the wagesetters receive new information. Thus, in the current period, half the wagesetters know current *w* and *x*. The other half are guessing current *w* and *x* based on information from the previous period. Their guesses are equivalent to expectations of current *w* and *x* formed in the previous period. The average wage this period is approximately:

$$w_t = 1/2 \left[\gamma (x - x^n)_t + w_t \right] + 1/2 \left[\gamma_{t-1} (x - x^n)_t^e + {}_{t-1}w_t^e \right] \tag{31}$$

which means:

$$\pi_t = \gamma(x - x^n)_t + \gamma_{t-1}(x - x^n)_t^e + {}_{t-1}\pi_t^e \qquad \textbf{(32)}$$

If expectations are rational,

$$_{t-1}\pi_t^e = \gamma_{t-1}(x - x^n)_t^e + \gamma_{t-1}(x - x^n)_t^e + {}_{t-1}\pi_t^e \qquad \textbf{(33)}$$

hence $_{t-1}(x - x^n)_t^e$ must be zero in all periods. That gives (2).

Table 1 Phillips Curve Regressions on Postwar Annual Data
Sample: 1956-1971 1977-1990 (30 observations)

Coefficient
[SE]
p-value

	Unemployment rate	Benchmark years		Constrained. trend	
		IP	GDP	IP	GDP
	(1)	(2)	(3)	(4)	(5)
Real activity	-0.004 [0.001] *0.00*	0.123 [0.042] *0.01*	0.158 [0.059] *0.01*	0.085 [0.025] *0.00*	0.148 [0.045] *0.00*
$\pi(t-1)$	0.709 [0.190] *0.00*	0.791 [0.184] *0.00*	0.889 [0.180] *0.00*	0.726 [0.180] *0.00*	0.818 [0.174] *0.00*
$\pi(t-2)$	0.298 [0.210] *0.17*	0.102 [0.181] *0.58*	0.004 [0.174] *0.98*	0.047 [0.164] *0.78*	0.016 [0.164] *0.92*
R^2	0.82	0.81	0.81	0.83	0.83

Table 2 Actual and Projected Annual AHE Inflation Rates in Postwar Downturns

	Unemp.	Benchmark years		Constrained			
Year	rate	IP	Real GDP	IP	Real GDP	Average	Actual
1957	0.050	0.045	0.043	0.044	0.043	0.044	0.044
1958	0.042	0.031	0.031	0.033	0.031	0.031	0.035
1960	0.041	0.038	0.038	0.038	0.036	0.038	0.029
1961	0.038	0.032	0.032	0.032	0.027	0.031	0.026
1969	0.068	0.066	0.065	0.069	0.068	0.067	0.058
1970	0.073	0.062	0.060	0.069	0.066	0.064	0.051
1979	0.084	0.082	0.082	0.079	0.081	0.081	0.079
1980	0.077	0.077	0.078	0.074	0.076	0.076	0.087
1981	0.076	0.080	0.081	0.077	0.078	0.079	0.094
1982	0.060	0.066	0.065	0.064	0.061	0.064	0.062
		Change in wage inflation					
1957-58	-0.008	-0.013	-0.012	-0.011	-0.012	-0.012	-0.009
1960-61	-0.004	-0.006	-0.006	-0.006	-0.009	-0.007	-0.003
1969-70	0.005	-0.005	-0.005	0.000	-0.001	-0.003	-0.007
1979-80	-0.006	-0.004	-0.004	-0.005	-0.005	-0.005	0.008
1980-81	-0.016	-0.014	-0.016	-0.014	-0.017	-0.015	-0.032

Table 3 Actual and Projected Annual AHE Inflation Rates, 1929-1932

Wage inflation rates

Real Activity Variable	Trend constrained?	Effect of lagged inflation?	1929	1930	1931	1932
Unemp. Rate	NA	No	0.010	-0.021	-0.056	-0.093
IP	No	No	0.016	-0.012	-0.040	-0.075
IP	Yes	No	0.008	-0.011	-0.030	-0.054
GDP	No	No	0.007	-0.015	-0.036	-0.069
GDP	Yes	No	0.006	-0.016	-0.037	-0.068
Unemp. Rate	NA	Yes	0.017	-0.007	-0.055	-0.134
IP	No	Yes	0.021	0.005	-0.034	-0.102
IP	Yes	Yes	0.012	-0.002	-0.031	-0.076
GDP	No	Yes	0.012	-0.004	-0.039	-0.103
GDP	Yes	Yes	0.010	-0.007	-0.042	-0.103
Average, simulations without lagged inf.			0.009	-0.015	-0.040	-0.072
Average, simulations with lagged inf.			0.015	-0.003	-0.040	-0.104
Actual			0.019	0.004	-0.038	-0.106

Change in wage inflation from 1929 wage inflation

Real Activity Variable	Trend constrained?	Effect of lagged inflation?	1930	1931	1932
Unemp. Rate	NA	No	-0.031	-0.035	-0.037
IP	No	No	-0.022	-0.020	-0.020
IP	Yes	No	-0.021	-0.009	0.002
GDP	No	No	-0.025	-0.015	-0.013
GDP	Yes	No	-0.026	-0.016	-0.013
Unemp. Rate	NA	Yes	-0.017	-0.035	-0.079
IP	No	Yes	-0.005	-0.014	-0.046
IP	Yes	Yes	-0.012	-0.010	-0.020
GDP	No	Yes	-0.014	-0.018	-0.048
GDP	Yes	Yes	-0.017	-0.021	-0.047
Average, simulations without lagged inf.			-0.025	-0.019	-0.016
Average, simulations with lagged inf.			-0.013	-0.020	-0.048
Actual			-0.006	-0.017	-0.051

Figure 1

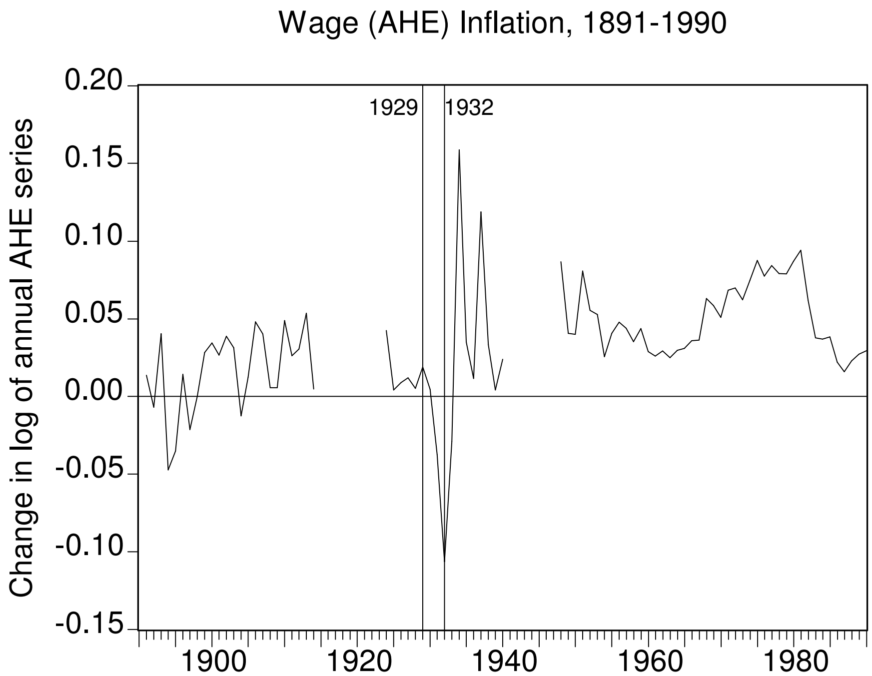


Figure 2

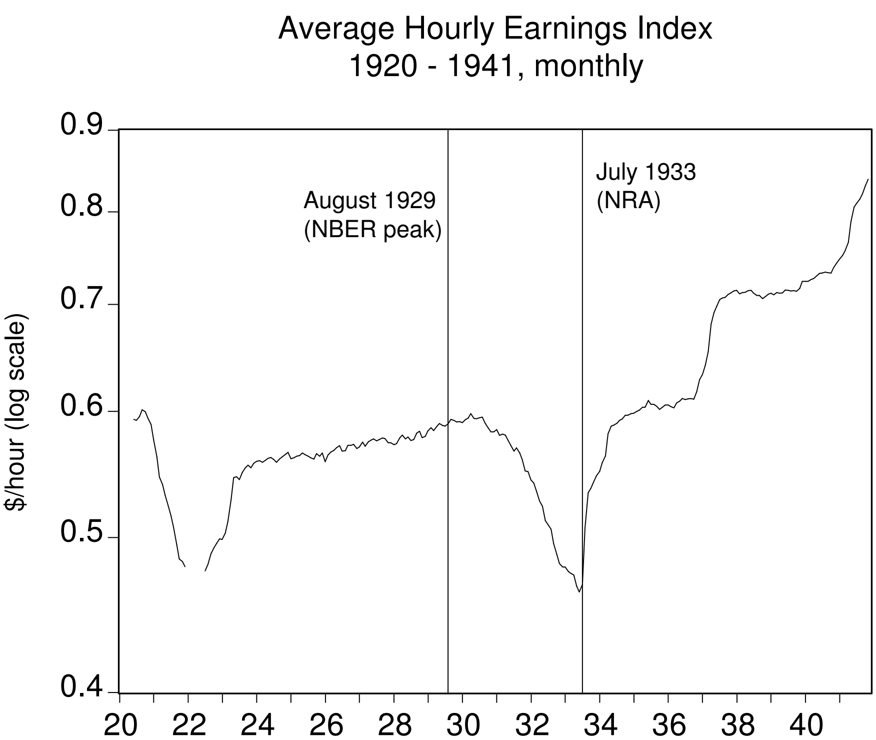
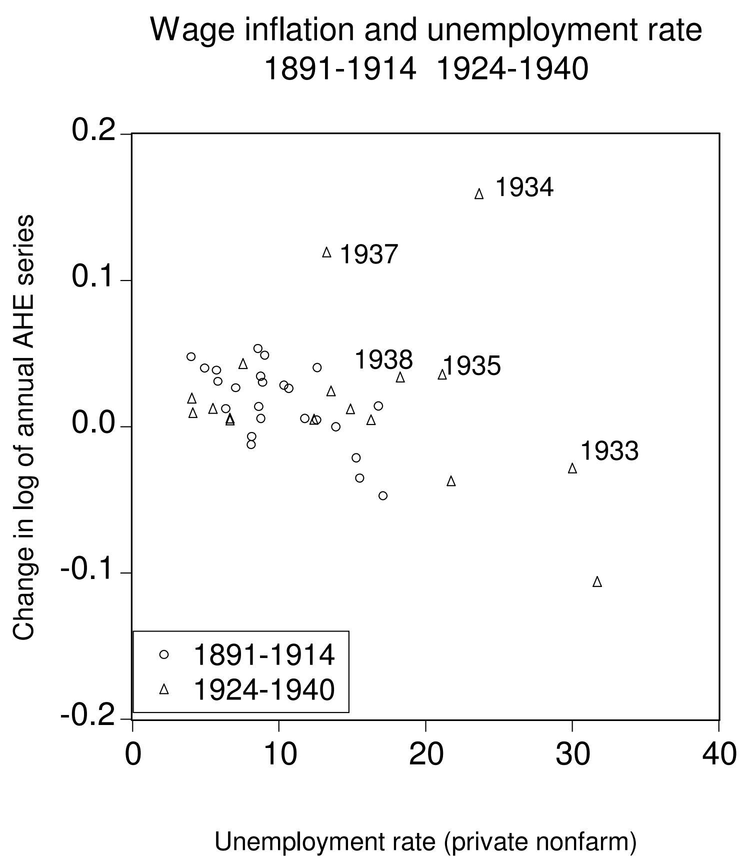


Figure 3

Figure 4



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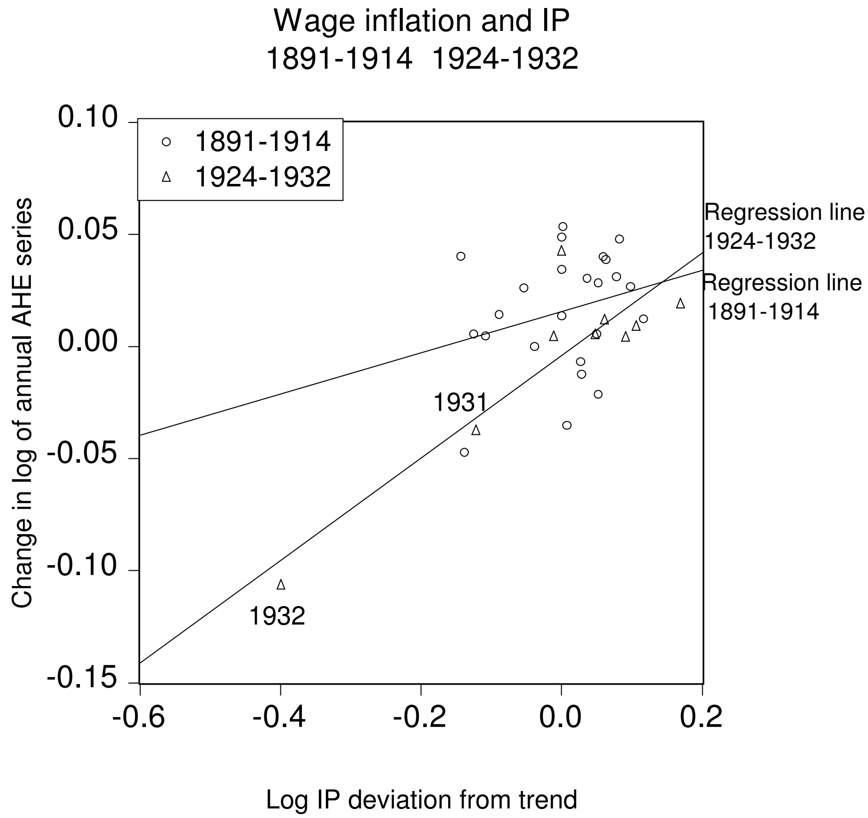

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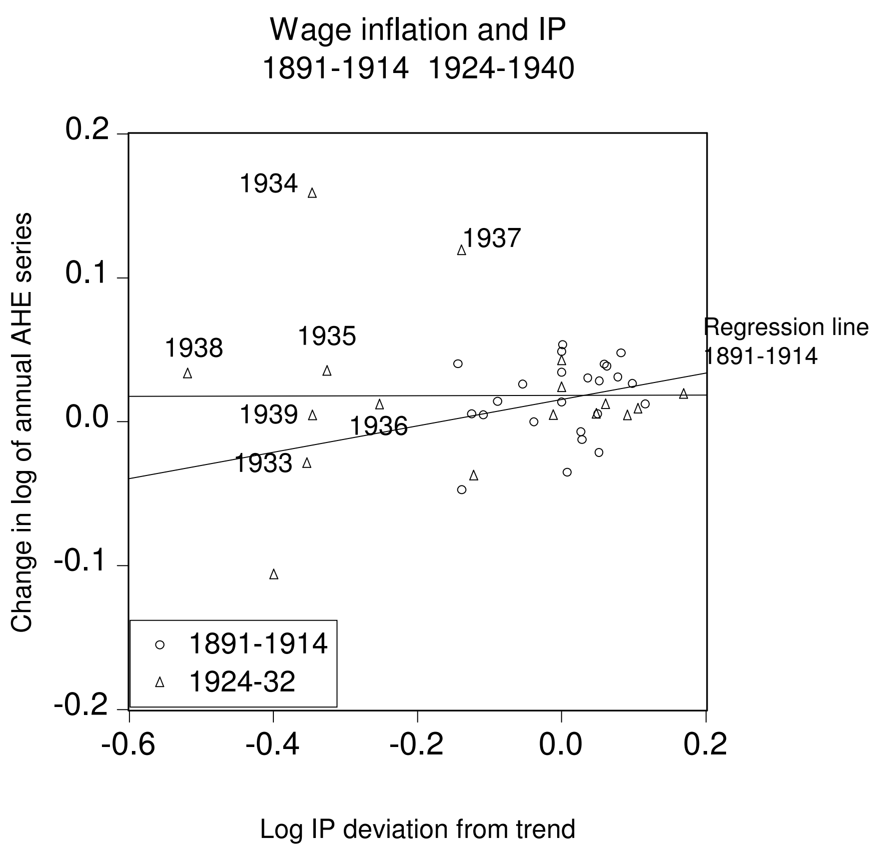


Figure 7

Figure 8

Figure 9

Figure 10

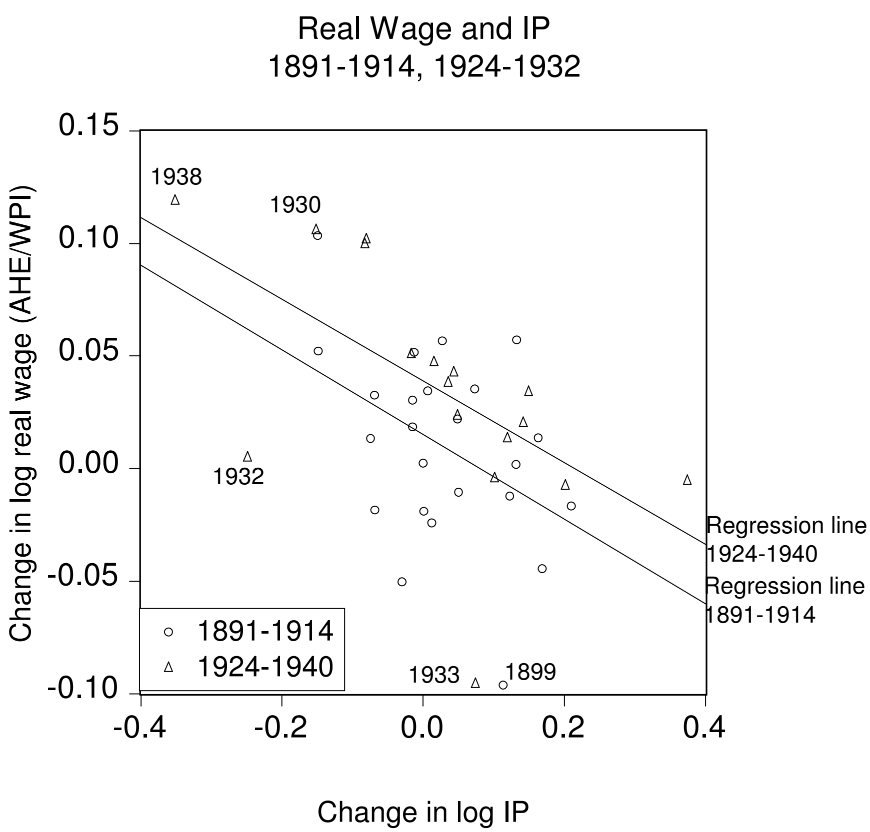
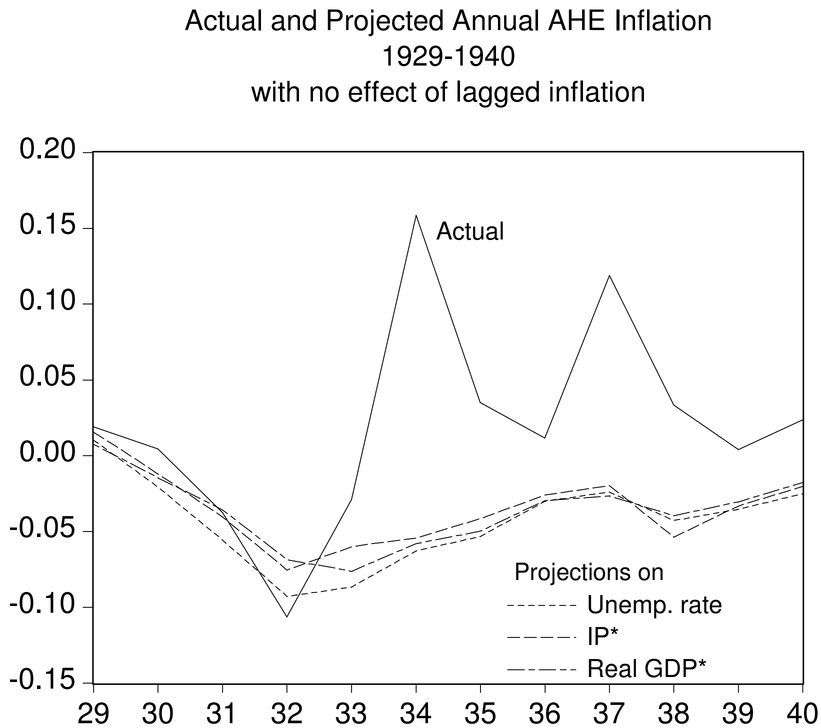
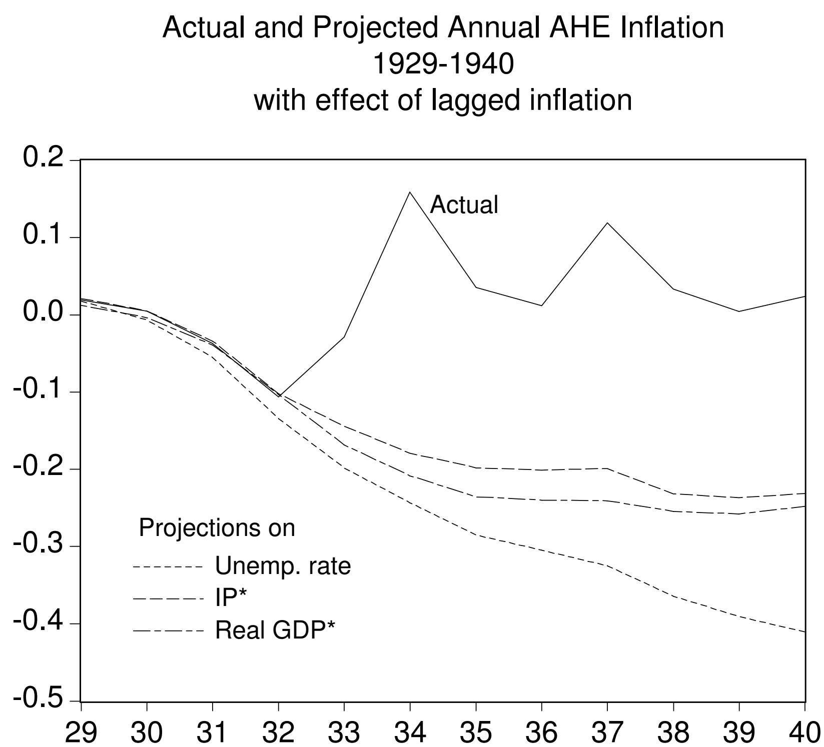


Figure 11



* Benchmark-year trends

Figure 12



* Benchmark-year trends

Figure 13

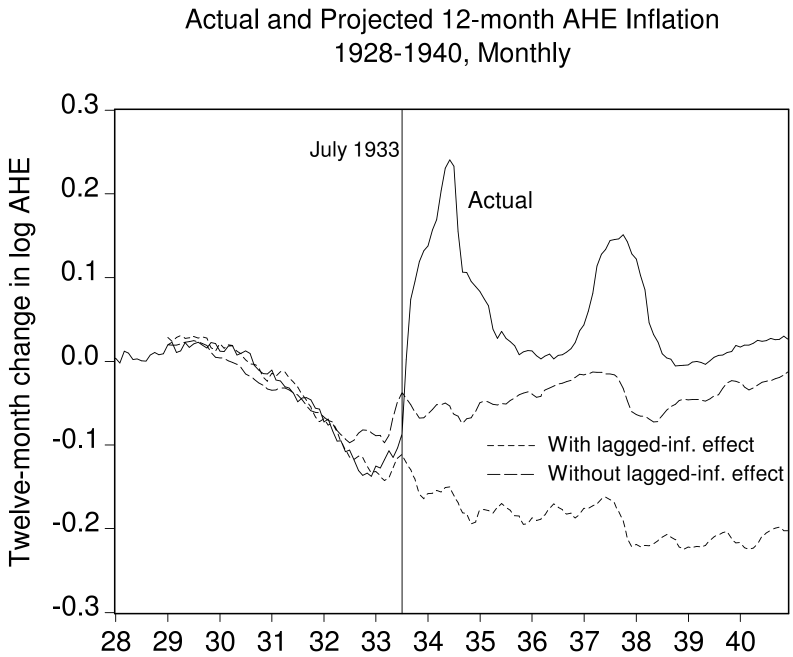


Table 14

Figure 15

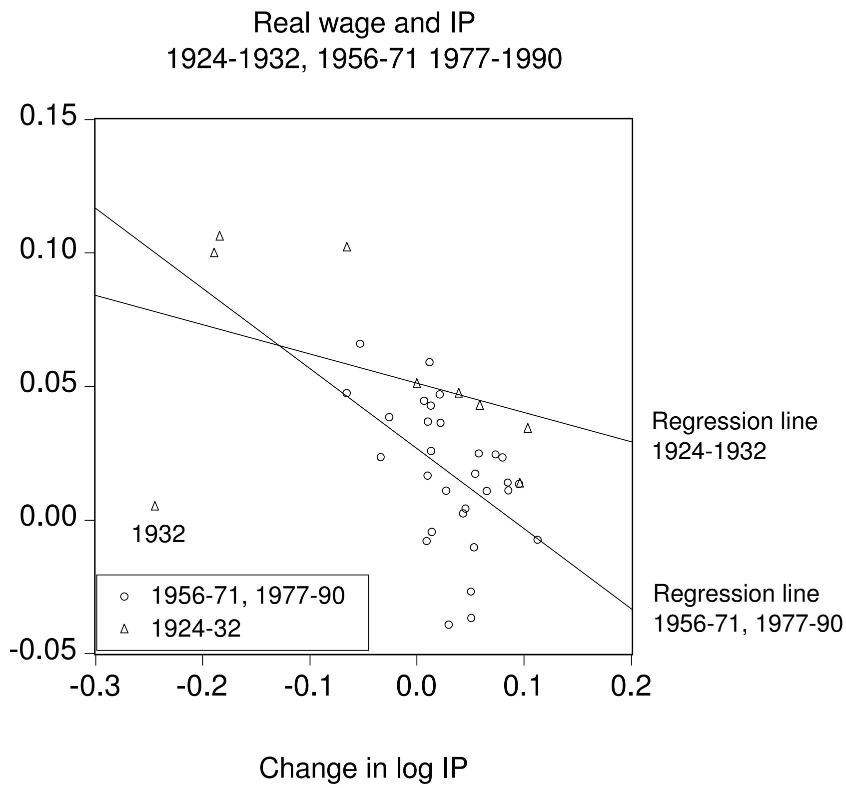
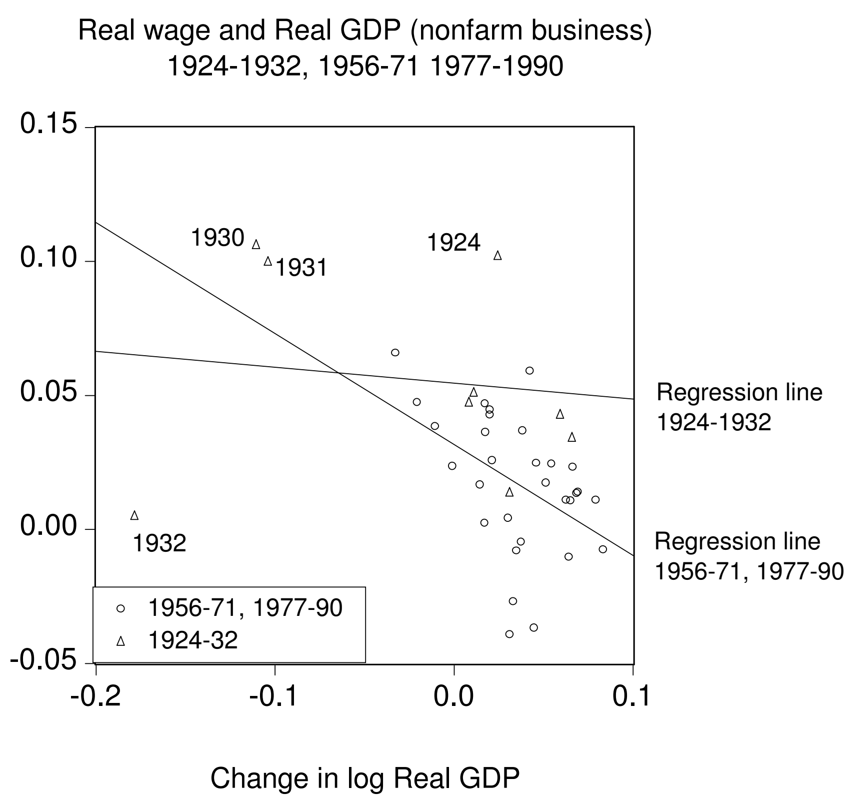


Figure 16



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