DISCUSSION PAPER SERIES

No. 3424

CAN PRODUCTIVITY GROWTH EXPLAIN NAIRU? LONG-RUN EVIDENCE FROM BRITAIN, 1871-1999

Tim Hatton

LABOUR ECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP3424.asp**

ISSN 0265-8003

CAN PRODUCTIVITY GROWTH EXPLAIN NAIRU? LONG-RUN EVIDENCE FROM BRITAIN, 1871-1999

Tim Hatton, University of Essex and CEPR

Discussion Paper No. 3424
June 2002

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 3424

June 2002

ABSTRACT

Can Productivity Growth Explain NAIRU? Long-run Evidence from Britain, 1871-1999*

The 'new economy' of the 1990s saw improving Phillips curve trade-offs coupled with faster productivity growth, particularly in the United States. This has led to a revival of the idea that there is an inverse relationship between productivity growth and the Non-Accelerating Inflation Rate of Unemployment (NAIRU). Because productivity trends evolve slowly, such effects have been difficult to identify using short runs of data. This paper investigates this relationship over a much longer period than usual. It draws on recently developed, historically-consistent, time series for the UK from 1871 to 1999. A two-equation model of unemployment and wage setting, that incorporates productivity effects, is estimated over the whole period allowing for shifts across major periods associated with changes in labour market institutions. The results indicate that trends in labour productivity do matter, but they go only part of the way towards explaining wide swings in average unemployment across the decades. Thus productivity is not the whole story, but it is some of the story. In addition, institutional changes appear to have enhanced the effects of productivity on the NAIRU, particularly in the post-Second World War era.

JEL Classification: E32, J64, N14 and N34
Keywords: productivity growth and unemployment

Tim Hatton
Department of Economics
University of Essex
Wivenhoe Park
Colchester
CO4 3SQ
Tel: (44 1206) 872748
Fax: (44 1206) 872724
Email: hatton@essex.ac.uk

* I am grateful for helpful comments from Gylfi Zoega and from participants at seminars at Australian National University and the University of Wollongong.

Submitted 23 May 2002

Introduction

The so called new economy of the 1990s was characterised by more rapid productivity growth than previously and an improved Phillips curve trade-off between inflation and unemployment, especially in the United States. These developments have led to a revival of the idea, briefly fashionable after the productivity slowdown of the 1970s, that higher productivity growth lowers the NAIRU and vice versa. Because productivity growth tends to vary only across fairly lengthy phases, it has been difficult to isolate such effects from those of other trending variables and from the higher frequency determinants of unemployment. Here we examine the impact of trends and shocks in productivity on one economy, the UK, over a much longer period than usual: from 1871 to 1999.

The strategy adopted here is to employ a relatively simple empirical model of wage setting and unemployment that emphasises the nexus between productivity and wage adjustment. The model is then used to assess the contribution of changes in productivity performance to the wide historical swings in average unemployment rates over the medium- and long-term. The institutional determinants of unemployment that have received much attention in the literature on European unemployment are not assessed directly. Long-term changes in the institutional setting are, instead, considered as changes in the environment, or regime, that condition the responsiveness of real wages and unemployment to their determinants. This is consistent with recent thinking that has stressed the interaction between economic shocks and (relatively fixed) institutional structures as the key to understanding medium-term trends in European unemployment.

The subsequent sections of the paper are laid out as follows. First we briefly outline developments in the literature on unemployment in the OECD (and Britain in particular) since the 1980s. Then we examine the historical record of developments in the UK labour market and identify some of the puzzles that emerge from this longer term view. A basic model of wage setting and unemployment is then briefly analysed. This is then applied to the long-run, taking advantage of recently developed consistent-over-time estimates of unemployment and average earnings. Finally we use these results to assess the contribution of shocks and trends in labour productivity on average unemployment rates.

The results indicate that productivity has contributed, and in the expected direction, to the wide swings in average unemployment. But it is only part of the story, and generally a relatively small part. However, there is evidence that the long-run evolution of labour market institutions added to the persistence of unemployment in response to shocks in a way that enhanced the effects of productivity on the NAIRU, particularly after the Second World War. Our overall conclusion is that productivity is by no means the whole answer to questions about medium-term variations in average unemployment: but it is *some* of the answer.

The Debate about the NAIRU

Following the oil shocks and the world-wide productivity slowdown that began in the 1970s, supply-side shocks were increasingly invoked to explain the apparent breakdown of the Phillips curve. Studies of OECD economies focused on the 'real wage gap'—the difference between the real wage and full-employment productivity—to explain the sharp rise in unemployment, particularly in Europe (Grubb, Jackman and Layard, 1983; Bruno and Sachs, 1985). Differences across countries in real wage rigidity in the face of these shocks were seen as reflecting degrees of coordination in wage setting that were conditioned by differences in levels of corporatism or by other aspects of labour market institutions. Such views fell out of favour largely because they predicted that the yawning real wage gaps (and hence excess unemployment) would disappear as the labour market eventually adjusted. Yet, in many European countries, high unemployment persisted throughout the 1980s and into the 1990s.

The alternative view was that changes in labour market institutions had permanently increased the NAIRU. In their influential studies, rooted in imperfectly competitive product and labour markets, Layard, Nickell and Jackman pointed to institutional developments affecting wage setting that had progressively raised the target wage and hence the equilibrium level of unemployment (Layard, Nickell and Jackman, 1991, 1994; Nickell, 1997). Their cross-country analysis suggested that variables such as replacement rates, the duration of unemployment benefit, union density and/or coverage, employment protection and taxes on employment were among the institutional factors that raised unemployment generally, and that could account for much of the variation in average unemployment rates across the OECD. But as Nickell has pointed out, this does not fully resolve the question about why

unemployment has remained so much higher, in so many countries, than it was in the 1960s. As he puts it "Comparing the 1990s to the 1960s, industrial militancy is no worse, oil prices are no higher, benefit systems are not much more generous (relative to average earnings), real interest rates are not much higher, and labour markets are not much more rigid" (1998, p. 814).

Another line of argument is that the key to understanding the persistence of unemployment is not the shocks alone, nor the institutions alone, but rather, the interaction between shocks and institutions. The role of labour market institutions—those that are seen as adverse to employment—is to weaken the pressure of high unemployment on wage adjustment and thereby to magnify the effects of economic shocks (Bruno and Sachs, 1985, Phelps, 1994). Adopting this view, Blanchard and Wolfers (2000) find that variables such as the replacement ratio, benefit duration, employment protection and union density, when interacted with shocks, help to explain both the differences across countries in the levels of unemployment and the persistence of unemployment from 1960s to the mid-1990s. Bertola et al. (2001) report similar results. But the shocks considered by these studies are not just those of the 1970s but ongoing effects of real interest rates that are higher than in the 1970s and putative labour demand shifts in the 1980s as well as productivity growth. In addition, Phelps and Zoega (2001) find negative correlations between unemployment and stock prices, where again, the responsiveness of unemployment to these and other shocks differs across countries according to their labour market institutions.

Events since the early 1990s are now opening a new chapter in thinking about unemployment in the medium-term. Nearly a decade of strong productivity growth in the United States coupled with tight labour markets and low inflation has lent a new twist to the study of the ever-shifting NAIRU. Some studies suggest that a variety of US-specific factors such as demographic trends and active labour market policies can help explain this (Katz and Krueger, 1999, Bertola et. al., 2001). But it has also led to a revival of the view that productivity growth matters—perhaps more than it has been given credit for in the past (DeLong, 2000). In a recent study Ball and Moffitt (2001) argue that more rapid productivity growth has increased real wage growth relative to slowly-adjusting real wage 'aspirations', which are, in turn, based on real wage growth stretching back into the past. As a result of lower wage pressure, the NAIRU has fallen significantly since the 1970s.

The evolution in views about OECD unemployment in general, is reflected in the studies of Britain in particular. While those of the early 1980s focused on the real wage-employment debate, attention soon turned to the effects of changes in institutionally determined wage pressure variables on wage setting and equilibrium unemployment. Layard and Nickell (1986) explained the substantial rise in UK unemployment largely in terms of these variables. Of the overall rise in unemployment of about 9 percentage points between the late 1950s and the early 1980s they attribute about 3 percentage points to employment protection and social security combined, another 3 percentage points to union militancy, and about one percentage point each to 'mismatch' and unemployment benefits. Other studies put rather more weight on unemployment benefits as a principal cause of rising unemployment (Minford, et. al., 1983).

More recently a number of studies have addressed the question of the persistence of high unemployment into the 1990s, despite labour market reforms that have gone further than almost anywhere else in the OECD. Thus Karanassou and Snower (1998) have argued that lags imposed on employment adjustment by firms' adjustment costs and on wage setting by insider membership effects, interact to produce long lags in the adjustment of unemployment. By contrast Phelps and Zoega (1998) stress the ongoing effects of real interest rates, energy prices and productivity rather than persistence in the labour market *per se*. As in the US, sharp falls in unemployment in the late 1990s coupled with low inflation have altered the terms of the debate and have led to the search for the 'new economy' in Britain (Wadhwani, 2001). But unless this reflects the lagged effects of the productivity revival of the 1980s, the most recent productivity spurt looks too modest to explain much of the improved labour market performance. What all of this does suggest, however, is that a longer-term view might be useful in order to get into perspective whatever productivity effects there are on unemployment.

The Historical Puzzle for the UK

As we have seen the puzzle of high unemployment in Europe, and Britain in particular, in recent decades might be posed differently, asking instead why unemployment was so low in the 1950s and 1960s. But then a further question emerges: why was unemployment so high in the interwar period? And why was it

much lower in the decades before that? These questions are best summarised in the graph of UK unemployment since 1870 (Figure 1). This series differs a little (especially pre-World War 1) from those previously available, and it is more consistent through time than the older series. Fluctuations before 1914 follow the familiar periodic cycles but they are somewhat milder in amplitude than in the older series, typically reaching 3 or 4 percent in booms and 8 or 9 percent in slumps. By contrast, the interwar period exhibits larger fluctuations about a much higher trend level, with sharp spikes in the early 1920s and in the early 1930s. Then comes the so-called golden age: nearly 30 years of very low unemployment with only tiny fluctuations around the mean. Unemployment then ascends in the 1970s towards levels and variability reminiscent of the interwar period. Finally, there is a hint that a new era might be opening, with the sharp reduction in unemployment levels from the mid-1990s.

The most important point stemming from Figure 1 is that patterns of unemployment differ greatly across the decades and the big question is what determines differences in unemployment levels between these major eras, not what drives unemployment fluctuations within each period. To pose the question more clearly, Table 1 provides key indicators for five periods, each of 20 years or more, between 1871 and 1999. The means and standard deviations of the unemployment rate speak for themselves, but the periods are marked out in other ways too. The overall price level was roughly stable in peacetime periods before the Second World War. The mild inflation of the early postwar period was followed by higher inflation rates, particularly in the 1970s and 1980s.

More important to the issue at hand are the labour market pressure variables. The unemployment insurance system was first introduced in a limited number of sectors in 1911, it was expanded in 1921 to embrace about two thirds of the labour force in the interwar period, and it became universal in 1946. The advent of unemployment insurance with relatively high benefit rates relative to wages and lengthy benefit duration has been seen by some as a key reason for higher average unemployment in the interwar period (Benjamin and Kochin, 1979). But two facts suggest this cannot have been the sole, or even the most important, reason for the doubling of the average unemployment rate. First, evidence from studies of microdata for the interwar period suggest that benefits had at best a very modest impact on

unemployment incidence (Eichengreen, 1986; Hatton and Bailey, 2002). Second, the replacement rate was only a shade higher in the decades after 1945 than it was in the decades before 1939 (Metcalf, Nickell and Floros, 1982). The replacement rate rose from the late 1960s and fell again in the 80s, but again, postwar micro-evidence suggests its effects were small (Narandranathan et. al. 1985). Looking at the period averages suggests that the benefit effect must have been modest. For the replacement rate to have mattered, there must have been other forces which drove down unemployment in the golden age relative to the periods before and after.

Before the First World War organisation in the labour market was patchy and unions were relatively weak. Unionism increased in fits and starts, with sharp increases in the late 1880s and in last few years before1914. This situation was dramatically altered with the increase in state intervention during and immediately after the First World War (Wrigley, 1987). Union density peaked at 45 percent in 1920 and, despite some retreat, the average for the interwar period was double that of the two decades before 1914. Unionism rose to a new plateau in the early postwar period, it increased further in the 1970s and, as is well known, it has declined sharply since then. But from the broad period averages alone, the hypothesis that unionism raises unemployment does not look promising: unionism rose across the Second World War when unemployment fell; and it fell (slightly) between the early and the late postwar period when unemployment rose. Furthermore, that pattern stands out just as starkly if we look at the coverage of national collective bargaining rather than at union density.

Another possible candidate is the degree of mismatch across skill groups, a variable that is sometime seen as a contributor to the rise in unemployment between the 1960s and the 1980s. In the interwar period too there were wide variations in unemployment rates by region and by industry as well as by skill-level, and these were associated with the collapse of some of the great export industries of the nineteenth century. Yet such disparities are largely symptoms rather than ultimate causes of high unemployment. Nevertheless, an index of short-run structural change shows some evidence of greater inter-sectoral turbulence during the interwar period as compared with the eras before and after. But there is no evidence of an increase in turbulence after 1973.

Other possible wage pressure candidates include things like minimum wages and employment protection. Minimum wages were introduced under the Trades Boards Acts of 1909 and 1918, in the latter case expressly to provide a substitute for collective bargaining in low-wage occupations. Coverage rose from around 10 percent of employees in the interwar period to 15 percent in 1950s then gradually declined until abolition in 1993 (Milner, 1995). Employment protection measures, such as redundancy payments, have been fairly limited. They were largely a product of the golden age and they survived into the 1980s but have since been weakened.

In terms of these wage pressure variables there seem to be explanations enough to explain the rise in average unemployment across the First World War. But, either individually or together, variables like these seem unable to account for the dramatic fall in average unemployment across the Second World War. And while there may have been an increase in some of these indices between the early postwar period and the late 1970s, they seem inadequate to explain much of the massive increase unemployment between the two periods as a whole. This is the essence of the historical puzzle and, following the current debate on persistently high unemployment in Europe, there seem to be three ways of resolving it.

The first is to say that there was something different about the golden age, such that the usual rules did not apply. The contrast would then be between the pre-First World War era of laissez faire in the labour market on the one hand and the interwar period plus the post-1973 period (leaving out 1946-73), on the other. Then it might be possible to tell a consistent story in terms of variables determining wage pressure with 1914-18 as the major watershed. The exceptionalism of the golden age has been attributed to the 'postwar settlement', which emerged in 1945 and broke down at the end of the 1960s. The postwar settlement has been characterised as an implicit agreement or consensus between the government, employers and unions. The government guaranteed full employment, and employers acquiesced to restrictive practices and shopfloor control, in exchange for wage restraint on the part of workers.[1] That would also fit with the idea of the NAIRU-reducing effects of a high degree of coordination or corporatism in wage setting as suggested by Calmfors and Driffill (1988). While there is some support for this view it is hard to believe that, by itself,

[1] For discussions of the nature and effects of the postwar settlement in Europe see Flanagan et. al. (1983) and Eichengreen (1996); on Britain see Jones (1985).

the early postwar institutional framework was sufficiently encompassing, coherent, and, above all, different from what went before or after, to deliver nearly thirty years of low unemployment. That specific line of argument will not be pursued further here.

The second possibility is that changes in labour market institutions and in the framework for wage setting led to much greater hysteresis than before. Thus institutions affect unemployment rates not (or perhaps not only) directly but, rather, through introducing much greater inertia into the labour market. This would be consistent with the idea, now popular in the European unemployment literature, that the interaction between shocks and institutions can cause greater persistence in unemployment than otherwise. One possibility, not stressed in the current debate, is that this could lead to persistently *low* unemployment as well as to persistently *high* unemployment. It is tempting to read Figure 1 in these terms, and the story would go as follows. In the laissez faire era before World War 1 the labour market adjusted rapidly to shocks, but after 1918 a series of negative shocks combined with the new institutional structure led to protracted high unemployment. These institutions, further strengthened, combined with positive shocks to produce the era of low unemployment after 1945. Then the negative shocks of the 1970s and 80s led once more to an era of persistent high unemployment (and to moves to dismantle the institutions).

In order to make such a story stick there must be shocks to interact with the changes in institutions. In the era before 1914 there were periodic demand shocks that caused deviations from the NAIRU and these were followed by much larger shocks in the interwar period, particularly in the early 1920s and the early 1930s. The buoyant demand conditions of the golden age ended with monetary shocks in the 1970s and, especially the early 1980s. But although these nominal shocks may have persisted, they should not have altered the NAIRU for periods as long as 20 or 30 years.

Following on from this, the third possibility is that other variables mattered, possibly in conjunction with institutions. The focus here is on the supply side and in particular on changes in the level and in the growth rate of productivity. The last line of Table 1 shows the average rate of growth of labour productivity across these major eras. Productivity growth was barely more than one percent to up to 1891 and it fell below that in the decades that followed, with a distinct slowdown coming after 1900. From 1921 to 1939 productivity growth returned to the level of the 1870s and 1880s and this was followed by a sharp upward step, to double the historical average,

between 1945 and 1973. Productivity growth slowed down again for a while from the mid-seventies, but for the post-1973 period as a whole, it remained distinctly higher than in any comparable period before the Second World War.

In the following sections we set out to examine the effects on the NAIRU of variations in productivity. But it is worth noting at the outset that this story too has its anomalies. Productivity growth would need to exert considerable leverage to account for major differences in average unemployment, and even then the pattern does not look consistent. While the productivity slowdown at the turn of the twentieth century was associated with a slight rise in average unemployment, productivity growth revived from 1921 onwards and yet average unemployment rose. One possible explanation is the sharp slump in the level of labour productivity that occurred between 1918 and 1921. In his influential account of the period Broadberry (1986, 1990) attributes this to the 13 percent fall in weekly hours of work in 1919, among other things.[2] As a result, over the decade beginning in 1914 level of productivity hardly grew at all. By contrast the decade from 1939 saw productivity grow by 12 percent. This suggests that an explanation of the NAIRU based on productivity would need to stress both the growth rate of productivity and its level as compared with the recent past. The model developed in the following section is framed with those considerations in mind.

A Model of the NAIRU

Here we develop a simple model of the NAIRU, drawing on empirical models in the recent literature, but with particular attention to the possible role of productivity and the dynamics that determine its effects. The NAIRU is determined through two equations, one for the real wage and one for unemployment.

The real wage equation is written, with all variables in natural logs, as:

$$\Delta(w-p)_t = \beta_0 + \beta_1(\pi_t - (w-p)_{t-1}) - \beta_2 u_{t-1} + x_t \qquad (1)$$

[2] The spate of negotiated hours reductions generally preserved the weekly wage. Thus on a weekly (or annual) basis it is manifested as a fall in labour productivity, whereas on an hourly basis it would appear (at least initially) as an increase in the real wage.

where $w - p$ is the real wage, π is labour productivity, u is the unemployment rate, and x represents a vector of wage pressure variables, including a stochastic term. This may be thought of as embodying the components of the feasible wage, as represented by labour productivity, and the target wage, as reflected in the negative relationship between unemployment and the real wage.[3] For a constant real wage equal to productivity (the actual real wage equal to the feasible real wage), unemployment is an increasing function of the wage pressure variables such that: $u = (\beta_0 + x)/\beta_2$. The dynamics are important, however, and they imply that the real wage adjusts slowly towards its determinants. For $0<\beta_1<1$, the real wage is a geometric lag of past values of its determinants; the smaller is β_1 the greater the weight given to the past.[4] Note also that the log of the unemployment rate, u, is lagged one period and affects the real wage negatively. This supports the interpretation that this is a wage setting function: causality runs from unemployment to the real wage and higher unemployment reduces the real wage.

The unemployment equation is an inverted Phillips curve:

$$u_t = \alpha_0 + \alpha_1 u_{t-1} - \alpha_2 \Delta\Delta p_t - \alpha_3(\pi_t - (w-p)_{t-1}) + z_t \qquad (2)$$

where $\Delta\Delta p$ is the change in nominal price inflation and z includes labour demand shift variables as well as a stochastic term. A positive price surprise has a negative effect on unemployment but there is also persistence, as represented by the lagged dependent variable. The third term implies that a rise in productivity relative to the lagged real wage reduces unemployment. Here the lagged real wage has a positive effect on unemployment. In contrast to (1) above, causality runs from the real wage to unemployment and the sign is opposite. This can be thought of either as a nominal price setting curve or as a dynamic labour demand equation (Manning, 1993). For a given (lagged) real wage and given employment, a fall in productivity raises the

[3] Manning (1992) discusses a variety of theoretical underpinnings that might be used to justify empirical models of this general type. One possible justification for the adjustment dynamics would be staggered contracts as suggested by Taylor (1979).

[4] In the recent literature there has been some debate about wage curves versus Phillips curves: whether it is the real wage *level* or the real wage *change* that adjusts to unemployment (Blanchflower and Oswald, 1994; Blanchard and Katz, 1997; Bell et.al., 2000). In equation (1) a real wage Phillips curve emerges when $\beta_1 = 0$; otherwise there is a relationship in levels between the real wage and unemployment.

current price level. Alternatively, for constant inflation, a fall in productivity increases unemployment.

It is useful to divide the third term on the right into two components:

$$u_t = \alpha_0 + \alpha_1 u_{t-1} - \alpha_2 \Delta\Delta p_t - \alpha_3 \Delta\pi_t - \alpha_3(\pi_{t-1} - (w-p)_{t-1}) + z_t \qquad (3)$$

Thus unemployment is a negative function of current productivity growth and of its lagged level, relative to the real wage. The real wage in turn is determined by the terms in the wage setting equation. Writing equation (2) in terms of geometric lags and substituting into (1) gives the expression for unemployment as:

$$u_t = \alpha_0 + \alpha_1 u_{t-1} - \alpha_2 \Delta\Delta p_t - \alpha_3(\pi_t - \beta_1 \Sigma_{i=1}^{\infty}(1-\beta_1)^i \pi_{t-i-1} + \beta_2 \Sigma_{i=2}^{\infty}(1-\beta_1)^i u_{t-i-1} \\ - \Sigma_{i=1}^{\infty}(1-\beta_1)^i x_{t-i-1} + \beta_0\beta_1) + z \qquad (4)$$

In this rendering, unemployment can be seen as depending on current productivity relative to the sum of past productivity. A sharp rise in productivity relative to the past reduces unemployment because of the persistence in the real wage. This is rather similar to the "wage aspirations" approach, where unemployment is determined by the difference between by the current real wage and the sum of past real wages, except that here the model is written in terms of productivity. Higher lags of unemployment and the wage pressure terms serve to increase persistence.

It is more illuminating to represent the NAIRU for constant values of the exogenous variables (denoted by *), but assuming productivity growth at a constant rate g^*, and setting $\Delta\Delta p = 0$. This reduces the NAIRU to the following:

$$u^* = \frac{\alpha_0 + z^* + \alpha_3\beta_0/\beta_1 + \alpha_3 x^*/\beta_1 - \alpha_3 g^*/\beta_1}{1 - \alpha_1 + \alpha_3\beta_2/\beta_1} \qquad (5)$$

Thus the NAIRU will be affected positively by the wage/price pressure terms *x* and *z* and it will be a negative function of the steady state rate of productivity growth. It is worth noting that the effect of productivity growth on unemployment will be more negative the higher are α_3 and α_1, and the lower are β_1 and β_2. Thus the bigger is the

short-run impact on unemployment, and the longer are the lags, the greater will be the effect of productivity growth.

Econometric Estimates

The strategy pursued here is to estimate the real wage and unemployment equations over the full period from 1870, leaving out the wartime periods 1914-20 and 1940-6. Since the focus is on the effects of productivity, labour market variables representing wage pressure are not entered directly but their effects in different eras are represented by a set of dummies.[5] This is intended to capture the idea that there have been different labour market regimes that relate only indirectly, or perhaps non-linearly, to the standard wage pressure variables. However, two wage/price wedge variables are included. These are the share of direct tax and the ratio of import prices to the GDP deflator. The data sources for the time series used in the regressions are given in the notes to Table 1.

Estimates of the real wage equation appear in Table 2. In the first column lagged unemployment is negative as expected but not significant at the conventional level, whereas both current productivity and the lagged real wage are strongly significant with coefficients that are almost equal in magnitude but opposite in sign. In the second column lagged unemployment is interacted with a dummy for the period post-Second World War. The coefficient is of a similar magnitude and opposite in sign to the uninteracted coefficient. This suggests that the negative effect of the level of unemployment on the real wage evaporated after 1945. This change definitely occurred after World War 2 rather than after World War 1.[6] The interaction with a post-First World War dummy proved to be very insignificant ('t' = 0.8)—even in the absence of the post-World War 2 dummy. Here the adjustment coefficient β_1 is little more than a quarter and it does not appear to have shifted over time, since interactions with period dummies were insignificant.

The estimates in the third and fourth columns impose the restriction that the coefficients on productivity and the lagged real wage are equal and opposite. In addition, the lagged unemployment effect is set to zero after World War 2 by

[5] The periodisation used here is consistent with the shifts in mean unemployment across the two World Wars and in 1973/4 identified by Bianchi and Zoega (1997) using a Markov switching model.

interacting it with a pre-World War 2 dummy.[7] In the column 3 estimate, the relative import price is negative and significant but the tax wedge remains insignificant. The final column eliminates some of the insignificant variables to give a more parsimonious specification. The import price coefficient implies that a rise of 10 percent in the import price wedge reduces the real wage by about 1.1 percent in the long run. Thus the incidence of the import price wedge fell mainly on workers rather than on firms. The only period dummy that retains significance is that for post-1973 and this implies a substantial downward shift in the real wage relative to productivity of 9 percent in the long run.

Estimates of the unemployment equation are presented in Table 3. In the first column the coefficients on the lagged dependent variable, the change in inflation, current productivity, and the lagged real wage are all highly significant with the expected signs. The coefficient on the lagged dependent variable was interacted with dummies for post-First and Second World Wars; only the latter was significant and this is added in column 2. It implies that the lagged dependent variable coefficient rises from 0.7 in the period before 1940 to 0.9 in the period after 1945. Clearly, this magnifies effects of the other explanatory variables on unemployment in the long run.

The estimates in the third and fourth columns impose the restriction, again easily accepted, that the coefficients on current productivity and the lagged real wage are equal and opposite in sign. It is notable that the negative coefficient on the price surprise is very similar to that on the productivity/real wage ratio. This suggests, plausibly, that the effect on employment of an unexpected fall in the price level is approximately the same as for a fall in productivity. In the last column, the insignificant import price and tax wedges are dropped. Now all the period dummies are significant and they closely follow the pattern of average unemployment. This provides an initial indication that a large part of the differences in average unemployment rates across the major eras will not be accounted for by differences in the other explanatory variables. In order to examine these contributions more fully we need to calculate the NAIRU for each period.

---

[6] This is consistent with the results of Broadberry (1994) who identifies structural breaks in a real wage equation estimated over the periods 1923-38 and 1951-73.

[7] It is sometimes argued that unless unemployment has a negative effect on the real wage, there will be nothing to tie down the unemployment rate in the long run (see Nickell, 1998). That is not the case here

Estimates of the NAIRU

Estimates of the NAIRU for each of five periods are reported in Table 4, based on the estimates in the last columns of Tables 3 and 4. It is calculated from the empirical analogue to equation 5 where the real wage is solved out and the inflation surprise is set to zero. The NAIRU is calculated from the period average productivity growth rate, the period average level of the relative import price, and the dummies. The values of the NAIRU that appear in the second row of the Table can be compared with the average unemployment rates in the first row. Although the differences in unemployment rates across period are slightly attenuated, the familiar pattern is still preserved with high unemployment in the interwar period and post-1973 and low unemployment in the golden age.

The next three rows show what happens when a common rate of productivity growth is applied to all five periods. The first row assumes a constant rate of productivity growth of one percent per annum—approximately the pre-Second World War average. Not surprisingly, for the first three periods, the NAIRU calculated in this way is similar to the figures in the first and second rows. But for the golden age, the NAIRU rises massively—to nearly 9 percent—and it also increases substantially for the post-1973 period. Had productivity growth after 1946 returned to the levels of Victorian Britain, with nothing else changed, it seems that the golden age of low unemployment would have evaporated.

The fourth row shows what happens when a constant productivity growth rate of 1.7 percent is assumed--approximately the post-1973 average. Although the values of the NAIRU for the first three periods are reduced, they do not fall by very much. But the NAIRU for the golden age rises to over 5 percent, only a little lower than the pre-1913 average. In the fifth row, productivity growth is set at the average for the golden age, 2.4 percent. This dramatically reduces the NAIRU for both the golden age and the post-1973 period, but it has a much smaller effect on the NAIRU in the earlier periods. These comparisons show that the value of the NAIRU is much more sensitive to changes in the average productivity in the periods after 1945. This is largely the result of the changes in the coefficients on lagged unemployment in the estimated

---

because the real wage is linked to productivity in the long run, and unemployment is driven by the gap between the real wage and productivity.

equations across the Second World War. These have the effect of substantially raising the responsiveness of unemployment to productivity growth by increasing the value of α_1 and reducing (to zero) the value of β_2, thereby shrinking the denominator in equation (5).

The final column of Table 4 evaluates the effects of the dummies in both equations (including the interactions with lagged unemployment), relative to pre-World War 1. Holding productivity growth at its period means, these shifts clearly raised unemployment in the interwar period and, especially post-1973. For the golden age, removing the effects of period dummies increases average unemployment to more than five percent. Comparing the last three entries for 1947-73 suggests that, as compared to adjacent periods, faster productivity growth can explain some (perhaps as much as half) of the spectacular unemployment performance during the golden age, but certainly not all of it.

Two Postwar Productivity Shocks

Calculations of the NAIRU based on average productivity growth fail to capture the effects of short run shocks to the levels and growth rates of productivity. These might have been very important at certain times but would be averaged away over the longer run. Here we look at the effects of productivity in the immediate aftermath of the two World Wars.

The most dramatic productivity shock of the whole period occurred after the First World War. Time series analyses of labour productivity identify 1918-20 as a "crash" of dramatic proportions.[8] From an index of 100 in 1913, the raw data shows output per worker rising to 107 in 1918, then falling to 91.4 in 1920, eventually recovering to its 1913 level in 1922.[9] By contrast, from a level of 100 in 1939, labour productivity rose to 107.1 in 1946 and continued to advance, reaching 115.0 in 1950. Thus there was no productivity shock after the Second World War that was remotely comparable to that after the First World War. Real wages rose strongly enough to outpace productivity growth across both wars, but the immediate postwar adjustments

[8] The exact dating differs depending on the methods used, but the break unambiguously falls between 1914 and 1920. See Greasley and Oxley (1996).

[9] These figures understate the true fall in productivity because of the separation of southern Ireland, which is excluded in the figures from 1920 onwards but included in the earlier years. The index for

did reflect the differences in productivity performance to some degree. Between 1918 and 1922 the real wage fell by 7.6 percent while between 1946 and 1950 the real wage increased by about the same amount. This suggests that the effects of productivity shocks were built into the real wage relatively quickly

The effects of differences in immediate postwar productivity performance can be assessed by simulating the two-equation system formed by the estimated equations in the last columns of Tables 3 and 4. The predicted series in Figure 2a begins the simulation in 1921, using as starting values the actual values of unemployment and the real wage in 1920. The exogenous variables including price inflation, the real import price and productivity follow their actual course. The model predicts a sharp increase in unemployment in 1920-2, declining to a plateau at about 8 percent in the-mid-1920s, which looks somewhat similar to the true unemployment series (the dotted line). Not surprisingly the predicted series fails to capture the sharp rise in unemployment at the onset of the great depression.

In the graph labelled "counterfactual", labour productivity is set at a level 10 percent higher than the actual for the entire period from 1920 onwards but, as before, unemployment and the real wage start from their actual values in 1920. This is equivalent to wiping out most of the once-and-for-all productivity shock between 1918 and 1920 but allowing some wage adjustment in the interim. As the figure shows, unemployment would have been much lower in the early 1920s--by as much as four percentage points in 1922. But this effect wears off quite quickly as the real wage catches up with productivity, and by 1929 it has entirely disappeared. Nevertheless, between 1921 and 1927 the counterfactual unemployment level is lower than the predicted level by more than two percentage points on average. The productivity shock mattered quite a bit in the 1920s, but it cannot explain the persistence of high unemployment throughout the interwar period.

For comparison, a similar exercise is performed for the immediate post-Second World War period. The series labelled "predicted" in Figure 2b is, as before, based on the actual values of the exogenous variables and it begins from the initial values of unemployment and the real wage in 1946. This series remains flat at about 2 percent right through until 1957. But this time the counterfactual asks: what if there

---

1920 with southern Ireland included is 89.3, which implies that the removal of Ireland *raised* UK productivity by a little over 2 percent (see Feinstein, 1972, p. T51).

had been a shock to labour productivity similar to the one that followed the First World War? This is characterised as a once-and-for-all ten percent reduction in productivity from 1946 onwards. As the figure shows, unemployment would have been significantly higher—by as much as 2 percentage points in 1950. Although unemployment remains low in absolute terms, the simulation suggests a large proportionate increase in unemployment that persists well into the late 1950s. Thus a negative shock to the level of productivity would have had proportionately larger, and longer lasting, effects after the Second World War as a result of the change in the responsiveness of unemployment to productivity.

Two Productivity Slowdowns

Much attention has been paid to the productivity slowdown that occurred, in the midst of other shocks, after 1973. By contrast, the productivity slowdown that occurred from the turn of the twentieth century has not been linked to unemployment despite the fact that the orders of magnitude are similar. The growth rate of productivity fell from 2.4 percent in 1947-73 to 1.7 percent between 1974 and 1985, a decline of 0.7 percentage points. In the earlier era productivity growth fell from 1.0 percent in 1871-99 to 0.4 percent in 1900-1911—a decline of 0.6 percentage points.[10] One reason that this Edwardian growth failure has not been linked to unemployment is that average unemployment rose only slightly (even on the revised estimates). Thus unemployment increased by less than one percentage point between 1871-99 and 1900-11 whereas it increased by more than 6 percentage points between 1947-73 and 1974-85.

The effects of these productivity slowdowns can be assessed using simulations similar to those above. In Figure 3a the simulation starts in 1900 and the predicted series shows a sharp rise to 1902 followed by a plateau at about 6 percent. For the counterfactual, productivity was assumed to grow from 1899 at a rate 0.6 percent faster than its actual rate. The result is a counterfactual unemployment rate lower than in the predicted series by just 0.65 of a percent between 1902 and 1911. So, on the one hand, the pre-First World War productivity slowdown had a small effect on average

[10] This earlier productivity slowdown is sometimes known as the late-Victorian or Edwardian climacteric (a term that originated with Phelps Brown and Handfield Jones, 1952). Its magnitude,

unemployment. On the other hand it explains virtually the whole of the modest increase in the average unemployment rate that actually occurred.

Predicted and counterfactual unemployment rates for the years after 1973 are displayed in Figure 3b. The predicted series captures the rise in unemployment to 1981 but not the deflationary shock that followed. The counterfactual series is based on a simulation where productivity growth is raised by 0.7 percent per annum from 1973. Counterfactual unemployment falls below the predicted unemployment by a growing margin up to the early 1980s. In the years 1981-85 the gap is 2.7 percentage points. Thus the post-1973 productivity slowdown had a much greater effect on unemployment than the one at the turn of the century. As we have seen, this is because productivity exerted much greater leverage on unemployment after the Second World War than it did in earlier periods. Nevertheless slower productivity growth can explain only about a quarter of the increase in unemployment between 1947-73 and 1974-85.

Conclusion

There has been a good deal of discussion of the effects of productivity growth on unemployment—a debate that emerged in the 1980s and has recently been revived. But the impact of productivity trends that are slow moving and change infrequently are often difficult to disentangle from other, higher frequency, events. An evaluation of these productivity effects therefore calls for analysis over longer periods of time than is typical in most empirical models of unemployment. The strategy pursued here has been to examine a simple model that emphasises the effects of productivity on unemployment. Within this framework institutional and structural changes are viewed as regime shifts across major eras rather than year-to-year influences on unemployment.

So what can we conclude from this exercise?

- An approach that embodies slow adjustment of the real wage to productivity, and which sees unemployment as driven by this gap, performs well on UK data stretching back over 130 years.

---

timing, and underlying causes, have been widely discussed by economic historians. See McCloskey (1970), Matthews, et. al. (1982) and Crafts, et. al (1989).

- Real wage and productivity variables alone cannot account fully for the seismic shifts in average unemployment rates that took place during the 20th century. The effects of regime shifts were even more important.
- Greater persistence in the labour market served to magnify the effects of changes in productivity in the more recent past. These shifts evidently took place across the Second World War, not across the First World War as might have been expected from patterns of persistence in average unemployment levels.
- Even under the post-1945 regime, productivity speedups and slowdowns can explain only a fraction of the large swings in average unemployment. But even though they are not the whole explanation, variations in productivity have contributed significantly to the medium-term ups and downs in unemployment over the whole period since 1870.

References

Bain George S. and Robert Price 1980. *Profiles of Union Growth,* Oxford:Blackwell.

Ball, Lawrence and Robert Moffitt 2001. "Productivity Growth and the Phillips Curve," NBER Working Paper 8421, Cambridge MA: National Bureau of Economic Research.

Bell, Brian, Stephen Nickell and Glenda Quintini 2000. "Wage Equations, Wage Curves and All That," CEP Discussion Paper 472, London School of Economics.

Benjamin, Daniel K. and Levis A. Kochin 1979. "Searching for an Explanation of Unemployment in Interwar Britain," *Journal of Political Economy,* 87, pp. 441-478

Bertola, Guiseppe, Francine D. Blau and Lawrence Kahn 2001. "Comparative Analysis of Labour Market Outcomes: Lessons for the US from International Long-run Evidence," CEPR Discussion Paper 3023, London: Centre for Economic Policy Research.

Bianchi, Marco and Gylfi Zoega 1997. "Challenges Facing the Natural Rate Theory," *European Economic Review,* 41, pp. 535-547.

Blanchard, Olivier and Lawrence F. Katz 1997. "What We Know and Do Not Know About the Natural Rate of Unemployment," *Journal of Economic Perspectives,* 11, pp. 51-72.

Blanchard, Olivier and Justin Wolfers 2000. " The Role of Shocks and Institutions in the Rise of European Unemployment: The Aggregate Evidence," *Economic Journal,* 110, pp. C1-C33.

Blanchflower, David G. and Andrew J. Oswald 1994. *The Wage Curve,* Cambridge MA: MIT Press.

Boyer, George R. and Timothy J. Hatton 2002. "New Estimates of British Unemployment, 1870-1913," *Journal of Economic History,* (forthcoming).

Broadberry, Stephen N. 1986 "Aggregate Supply in Interwar Britain," *Economic Journal,* 96, pp. 467-481.

Broadberry, Stephen N. 1990. " The Emergence of Mass Unemployment: Explaining Macroeconomic Trends during the trans-World War I Period," *Economic History Review,* 43, pp. 272-282.

Broadberry, Stephen N. 1994. "Why was Unemployment in Postwar Britain so Low?" *Bulletin of Economic Research,* 46, pp. 241-261.

Bruno, Michael. and Jeffrey D. Sachs 1985), *The Economics of Worldwide Stagflation,* Oxford: Blackwell.

Calmfors, Lars and John Driffill 1988. "Bargaining Structure, Corporatism, and Macroeconomic Performance," *Economic Policy,* 6, pp. 13-61.

Crafts, Nicholas F. R., Stephen J. Leybourne and Terence C. Mills 1989. "The Climacteric in LateVictorian Britain and France," *Journal of Applied Econometrics,* 4, pp. 103-117.

DeLong, Bradford, 2000. "What Went Right in the 1990s? Sources of American and Prospects for World Economic Growth," in David Gruen (ed.), *The Australian Economy in the 1990s,* Sydney: Reserve Bank of Australia

Eichengreen. Barry J. 1986. "Unemployment in Interwar Britain: Dole or Doldrums?" *Oxford Economic Papers,* 39, pp. 597-623.

Eichengreen, Barry J. 1996. " Institutions and Economic Growth: Europe after World War II," in Nicholas Crafts and Gianni Toniolo (eds.), *Economic Growth in*

Europe after 1945, Cambridge: Cambridge University Press.
Flanagan, Robert J, David W. Soskice and Lloyd Ulman. 1983 *Unionism, Economic Stability and Incomes Policies: The European Experience*, Washington D C: Brookings Institution.
Greasley, David and Les Oxley 1996. "Discontinuities in Competitiveness: The Impact of the First World War on British Industry," *Economic History Review*, 49, pp. 82-100.
Grubb, David, Richard Jackman and Richard Layard 1983. "Wage Rigidity and Unemployment in OECD Countries," *European Economic Review*, 21, pp. 11-39.
Feinstein, Charles H. 1972. *National Income, Expenditure and Output of the United Kingdom, 1855-1965*, Cambridge: Cambridge University Press.
Feinstein, Charles H. 1995. "Changes in Nominal Wages, the Cost of Living, and Real Wages in the United Kingdom over Two Centuries, 1780-1990," in Peter Scholliers and Vera Zamagni (eds.), *Labour's Reward*, Aldershot: Edward Elgar.
Hatton, Timothy J. and Roy E. Bailey 2002. " Unemployment Incidence in Interwar London," *Economica*, (forthcoming).
Jones, Russell 1987. *Wages and Employment Policy, 1936-1985*, London: Allen and Unwin.
Karanassou, Marika and Dennis J. Snower 1998. " How Labour Market Flexibility Affects Unemployment: Long-term Implications of the Chain Reaction Theory," *Economic Journal*, 108, pp. 832-849.
Katz, Lawrence F. and Alan B. Krueger 1999 "The High-pressure Labor Market of the 1990s," *Brookings Papers on Economic Activity*, 1, pp. 1-65.
Layard, Richard and Stephen J. Nickell 1986. "Unemployment in Britain," *Economica*, 53, S121-S169.
Layard, Richard, Stephen J. Nickell and Richard Jackman 1991. *Unemployment, Macroeconomic Performance and the Labour Market*, Oxford: Oxford University Press.
Layard, Richard, Stephen J. Nickell and Richard Jackman 1994. *The Unemployment Crisis*, Oxford: Oxford University Press.
Manning, Alan 1992. "Productivity Growth, Wage Setting and the Equilibrium Rate of Unemployment," CEP Discussion Paper 63, London School of Economics.
Manning, Alan 1993. "Wage Bargaining and the Phillips Curve: The Identification and Specification of Aggregate Wage Equations," *Economic Journal*, 103, 98-118.
McCloskey, Donald N. 1970. "Did Victorian Britain Fail?" *Economic History Review*, 23, pp. 446-459.
Matthews, Robin C. O., Charles H. Feinstein and John C. Odling-Smee 1982. *British Economic Growth,1856-1973* Oxford: Clarendon Press.
Metcalf, David, Stephen J. Nickell and Nicos Floros 1982. "Still Searching for an Explanation of Unemployment in Interwar Britain," *Journal of Political Economy*, 90, pp. 386-399.
Milner, S. 1995. "The Coverage of Collective Pay-setting Institutions in Britain, 1895-1990," *British Journal of Industrial Relations*, 33, pp. 69-91.
Minford, Patrick with David Davies, Michael Peel and Alison Sprague 1983. *Unemployment: Cause and Cure*, Oxford: Martin Robertson.
Narandranathan, Wiji, Stephen J. Nickell and Jon Stern 1985. "Unemployment

Benefits Revisited," *Economic Journal,* 95, pp. 307-329.
Nickell, Stephen J. 1997. "Unemployment and Labor Market Rigidities: Europe versus North America," *Journal of Economic Perspectives,* 11, pp. 55-97.
Nickell, Stephen J. 1998. "Unemployment: Questions and Some Answers," *Economic Journal,* 108, pp. 802-816.
Nickell, Stephen J. 2001. "Has UK Labour Market Performance Changed?" *Bank of England Quarterly Bulletin,* 41, pp. 340-350.
Phelps, Edmund S. 1994 *Structural Slumps,* Cambridge MA: Harvard University Press.
Phelps, Edmund S. and Gylfi Zoega 1998. "Natural Rate Theory and OECD Unemployment," *Economic Journal,* 108, pp. 782-801.
Phelps, Edmund S.and Gylfi Zoega 2001. "Structural Booms: Productivity Expectations and Asset Valuations," *Economic Policy,* 32, pp. 84-126.
Phelps Brown, E. H. and S. J. Handfield Jones 1952. "The Climacteric of the 1890's," *Oxford Economic Papers,* 4, pp. 266-307.
Taylor, John B. 1979. "Staggered Wage Setting in a Macro Model," *American Economic Review,* 69 (Papers and Proceedings), pp. 108-113.
Wadwhani, Sushil B. 2000. "British Unemployment and Monetary Policy," *Bank of England Quarterly Bulletin,* 40, pp. 88-102.
Wrigley, Christopher J. 1987. "The First World War and State Intervention in Industrial Relations, 1914-1918," in Christopher J. Wrigley (ed.) *A History of British Industrial Relations,* Vol. 2, Brighton: Harvester.

Table 1
Five Economic Eras

	1871-1891	1892-1913	1921-1939	1947-1973	1974-1999
Unemployment rate (%)	5.5	6.2	10.8	2.1	10.1
Standard deviation of unemployment rate	1.83	1.31	2.95	0.69	3.88
Average rate of price inflation (% p.a.)	–0.4	0.5	–1.1	4.6	7.4
Average rate of wage inflation (% p.a.)	0.9	1.2	–1.4	7.2	8.8
Replacement rate (percent)	--	--	41.0	43.6	41.6
Trade union density (%)	--	13.0	27.2	44.4	41.7
Coverage of national collective bargaining (%)	--	10.4	42.3	72.0	65.3
Structural change index	2.26	1.97	4.04	2.33	2.24
Income tax and social insurance contributions/nominal GDP (%)	1.1	1.8	10.3	18.9	23.4
Import price/GDP deflator (1913=100)	119.0	97.6	67.8	83.5	69.0
Labour productivity growth (% p.a.)	1.07	0.77	0.96	2.40	1.69

Sources and notes
Unemployment rate: Boyer and Hatton (2002) Appendix Table A2. p. 31. Price index (implicit deflator for GDP at factor cost): 1870-1965 Feinstein (1972) Table 61, pp T132-3; 1966-90 *Economic Trends, Annual Supplement* (2000) Table 1.1 p. 7. Nominal earnings (full-time manual employees): 1870-1990 Feinstein (1995) Table A.24, pp. 263-266; 1990-99 *Labour Force Trends* (2000) Table 3.2 p. 40. Replacement rate: 1922-38 and 1953-1973 from the discussion paper underlying Metcalf Nickell and Floros, (1982), Table 1, p. 4-5; 1976-97 Bank of England figures from Nickell (2001), p. 344, period averages spliced to data for 1950-73. Trade union density: Membership: 1892-1977 Bain and Price (1980), Table 2.1 p. 37; 1978-99 *Department of Trade and Industry* (http://www.dti.gov.uk/er/mar/trade.tables.pdf); Labour force: own calculations based on Feinstein (1972) Table 57, p. T125-6 for 1892-1913 and Boyer and Hatton (2002) for 1920-99. Coverage of national agreements: calculated (as mid-point of range, benchmark estimates) from the discussion paper underlying Milner (1995) p. 82. Pre-1974 figures are from changes-in-pay-rates data, post-1973 from survey data. Structural change index (defined as $S_t = \Sigma_i w_i |g_{i,t} - g_t|$, where w_i are value added weights, g_i and g are one year growth rates of individual sectors and GDP respectively): Calculated on 12 sectors; 1871-1947: Feinstein (1972), Table 8, p. T24-5, Table 51, p. T111-3, Table 53, p. T116-7; 1948-99: http://www.statistics.gov.uk/statbase/TSD/timezone.asp, and various issues of *United Kingdom National Accounts*. Income tax and National Insurance contributions/nominal GDP: Tax revenue: 1870-1965 Feinstein (1972) Table 14, p. T35; 1966-99 *Economic Trends Annual Supplement* (2000), Table 5.4, p. 245. Nominal GDP at factor cost (income estimate): 1870-1965: Feinstein (1972), Table 1, p. T35; 1966-1999 *Economic Trends Annual Supplement* (2000), Table 1.2. p. 11. Import price/GDP deflator: Import price: 1870-1965 Feinstein (1972), Table 64, p. T139; 1966-99 *Economic Trends Annual Supplement* (2000), Table 1.21, p. 131; GDP deflator as above. Labour productivity (GDP per worker): 1870-1965 Feinstein (1972), Table 20, p. T51; 1966-1999 *Economic Trends Annual Supplement* (2000), Table 3.8, p. 172.

Table 2
Real Wage Estimates, 1871-1999

Dependent variable	Δ Ln $(W/P)_t$	Δ Ln $(W/P)_t$	Δ ln $(W/P)_t$	Δln $(W/P)_t$
Constant	–0.001 (0.01)	0.237 (1.3)	0.206 (3.5)	0.208 (5.9)
Ln U_{t-1}	–0.010 (1.8)	–0.024 (3.6)		
Ln $U_{t-1} \times$ Post-WW2		0.030 (3.4)		
Ln $U_{t-1} \times$ Pre-WW2			–0.025 (3.9)	–0.025 (8.7)
Ln Π_t	0.349 (5.8)	0.268 (4.3)		
Ln $(W/P)_{t-1}$	–0.330 (5.6)	–0.275 (4.7)		
Ln Π_t – ln $(W/P)_{t-1}$			0.300 (6.0)	0.287 (6.6)
Ln $(Pm/P)_{t-1}$	–0.016 (0.9)	–0.030 (1.7)	–0.029 (2.9)	–0.033 (4.6)
Ln $(T/Y)_{t-1}$	0.003 (0.3)	–0.004 (0.2)	–0.004 (0.5)	
Post-WW1	0.002 (0.1)	–0.005 (0.0)	–0.005 (0.3)	
Post-WW2	0.037 (2.5)	–0.003 (0.2)	–0.006 (0.3)	
Post-1973	–0.021 (2.0)	–0.033 (2.9)	–0.034 (1.2)	–0.027 (5.8)
Adj. R^2	0.31	0.37	0.38	0.39
D.W.	1.66	1.72	1.67	1.68
RESET	1.34	1.08	3.14	1.16
HETERO	6.24	1.37	0.87	0.41

Notes: 't'statistics in parentheses. RESET is the functional form test using the powers of the fitted values, distributed as $F_{(3, n-k)}$. HETERO is the test for heteroskedasticity using the fitted values, distributed as $\chi^2_{(1)}$

Table 3
Unemployment Rate Estimates, 1871-1999

Dependent variable	Ln U_t	Ln U_t	Ln U_t	Ln U_t
Constant	–2.445 (1.2)	–1.006 (0.5)	0.256 (0.3)	0.578 (4.2)
Ln U_{t-1}	0.801 (12.3)	0.694 (7.6)	0.683 (7.7)	0.675 (8.7)
Ln U_{t-1} × Post-WW2		0.197 (1.7)	0.224 (2.0)	0.204 (1.9)
$\Delta\Delta$ ln P_t	–2.926 (6.5)	–2.595 (5.3)	–2.579 (5.3)	–2.673 (5.6)
Ln Π_t	–2.219 (3.1)	–2.661 (3.5)		
Ln $(W/P)_{t-1}$	2.254 (3.6)	2.814 (3.9)		
Ln Π_t – ln $(W/P)_{t-1}$			–2.805 (3.9)	–2.735 (4.1)
Ln $(Pm/P)_{t-1}$	0.316 (1.6)	0.238 (1.1)	0.143 (1.1)	
Ln $(T/Y)_{t-1}$	–0.004 (0.0)	–0.056 (0.5)	–0.084 (0.8)	
Post-WW1	0.170 (0.8)	0.124 (0.1)	–0.072 (0.0)	0.184 (2.7)
Post-WW2	–0.818 (4.6)	–1.113 (4.5)	–1.085 (4.5)	–0.999 (4.5)
Post-1973	0.270 (2.1)	0.206 (1.5)	0.250 (2.2)	0.281 (2.5)
Adj. R^2	0.926	0.927	0.928	0.928
D.W.	1.67	1.62	1.61	1.63
RESET	4.32	3.95	5.46	2.57
HETERO	1.26	1.40	1.66	2.12

Notes: 't'statistics in parentheses. RESET is the functional form test using the powers of the fitted values, distributed as $F_{(3, n-k)}$. HETERO is the test for heteroskedasticity using the fitted values, distributed as $\chi^2_{(1)}$

Table 4
Estimates of the NAIRU for different periods

	1871-1891	1892-1913	1921-1939	1947-1973	1974-1999
Average Unemployment Rate	5.5	6.2	10.8	2.1	10.1
Long-run NAIRU (equation 5)					
Actual productivity growth (period averages)	5.4	6.4	9.8	2.9	9.6
Productivity growth = 0.010	5.5	6.2	10.4	8.8	16.5
Productivity growth = 0.017	4.9	5.5	9.2	5.1	9.5
Productivity growth = 0.024	4.3	4.9	8.2	2.9	5.5
Actual productivity growth; Post-WW1 dummies = 0	5.4	6.4	7.1	5.3	6.6

Figure 1: UK Unemployment Rate, 1870-1999

Figure 2a: Productivity Shock, Post- World War 1

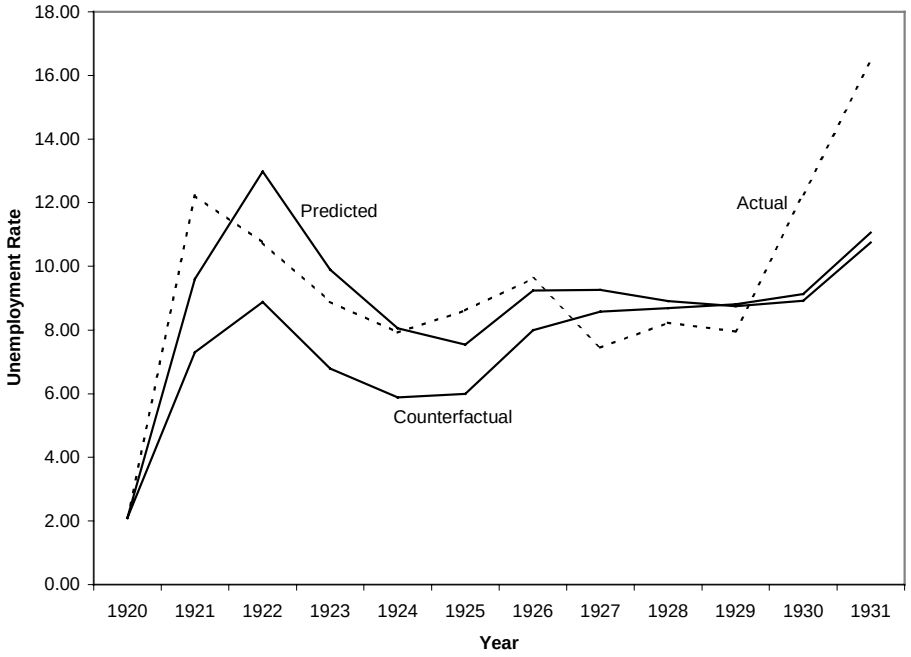

Figure 2b: Productivity Shock, Post-World War 2

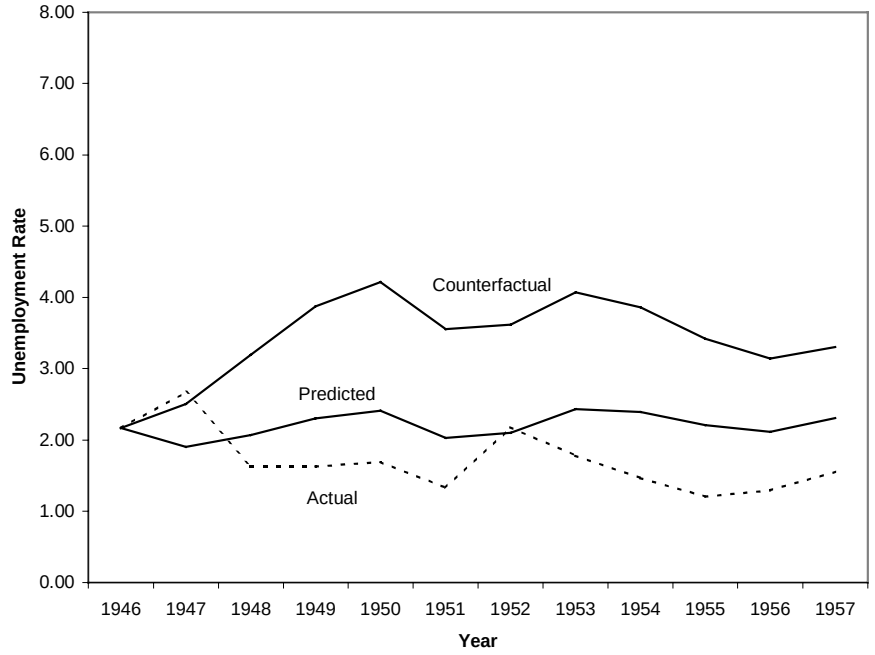

Figure 3a: Productivity Slowdown, 1899-1911

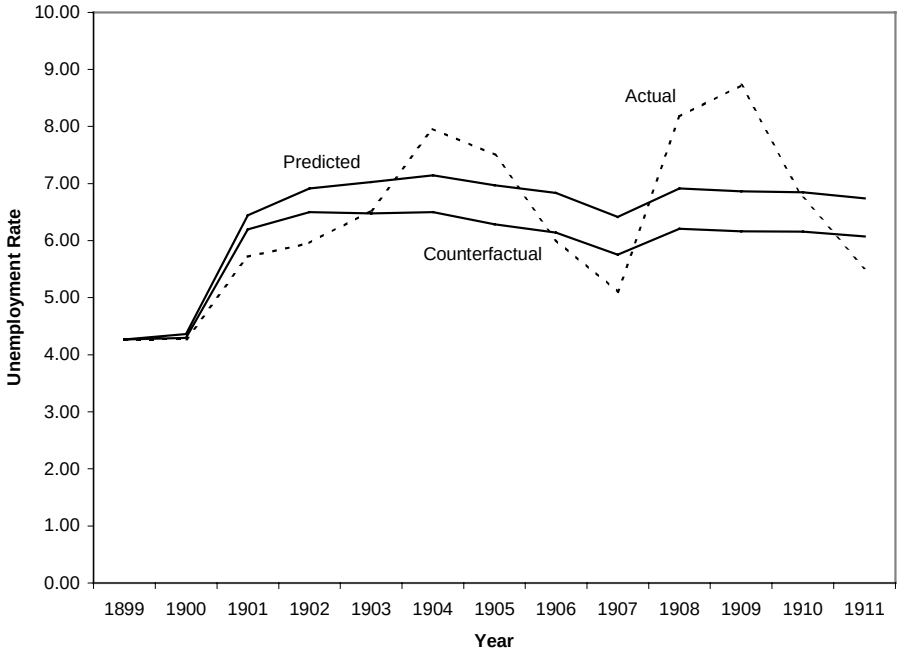

Figure 3b: Productivity Slowdown, 1973-1985