Do changes in structural factors explain movements in the equilibrium rate of unemployment?

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Abstract

In this paper we examine the role played by various structural economic changes in explaining movements in the equilibrium rate of unemployment. We use the theoretical framework developed by Layard, Nickell and Jackman (LNJ) to explain changes in the equilibrium unemployment rate. In the LNJ framework, equilibrium unemployment is determined by the interaction of the price and wage-setting behaviour of firms and workers. The natural rate is a function of structural variables such as the replacement ratio and union power that affect the size of firms' and workers' mark-ups. Examining a wide range of equations with different combinations of structural variables, we find it extremely difficult to derive robust coefficient estimates that are statistically significant and have the expected signs on structural variables, unless a trended variable such as the owner-occupied housing rate is included. However, it is likely that these variables are simply capturing the upward trend in actual unemployment over most of the sample period in response to exogenous shocks. We find these results to be robust over different sample periods and different equation specifications. Therefore the results indicate that it is not possible to explain accurately movements in the natural rate using this approach, supporting the findings of other recent studies that suggest focusing on alternative less structural methods for estimating the equilibrium unemployment rate.

Summary

Movements in the unemployment rate relative to its equilibrium level are potentially an important indicator of inflationary pressure. The equilibrium unemployment rate is, however, unobservable and can vary over time in response to changes in an economy's structure. In this paper we follow the approach of Layard, Nickell and Jackman (LNJ) to examine the extent to which movements in the equilibrium unemployment rate can be explained by changes in the structure of the UK economy since the early 1960s. In the LNJ model the equilibrium unemployment rate is determined by the interaction of the price and wage-setting behaviour of firms and workers. The price-setting curve is determined by firms' mark-up over their unit labour costs, while the wage-setting curve is determined by the wage bargaining of firms and workers. The natural rate of unemployment is a function of exogenous structural variables such as the replacement ratio and union power that affect the size of firms' and workers' mark-ups. In theory, this framework can be used to determine the contributions of each of these structural variables to movements in the natural rate.

There are well-known problems identifying the price and wage equations separately and, given that we are interested primarily in the model's solution for equilibrium unemployment, we estimate a reduced-form equation in which the natural rate is a function of exogenous structural variables such as the replacement ratio and union density. Dynamic adjustment terms capture the divergence between the actual unemployment rate and the natural rate in an error-correction model. To estimate the model we construct a database for the period 1960-98. Most of the structural variables are unobservable or difficult to measure, so we produce a range of proxy variables to approximate the variables in the theoretical model.

A wide range of specifications for the estimated models were tested. Overall, the empirical results can be summarised with three main findings. First, the coefficient on the unemployment rate was often statistically insignificant, indicating that the unemployment rate was not cointegrated with the structural explanatory variables. Second, in many of the equations tested the long-run coefficients on structural variables were statistically insignificant or did not have the expected sign. Finally, equations in

which the long-run coefficients were statistically significant generally included variables with a positive trend over the sample period. One example was the owner-occupied housing rate, which can be used as a proxy for the degree of labour mobility. However, typically, re-estimating the equation with a linear trend rather than the trended variable produced similar results, suggesting that these variables are simply capturing the upward trend in *actual* unemployment over most of the sample period, rather than capturing a structural link.

The finding of a lack of a robust and significant relationship does not necessarily mean that the natural rate does not exist, or that it is unaffected by structural economic changes. Rather, it highlights the difficulty in identifying the relationship, possibly due to the difficulty in accurately measuring structural changes, and is consistent with the findings of several other recent studies. We suggest that future work aiming to model movements in the natural rate should concentrate on alternative techniques, for example using the Kalman filter.

1. Introduction

Movements in the unemployment rate relative to its equilibrium level are potentially an important indicator of inflationary pressure. However, the equilibrium unemployment rate is unobservable and can vary over time in response to changes in an economy's structure. This paper examines the link between movements in the equilibrium rate of unemployment and structural economic changes. We use the labour market model developed by Layard, Nickell and Jackman (LNJ) (1991) as our theoretical framework. In the LNJ model the equilibrium unemployment rate is determined by the interaction of the price and wage-setting behaviour of firms and workers. The natural rate is a function of exogenous structural variables such as the replacement ratio and union power that affect the size of firms' and workers' mark-ups. In theory, this framework can be used to determine the contributions of each structural variable to movements in the natural rate.

There are several well-known problems associated with using the LNJ framework in empirical work to derive estimates of the natural rate and decompose the contributions of individual structural factors. First, it has long been recognised that the wage-setting curve is not identified, as all the exogenous variables that affect the price setting curve can also influence wage-setting behaviour. As a result, we proceed by estimating directly a reduced-form equation in which the natural rate of unemployment is a function of exogenous structural variables such as the replacement ratio and union density. In our estimated equation, deviations between the actual unemployment rate and the natural rate or the NAIRU are explained by dynamic adjustment terms in an error-correction model. Another problem is that most of the structural variables in the LNJ model are unobservable or difficult to measure and need to be proxied with other series. We construct a database for the period 1960-98 at annual frequency with a range of proxy variables.

The rest of the paper is organised as follows: Section 2 presents LNJ's theoretical framework that is used to explain movements in the natural rate of unemployment and describes the identification problems associated with estimating the parameters in the wage-setting curve. Section 3 describes how this framework is extended to incorporate the dynamics of actual unemployment around the natural rate to derive a model that we can estimate. Section 4 examines the problems associated with measuring many of the unobservable structural variables in LNJ's model and describes the proxy variables that we used. Section 5 presents the results of the empirical analysis and compares our findings with other recent studies. Finally, Section 6 provides a summary and conclusion.

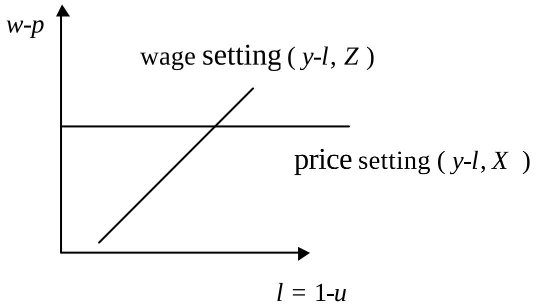
2. Explaining the natural rate of unemployment

There is an enormous literature on measuring the natural rate of unemployment.[1] Most of these studies have focused on explaining the high average unemployment rates experienced by many European countries over the past three decades, relative to both their own previous levels and to the rates seen in the United States over the same period. In European studies, structural estimates of the natural rate are usually based on the framework developed by Layard, Nickell and Jackman (1991) (LNJ).

The LNJ framework can be thought of encompassing union bargaining, efficiency wage, and search models of the labour market. The common theme to all of these models is that the natural rate is determined by the intersection of a wage-setting curve, which relates the outcome of the wage bargain to the level of unemployment, and a price-setting (or labour demand) curve, which relates the level of employment demanded by employers to the real wage (Figure 1).

Figure 1

The Layard, Nickell, Jackman (1991) framework



The determinants of the wage-setting curve generally include labour productivity, as well as a number of structural factors relating to wage bargaining. Equation **(1)** shows the

[1] See Bean (1994) for a survey.

wage-setting curve (in logs) where *w-p* represents real wages; *y-l* represents labour productivity; *Z* represents the structural determinants of wage setting; *u* represents unemployment; and e_1 is an error term.

$w\text{-}p = a_0 - q\,u + (y\text{-}l) + a\;Z + e_1$	**(1)**	wage setting
$p\text{-}w = b_0 \qquad - (y\text{-}l) + b\;X + e_2$	**(2)**	price setting

The price-setting curve is generally derived by solving the firm's profit maximisation problem. It relates real wages to labour productivity, and to structural variables affecting the firm's labour demand, summarised by *X* in equation **(2)**. For simplicity, we assume that the unemployment rate does not affect firms' mark-ups.[(2)] Adding the unemployment rate to the price-setting curve would not affect our results. As in LNJ's work, we also assume that productivity growth has a unit coefficient in both equations, so productivity changes only influence real wages in the long run, rather than the NAIRU.

Although **(1)** and **(2)** may well provide a perfectly adequate description of the functioning of the labour market, there are a number of serious empirical problems in estimating the two equations. Precisely which factors are contained in *Z* and *X* depends on exactly how the model is specified. But the factors in the price-setting curve, *X*, will generally include the degree of product market competition, as well as any structural factors in the firm's production function, for example, technological conditions. The determinants of the wage-setting curve, *Z*, depend on how the wage bargain is modelled. In the union bargaining model, *Z* contains factors such as trade union power, the replacement ratio, and the trade unionists' discount rate. In addition, when pushing for higher wages, unions take account of the scope for achieving those demands without job losses. This will depend on the factors entering the price-setting curve such as the firm's elasticity of product demand and its capital stock. In fact all of the variables affecting the price-setting curve (*X*) can be shown to enter the wage-setting curve (*Z*).

As many people have pointed out (see, for example, Layard, Nickell and Jackman (1991) and Bean (1994)), the fact that all the determinants of the price-setting curve also appear

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[(2)] Rotemberg and Woodford (1999) argue that US price mark-ups are negatively correlated with the business cycle.

in the wage-setting curve makes the latter unidentified. One way to see this is with reference to Figure 1. It is impossible to determine empirically the slope of the wage-setting curve, because whenever one of the X variables shifts the price-setting curve, the wage-setting curve moves too. In fact, as Bean (1994) explains, the identification problem is not limited to a union bargaining framework. It will occur in any model of wage setting. For example, with efficiency wages, firms set wages to deter shirking. But the degree to which they want to deter shirking depends on how much profits increase for an extra unit of effort, which in turn depends on the price-setting factors, X.

Different researchers have handled the identification problem in a number of different ways. Some have simply ignored it, and estimated the wage equation using Ordinary Least Squares. Bean (1994) points out that this approach is only valid if the contemporaneous elasticity of employment with respect to real wages is very small and if the error terms in the price and wage equations are uncorrelated. An alternative solution is to impose restrictions on the wage-setting curve, by excluding particular variables and only using lagged values of the exogenous variables.[3] But neither ignoring the problem, nor imposing *ad hoc* exclusion restrictions seems particularly satisfactory.

A third strategy is proposed by Manning (1993).[4] Starting with the union's utility maximisation problem, Manning derives a wage-setting curve from first principles. The result is a wage-setting curve which excludes real wages (ie is vertical in Figure 1). This gets around the identification problem because Manning's vertical wage-setting curve simply relates unemployment to some exogenous variables, and so can be estimated by OLS.

However, there is a problem with Manning's approach. In his model unions strike a Nash bargain with firms in an attempt to maximise their members' expected utility. One factor that affects how hard they push for higher wages is the expected employment cost

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(3) A recent example of this is Banerjee *et al* (2000), who argue that inflation should be included as a variable in the price-setting curve that affects firms' mark-ups. Although this could overcome the identification problem, it would introduce non-neutrality into the model, as the NAIRU would depend on the money growth rate.

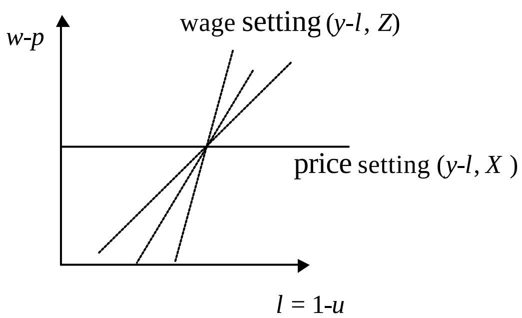
(4) See also Barrell *et al* (1994).

of higher wages, or the elasticity of employment with respect to wages. With a Cobb-Douglas production function Manning shows that this elasticity is constant, and he relies on this to derive his vertical wage-setting curve. But this use of the production function to substitute for the elasticity in the wage-setting function is far from innocuous. By combining the wage and price-setting sides of the model, Manning is actually estimating a reduced form, rather than a wage-setting curve. He has effectively eliminated real wages from equations **(1)** and **(2)** leaving a relationship between unemployment and the structural variables. Although, there is nothing wrong with doing this, it will not allow recovery of the parameters of the wage-setting curve. Given a system of simultaneous equations, it is always possible to estimate a reduced form. But if the system is unidentified then recovery of the structural parameters will not be possible.

If we are only interested in finding out what the determinants of the natural rate are, is lack of identification really such a problem? As Westaway (1997) points out, the identification problem leads to uncertainty about the slope of the wage-setting curve, but not about where it intersects with the price-setting curve (Figure 2). So we can still find how the intersection of the two curves (ie the natural rate) moves with the structural variables. Econometrically this is done by estimating the reduced form of equations **(1)** and **(2)**, and this is how we proceed.

Figure 2

The identification failure of the wage-setting curve



3. Incorporating dynamics

Before we can estimate the reduced form of the model above, we need to extend it into a dynamic setting. In this section, we explain the dynamic adjustment of the actual unemployment rate around the natural rate.

We start with a more general specification that allows for expectational errors. Suppose that prices are set at the start of each period on the basis of firms' expectations about the outturn of wages, and wages are set on the basis of agents' expectations about prices. In this case the wage and price-setting curves will be almost the same as **(1)** and **(2)**, except that there will be terms in wage and price expectations. Note that for simplicity we have dropped the constants.

$$w - p^e = y - l - qu + aZ \quad \textbf{(3)}$$

$$p - w^e = -(y - l) + bX \quad \textbf{(4)}$$

Expectations can only be met ($p=p^e$, $w=w^e$) when unemployment is at its natural rate, u^*. In this case **(3)** and **(4)** reduce to **(1)** and **(2)**. Solving these equations, the natural rate of unemployment can be expressed as:

$$u^* = \frac{1}{q}\left(aZ + bX\right) \quad \textbf{(5)}$$

When unemployment is not at the natural rate, either wage setters or price setters will be disappointed at any point of time as the actual real wage deviates from their expected or desired level. Equations **(3)** and **(4)** can be written as:

$$w - p = y - l - qu + aZ - (p - p^e) \quad \textbf{(6)}$$

$$p - w = -(y - l) + bX - (w - w^e) \quad \textbf{(7)}$$

Suppose that agents expect wage and price inflation to follow a random walk, so that $\Delta p^e = \Delta p_{-1}$. In this case we can substitute for the two surprise terms to get:

$$w - p = y - l - qu + aZ - \Delta^2 p \quad \textbf{(8)}$$

$$p - w = -(y - l) + bX - \Delta^2 w \quad \textbf{(9)}$$

giving a reduced form of

$$u = \frac{1}{q}\left(aZ + bX - \Delta^2 (p + w)\right) \quad \textbf{(10)}$$

For simplicity, it is generally assumed that $\Delta^2 p \approx \Delta^2 w$ (see for example Layard, Nickell and Jackman (1991)), in which case the reduced form becomes a Phillips curve:

$$u = u^* - 2/q\, \Delta^2(p) \quad \textbf{(11)}$$

In estimating the structural determinants of the natural rate, we would ideally like to regress u^* on the relevant structural variables, X and Z. This is not possible because u^* is unobserved. Equation **(11)** suggests that an alternative is to regress actual unemployment on the structural variables and on price surprises, $\Delta^2 p$. Failure to include the latter term may lead to omitted variable bias.

What happens when there are other forms of inertia so that the wage and price-setting curves do not take the simple form they do in **(3)** and **(4)**? There are three sources of real inertia that can complicate the two equations. First, in the presence of hysteresis, either because of insider-outsider issues or because of deskilling of the long-term unemployed, the wage-setting curve will depend on lagged as well as contemporaneous unemployment. Second, it may take wage bargainers some time to adapt to changes in the structural variables, or to changes in the trend rate of growth in productivity, in which case lagged values of these variables will also feature in the curves. Finally, changes in the wedge between the real product wage and the real consumption wage may also influence the wage or price-setting curves. All of these possibilities can be allowed for by including lagged difference terms in the equations:

$$w - p = (y - l) - qu + aZ - \Delta^2 p - g_1 \Delta^2 (y - l) - g_2 \Delta u - g_3 \Delta Z + g_4 \Delta wedge \quad \textbf{(12)}$$

$$p - w = -(y - l) + bX - \Delta^2 w + l_1 \Delta^2 (y - l) - l_3 \Delta X \quad \textbf{(13)}$$

The specification of these dynamic terms is somewhat *ad hoc*. For example, the choice of whether they enter in first differences or second differences depends on how agents form their expectations. If people expect productivity to grow at trend, then real wage rigidity would occur when there is a change in productivity growth. For the specification in **(12)** and **(13)** we have assumed that people expect constant growth in productivity and prices but constant levels of structural variables and the wedge. The second decision that needs to be taken is on the number of lags. This is an empirical issue, though in our regressions we allow up to two lagged difference terms because we use annual data and longer lags seem implausible, and because having more lags would not leave many degrees of freedom.

When the wage and price-setting curves take the form of **(12)** and **(13)**, the reduced form is:

$$u = u^* + \frac{1}{q}\left(-2\Delta^2 p - g_2\Delta u - g_3\Delta Z - l_3\Delta X + \Delta wedge + (l_1 - g_1)\Delta^2(y-l)\right) \qquad \textbf{(14)}$$

In other words, unemployment can diverge from its long-run natural rate not just when there are price surprises, but also when there have recently been changes in the structural variables; in the unemployment rate; in the tax wedge; or in the rate of productivity growth. This allows us to define a series of different NAIRUs:[(5)]

- the *natural rate* is the unemployment rate when all the structural variables are at their equilibrium levels, and all sources of real and nominal rigidity have washed out:

$$u^* = \frac{1}{q}\left(aZ + bX\right) \qquad \textbf{(15)}$$

- the *long-run NAIRU* is the unemployment rate when the structural variables are away from equilibrium, but all other rigidities have washed out:

$$NAIRU_L = u^* + \frac{1}{q}\left(-g_3\Delta Z - l_3\Delta X\right) \qquad \textbf{(16)}$$

- the *short-run NAIRU* is the unemployment rate when all sources of nominal inertia have washed out but still allowing for the impact of real inertia:

$$NAIRU_S = u^* + \frac{1}{q}\left(-g_3\Delta Z - l_3\Delta X\right) + \frac{1}{q}\left(-g_2\Delta u + \Delta wedge + (l_1 - g_1)\Delta^2(y-l)\right) \qquad \textbf{(17)}$$

Naturally, to derive these equilibrium rates we need to have measures of the structural variables in the *X* and *Z* matrices. The next section discusses the variables we constructed.

4. Measurement of structural variables

There is wide disagreement about exactly which structural variables should enter the wage and price-setting curves. We attempt to encompass a variety of models by

(5) See also Melliss and Webb (1997) for a discussion of long-run and short-run NAIRUs.

obtaining data on a wide range of variables. We tried to obtain data for each series from 1960 to 1998. However, some variables are either unavailable or only available for limited periods.

Replacement ratio

The replacement ratio (the ratio of workers' earnings to the benefit payments received by the unemployed) is clearly important in a perfectly competitive framework on the perfectly elastic portion of the labour supply curve, where wages will be bargained down to workers' reservation wages, which will be closely related to the replacement ratio. But the replacement ratio also acts as the anchor in most other models of wage setting. For example, LNJ's (1991) union bargaining model derives wages as a mark-up over benefits, as does Shapiro and Stiglitz's (1984) efficiency wage model.

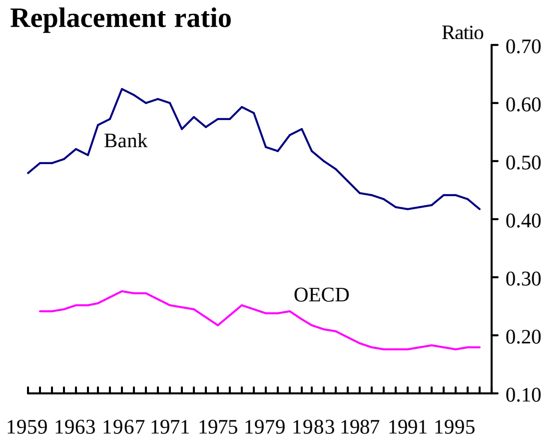
There are many different ways of measuring the replacement ratio, though they can broadly speaking be divided into two types. Macroeconomic measures start with aggregate data on government expenditure on unemployment benefits plus some social security payments, and divide them by the total number of recipients to estimate average benefits. This is then divided by a figure for average earnings. Macroeconomic measures are generally easy to construct, but they suffer from the disadvantage that it is very hard to control for compositional change. If, for example, there is a shift from unemployed childless people to unemployed people with children, there may be a rise in the estimated replacement ratio, even though the benefit rules have not changed.

To avoid this problem we experiment with two microeconomic replacement ratios. These are typically constructed from the unemployment benefits and average earnings of one or more representative family groups.[(6)] Our preferred measure is calculated by the OECD (Martin 1996), and weights together benefit receipts for three types of individual according to their family circumstances — single people, married people with a dependent spouse, and married people with a working spouse. Replacement rates for

[(6)] A more accurate picture of the incentives faced by workers could be obtained by examining the distribution of replacement ratios across the population, rather than concentrating on a few specific representative agents. However, it would be extremely difficult to construct these distributions over our entire sample period.

each group at three different unemployment durations (first year, second-third year, fourth-fifth year) are averaged to produce an aggregate replacement ratio.[7] Unfortunately the OECD measure is biannual, and so has to be interpolated. We also try using an internally calculated measure which is based only on data for only one type of family group — married couples with two children. Although this measure is simpler than the OECD one, it can be calculated annually. The chart below illustrates that although the levels of the two measures are different, they do have similar trends.

Chart 1



As well as the size of benefit payments, we would also like to have measured the stringency of benefit enforcement. There have been a large number of changes to the benefits system which are not captured by our replacement ratio series, such as the ending in 1982 of the requirement to register for work at a Jobcentre to claim unemployment benefit,[8] the introduction of the Job Seekers' Allowance in 1996, and of the New Deal in 1998. Benefit enforcement tends to be captured in a qualitative manner in cross-country regressions, but we have not seen any papers which manage to quantify these changes to allow time series regressions. One possibility would be to dummy every change, but there have been so many that this would dramatically limit our degrees of freedom. Consequently we do not capture the effect of changes to benefit enforcement.

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(7) The ratio is calculated using earnings and benefits before tax. Payments of housing benefits are excluded from the calculations. This may overstate the fall in the replacement ratio, because in high-rent areas such as London, housing benefits can make up a significant proportion of an unemployed person's total benefit package. See Nickell (1999).

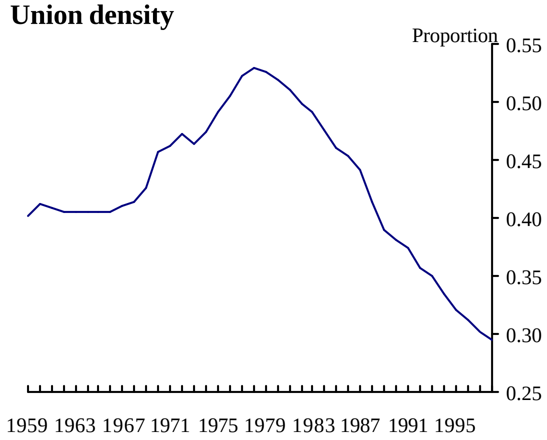
(8) See Denman and McDonald (1996) for more details.

Trade union power

Most models of trade union wage setting predict that the natural rate will increase with the degree of trade union power (eg LNJ (1991)), particularly in countries such as the United Kingdom where wage bargaining is decentralised. Of course, union power is not actually observable, so a variety of different proxies have been used.

In common with other studies, (eg Manning (1993)) we use trade union density. Our measure comes from the *Labour Force Survey* after 1989, and from the Certification Officer for Trade Unions and Employers' Associations before then (see Cully and Woodland (1998) for details). Other studies, such as Layard and Nickell (1986), use the union wage mark-up over non-union wages. These measures are generally derived from microeconomic wage equations, and as such are relatively complicated to update. A third possibility is to use trade union coverage (ie the proportion of people whose pay is determined by union bargains, rather than the proportion who are members) as a proxy for union power. Unfortunately, the earliest data on union coverage rates, from the *New Earnings Survey*, begin only in 1974.

Chart 2



Unemployment mismatch

Layard, Nickell and Jackman (1991) show that when the wage-setting curve is convex and the labour market is segmented either by region, skill level or industry, an uneven distribution of unemployment across sectors can raise the natural rate of unemployment.

In this case there will be a relationship between the natural rate of unemployment and the dispersion of unemployment.

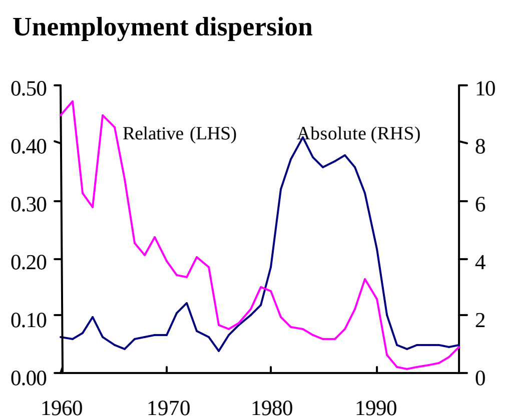
Most attention in the literature has concentrated on the mismatch between the unemployed and vacancies across regions.(9) Unemployment dispersion across regions can be measured in either absolute (*AD*) or relative (*RD*) terms. The formulae for these measures are:

$$AD_t = \sum_{i=1}^{r} \frac{N_{it}}{N_t} (U_{it} - U_t)^2$$

$$RD_t = \sum_{i=1}^{r} \frac{N_{it}}{N_t} ((U_{it} / U_t) - 1)^2$$

where N_{it} is the labour force of region *i*, N_t is the aggregate (nationwide) labour force, U_{it} is the unemployment rate in region *i*, U_t is the aggregate (nationwide) unemployment rate, and *r* is the number of regions. The two measures are illustrated in the chart below.

Chart 3



Clearly, the two measures can produce quite different profiles for the degree of regional mismatch. There is no consensus in the literature about which is the preferred measure.(10) In addition, the Standard Statistical Regions we use to calculate the dispersion measures are rather large; for example the whole of Scotland is one region, but it would clearly not be possible for someone in Aberdeen to commute to a job in

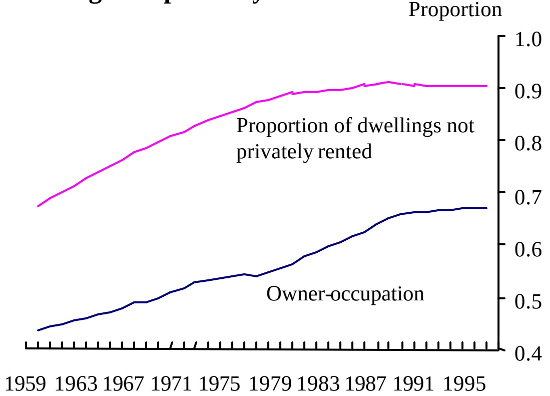
(9) See Jackman, Layard and Savouri (1991).
(10) See, for example, Jackman, Layard and Savouri (1991) and Jackman and Savouri (1999).

Edinburgh. Unfortunately, the data required to calculate unemployment dispersion at the county or Travel-to-Work area levels do not go back far enough to include in our model.

An alternative way to capture regional unemployment dispersion is to use a variable that should be correlated with it. A number of authors, including Bover, Muellbauer and Murphy (1989); Oswald (1996); Henley (1998) and Pehkonen (1999) have suggested that the degree of owner occupation may be an important determinant of regional mismatch: owner-occupiers tend to face higher relocation costs if they want to move to find a job, especially when levels of house prices are very different across regions. Also, a high proportion of owner-occupiers in a region may make it difficult for young capital-constrained workers to enter that region in search of work. To pick up this effect we experiment with including both the aggregate owner-occupation rate, and the 'non-rental' rate, which includes owner-occupation and local authority housing.

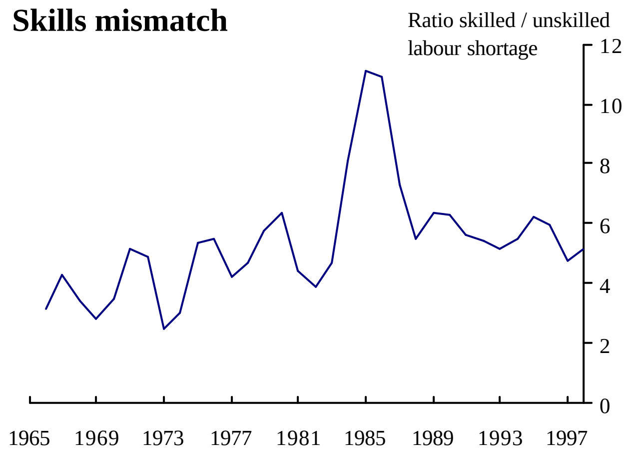
Chart 4

Owner occupation rate and proportion of dwellings not privately rented



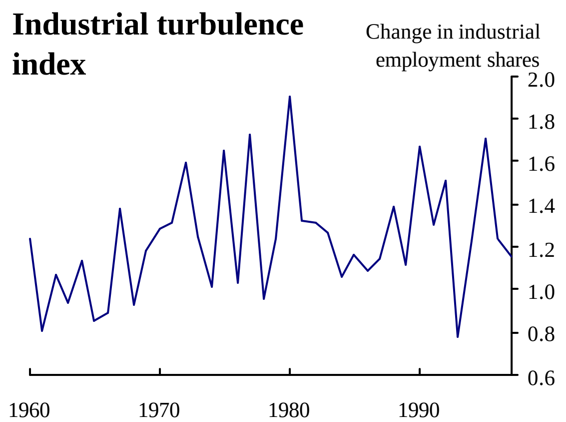
The impact of mismatch between the skill levels of the unemployed and the skills required to fill vacancies has had relatively less attention in the literature than regional mismatch, given the difficulties associated with trying to measure it. Most studies (Nickell and Bell (1995); Nickell (1998); Manacorda and Petrongolo (1999)) have proxied skills mismatch using either household survey data on unemployment rates for individuals with different educational qualifications, or business survey responses on the shortages of skilled staff relative to unskilled staff. For our study, we use the ratio of shortages of skilled staff to unskilled staff from the CBI *Industrial Trends Survey*.

Chart 5



Measuring mismatch between those sectors with high unemployment and those with vacancies is also difficult. Data on the industry of unemployed claimants used to be collected when people registered for employment at Jobcentres. But in 1982 Jobcentre registration no longer became necessary to claim benefits, so claimant count data by industry stopped being collected. In principle one could use LFS data to measure unemployment by industry since 1984, and tack the two series together. Instead we pursue a different approach, and calculate the industrial turbulence index used by Layard and Nickell (1986). This involves proxying industrial mismatch by the sum of the absolute changes in the industrial composition of employment. The idea is that when there are large shifts in the industrial composition of employment, there are also likely to be a large number of unemployed whose skills do not match those sought by employers.

Chart 6



Demographics

In most countries young people tend to have higher unemployment rates than older workers. This has led several authors, such as Perry (1970) and Katz and Kreuger (1999) to suggest that demographics may affect the natural rate of unemployment. Studies investigating this include Shimer (1998), who suggested that around 70% of the fall in US unemployment since 1979 could be attributed to demographics, and Barwell (2000), who found that the proportion was smaller in the United Kingdom at around 10%. It is not immediately obvious that demographics should show up in our regressions, given that we are already conditioning on several other variables. For example, if it were the case that the young have higher unemployment rates because they tend to be more unionised, then we would expect the demographic effect to already be captured by union density. However, in practice the young are probably less unionised, have lower replacement ratios, and are more regionally and industrially mobile than the old. Therefore, a better way of thinking about the demographic variable is as a proxy for an unobserved characteristic, such as average job experience or average time spent in the labour market.

We experiment with two structural variables that attempt to capture demographic effects on unemployment. The first is the proportion of young people in the population (aged 15-24), which captures the effects of young people on unemployment. The second is constructed by taking the ratios of the unemployed to the population for each age group in a base year (1986) and weighting them together according to the age distribution of the population in each period. This attempts to capture the effects of changes in the age structure of the population on the unemployment rate.

Chart 7

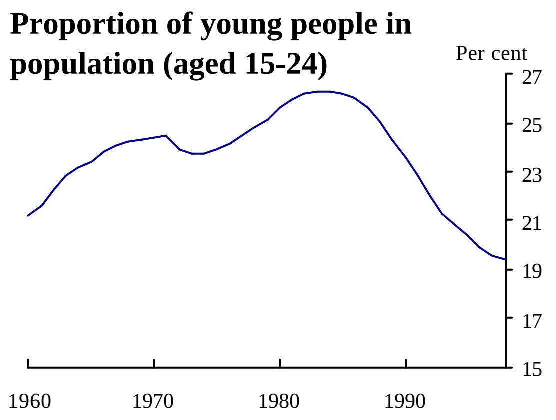
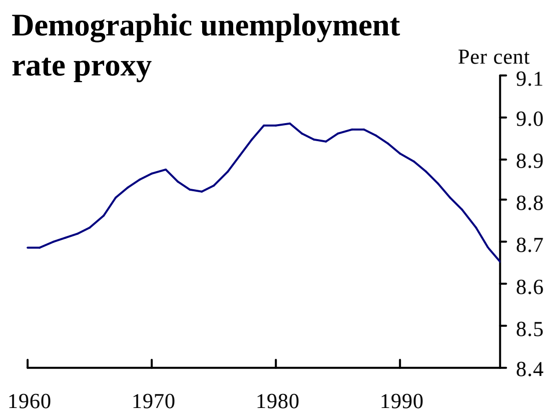


Chart 8



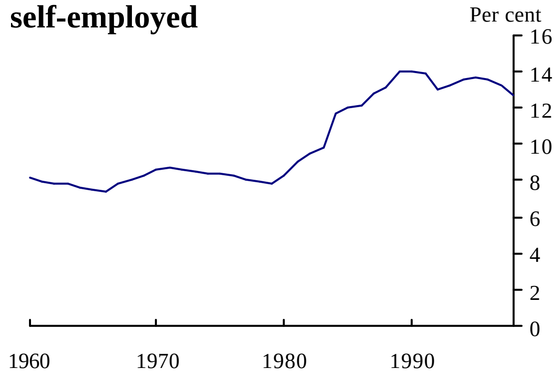
Labour market flexibility

The economic and political debate during the 1990s has placed particular emphasis on the importance of labour market flexibility, although often without defining exactly what is meant. As Millard (2000) notes, increased flexibility can take many forms, at both the microeconomic and macroeconomic level. He also makes a distinction between *wage* flexibility, which relates to the ability of wages to adjust downwards in response to adverse shocks, and *employment* flexibility, which encompasses hiring and firing regulations; job mobility; and the scope for non-standard hours contracts and part-time working. Unfortunately, these are all difficult concepts to measure, and we are unaware of any econometric time series studies that have included any of these factors other than labour mobility.

We investigated two proxies for labour market flexibility. The first was to use the proportion of employees who work part time. Unfortunately data for this are only available back to 1971. The second was to use the proportion of employment accounted for by self-employment. There are many possible reasons why the self-employed should be more flexible, and why they should have lower natural rates of unemployment. First, the self-employed are able to monitor their own levels of effort, and to judge their own levels of ability. Consequently there should be no need for efficiency wages as an enforcement mechanism or to avoid adverse selection problems. Second, the self-employed are generally not unionised. This means that not only will they avoid pricing themselves out of a job, but they should also be able to undercut heavily unionised competitors, thus reducing union power in other firms. Third, people often associate high levels of self-employment with high rates of new firm creation. Other things being equal, the entry of new firms should increase product market competition, which would reduce the natural rate. Consequently, our labour flexibility proxy is the self-employment share.

Chart 9

Proportion of employment that are self-employed



Product market competition

Most attention in the literature has been focused on variables that affect the natural rate by shifting the wage-setting curve. However, at least in the Layard-Nickell-Jackman framework, the natural rate can also be affected by factors that shift the price-setting curve. In the case of product market competition, an increase in competition reduces the mark-up of prices over wages that firms can set, increasing the real wages they are willing to pay. This shifts the price-setting curve up and reduces the NAIRU.

Once again, product market competition is very difficult to measure, and we try using two different proxies. The import penetration ratio (ie imports as a proportion of GDP) constructed from the National Accounts is used to capture the economy's degree of openness to external competition. The degree of competitive pressures in the domestic economy is represented by the number of private sector employees as a proportion of total employment. This variable is constructed using data from the Workforce Jobs survey.

Chart 10

Imports as % of real GDP

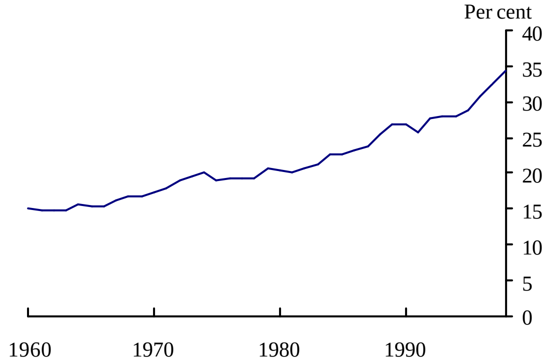
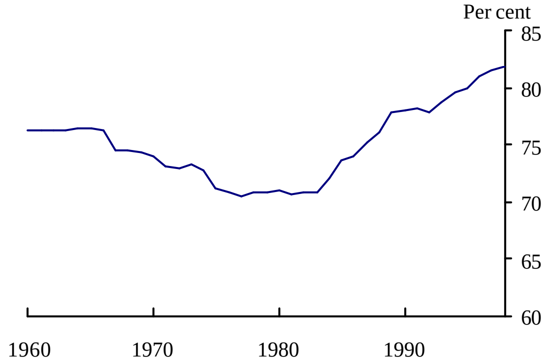


Chart 11

Private sector employment (% of total)

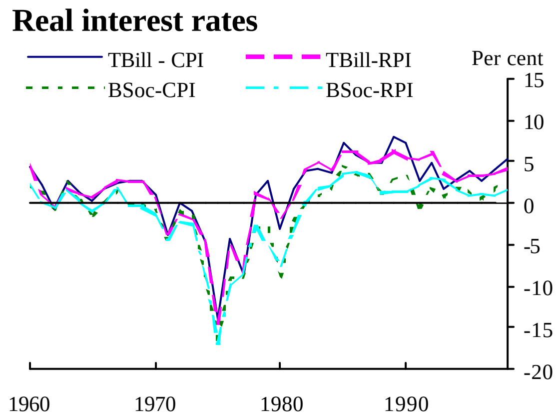


Real interest rate

The effect of real interest rates on unemployment has been a controversial issue in the literature. Layard *et al* (1991) argue that interest rates do not affect the natural rate. The only role for interest rates in their model is as a tool for demand management to temporarily manipulate the level of unemployment relative to its natural rate. However, other authors, notably Phelps and Zoega (1998) and Carruth *et al* (1994, 1998) have argued that higher interest rates affect the natural rate of unemployment by raising the cost of capital to firms, reducing profits and thereby reducing labour demand. Others, such as Manning (1993), use real interest rates as a proxy for workers' rate of time preference in their models of the natural rate.

We investigate the use of four different measures of real interest rates, constructed from two nominal interest rates and two inflation series. The two nominal interest rates are the Treasury bill rate and the building society interest rate on ordinary shares. The inflation series are based on the retail price index (RPI), and the deflator for final consumption expenditure by households and non-profit institutions (CPI) from the National Accounts.

Chart 12



Wedge effects

Workers bargain for a desired consumption wage, which may diverge from the real product wage paid by firms due to 'wedge' factors. Most wedges between the product wage and the consumption wage can be explained by indirect and employment taxes, and by movements in the prices of imported consumption items. These wedges affect unemployment as workers resist real wage falls and bargain to restore their consumption wage to its previous level. Layard *et al* (1991) argue that the *level* of the wedge will not affect the natural rate of unemployment because in the long run the impact of tax changes and import price shocks is borne entirely by workers, who accept reductions in their share of income. *Changes* in the wedge can temporarily affect unemployment in their model if workers try to restore their previous consumption wage – a phenomenon known as real wage resistance.

However, in other models (Carruth, Hooker and Oswald (1994, 1998); Phelps and Zoega (1998)) it is argued that changes in imported *input* prices, such as oil, can permanently affect the natural rate of unemployment. This impact arises because higher input prices increase firms' non-labour costs, causing them to increase their mark-up of prices over wages. This reduces firms' labour demand, leading to a fall in wages and a rise in equilibrium unemployment.

Although some researchers have used the difference between the real product wage and real consumption wage directly as their wedge variable, consistent data for the consumption wage deflator is only available from the mid-1970s onwards. As a result, we use three variables to capture the impact of separate wedge effects on unemployment. Our measure of the tax wedge, which is constructed from National Accounts data, is the sum of employers' and employee' National Insurance contributions plus taxes on income expressed as a proportion of total wages and salaries. We have two variables to capture the import price wedge. Our first measure is the aggregate import price deflator relative to the overall GDP deflator. We also use the price of oil as a separate variable to reflect movements in non-labour input costs. This variable was calculated as the price of oil in sterling relative to the RPI basket of goods and services.

Chart 13

Tax wedge

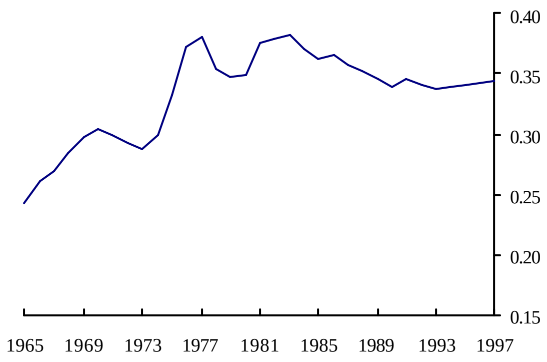


Chart 14

Import price wedge

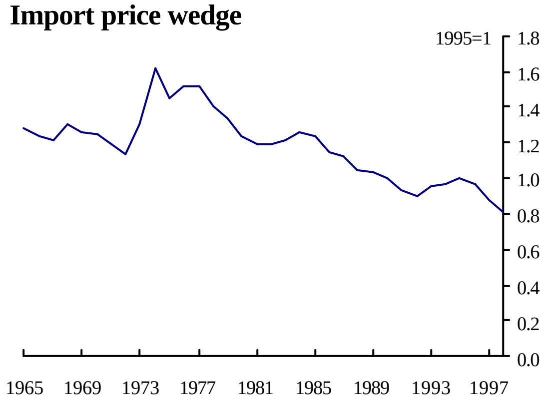
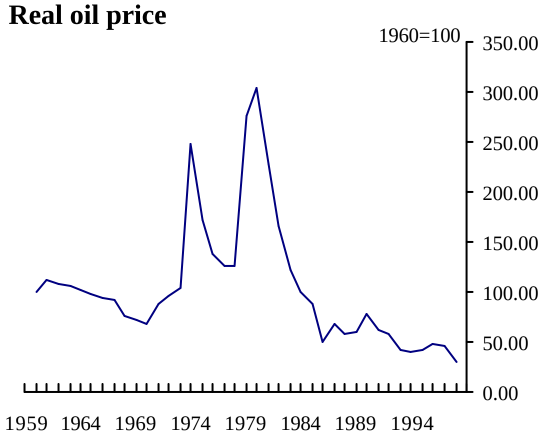


Chart 15

Real oil price



5. Empirical findings

(i) Model specification

In Section 3 we derived a reduced-form equation **(14)** for unemployment which could be used to construct estimates of the natural rate, along with the long-run and short-run NAIRU. It should be possible to estimate this equation and use the structural variables described in Section 4 to construct all three equilibrium concepts.

However, before estimating the equation it is necessary to address the question of stationarity. In principle, the unemployment rate, and all its structural determinants should be I(0).(11) As a rate, unemployment is bounded between zero and one. Though long time series of unemployment show sustained periods of high unemployment lasting up to 10 or 20 years, there is a clear process of mean reversion in between. But statistical tests on sub-samples of the data (in our case the past 38 years) point to an I(1) series.(12) Similarly, structural determinants such as the replacement ratio, union density and the owner-occupation rate, are all bounded between zero and one, yet statistical tests typically suggest they are I(1). So although we may have priors suggesting that in the long run these series must be I(0), if we ignore the statistical results we may be risking spurious correlation. To overcome this problem we carry out our regressions in a cointegration framework.

There should only be one cointegrating vector between unemployment and the structural variables since we assume that the factors affecting the natural rate are all exogenous. Therefore, we can estimate an error-correction model (ECM), regressing the change in the unemployment rate on the lagged unemployment rate and structural variables, and on the dynamic terms.(13) Using the coefficients of this regression it is possible to recover estimates of the natural rate, and the long and short-run NAIRUs:

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(11) See Appendix 1 for results of unit root tests.
(12) Henry and Nixon (2000) argue that the unemployment rate is actually an I(0) variable with temporary mean shifts.
(13) Hendry and Mizon (1998) discuss the estimation of cointegrating relationships when variables ‘co-break’ in response to policy regime changes. However, we have too few observations in our study to accurately capture regime changes.

$$\Delta u = [a_0 + a_1 u_{-1} + a_2 X_{-1} + a_3 Z_{-1}] + a_4 \Delta X_{-1} + a_5 \Delta Z_{-1} + a_6 \Delta u_{-1} + a_7 \Delta wedge_{-1} + a_8 \Delta^2 (y-l)_{-1} + a_9 \Delta^2 p_{-1} \quad \textbf{(18)}$$

The first four terms of the regression can be interpreted as the error-correction mechanism defining the long-run natural rate. Adding in the dynamic terms in *X* and *Z* define the long-run NAIRU. Finally, adding in the dynamic terms in unemployment, the wedge and productivity gives the short-run NAIRU.

To ensure that our approach is valid, we used Johansen's (1988) method to test the number of cointegrating vectors.[(14)] The results were extremely sensitive to the model specification and the inclusion or exclusion of constants and trend, and in most cases there appeared to be several cointegrating vectors. However, when we adjusted our test statistics using Reimers' (1992) small-sample correction,[(15)] there appeared to be a single cointegrating relationship. As a result, in the rest of this section we present the results of our empirical work using a single-equation ECM.

For several reasons, we could not test the significance of all the structural variables by including them all in a single equation. First, given the small sample size, there would be very few degrees of freedom left if all the series were used together. Second, many of the structural variables are highly correlated, which would lead to collinearity problems. To overcome this problem, a wide range of model specifications was tested that used a subset of the series available to proxy each theoretical concept.

Furthermore, in most cases, it was unclear *a priori* whether a regressor should be included in levels or log levels, since theory did not specify whether the relationship between a structural variable and unemployment should be linear or non-linear. Consequently, we estimated equations using series in both levels and log levels to test the robustness of our conclusions. The theory also provides little guidance on the structure of the dynamic terms in the equations, so we followed a general-to-specific approach to eliminate statistically insignificant lagged dynamics.

[(14)] See Appendix 2 for results for the baseline model.

[(15)] Reimers suggested that in small samples Johansen's Trace test for the number of cointegrating vectors should be multiplied by *(T-nk)/T*, where *T* is the number of observations, *n* is the number of variables and *k* is the number of lags in the VAR model.

(ii) Results

A wide range of linear and log-linear specifications was tested, with different combinations of structural variables.[16] Overall, the empirical results can be summarised as follows:

- The coefficient on the unemployment rate was often statistically insignificant, indicating that the unemployment rate was not cointegrated with the structural variables.

- In many equations, the long-run coefficients on structural variables were statistically insignificant and / or did not have the expected sign.

- Equations in which the long-run coefficients were statistically significant generally included variables with a positive trend over the sample period, such as the owner-occupied housing rate.

These results are illustrated below in Table A. The equation in column (1) has a measure of the replacement ratio, union density and real interest rates as long-run explanatory variables of the natural rate. An inflation surprise term is also included in the dynamics. The coefficients on union density and the real interest rate in the cointegrating vector are statistically insignificant from zero. Furthermore, the coefficient on the lagged unemployment rate is also statistically insignificant, suggesting that the long-run variables in the model are not cointegrated. In column (2), we include the owner-occupied housing rate in the model's long-run component and in the dynamics. This raises the statistical significance of union density and real interest rates and also improves the statistical significance of the lagged unemployment rate, which increases the probability that the I(1) variables are cointegrated.[17] The replacement ratio remains statistically insignificant.[18] However, as shown in column (3), similar results are obtained when a linear time trend is included in the equation rather than the home-ownership rate. When the ownership rate and a time trend are included in the equation together (column (4)), the coefficients on both variables are insignificant, possibly due to collinearity.

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(16) See Appendix 3 for details of the model specifications examined.
(17) Similar results are found with the replacement ratio series constructed by the OECD.
(18) These estimates based on Ordinary Least Squares are broadly similar to results derived using Johansen's methodology in Appendix 2.

These broadly negative results for natural rate equations based on structural variables are in contrast to those in Nickell (1998). In Nickell's model equilibrium unemployment is a function of industrial turbulence, the replacement ratio, the terms of trade, skills mismatch, union mark-up, the tax wedge and real interest rates. We re-estimated our equation over the period 1964-92, the same period as in Nickell's study (column (5)), but found broadly similar results to those from the full sample — obtaining statistically significant results depends on the inclusion of the owner-occupied housing rate. Therefore, the different outcomes must be due to some other difference between the two studies, such as the data frequency (annual in our study, quarterly in Nickell's) or measures of structural variables used.

Table A

Dependent variable: Dln(u)

Estimation period:	(1) 1963-1998	(2) 1963-1998	(3) 1963-1998	(4) 1963-1998	(5) 1964-1992
Long-run:					
Constant	-5.23 (-0.72)	-6.64 (-4.96)	-2.81 (-2.30)	-5.00 (-1.28)	-3.94 (-0.31)
ln(U)$_{-1}$	-0.11 (-1.19)	-0.53 (-3.08)	-0.58 (-3.08)	-0.56 (-2.95)	-0.09 (-0.54)
UNION$_{-1}$	10.25 (0.96)	8.05 (3.60)	6.43 (3.83)	7.85 (3.62)	7.90 (0.38)
ln(RRBANK)$_{-1}$	-3.37 (-0.60)	0.46 (0.35)	-0.34 (-0.30)	0.18 (0.13)	-3.02 (-0.37)
REALR1$_{-1}$	-0.08 (-0.53)	0.05 (1.77)	0.03 (1.52)	0.05 (1.87)	-0.11 (-0.29)
OOR$_{-1}$	-	0.09 (5.74)	-	0.05 (0.53)	-
Trend	-	-	0.06 (6.44)	0.03 (0.44)	-
Dynamics:					
ΔUNION$_{-1}$	-2.52 (-0.47)	-6.24 (-1.25)	-2.96 (-0.60)	-5.67 (-1.08)	-2.16 (-0.33)
Δln(RRBANK)$_{-1}$	-0.39 (-0.32)	-0.35 (-0.33)	0.10 (0.09)	-0.19 (-0.17)	-0.56 (-0.37)
ΔREALR1$_{-1}$	-0.03 (-1.34)	-0.05 (-2.56)	-0.03 (-2.25)	-0.05 (-2.55)	-0.02 (-0.97)
Δln(U)$_{-1}$	0.30 (1.53)	0.57 (2.91)	0.59 (2.88)	0.59 (2.88)	0.29 (1.02)
ΔΔln(PGDP)$_{-1}$	-0.56 (-0.30)	-1.89 (-1.12)	-1.52 (-0.90)	-1.94 (-1.12)	-0.53 (-0.23)
ΔOOR$_{-1}$	-	-0.24 (-1.80)	-	-0.21 (-1.41)	-
Adjusted R-squared	0.15	0.35	0.32	0.32	-0.03
Standard Error of Regn	0.21	0.19	0.19	0.19	0.25
Durbin-Watson	1.82	2.18	2.18	2.22	1.67

Definitions: U = unemployment rate, UNION = union density, RRBANK = replacement ratio (bank estimate), REALR1 = real interest rate = building society interest rate - RPI , OOR = owner-occupied housing rate, PGDP = GDP deflator.

Owner-occupied housing is successful in obtaining statistically significant relationships between the unemployment rate and many of the structural variables. However, we believe that it is unlikely that on its own it could have played such a dominant role in explaining movements in the natural rate as suggested in the results above. Rather, it is likely that, to a large extent, it is capturing the positive trend in the actual unemployment rate over most of the sample period. Most previous studies (Oswald (1996); Henley (1998); Pehkonen (1999)) that have examined the link between home-ownership and equilibrium unemployment have been based on cross-sectional or panel datasets, and it is likely that these studies are better able to capture the link between home-ownership and unemployment than a time series approach like ours.

Our findings are consistent with the results of several other recent studies that have assessed different methods of estimating the natural rate of unemployment. For example, Henry and Nixon (2000) find that many of the structural variables that theoretical models suggest should affect the natural rate generally explain little of the variation in UK unemployment. They argue that UK unemployment is actually an I(0) variable with temporary (but long-lasting) mean shifts. If unemployment is incorrectly treated as an I(1) variable, some other stochastically-trended variable, such as home-ownership, is needed to explain it. The instability of the relationship between the natural rate and structural variables in the United Kingdom was also documented by Coulton and Cromb (1994).

In addition, a recent OECD Economic Policy Committee Working Party has suggested that the most useful estimates of the NAIRU are those derived from reduced-form methods. The most commonly used approach recently has been to use a Kalman filter to estimate simultaneously the NAIRU and a Phillips curve.[19] Although approaches based on structural variables could complement the reduced-form models, it was difficult to identify accurately the specific contributions of the various factors that determine the NAIRU.[20]

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[19] See, for example, Bank of England (1999).
[20] See OECD (2000).

6. Conclusions

The aim of this paper has been to examine the relationship between the natural rate of unemployment and structural changes in the UK economy. We use the theoretical framework developed by Layard, Nickell and Jackman (1991), in which the natural rate of unemployment can be expressed as a function of exogenous structural factors that affect price and wage-setting behaviour. Given the problems associated with identifying a wage curve in the LNJ system, we proceed by estimating a reduced-form equation in which the natural rate of unemployment is a function of exogenous structural variables such as the replacement ratio, union density and unemployment mismatch. Deviations between the actual unemployment rate and the natural rate or the NAIRU are explained by dynamic adjustment terms in an error-correction model. Since most of the structural factors in the LNJ model, such as the replacement ratio and union power, are difficult to measure, we construct an annual dataset for the period 1960-98 with a range of proxy variables for each factor in the theoretical model.

A wide range of equations with different combinations of structural variables was examined. Overall, the estimation work has shown that it is extremely difficult to link movements in the natural rate to structural economic changes. It is generally difficult to derive robust coefficient estimates for structural variables that have the expected sign and are statistically significant. To overcome this, it is necessary to include a variable such as the owner-occupied housing rate. However, although it may reduce the degree of labour mobility, it is implausible that this variable could play a leading role in determining the profile of the natural rate. Instead, it is likely that it is simply capturing the upward trend in *actual* unemployment over most of the sample period in response to exogenous shocks.

The lack of robustness of these results is consistent with the findings of some other recent studies that have tried to explain the path of the natural rate of unemployment with movements in structural variables. In general, these studies have had poor results, no doubt partly reflecting the difficulties of measuring the key underlying structural influences on unemployment. It should be stressed that this does not necessarily imply that the NAIRU does not exist. Rather, it indicates that it is difficult to estimate it accurately using this approach and to explain movements in the NAIRU using data on structural variables in the United Kingdom. As a result, less structural estimation methods should be explored. A recent OECD study that reviewed alternative methods for estimating the natural rate of unemployment found that reduced-form Phillips curve models based on a Kalman filter approach tend to produce more robust and plausible estimates than models based on structural variables. While still imposing a minimum theoretical structure, the Kalman filter models are more transparent, have more limited data requirements and are likely to be more robust to specification errors than the structural approach. Therefore, we believe that future work aiming to estimate the NAIRU should concentrate on these reduced-form techniques.

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Appendix 1
Unit root tests

Variable	t_{ct}	t_c	f_3	Conclusion
Unemployment rate	-2.36	-2.00	3.24	I(1)
Replacement ratio (OECD)	-2.44	-0.34	3.15	I(1)
Replacement ratio (Bank)	-2.30	-0.54	4.37	I(1)
Union density	-0.68	-0.41	1.61	I(1)
Unemployment dispersion (Absolute)	-2.13	-2.24	2.45	I(1)
Unemployment dispersion (Relative)	-1.46	-1.45	1.49	I(1)
Owner-occupied housing rate	-2.86	-0.29	4.08	I(1)
Skills mismatch	-1.75	-1.94	1.90	I(1)
Industrial turbulence index	-6.98**	-6.36**	24.37**	I(0)
15-24 year olds as % of population	-2.40	-2.46	3.29	I(1)/I(2)?
Demographic unemployment rate proxy	0.22	-2.02	2.77	I(1)
Self-employed as % of total employment	-1.83	-0.83	1.68	I(1)
Imports as % of real GDP	-0.27	2.57	3.70	I(1)
Private sector emp as % of total employment	-0.80	-0.19	3.06	I(1)
Real interest rate 1 = Building Soc rate – RPI	-2.60	-2.38	3.44	I(1)
Real interest rate 2 = Building Soc rate - CPI	-2.56	-2.37	3.48	I(1)
Real interest rate 3 = Treasury Bill rate - RPI	-3.20*	-2.80*	5.14	I(1) / I(0)
Real interest rate 4 = Treasury Bill rate - CPI	-3.23*	-2.80*	5.38	I(1) / I(0)
Tax wedge	-1.74	-2.54	3.16	I(1)
Import price wedge	-1.79	-0.69	1.84	I(1)
Real oil price	-2.11	-1.90	2.34	I(1)

* denotes significant at 10% critical value.
** denotes significant at 1% critical value.

Based on critical values for t-tests for models with both constant and trend (t_{ct}) and only constant (t_c) are from Davidson and MacKinnon (1993). Critical values for the joint test of unit root and trend (f_3) are from Dickey and Fuller (1981). Lags lengths for ADF tests were chosen by deleting insignificant lags in a general to specific search.

Appendix 2
Johansen cointegration tests for baseline equation
Sample: 1960-98
Series: ln(U), UNION, ln(RRBANK), REALR1, OOR
(Assumes linear deterministic trend in the data, 1 lag)

Hypothesised no. of cointegrating vectors	Uncorrected likelihood ratio test	Corrected likelihood ratio test
None	88.93**	76.22**
At most 1	53.57*	45.91
At most 2	30.68*	26.30
At most 3	15.16	12.99
At most 4	6.28*	5.38*
Conclusion	3 cointegrating vectors at 5% significance level	1 cointegrating vector at 5% significance level

Cointegrating vector: (t-statistics in parentheses)

ln(U) = 12.57UNION + 1.70ln(RRBANK) + 0.14REALR1 + 0.13OOR
(6.98) (1.65) (7.0) (10.0)

Definitions: U = unemployment rate, UNION = union density, RRBANK = replacement ratio (bank estimate), REALR1 = real interest rate = building society interest rate - RPI , OOR = owner-occupied housing rate.
Correction for small sample based on Reimers (1992). Likelihood ratio statistic is multiplied by (T-nk)/T, where T = number of observations, n = number of variables and k = number of lags in the VAR.

Appendix 3
Summary of regression specifications tested

Union	Replacement ratio	Mismatch	Self-employment	Product market competition	Demographics	Real interest rate	Wedges
·	·	·				●	3 ΔPr
·	·	·	·				3 ΔPr
·	·	·		·		●	3 ΔPr
·	·	·		·			2 ΔPr
·	·	·	·				3 2 ΔPr 3 ΔPr
·	·	·	·				3 ΔPr
·	·	·			·		3 ΔPr
·		·		·			3 ΔPr
·		·	·		·		3 ΔPr
·	·	·				●	OIL 2 ΔPr
·	·	·	·				OIL 2 ΔPr
·		·	·				OIL 2 ΔPr
·		·		·		●	OIL 2 ΔPr
·	·	·			·		OIL 2 ΔPr

'•' denotes that a variable is included in the regression.
Under Wedge, the number indicates the number of wedge variables included (import prices, taxes and oil prices), 'ΔPr' indicates that the change in productivity is included too, 'OIL' indicates that oil prices are included in levels.