

Research Technical Paper
**Wage Inflation and Structural Unemployment in
Ireland**

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Abstract

In this paper we represent structural unemployment by relating observed unemployment to wage inflation. An estimated series for the non-accelerating wage rate of unemployment (NAWRU) shows that the unemployment gap between observed unemployment and the structural rate provides an intuitive account of prevailing aggregate demand conditions within the Irish economy over the period 1980 to 2005. This indicates that the estimated NAWRU series is a good measure of Irish structural unemployment over the period. The estimated NAWRU was at a high level throughout the 1980s and declined over time such that any excess labour slack was dissipated by the mid-1990s. Between 1994 and 2001, the observed unemployment rate was below the estimated NAWRU indicating that the substantial inflationary pressure on wages was justified for the period. Since then, the gap between the estimate of the structural rate and observed rates of unemployment was not that substantial and reflects a healthier situation vis-à-vis wage inflationary pressure. The situation may have been helped by significant inward migration and productivity increases becoming embedded in the Irish economy.

JEL Classifications: E24, E31, C13, C22

Keywords: Wage Inflation, Unemployment, Productivity

Non Technical Summary

This paper uses an advanced econometric technique to extract a historical data series known as the structural rate of unemployment that cannot be observed directly. This "full employment" unemployment rate is sometimes termed the "inflation-threshold unemployment rate": if actual unemployment falls below the structural rate, the inflation rate is likely to rise quickly. Unexpected inflation might allow unemployment to fall below the natural rate by temporarily depressing real wages, but this effect would dissipate once expectations about inflation were corrected. Only with continuously accelerating inflation could rates of unemployment below the natural rate be maintained. The structural rate is derived from the Phillips Curve after Phillips (1958) first observed that there was a negative empirical relationship between the unemployment rate and inflation.

In terms of output, the structural rate of unemployment corresponds to potential output, the highest level of real gross domestic product that can be sustained at any one time. It reflects the fundamental labour capacity and productive potential of an economy. It is a very important indicator for macroeconomic modelling and is used widely, for example in the CBFSAI macroeconomic model.

This paper uses a semi-structural model which does not imply a commitment to any particular theoretical explanation. Most importantly, the method can capture the

principle that the rate would not be stable over time reflecting the fact that fundamental and longterm conditions in the economy change – most pertinently during the Celtic Tiger era. A methodological extension to previous studies includes the inclusion of an aggregate productivity measure in our estimation for Ireland. As unemployment rates fell in buoyant economic conditions, aggregate productivity reflected an improvement in the skill set of the labour force and more effective use of capital. We refer to this as ‘reverse hysteresis’.

The paper is structured into six sections. After an introduction to the paper, wage inflation and observed unemployment are charted since 1980. A joint estimation of the structural rate, the unemployment gap and productivity (while controlling for other shock factors known to affect wage inflation) is undertaken to produce a representation of the path of the Irish structural rate. As expected, the external trade environment is also found to significantly affect wage inflation conditions. Changes in the structural rate of Irish unemployment are found to be less dramatic compared with changes in the overall unemployment rate.

The paper then discusses the findings in terms of three distinct historical phases of wage inflation and structural unemployment pressures in Ireland. First, between 1980 and 1994, the structural unemployment rate declined due to excess labour slack and associated net emigration. Second, the structural rate is then shown to have declined faster than the observed unemployment rate between 1994 and 2002. We relate this to productivity increases becoming embedded in our economy not least due to significant FDI (imported capital and labour productivity gains) and successive wage bargaining rounds. A third phase between 2002 and 2005 shows a zero or slightly negative unemployment gap i.e. the labour market had a higher rate of employment than that dictated by labour market capacity. Significant inward migration can explain the absence of a substantial adverse wage-inflationary reaction.

The paper concludes that productivity-driven competitiveness is key to keeping wage inflation in line with the labour capacity in our economy. We have found evidence that the rate of structural unemployment ‘bottomed-out’ and became stable at historically low levels. Recent observations of cyclical increases in observed unemployment, bringing back a positive unemployment gap, should translate into a easing of the inflationary pressure on wages.

1: Introduction

The notion of a structural rate of unemployment is central to prevalent economic theories explaining labour market behaviour and the relationship between unemployment and inflation. The observed unemployment rate is decomposed into its trend and cyclical elements. The trend component, identified as the structural rate of unemployment plays a key role in the determination of the output gap and thereby the assessment of economic sustainability. As such, the structural rate indicates the rate of unemployment that, based on the actual history of unemployment, would be associated with a constant rate of nominal wage increases. In general, medium-term analysis and projections rely on pinpointing policies that will close the output gap over the medium term.

Structural unemployment estimates, dependent on a measure for inflation, are somewhat problematic for a small open economy having undergone significant economic growth and engaged in a common currency. Foreign prices due to our open economy position play a huge role in our inflation measurements. However, we will assume that domestically generated inflationary pressures for Ireland show up mainly in wages. At the same time, wages which typically represent the majority share of production costs, are widely regarded as the principal factor determining the competitiveness and export share of a small open economy.² It is timely to study the effects and determinants of wage inflation in Ireland and examine specifically its response to aggregate demand pressures – measured by the slack in the labour market or the gap between observed unemployment and the structural rate of unemployment over the period 1980 to 2005.

Central Banks frequently use empirical estimates of the structural rate of unemployment measured by the non-accelerating inflation rate of unemployment (the NAIRU). As a measure of the unemployment rate at which wage growth is stable, a measure of the structural rate of unemployment is vital in the calculation of the output gap. However, the structural rate and associated unemployment gap cannot be

² This is particularly true when the exchange rate instrument, an effective mechanism for improving international competitiveness, is no longer available (FitzGerald, 2001).

observed directly despite serving as an important input into various assessments of inflationary pressures, fiscal positions and structural issues.³

This paper employs a Kalman filter estimate of unobserved states to measure a quarterly NAWRU for Ireland – the rate of unemployment at which *wage* inflation is stable. The NAWRU indicator is based on the idea that actual unemployment below structural unemployment is associated with inflation above its expected value. This method, similar to that employed by Richardson *et al.* (2000) and Laubach (2001) is used to identify how the Irish economy since 1980 has successfully achieved a reduction in the NAWRU. The method has the advantage of considering the unobserved structural rate of unemployment as a time-varying variable. In applying the Kalman filter, this approach extends previous studies by inserting productivity as a cointegrating variable with the unemployment gap for Ireland; testing a Stock and Watson (1998) procedure to estimate the signal-to-noise ratio instead of taking standardised, rule-of-thumb measures; as well as making use of Irish quarterly data up to the end of 2005.

The novel approach of applying the Kalman filter technique with an explicit exogenous variable, such as aggregate productivity, allows us to isolate aggregate productivity changes from changes in the unemployment gap. As unemployment falls, a shift in cyclical employment associated with higher effective demand (narrowing labour market slack) is significantly aided by total factor productivity (TFP) (McQuinn and Whelan, 2006). At the same time, an improvement in the skill set of the labour force or more effective use of capital (capital deepening) changes the structural rate of unemployment such that there could be an actual reduction in the inflationary pressures associated with any given level of unemployment in the long run.

The paper is structured as follows: the next section outlines indicators of wage inflation and unemployment since 1980 which suggest that *a priori* that labour market structural conditions have changed over the period. This would require that the

³ The concept of structural unemployment is also central to the estimation of the ‘sacrifice ratio’, which takes the increase in unemployment above its equilibrium level as the cost of squeezing inflation out of the economy. However, the relevance of a rise in unemployment to price disinflation in a small open economy is weak (Walsh, 2000).

NAWRU could not have been constant for the duration to 2005 and requires a time-varying model to capture the NAWRU. Section 3 outlines alternative approaches to estimating a structural rate of unemployment. We conclude that a semi-structural approach modelled as an unobserved components model with a Kalman filter, allowing for productivity movements generates a good representation of the structural rate in an Irish context. The empirical results are outlined in Section 4 and discussed in Section 5. A concluding section follows.

2: The Irish Labour market

Labour cost is primarily measured with a unit labour cost measure of earnings at an aggregate level. On that basis, annual nominal wage inflation in Ireland has eased from rates in excess of 15 per cent in the early 1980s. Figure 1 shows an average of 5.3 percent for 2004 following a peak of 9 per cent in quarters 2 and 3 in 2000 with further moderation having occurred since.⁴

Against a backdrop of buoyant labour demand up until 2007, forecasts suggested that aggregate wage inflation was unlikely to fall below 4 per cent but the detailed picture at industry level shows that the trend was by no means uniform. Nominal earnings growth in building and construction continued to outpace the manufacturing wage rate, however recent indications report a reversal of this trend. Given the change in the structure of employment in this mostly domestically traded sector, the trend clearly implies that migration inflows had begun to dampen cyclical wage pressures before the end of 2005.

⁴ There is the potential for differences between the traded and non-traded sectors of the Irish economy: the quarterly manufacturing wage rate should broadly represent the former while the hourly wage rate in the Building and Construction sector was also tested to see if wage inflation in non-traded sectors was significantly different.

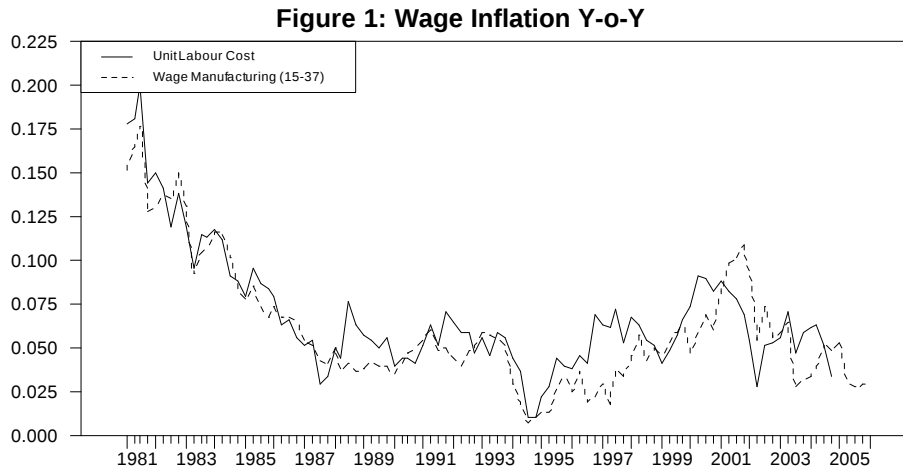
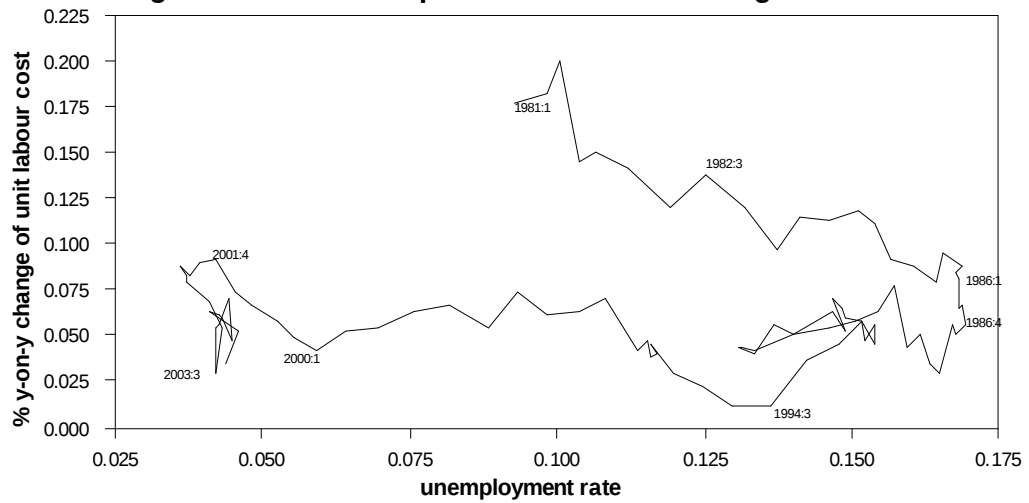


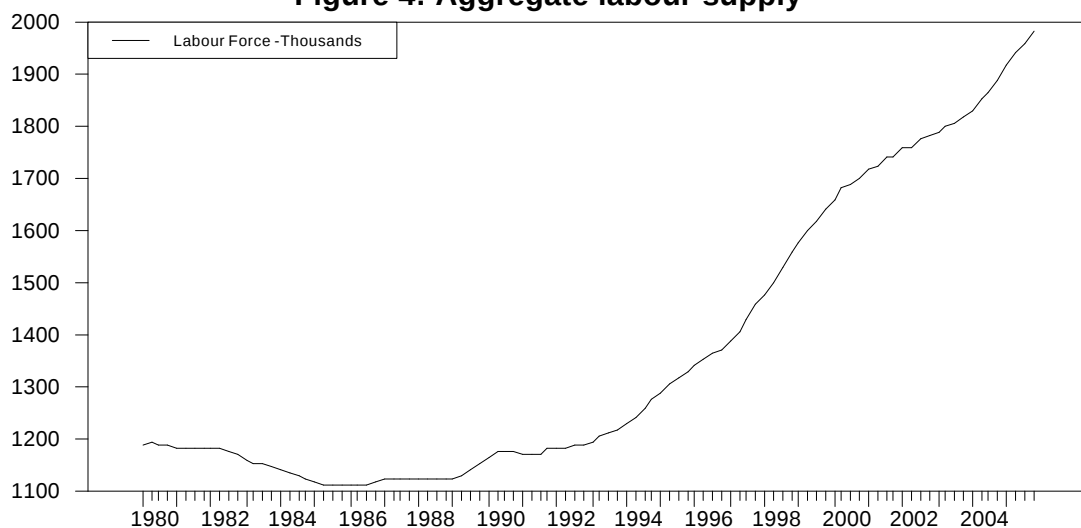
Figure 2 charts the recorded Irish unemployment rate between 1980 and 2005. The sharp decline in the Irish unemployment rate since the ‘twin peaks’ of 1986 and 1994 occurred quite suddenly until 2000. Since 2000 the rate stabilised at less than 5 per cent. This implies a Phillips curve over the period 1980 to 2005 with at least three different slopes. This is charted in Figure 3 which shows a strong negative slope between 1980 and 1994 with a flatter (albeit still negative) slope between 1994 and 2000. Since 2000, the Phillips curve is showing signs of having a vertical characterisation.

Figure 3: Irish Phillips Curve based on Wage Inflation



As a result, it is plausible to assume that the structural rate of unemployment may well have shifted many times during the past two and a half decades. During the early 1980s wage inflation was historically unstable, albeit on a downward trend; at the same time the unemployment rate was increasing. By the mid 1980s the unemployment rate had reached in excess of 15 per cent but wage inflation had stabilised. In recent years, the wage inflation rate appears less stable and is allied with an unemployment rate remaining consistently below the 5 per cent level.

Figure 4: Aggregate labour supply



Ireland has witnessed large changes in total labour supply and participation in recent years. Figure 4 shows the extent of the increases in labour supply over the period. However, the NAWRU is neutral with respect to the size of the labour force and the level of participation rates in the labour force. While an increase in labour supply (participation or inward migration) may increase the unemployment rate in the first instance, wage setting should imply that inflationary pressures fall. This is reflected by the cyclical component of unemployment and there is no reason to suppose that the NAWRU will change as a result, other than in the short-run. The long-run NAWRU is unaffected because any rise in labour supply needs to be matched by an equal rise in labour demand, employment and output to keep inflation steady. Increased participation and/or inward migration, in terms of its impact on the NAWRU, is therefore analogous to productivity growth.

3: Deriving estimates of Structural Unemployment

At the empirical level,⁵ it has been difficult to achieve robust estimates of the unobserved rate of structural unemployment as its measurement is far from uncontroversial. There are three main explanations for the large degree of uncertainty in estimates of the NAIRU/NAWRU:

- Different measurement methodologies for measuring the NAIRU and not knowing the correct parameters of the model (as with any econometric estimation) lead to important divergences in estimates.
- The potentially stochastic random nature of the NAIRU/NAWRU means that it may well differ in the short, medium and the long-term. Moreover, the equilibrium rate of unemployment may have changed in several instances through time.
- Most models require an estimate of inflationary expectations to explain inertia in wages and prices. Often, expectations are set equal to the previous period's wage/price inflation so $\Delta w_t^e = \Delta w_{t-1}$. Other options are to use survey methods of wage expectations or some other moving average function of previous rates.

⁵ We only refer to recent theoretical debates affecting the NAIRU in passing as the focus of this paper is on deriving an empirical estimate of the natural rate (see Fabiani and Mestre, 2000; McAdam and Mc Morrow, 1999 for a full discussion of the New Keynesian Phillips Curve).

Very often using alternative expectations mechanisms can lead to different structural rate estimates.

As such, there are a number of different techniques that could be used to measure a NAWRU. This section briefly discusses the commonly used techniques and explains why this study concentrates on a multivariate filtering approach adopted later.

3.1 Structural models

The most information-complete method to derive the NAIRU is to use a structural model where the NAIRU is the equilibrium of a model of aggregate wage and price setting behaviours (see for example, Layard *et al.*, 1991, Phelps, 1994). These models usually assume full adjustment of firms and workers to all shocks so the derived equilibrium measure of unemployment corresponds most closely to the long-run equilibrium rate of unemployment.⁶ The key advantage of structural models is that they provide more information on the determinants of the NAIRU, as well as its level, and are based on a theoretical framework that explains how macroeconomic shocks and policy instruments impact on the long-term equilibrium rate of unemployment. However, the use of structural models in this context faces a number of significant drawbacks: they cannot be calculated in a timely manner; they face a number of challenging econometric and measurement issues and generally lack parsimony; and, they rely on assumptions about underlying behaviour of economic agents for which there is no consensus (Richardson *et al.*, 2000).

3.2 The reduced form approach

A second group of methods also analyses the role of the unemployment gap at explaining inflation. These are typically a reduced-form expectations-augmented Phillips Curve. Elmeskov (1993) originally used a simplified version of this approach in a NAWRU setting. It also allows one to control for a range of factors wider than the inflation/ unemployment relationship. For these reasons, the reduced form approach is, arguably, the most popular technique in recent studies. However, the reduced form approach also has a number of disadvantages: it requires some form of

⁶ The natural rate hypothesis by Friedman (1968) and Phelps (1968) is that there is some natural or normal (structural) rate of unemployment that is determined by real not nominal forces below which ... any short-term improvements relative to the NAIRU resulting from stimulatory monetary policy will be accompanied by higher rates of inflation.

estimation of inflation expectations; it is atheoretical which has the advantage of not relying on assumptions about behaviour. It leaves the interaction between unemployment and inflation indeterminate but the approach requires an estimate or proxy of the natural rate as a starting-point.

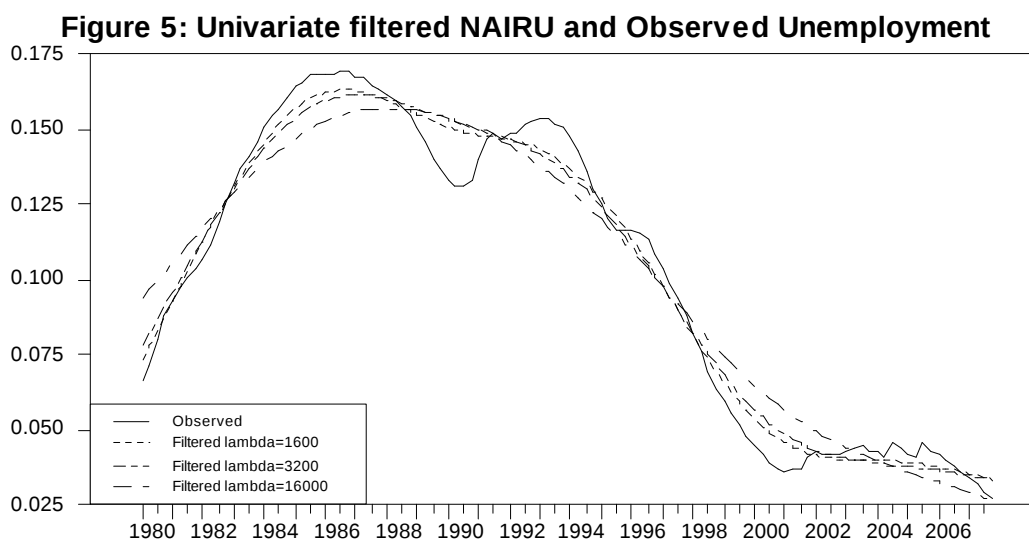
3.3 Pure statistical models – univariate estimation

Pure statistical models have the advantage of being timely and relatively easy to calculate. In order to define the NAIRU, only information on the singular behaviour of the observed rate of unemployment is required. The unemployment rate is decomposed into a permanent (in general, non-stationary) and transitory (stationary, capturing business-cycle fluctuations) elements. Under this approach the permanent component in observed unemployment is identified as the NAIRU.

While univariate statistical methods allow indicators of trend unemployment to be estimated in a timely and consistent way, there is no theoretical framework or economic structure underlying the filtering technique as they are based on just one behavioural equation without taking any information on inflation into account. As a result, they are not particularly useful from a policy analysis perspective in the context of scenario analysis where the specific impact of a variable on the structural level can be analysed.

One of the more commonly used filtering methods - the Hodrick-Prescott filter - identifies the permanent component as a weighted moving average of lags and leads of the observed data on the employment rate. The span of the moving average has to be selected, which in turn affects the degree of smoothing that identifies the trend component of unemployment.⁷ However, the specific problem of the (undue) influence of the end-point is raised when recent observations become disproportionately influential. It often happens that these could be substantially modified with new information – revisions or extensions of the actual data series. A standard smoothness parameter ($\lambda = 1600$) aims to eliminate the cyclical element between two and eight years from time t or 24 and 32 quarters.

⁷ The H-P filter removes the high frequency components when calculating the deviations from trend (but the noisy or even the seasonal terms could still be present).



Using data for the observed unemployment rate, Figure 5 shows that the filtered series (representing the NAIRU) is extremely dependent on the structure of the observed unemployment data. Further, a higher lambda (curvature parameter) produces filtered results that are strikingly similar to the default smoothness level. Most of the filters behave like simple moving averages and so perform poorly if there are sudden or large changes in the unemployment rate, such as that experienced in the Irish context. It is assumed that underlying (but unspecified) forces/mechanisms drive unemployment back to its trend NAIRU rate after a shock and that those fluctuations around the trend are temporary.

3.4 Multivariate filtering approach

Finally, the so-called “semi-structural methods” involves an advantageous hybrid of the two previous groups of methodologies but has the advantage of estimating both elements simultaneously. The models take ‘economic information’ on board as well as filtering to identify a time-varying path for the NAIRU, without requiring specific information of its determinants (OECD:2000:5). Moreover, this approach provides timely estimates and remains consistent with a variety of structural approaches, leaving aside theoretical debates concerning their form and for these reasons we proceed with employing such an approach in the Irish context.

In empirical operation, the method simultaneously minimises the squared unemployment gap subject to a smoothness constraint (from a Kalman (1960) filter)

and a goodness-of-fit restriction from the Phillips curve framework.⁸ It is possible to generate standard errors for the NAWRU estimates as a maximum likelihood estimation method is used (see Staiger *et al.*, 1997).

4: Estimation and results

In this section we proceed with the semi-structural approach and present the results of an unobserved components model, made popular by Gordon (1997). Inflation is assumed to depend only on nominal factors in the long run (i.e. the coefficients of lagged inflation are constrained to add up to unity). This long-run nominal homogeneity restriction allows the Phillips curve to be expressed in terms of the first difference of inflation and guarantees the existence of an equilibrium value for unemployment. This unobserved component (the unemployment gap) is treated as endogenous and estimated simultaneously with the parameters of the Phillips curve.

4.1 Estimation procedure

The model must be written in state-space form⁹ and allows one to undertake the simultaneous maximum likelihood estimation of the Phillips curve equation together with the smoothing of the transition equation with a Kalman filter. (For more detail on the Kalman filter, see Harvey 1990).

The specification used follows the basic model used by the Bank of England (Greenslade *et al.*, 2003). Their model is extended to allow the inclusion of an the additional TFP term:

$$\Delta w_t = r(L)(u_t - u_t^*) + a(L)(\Delta p_{t-1}) + q(L)TFP + b(L)X_t + e_t^{\Delta p} \quad (1)$$

⁸ This is done via a prediction error decomposition method (Harvey, 1990, p100). The Kalman filter is a recursive procedure for computing the optimal estimator of the state vector at time t , based on information up to and including time t and the filter enables the estimate of the state vector to be continually updated as new observations become available. All observations – the full information set – are used for the smoothing process.

⁹ A state-space model is one in which an observed variable is the sum of a linear function of the state (unobserved) state variable plus an error. The state variable, in turn, evolves according to an equation that depends on parameters in economic applications that are generally unknown and must be inferred from the data. State-space form describes the way in which the equations are set up for analysis in matrix form such that the model appears as only two equations: a state equation and a measurement equation [Kim and Nelson:1999:29]. See appendix A for details of how we set up our state-space formulation.

$$\text{with } e_t^{\Delta p} = N(0, s_{\Delta p})^2$$

$$u_t^* = u_{t-1}^* + e_t^{u^*} \quad (2)$$

$$e_t^{u^*} = N(0, s_{u^*}^2) \text{ and } \text{cov}(e_t^{\Delta p}, e_t^{u^*}) = 0$$

$$u_t^* - u_t = d_1(u_{t-1}^* - u_{t-1}) + d_2(u_{t-2}^* - u_{t-2}) + e_t^{gap}$$

Equation (1), the measurement equation, is a standard triangular Phillips curve and models the change in wage inflation $(\Delta w_t)^{10}$ as a function of temporary supply shocks (X_t) ; the NAWRU (u_t^*) and the unemployment gap $(u_{t-1} - u_{t-1}^*)$, the difference between the first lags of the NAWRU and the observed unemployment rate. The NAWRU measures the unobserved structural rate of unemployment and is the state variable that must be extracted from the data because it cannot be observed directly. It is by definition time varying in this instance and is assumed to follow a random walk.

Productivity is measured with an exogenous filtered measure of total factor productivity as a Solow residual from a growth accounting exercise (McQuinn and Whelan, 2006). In this way we specifically test for productivity persistence or reverse hysteresis in the effect of productivity shocks. Empirically, we will initially test lagged nominal wage growth and contemporaneous and lagged price inflation in order to capture the process of expectation formation and inertia effects observed in virtually all inflation rate time series (Mankiw, 2000). Downward wage rigidity is thus assumed and implies a more realistic dynamic behaviour of wage adjustment (Whelan, 2002).

Unit root tests for stationarity reveal that Irish wage inflation rate is an $I(1)$ series and only its first differences follow an $I(0)$ process. The model is expressed as year-on-year wage inflation *changes* (wage inflation levels could be influenced by short-run nominal facts absent from the specification). Inflation changes in Equation (1) are assumed to be explained by the lagged unemployment gap $(u_t - u_t^*)$ to proxy

¹⁰ This is a way of imposing dynamic homogeneity, disentangling the NAIRU from nominal factors, to ensure a meaningful structural rate. Another way it can be imposed is to model wage inflation in levels but impose the sum of lagged inflation terms to be equal to one.

aggregate demand pressures in the economy exerting pressure on wages. Lagged inflation/inflation expectations pick up any inertia effect.

Equation (1) includes a set of variables X_t that may proxy for shocks that affect inflation in addition to demand and labour market pressure – namely supply-shocks. Here we will test the import deflator, oil prices and changes in the sterling exchange rate to catch changes in trade conditions as well as relative changes in UK wage rates.¹¹

Productivity is known to have important and long-lasting supply-shock effect on wage expectations and its inclusion is hypothesised to have a significant effect on employment separation and vacancy rates, *ceteris paribus*, in the Irish context. Aggregate productivity growth (TFP) is also added as an exogenous shock.¹² Typically lagged values of productivity growth appeared to be insignificant in the model tested, though this was not the case for the change in productivity growth.¹³

The state or transition equation, Equation (2), follows the seminal unobserved components model in Watson (1986) as it decomposes the actual unemployment rate into the trend component – the NAIRU – and the remaining cyclical unemployment gap. Equations (3) and (4) specify the trend and cyclical unemployment in the form needed to set up a State Space model (see Appendix 1 for a detailed description of the State Space Model). The (cyclical) unemployment gap is modelled as a stationary autoregressive process of order 2,¹⁴ which is the assumption made in Watson (1986) and Kuttner (1994) when using an unobserved components model to estimate the output gap. Other authors who have used this specification for the unemployment gap include Apel and Jansson (1999) and Laubach (2001).

¹¹ The null hypothesis of no cointegrating vectors between these variables is rejected at the 95% confidence level.

¹² Based on the f-statistic for a cointegrating relationship, the null hypothesis that there is no long-run relationship between unemployment and earnings could not be rejected but the null hypothesis of a relationship between earnings and total factor productivity is.

¹³ This specification implies a fast pass-through from productivity to earnings.

¹⁴ In such an AR(2) process the value of the unemployment gap depends on its values in the previous 2 periods and a disturbance term with mean zero. This approach makes it possible to model the NAWRU as an I(2) variable and is more general than the random walk approach (with one lag with or without drift). A constant cannot be estimated for the NAWRU equation i.e. the program sets

$E(u_t - u^*_t) = 0$ implying that the unemployment gap oscillates around zero.

The NAWRU is assumed to change over time according to a random walk following Gordon (1997). This is a standard assumption in the literature. As pointed out by Laubach (2001), the assumption that the NAIRU follows a random walk will conveniently work for the US but must be carefully considered for European countries where NAIRUs tended to follow an $I(2)$ process. The assumption of the first order autoregressive process for developments in the NAWRU is of particular interest in an Irish context as it provides evidence of how slowly the NAWRU adjusts to long lasting supply shocks, such as productivity changes.

Unobserved components models universally assume that the random exogenous events or ‘noise’ $(e_t^{\Delta p}, e_t^{u^*}, e_t^{gap})$ are *iid*, normally distributed and assumed to have mean zero and constant variances. As such, a Kalman filter can compute a log-likelihood function that allows estimation of the error parameters using the maximum likelihood method. The ratio of the variance of the two error terms $(s_{\Delta p}^2 / s_{u^*}^2)$ is the signal-to-noise ratio, reflecting the assumption that the NAWRU is determined by structural factors that evolve gradually over time. Past studies have tended to arbitrarily select the signal-to-noise ratio, but this paper applies Stock and Watson’s (1998) endogenous estimation to determine the signal-to-noise ratio.

4.2 Stock and Watson innovation

The signal-to-noise ratio s_h measures the volatility in the NAWRU in relation to volatility in wage inflation and so determines the smoothness of the estimated series. The standard approach is to *impose* a low value for s_h proposing that any changes in the unobserved structural rate are likely to be driven by structural changes in the labour market i.e. capturing the principle that the labour market evolves slowly.

Others have found that when the smoothness parameter for the unobserved structural rate is estimated endogenously, it has led to unsatisfactory results because the NAIRUs produced are very small and follow the observed unemployment rate almost identically. Stock (1999) and Stock and Watson (1999) found that when the true variances of (non-stationary) unobserved variables are small, the estimation can find a

corner solution involving no fluctuations in the unobserved variable. This is why many applications tended to fix the variance of the unobserved NAIRU or alternatively choose a set noise-to-signal ratio. By not exogenously restricting the standard deviation on the noise term in the NAIRU random walk ($s_{u^*}^2$), the standard deviation here is estimated as part of the likelihood estimation as per Stock and Watson (1998).

Initial values had to be chosen for the parameters of the model. As a general rule, these should be as close as possible to the true values to ensure that the optimisation process will converge. The starting values chosen in this application were similar to those of Greenslade *et al* (2003). The results achieved proved very robust to the levels of these starting values.

All the estimates shown in this paper are *smoothed* NAWRU estimates (which use the full information set) rather than *filtered* estimates (which only use the information available at the time that the forecast was made).

4.3 Estimation Results

Table 1 below shows the results of estimating a model for wage inflation for the period 1980 to 2005. A general-to-specific estimation strategy was employed testing (omitting insignificant exogenous control variables). Final regressors were the current value of the unemployment gap (the ‘aggregate demand’ effect), lagged annual price inflation (core HICP) capturing inertia in the real wage effect and a lagged change in the quarterly sterling exchange rate reflecting external trade conditions. It is hypothesised that this variable also captures any change in the short-term UK unemployment gap relative to Ireland’s, as the UK was traditionally the main comparator for workers considering migration. The top section of the table gives the estimated coefficients for the state equation where the key dependent variable is the current unemployment gap. The results show a strong negative persistence between the first lag of the unemployment gap and the current gap, which has substantially diminished by the second lag.

The second panel of the results table shows the observation equation (Phillips curve) and reports that the changes in wage inflation are negatively correlated with the estimated unemployment gap. Since there is at least one lag, the effect of the change in the demand variable (the unemployment gap) on inflation is automatically captured (see Gordon (1997, page 16)).¹⁵ We can say that up to 40 per cent of the estimated unemployment gap could “explain” the variation in wage inflation immediately.

Table 1: Output of the Kalman Filter estimate with TFP as exogenous variable

Maximum Likelihood estimates and Statistics				
Sample: 1982:3-2005:4 (95 obs.)				
Variables		Coefficients	s.e.	t-stat
<i>State equation</i>				
AR(1) uegap	d_1	-0.7777	0.0050	6.05647****
AR(2) uegap	d_2	-0.0325	0.0217	1.4964*
Var(e^{nairu})	$s_{u^*}^2$	-0.0000	--	--
<i>Phillips Curve (Measurement equation)</i>				
Intercept		3.0875	0.0095	23.7208****
$u_t - u_t^*$	r_1	-0.4019	0.0015	-5.4348****
$u_{t-1} - u_{t-1}^*$	r_2	-0.6878	0.0010	-8.7675****
p_{t-1}^{yoy}	a_1	1.0020	0.9238	1.0846
Δw_{t-1}	a_2	-0.0276	0.1099	-0.2511
ΔTFP_{t-1}	q	0.6408	1.7831	2.4041*
ΔGBP_{t-1}	b_{er}	0.0442	0.0248	1.7831*
Var($e^{Phillips}$)	$s_{\Delta p}^2$	-0.0001	--	--
Log likelihood		191.0815		

Variables:

Δw_{t-1} : First lag of the dependent variable

p^{yoy} : year on year inflation in core HICP in %

TFP: Year on year growth in % of TFP (HP smoothed)

GBP: Quarterly sterling exchange rate

Δ : 1st difference ($\Delta X_t = X_t - X_{t-1}$)

All variables are seasonally adjusted. Interpolated quarterly data pre 1995.

¹⁵ More than two lags of the cyclical fluctuation term i.e. the unemployment gap were tested but only two lags turned out to be significant with their sum slightly greater than 1.

The results show that the external trade environment in an Irish context is an important shock variable affecting wage inflation conditions. It is captured by changes in the sterling-Irish pound/Euro exchange rate.¹⁶

The productivity effect shown by the first difference in the lagged TFP variable shows that unemployment dynamics are not the only reason for changes in the wage inflation rate. Irish wage inflation rates appear to have been at least partially justified by economy-wide increases in total factor productivity – all else equal. Rapid productivity growth raises the marginal productivity of new jobs, affects vacancies and lowers the equilibrium unemployment rate – a so-called ‘capitalisation’ effect. Secondly, rapid productivity growth tends to increase future real wages, perhaps making workers less inclined to press for higher wages now. As the value of the incumbent worker is raised in the current period, faster productivity growth comes at the expense of labour downsizing and other ‘creative destruction’ mechanisms (Davis *et al.*, 1996).

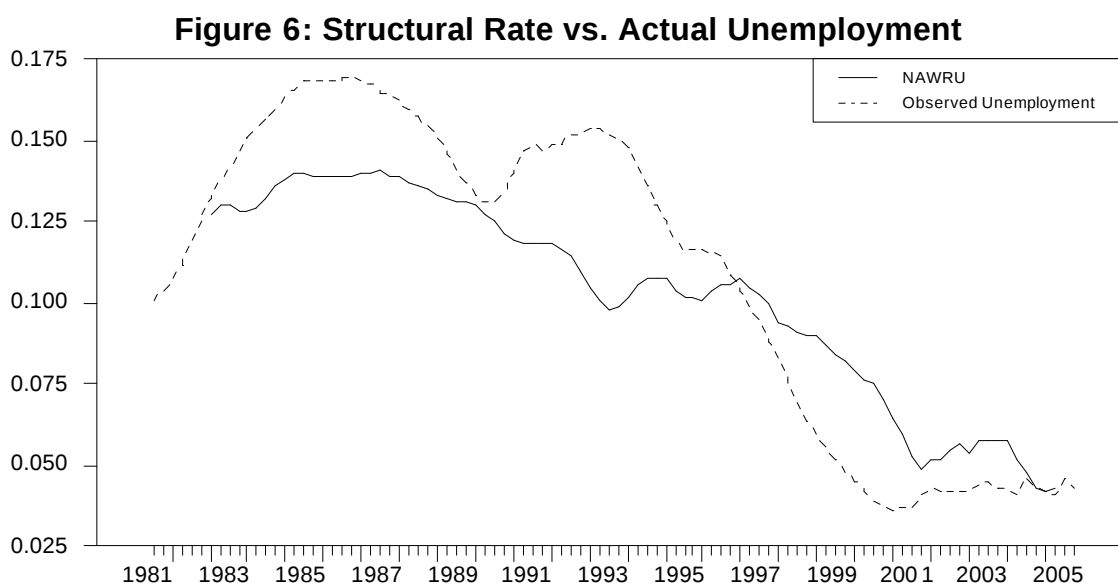
4.4 Derived structural rate estimates

Figure 6 below presents the NAWRU estimates and the implied unemployment gap for the period under consideration.¹⁷ The AR(2) process of the unobserved state equation appears to have very good explanatory power and did not produce a NAWRU which mirrors the observed actual employment rate i.e. a meaningful unemployment gap is observed. Changes in the NAWRU occur at a lower frequency compared with changes in the overall unemployment rate that is made up of both structural and cyclical elements. In turn, the unemployment gap captures factors affecting the cyclical unemployment in the labour market and determines the level of labour market slack (the aggregate demand effect). The Kalman estimates of the NAWRU, thus, yields plausible results indicating that the method captures the econometric properties of the NAIRU quite well. Significant improvements in the goodness-of-fit were observed only when productivity was included.¹⁸

¹⁶ Other temporary supply shocks affecting inflation generally which could have been represented by real import prices or oil prices have been superseded by the exchange rate effect in the estimation and were dropped from our general specification of the observation equation.

¹⁷ As expected, the structural estimates are correlated with but since 2001 are not as stable as the long term unemployment rate; see http://www.cso.ie/qnhs/documents/table_16_post_census.xls

¹⁸ As a robustness check, we tested the goodness-of-fit of our results by placing the Kalman Filter NAWRUs obtained into an OLS estimation of wage inflation and compared it to the NAIRU estimates



Accurate estimates of the structural unemployment rate are essential from an efficient policy-making perspective. Over optimistic evaluations of potential reductions in the NAIRU would lead to an over-estimation of potential and actual growth performance for an economy. In the short-term, the structural rate of unemployment could fall but a permanent shift depends on the persistence effects of shocks. More significantly, it is the gap between the structural rate and the actual rate that proves to be the best indicator of labour market reform and performance generally. The unemployment gap can be maintained for a substantial period of time before equilibrium forces move to close it – we find this time span to be 5 to 6 years for three separate episodes of noted unemployment gaps over the past 25 years.

Figure 3 suggests at least three distinct historical phases in wage inflation and structural unemployment pressures in Ireland.

- First, the coincidence of declines in the unemployment rate combined with a positive wage inflation rate between 1980 and 1994 was due solely to excess labour slack. FitzGerald and Hore (2002) hold the view that outward migration played the most prominent role for the cyclical nature of unemployment but

obtained by the Hodrick-Prescott filter estimates (Figure 5) using adjusted R^2 and Akaike and Schwartz information criteria. The results showed that our Kalman Filter estimates of the structural rate of unemployment were much more informative.

only very slowly reduced the structural unemployment rate as domestic labour demand conditions were not improving as a result.

- Second, between 1994 and 2001 declines in the structural rate dominated the process of the decline in observed unemployment. The structural effect was so significant that a negative unemployment gap prevailed. The sharp decline in the unemployment rate after 1994 would have left the labour market much tighter and exerted significantly higher pressure on wages had it not been for large structural rate declines.
- Between 2001 and 2005, the results show that the structural rate of unemployment stabilised while there were further cyclical declines in the unemployment rate due to the booming economic conditions. The associated rise in wage inflation is likely to have come about due to the dissipation of all slack in the labour market, favourable economic sentiment and labour market capacity constraints (particularly for certain types of skilled labour servicing the construction and other non-traded sectors).

5: Discussion

So why did the substantial unemployment gap over the Celtic Tiger era not force wage inflation significantly higher?

5.1 Reverse hysteresis

It is now accepted that persistence in unemployment is affected by aggregate demand in the long run by what Blanchard and Summers (1986) termed hysteresis. For Ireland during times of rising unemployment, Walsh (2000) pointed to this phenomenon and the possibility that the equilibrium unemployment rate was drifting up with the actual rate during the 1980s. The increasing proportion of the unemployed who had been out of work for a year or more would lead to a degradation of their skills and employability, and coupled with a significant welfare trap, led to a situation where the unemployment rate could not be expected to fall even if there was an increase in the demand for labour.¹⁹

¹⁹ The long-term unemployment problem was not helped by increasing evidence of a welfare trap in the trade-off between social welfare entitlements and stagnant real wage rates facing the Irish jobseeker (Layte and Callan, 2001). The already-low labour force participation rate fell further and by the end of

Most studies of hysteresis focused on its role in explaining increases in employment. However, Ball *et al* (1999) asked whether hysteresis was symmetric such that demand expansions could reduce the NAIRU as well as increase it. Stiglitz (1998) also raises the possibility that as the unemployment rate is reduced so that previously marginalised workers would be drawn into the labour market where they would develop and maintain worker and job search skills that might otherwise have atrophied. The economy's NAIRU would then be lowered. As discussed above, most labour market slack was dissipated by 1994 leading to a situation where the structural unemployment rate is likely to have fallen faster than the observed unemployment rate. This 'celtic tiger' period compares favourably with what Krueger and Pischke (1997) referred to as the US 'employment miracle', which they credited to greater wage flexibility allowing the absorption of many new entrants to the US labour market.

The reverse hysteresis argument is supported by several empirical and policy observations in the Irish context. First, in most OECD countries, part-time contracts contributed to the bulk of any observed employment growth. The extreme example has been the Netherlands, where women working part-time in the service sector accounted for over half the total increase in employment between 1983 and 1997 (Garibaldi *et al*, 2002). In contrast, the Irish employment boom was biased towards full-time jobs (Walsh, 2004). While the share of part-time women in the total increase in employment doubled, the proportion of these who declared they were underemployed fell to less than one per cent of all females working part-time. Participation rates aside, any difference in the unemployment rates for men and women also disappeared in the period.

While the average level of education increased significantly over the period, both the participation and employment rates of those at the lower educational categories increased in tandem.²⁰ Explicitly modelling the educational structure of the labour

the decade, renewed emigration led to a decline in the population of 16 to 65 year olds considered the active age of the population.

²⁰ Quarterly figures from direct QNHS data examined from 2002 and old broader QNHS data by principal economic status from 1997 to 2002

force in our model was not possible - it is endogenous - but rising skill levels within the workforce is captured by the measure of productivity (Table 1).

5.2 Labour market policy

Many commentators ascribe successes in reducing unemployment to changing labour regulations and institutions; lower rates of taxation on labour lowering the reservation wage and changing population demographics, including inward migration. These are regarded as compositional not quality effects in the labour force affecting cyclical unemployment not the structural rate. O'Connell (2000) criticised some of the employment outcomes from labour market policies but asserts that up to one percentage point of the total reduction in the peak unemployment rate (narrowing the unemployment gap) may have been related to a plethora of labour market schemes and incentives including the use of a pre-retirement allowance moving a sizable number of those claiming unemployment payments out of the official definition of unemployed.²¹ The provision of employment schemes reduced substantially since 2003 and there is no evidence that this has adversely affected labour market indicators since then.

Ball *et al.* (1999) express the view that an incomes policy arising from collective bargaining cannot be ignored in analysing the reduction in Ireland's unemployment rate.²² The national pay agreements brought about a significant reduction in the tax wedge and associated replacement rates in return for wage constraint.²³ A reduction in the tax wedge combined with a favourable corporate tax regime in turn led to a significant inward flow of FDI over the period to 2005 (Walsh, 2000). Capital and labour productivity gains could have been "imported" in a new economy setting and the domestic cost pressures superseded by international competitiveness pressures. The general productivity (TFP) measure was intended to also capture stochastic

²¹ Turner *et al* (2001, page 197 footnote 47) cite labour market reforms in the late 1980s to mid 1990s for reducing the NAIRUs of the Netherlands, New Zealand, Spain and the UK by a half percentage point per year over 4 to 5 years.

²² Other factors such as the productivity conditions attached to the national wage agreements (in return for wage constraint) are also likely to have had an effect albeit difficult to measure in macroeconomic data.

²³ The analysis period does not cover the current social partnership agreement "Towards 2016". From 2004, the *Sustaining Progress* agreement became Ireland's National Reform Programme under the Lisbon Agenda for improved competitiveness, economic growth and greater job creation across Europe.

innovation from R&D in our economy. As a small open economy, however, the productivity effect needs not necessarily to have occurred in Ireland.

Our analysis shows evidence of the wage inflation NAWRU stabilising in recent years at a historically low level. To the extent to which it has “bottomed out” leaving further declines in the NAIRU unlikely is hard to say but increases in cyclical unemployment (reversing any negative employment gap) in Ireland will ease the inflationary pressures for wages in the absence of further productivity improvement. Hall (2005) observes that when the labour market is tight and unemployment is low, employers devote substantial resources to recruiting workers. Job-finding rates for the unemployed are high. By contrast, when the market becomes slack and unemployment is rising, employers recruit less aggressively and job-finding rates are low. Further, transitions from strong markets with low unemployment and high vacancies to weak markets with high unemployment and low vacancies seem to occur without large measurable changes in driving forces. Even shocks confined to a small number of inter-related industrial sectors can stimulate large responses of general unemployment.

Steady improvements in competitiveness explain the lack of inflation, when by definition, inflation should have risen when demand expansions pushed unemployment below the natural rate. Labour costs needed to be kept at a level such that export shares increased at the same time as the aggregate unemployment rate declined. A tapering-off of our positive competitive environment is probably what explains the return of inflationary trends in recent times.

6: Conclusions

In general it is difficult to envisage a clear relationship between unemployment and price inflation in a small open economy. Meyler’s (1999) solution was to differentiate domestically generated inflation from price inflation generally. This paper, however, has formulated estimates for Irish structural employment in terms of *wage* inflation – the NAWRU - on the assumption that persistence in our domestically-generated price

inflation is dominated by developments related to wages. The intuition was that, as price-takers in a small open economy, any potential for mark-up pricing forces aggregate prices and wages (as the vast majority of production cost) to move substantially in tandem.

A semi-structural model was chosen as the optimal means of deriving the Irish structural unemployment rate. It was able to match the behaviour of observed data series. Short of a full-scale structural model specifying the forces determining the structural rate²⁴, this approach has the advantage of allowing us to follow developments in the unemployment gap while being tractable and transparent. In this paper, we used a flexible dynamic linear model with additional productivity information to obtain endogenously-determined Kalman estimates of changes in the structural rate of unemployment. The mean squared errors from the unobserved components model allow vigorous econometric testing of the results. The NAWRU series produced has shown itself to be credible, as it matched macroeconomic developments generally over the period 1980 to 2005.

The structural rate of unemployment and associated non-accelerating wage inflation rate of unemployment are of major importance to the analysis of macro and structural economic developments although in practice these concepts are difficult to estimate and, consequently there is considerable uncertainty concerning their measurement and policy use. This paper finds that the multivariate modelling method, in line with Richardson *et al.* (2000), provided a credible set of estimates for this concept in an Irish case. These results are of particular interest in the context of the substantial changes which occurred in the labour market over the period. The employment rate in 2005 was shown to be very close to the calculated structural rate implying a then unemployment gap of close to or slightly below zero. The 2005/6 capacity constraints in the Irish labour market (arising from full employment in the domestic construction sector) and our need for inward migration to stem very significant wage inflation have since eased.

²⁴ See Layard *et al* (1991) or Blanchard and Katz (1997) where the relationship between wage and price-setting are explicitly explored.

Continued improvements in total factor productivity will be paramount for future wage determination, if wage inflation is to be avoided. Real wage increases can only be justified in a low-inflation environment if they reward structural improvements as captured by our measure of productivity. Our argument of reverse-hysteresis was that the decline in the natural rate of unemployment due to productivity increases was path-dependent. As the number of long-term unemployed persons fell, the latter exerted a significant influence on labour market developments and on wages in particular. This is not guaranteed for the future and new productivity improvements are necessary to perpetuate the process.

Moreover, the above model assumed that the wage inflation-unemployment gap relationship can be divorced from developments in neighbouring labour markets as wage-setting would adjust to foreign labour market conditions leaving our long-run NAWRU unaffected i.e. conditions encouraging migration would be matched by conditions affecting labour demand such that cyclical employment and output would adjust to keep inflationary conditions steady. Further research could thus address the link between Irish and foreign structural unemployment rates.

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APPENDIX A – Modelling Technique

Specification of the STATE-SPACE MODEL

A State-Space model finds a relation between observed time series and an unobserved one (called the state variable). The observation equation(s), also called the measurement equation, specifies this relation while the state equation specifies the dynamic process driving the state. Both equations together define the space within which the state is allowed to move. The Kalman filter estimation undertakes a dynamic maximum likelihood model filtering and smoothing procedures for specified unobserved components in the model. First, a recursive process constructs the estimates for period t building on the information on the observed variables available at $t-1$, minimizing the forecast error. A second procedure smoothes the obtained estimate on the basis of the information available over the whole sample period.

Measurement

$$Y_t = cU_t + e_t^O$$

with

$$y_t = \begin{bmatrix} u_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 0 & r_1 & r_2 \end{bmatrix} \begin{bmatrix} u_t^* \\ u_t - u_t^* \\ u_{t-1} - u_{t-1}^* \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ a_1 & a_2 & a_3 & a_4 \end{bmatrix} \begin{bmatrix} \Delta p_{t-1} \\ \Delta p_{t-2} \\ \Delta p_{t-3} \\ \Delta p_{t-4} \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 \\ b_1 & b_2 & b_3 & b_4 \end{bmatrix} \begin{bmatrix} x_t^1 \\ x_t^2 \\ x_t^3 \\ x_t^4 \end{bmatrix} + \begin{bmatrix} e_t^O \\ e_t^U \end{bmatrix}$$

where the variance-covariance matrix of $e(y)$ is: $\Sigma_{e(y)} = \begin{bmatrix} 0 & 0 \\ 0 & (s^{\Delta p})^2 \end{bmatrix}$

State

$$U_t = aU_{t-1} + e_t^U$$

with

$$U = \begin{bmatrix} u_t^* \\ u_t - u_t^* \\ u_{t-1} - u_{t-1}^* \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & d_1 & d_2 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} u_{t-1}^* \\ u_{t-1} - u_{t-1}^* \\ u_{t-2} - u_{t-2}^* \end{bmatrix} + \begin{bmatrix} e_t^* \\ e_t^{gap} \\ 0 \end{bmatrix};$$

where the variance-covariance matrix of $e(U) = \Sigma_{e(U)} = \begin{bmatrix} (s^{u^*})^2 & 0 & 0 \\ 0 & (s^{gap})^2 & 0 \\ 0 & 0 & 0 \end{bmatrix}$

The measurement equation is based on observed variables only (expected/lagged inflation rates and supply side proxies) and the Phillips relation slope parameter estimated as r_L for each lag L . U_t is the transition vector of unobserved variables, composed of the coefficients associated with the unobserved NAWRU (u_t^*) variable to be estimated i.e. equilibrium employment, gap and NAWRU drift. In the transition system, $e(U)$ is a vector of innovations, assumed to be normally distributed as shown by the variance-covariance matrix $\Sigma_{e(U)}$ (often referred to as the Q matrix):

$$e_t^U \sim N(0, Q)$$

This matrix has by assumption (imposed), all elements equal to zero except the diagonal ones associated with the NAWRU and the unemployment gap - s_{e^N} and $s_{e^{gap}}$ so that the only parameters which really vary with time are the NAIRU and the gap.

Estimation of Kalman recursive equations requires that initial values for the state vector are required but the impact of the starting values on current values for the states is considered negligible. The starting values for the NAWRU has been set to the corresponding observed value for unemployment, with the gap and drift initially set at zero as a consequence. This empirical strategy basically treats the standard formulation of the Phillips equation as a linear model and only when the tradeoff parameter r_L takes on a positive value is the alternative hypothesis that there is a drift or cyclical state of the economy tested. Following suggestions in the literature, a wide range of priors was tested assuming large starting values for the unobserved variance

matrix. The standard deviation of the first lag of the system unobserved components was tried at 2 per cent for the NAWRU and at 0.75 percentage points for the NAWRU drift.

DATA

We use quarterly series for unit labour costs, the manufacturing wage rate, UK sterling exchange rate and the unemployment rate. The manufacturing wage series is the hourly wage of all industrial workers employed in manufacturing sectors 15-37 based on the published quarterly data by the CSO since 1980. Unit labour cost is calculated as total remuneration of employees (National Accounts) divided by total numbers employed. Data on the unemployment rate is taken from the Labour Force Surveys (ILO definition) and interpolated into quarterly observations. All data are seasonally adjusted.

The system described above was estimated using the Kalman filter and maximising the dynamic log-likelihood function using the numerical algorithm BFGS in the econometric package RATS 6.0.