The non-accelerating inflation rate of unemployment (NAIRU) in a small open economy: The irish context

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ABSTRACT

In Ireland the link between real disequilibrium (such as the unemployment gap) and inflation (either price or wage) is blurred by external factors, operating through traded goods price inflation. Attempts to extract information about the unobservable NAIRU from aggregate inflation measures, such as the HICP or wages inflation, are likely to be swamped by these external factors. This paper uses a measure of 'domestically generated' inflation (defined as the gap between the services inflation rate and the goods inflation rate), to capture domestic inflationary pressures arising from the labour market. A strong relationship is seen to exist between 'domestically generated' inflation and labour market tightness. The results also suggest that the NAIRU may not have varied significantly since 1979, despite the large movements in unemployment over the same period.

INTRODUCTION

During the 1980s and early 1990s, studies of the Irish labour market were concerned with the seemingly intractable problem of unemployment.[1] However, since 1994 the performance of the Irish economy generally and the Irish labour market in particular has been virtually unprecedented among European economies. The rate of unemployment, which was amongst the highest in Europe, has declined markedly and is now significantly below the EU average. The ongoing strong performance of the Irish economy has led to concern that continued tightening of the labour market could result in an easing of the relative wage restraint that has characterised the Irish labour market since 1988. Such a scenario could impact on inflationary developments in the Irish economy.

In this paper, the concept of the non-accelerating inflation rate of unemployment (NAIRU) is examined. The validity of the NAIRU in a small open economy (SOE), such as Ireland, is also addressed. Note, however, that this paper does not attempt to explain the evolution of Irish unemployment[2], nor does it seek to determine the underlying structural forces driving the natural rate of unemployment. Furthermore, it does not seek to explain price developments, rather it represents an attempt to use the information contained in price data to extract the unobservable NAIRU.

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1 McCarthy (1993), Browne and McGettigan (1993b and 1993a), and Barry and Bradley (1991)

2 For an analysis of Irish unemployment, see Browne and McGettigan (1993b, 1993a).

The NAIRU is the rate of unemployment at which there is no upward or downward pressure on the inflation rate.[3] Thus it is of obvious concern to monetary authorities, as it indicates whether there is a risk of inflationary build-up in the economy. The NAIRU concept is embedded in the Phillips curve, which attempts to model the relationship between inflation and some measure of excess demand. However, the Phillips curve is very much a 'reduced-form' concept, that is, use of Phillips curve analysis does not presuppose any specific underlying structural model. A number of alternative models can be shown to be consistent with a Phillips curve reduced-form.[4] Thus Phillips curve models are mainly used in applied empirical work rather than in testing economic theory.

The recent fall in Irish unemployment coupled with the lack of any significant increase in inflation could lead to one of two conclusions. First, that the Phillips curve relationship is not valid for a SOE such as Ireland, or second, that the NAIRU in Ireland has fallen in parallel with the fall in the unemployment rate. The United States is in a relatively similar situation to Ireland, in that the unemployment rate has fallen below what many considered to be the NAIRU however inflation has yet increase significantly. Some commentators have argued that this is the result of fortuitous circumstances, such as low commodity prices and excess global

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[3] The more correct nomenclature would be the non-changing inflation rate of unemployment (NCIRU). However, the term NAIRU has entered the literature and is retained here.

[4] For example, Roberts (1995) shows that models of staggered contracts and models of costly price adjustment have a common formulation to the expectations augmented Phillips curve.

capacity.[5] Whilst others argue that it reflects a fundamental shift in productivity that enables output and unemployment to remain low without generating increasing inflation: the so-called 'new economy'.[6]

To allow for the SOE nature of the Irish economy, consideration is given to the relationship between 'domestically generated' inflation and the labour market. This paper defines 'domestically generated' inflation as the gap between the services inflation rate and the goods inflation rate. This approach recognises that traded goods inflation in an SOE is largely determined by external factors. Furthermore, non-traded goods inflation (mainly services), is mainly driven by traded goods inflation in the long-run, but domestic labour market pressures can cause traded and non-traded inflation to diverge, at least in the short run. Thus, the gap between the services inflation rate and the goods inflation rate (domestically generated inflation) should capture the domestic inflationary pressures generated by labour market disequilibrium.

Given the large fluctuations in the rate of unemployment in Ireland, it is unreasonable to simply assume a fixed NAIRU, as has often been done for economies such as the United States (Stock and Watson, 1999) and Portugal (Marques and Botas, 1997). In this paper the Kalman filter technique is used to estimate a time-varying NAIRU for Ireland. The results indicate that a time-varying NAIRU is not necessarily supported by the data.

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[5] See, for example, Brinner (1999). In essence, it is argued that the United States is experiencing favourable supply-side shocks as opposed to the negative supply-side shocks it experienced during the 1970s.

The layout of this paper is as follows: Section 1 discusses the relationship between the labour market and price dynamics. This focuses on Phillips curve analysis. Section 2 presents a brief overview of the Irish labour market since the late 1970s. Attention is focused on the increase in long-term unemployment (which indicates considerable hysteresis) and on the links between the Irish and UK labour markets (which may weaken the relationship between the labour market and price dynamics in Ireland). Section 3 presents a framework by which a time-varying NAIRU may be estimated. This is Gordon's (1997) 'triangular' model. Section 4 presents estimation results using a number of alternative measures of inflation. Section 5 addresses some additional issues to be considered when estimating the NAIRU. Section 6 considers the link between the Irish and UK labour markets. Section 7 concludes.

1. THE LABOUR MARKET-INFLATION NEXUS

Since Phillips' (1958) work on the link between UK unemployment and wages, the Phillips curve has been used throughout the world to examine the link between inflation (either wage or price) and excess demand (measured either in terms of output or unemployment). In his original work, Phillips illustrated a negative relationship between wage inflation and unemployment in the United Kingdom. This was taken to imply that unemployment could only be reduced at the cost of higher inflation. However, the performance of the Phillips curve during the 1970s, when

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[6] See, for example, The Economist (1999).

both inflation and unemployment were rising, led to Phillips curve analysis being discredited.

In response to its inability to explain stagflation during the 1970s and other criticisms, Phillips curve analysis has been extended in three main directions. First, incorporating inflation expectations means that there is no long-run relationship between inflation and unemployment (Friedman 1968 and Phelps 1968). Thus, attempts to increase output or lower unemployment through increased inflation only have a short-run impact and lead to permanently higher inflation in the long-run with output and unemployment returning to their natural level.[7] This is illustrated in Figure 1. The short-run Phillips curve shows a trade-off between inflation and unemployment. However, when inflation expectations adjust, unemployment returns to its natural rate, U^*, but at a higher rate of inflation. Second, supply-side shocks are incorporated, usually using commodity prices and world price developments. The oil price shocks during the 1970s ratcheted up global inflation and resulted in an international economic slowdown. Without incorporating supply-side variables, Phillips curve analysis is unable to account for episodes where inflation and unemployment move in the same direction. Some commentators currently argue that favourable commodity price developments have helped maintain low inflation in the United States, even though unemployment is significantly below the previously estimated

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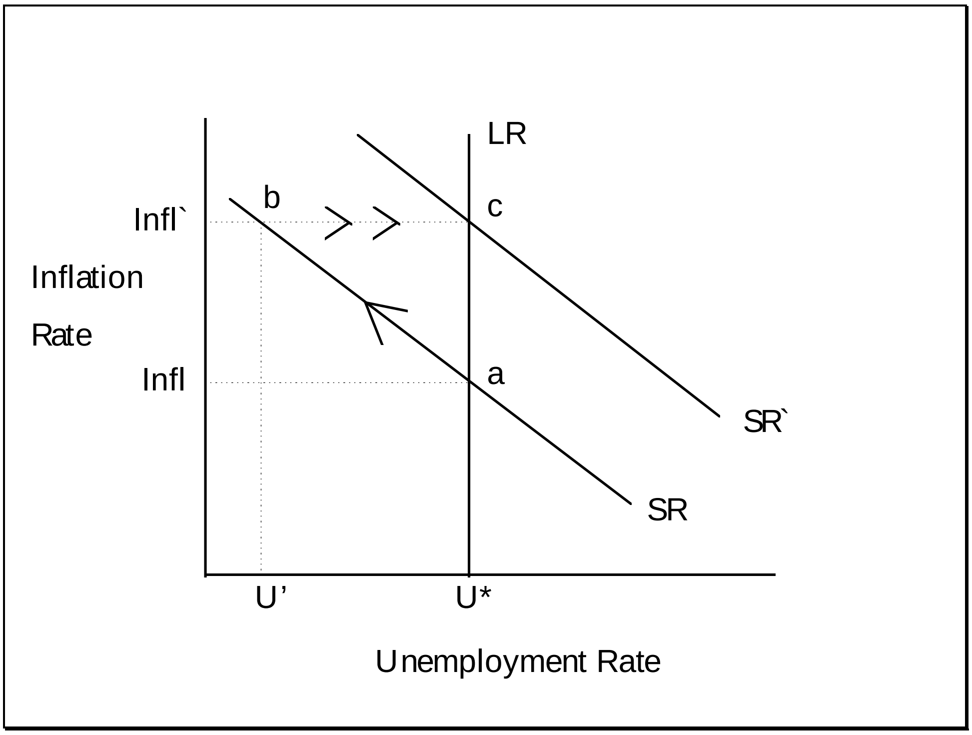
[7] Friedman (1968) describes the natural rate of unemployment as “the level which would be ground out by the Walrasian system of general equilibrium equations, provided that there is imbedded in them the actual structural characteristics of the labour and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labour availabilities, the costs of mobility, and so on.”

NAIRU. This, it is argued, is the reverse to the situation during the 1970s. Third, the persistent increase in unemployment in most OECD economies over the 1980s and 1990s would appear to imply that the NAIRU is not constant. Thus, any estimates of the NAIRU must be capable of handling variations in the estimated NAIRU across time. The Kalman filter used in this paper is one method for extracting the unobservable time-varying NAIRU from price data.

FIGURE 1 - THE SHORT- AND LONG-RUN PHILLIPS CURVES



Notwithstanding its poor performance during the 1970s and frequent criticism by academics[8], the Phillips curve is still a widely used tool by economic policy makers. Its attractions are summarised by Stiglitz (1997) as threefold: (i) it describes the determinants of inflation; (ii) it provides a framework for policy decisions; and, (iii) it can be used for forecasting inflation.[9] However, as highlighted above, the Phillips curve is a reduced-form concept, and should not be used on its own to support any particular policy option, rather it should be used in conjunction with structural analysis to guide economic policy-makers. The Bank of England (1999) uses Phillips curve analysis to supplement its other models.

"Variants of these models [Phillips curve] estimated at the Bank have been used to examine issues associated with monetary policy credibility and for producing wage and price projections as a **cross-check** on forecasts from the Bank's macroeconometric model" (Bank of England, 1999, pg. 77, emphasis added).

1.1. The Phillips Curve in a Small Open Economy

It is widely understood that the inflation process differs significantly between a large economy and a small open economy. Consider, for example, the United States, where total trade accounts for approximately 24 per cent of GDP, and Ireland, where total trade accounts for 160 per cent of GDP. Inflation in the United States is generally considered to be primarily domestically generated, whereas in Ireland external price developments play a crucial role.

The Phillips curve relationship is essentially a large economy phenomenon. In a small open economy the inflation process is more complicated, with distinct dynamics driving inflation in the traded and non-traded sectors of the economy. This is the Scandinavian model of inflation that allows for

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[8] Galbraith (1997, pg. 106) "Can economics live without the aggregative labour market, the natural rate and the NAIRU? Could physics survive without ether?".

[9] Stock and Watson (1999, pg. 22) report that ".. the Phillips curve, interpreted broadly as a relationship between current real economic activity and future inflation,

traded and non-traded goods inflation to be determined differently. The more open the economy the more inflation is determined by international price developments. In terms of the spectrum between the large economy and the small open economy, the Irish economy lies closer than most economies to the small open economy end of the spectrum.

Long-run traded goods inflation is usually modelled using the relative purchasing power parity (PPP) condition. Thus, real disequilibria in the domestic labour market are unlikely to impact significantly on traded goods inflation. Non-traded goods inflation is modelled as cointegrating with traded goods inflation in the long-run, although PPP for non-traded goods is generally rejected, but traded and non-traded goods inflation can deviate in the short-run.[10]

However, it is not just the product market that is open in the Irish economy. The Irish labour market is also relatively open, especially by European standards, with traditionally strong links to the UK and US labour markets. This further complicates Phillips curve analysis in the Irish case. In addition to open product and labour markets, foreign direct investment (FDI) plays an important role in the Irish economy.[11]

Previous studies examining the relationship between unemployment and inflation in Ireland have reported little success, with little or no relationship being evident between labour market tightness and either price or wage

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produced the most reliable and accurate short run forecasts of U.S. price inflation across all of the models that we considered over the 1970-1996 period."

[10] For an analysis of traded and non-traded inflation in a small open economy, see Kenny and McGettigan (1999)

[11] For a recent discussion on the role of FDI in Ireland, see McCarthy (1999).

inflation. See, for example, Walsh (1999), and Curtis and FitzGerald (1996). For Phillips curve analysis to be tractable in a small open economy, a measure of inflationary pressure that is responsive to domestic real disequilibrium must be found.

This paper considers three alternative measures of price inflation.[12] First, overall HICP (harmonised index of consumer prices) inflation is used. However, the HICP aggregates traded and non-traded inflation that are driven by different factors. Second, services inflation is considered. Services inflation should better capture inflationary pressures arising from domestic labour market disequilibrium. However, services prices are not determined independently of traded goods inflation and many services include a traded good element. Thus, external factors, through traded goods inflation, will also impact on services inflation especially in the long-run. A final measure of price inflation uses the gap between services inflation and goods inflation as a proxy for 'domestically generated' inflation. It is hypothesised that the gap between services inflation rate and the goods inflation rate captures excess domestic inflation arising from domestic labour market disequilibrium. A Phillips curve model using wage inflation is also considered.

[12] Each of the price series used is plotted in Appendix I.

2. AN OVERVIEW OF THE IRISH LABOUR MARKET

Figure 2 plots the unemployment rate in Ireland since 1975.[13] There has been considerable variation in the unemployment rate over this period. The unemployment rate ratcheted upwards significantly in the early 1980s. This upward progression continued until 1986, more than doubling from 7 per cent in 1980 to 17 per cent by 1986. The reasons for this dramatic increase in unemployment have been examined elsewhere and are beyond the scope of this study. For an analysis of the increase in Irish unemployment during the 1980s, see Browne and McGettigan (1993b).[14] The unemployment rate fell back slightly to 13 per cent by 1990, but rose again to 16 per cent by 1993. However since then the unemployment rate has fallen steadily to below 6 per cent.

[13] Data sources and construction are described in Appendix I.

[14] Browne and McGettigan (1993b) decompose unemployment changes over the period 1979-1986. They allocate approximately 50 per cent of the increase in unemployment over that period to domestic policy factors (i.e., the tax wedge and the replacement ratio), 30 per cent to external factors (UK unemployment) and 20 per cent to demographic factors. These findings are different to those of Newell and Symons (1990) who allocate a larger portion to external factors (45 per cent) and demographic factors (35 per cent).

Figure 2 - Unemployment in Ireland, 1975 - 1998

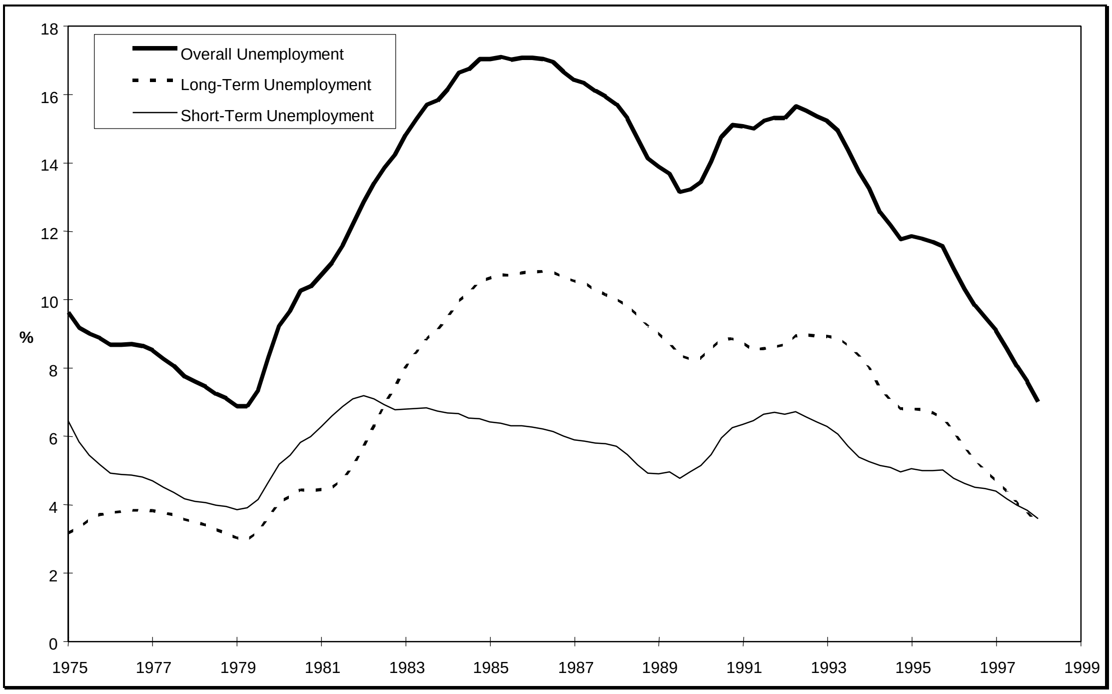


Figure 2 also displays the rate of short- and long-term unemployment. Although similar trends are evident in both series, the short-term rate of unemployment is less variable than the long-term unemployment rate. The short-term rate of unemployment fluctuated between 3.6 per cent and 7.2 per cent, whereas the range for long-term unemployment was larger, at 3.0 per cent to 10.8 per cent. This accords with cross-country analysis by Walsh (1999) who shows that the variation in short-term unemployment rates between OECD countries is significantly lower than the variation in long-term unemployment. Thus, countries with high rates of unemployment appear to have relatively similar short-term (or frictional) unemployment rates, but markedly different long-term unemployment rates to countries with low unemployment rates. Thus, while entry rates into unemployment are relatively similar over the economic cycle, in countries with high unemployment rates, people exiting short-term unemployment exit to long-term unemployment, whereas in countries with low unemployment rates, people are more likely to exit short-term unemployment to employment.[15]

Examining the short- and long-term rates of unemployment adds credence to the argument that the downturn during the 1980s represented a significant structural shift in the composition of employment. The short-term rate of unemployment peaked initially in 1982, whereas the long-term rate did not peak until four years later in 1986. This would indicate that entrants to short-term unemployment were not exiting to employment but added to the numbers of long-term unemployed. However, the pattern during the early 1990s was somewhat different. When the short-term rate of unemployment peaked in 1992, the long-term unemployment rate peaked less than a year later in 1993, indicating that the short-term unemployed were able to successfully exit to employment rather than adding to the numbers of long-term unemployed.

2.1. The Link Between the Irish and UK Labour Markets

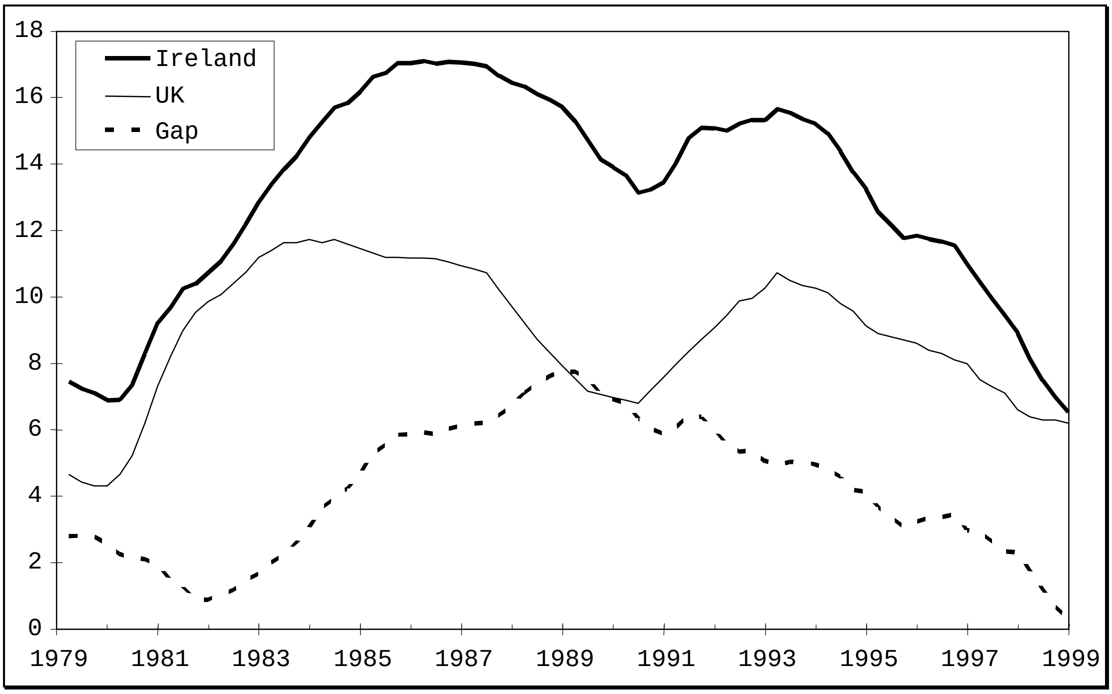
Previous analysis of the Irish labour market has stressed the link between the Irish and UK labour markets (FitzGerald, 1999 and Honohan, 1984). Honohan (1984) estimated that a gap of 5 per cent between Irish and UK unemployment was the equilibrium gap. However, in a later paper, Honohan (1992, pg. 34) notes that "we no longer maintain that the long-term gap is constant: there does appear to have been an upward drift in Irish unemployment that cannot easily be explained by UK trends. Nevertheless, most of the increase in, and of the fluctuations of, male

[15] See Harrison and Walsh (1994) for a flow analysis of Irish unemployment.

unemployment in Ireland can be associated with the movements in UK unemployment."

Figure 3 plots the UK and Irish unemployment rates over the period 1979-1998. The trends in both labour markets are similar. However, while the gap between the Irish and UK unemployment rates was, on average, approximately 4 per cent over the entire period, this gap has fluctuated between zero and eight per cent. This gap peaked in 1989 and has been declining steadily ever since. In 1999, based on provisional data, the gap has been reversed for the first time, and Irish unemployment is below that of the United Kingdom.

Figure 3 - UK and Irish Unemployment Rates and Gap



The factors behind the close relationship between the Irish and UK labour markets are close geographic proximity, lack of restrictions on movements between the two countries and a common language. Although relative immigration and emigration patterns have changed substantially in recent years, the United Kingdom still accounts for almost half of the estimated gross migration flows into and out of Ireland.[16]

TABLE 1 - ESTIMATED GROSS MIGRATION FLOWS CLASSIFIED BY COUNTRY OF DESTINATION/ORIGIN (000S), 1994-1998

	UK	Rest of EU	USA	RoW	Total	% UK
1994	30.0	11.3	13.9	9.7	64.9	46.2
1995	28.9	11.4	12.0	12.1	64.3	44.9
1996	31.7	12.3	11.6	14.8	70.4	45.0
1997[e]	32.9	12.2	10.7	16.9	73.0	45.1
1998[e]	29.6	13.0	9.2	13.4	65.2	45.4

Source: CSO, Population and Migration Estimates, April 1999.
'e' denotes preliminary estimate.

What are the implications for Phillips curve analysis in Ireland. If the Irish labour market can be considered a regional sub-market of the UK labour market, then it is labour market developments in the United Kingdom and not Ireland that will impart inflationary pressures in the Irish economy.[17] To test for this the relationship between Irish 'domestically generated' inflation and the UK labour market is examined below and the results compared to those obtained using the Irish labour market.

[16] See FitzGerald and Kearney (1999) for a discussion on migration and the Irish labour market.

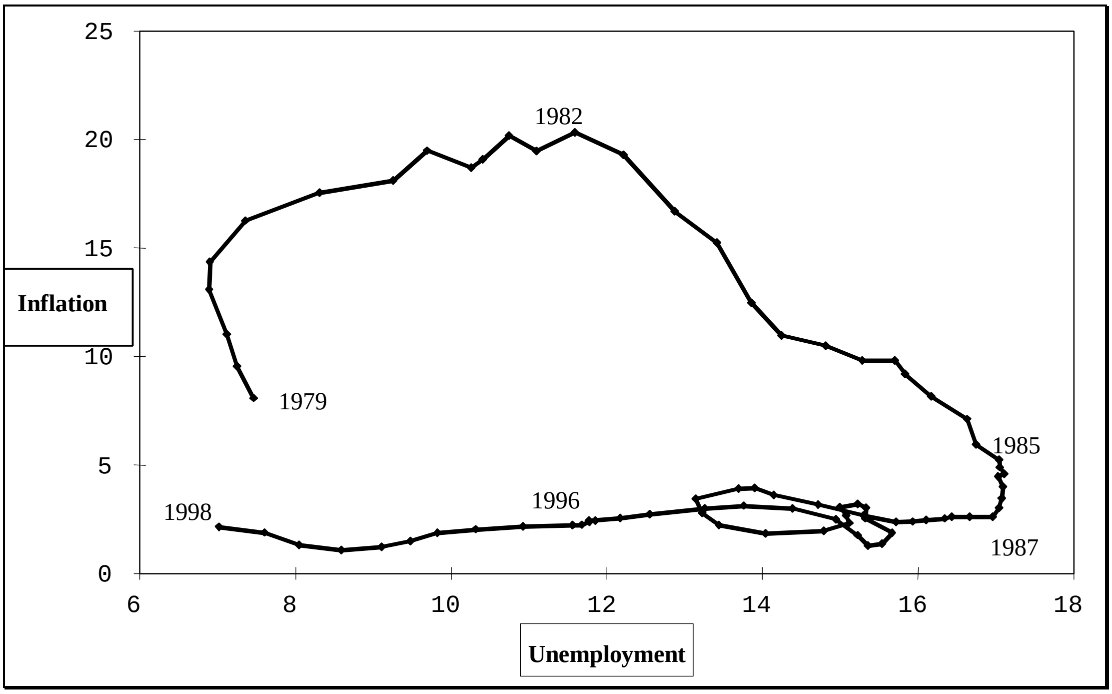
[17] FitzGerald (1999) estimates a closed economy labour market model as well as an open economy model incorporating the UK labour market, and finds that, while the open economy model performs best, it does not "dominate" the closed economy model.

3. APPLIED PHILLIPS CURVE ANALYSIS

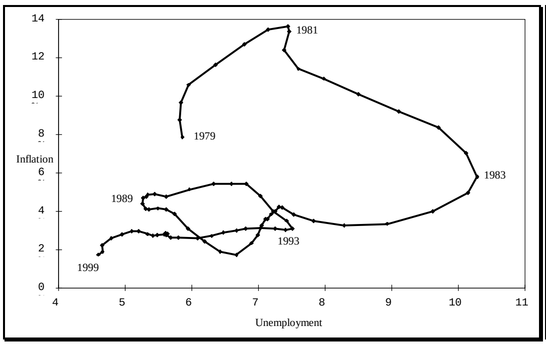
Figure 4 plots the relationship between HICP inflation and overall unemployment in Ireland. From this it would appear that no Phillips curve relationship (neither long-run nor short-run) exists. Only in the periods 1982 to 1985 (downward sloping) and 1985 to 1987 (vertical) does a meaningful Phillips curve relationship appear to hold. Over the period 1987 to 1998 the unemployment rate fell from 17 per cent to 6 per cent, yet inflation remained relatively constant. However, when one plots Phillips curve relationships for the United States and the United Kingdom a similar profile is evident. This could imply that the Phillips curve has shifted in large closed economies as well as in Ireland[18] and that identifying a Phillips curve in a small open economy is no more difficult than in a large relatively closed economy. Alternatively, it may reflect the linkages between the Irish economy and global developments both in terms of prices and the labour market.

[18] This is consistent with analysis by Turner and Seghezza (1999) who test a sample of 15 OECD countries for a common sacrifice ratio. They find that the data support a common sacrifice ratio for most countries. Although Ireland is the only country that causes the probability of accepting the null hypothesis of a common sacrifice ratio to fall below the 10 per cent level.

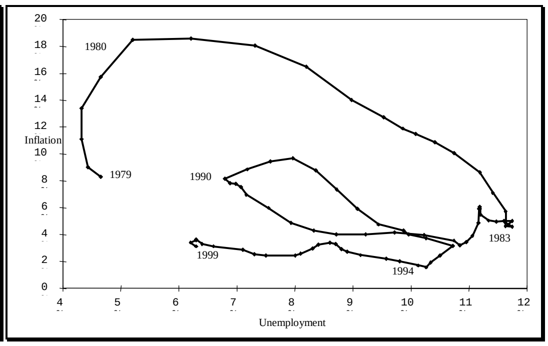
Figure 4 - The Irish, US and UK Phillips curves



United States



United Kingdom



However, as highlighted above, basic Phillips curve analysis has been augmented to allow for changing inflation expectations, supply-side shocks and a time-varying NAIRU. These adjustments to the analysis alter the basic underlying two dimensional relationship and graphical representation. Thus it is necessary to model the Phillips curve explicitly.

The basic model used is as follows:

$$p_t = p_t^e + f_1\left(d_t - d_t^*\right) + f_2\left(S_t\right) \qquad (1)$$

This is Gordon's (1997) 'triangular' model where inflation is modelled using (i) inflation expectations, p_t^e, (ii) a measure of excess demand or real disequilibrium, such as the unemployment or output gap, $\left[d_t - d_t^*\right]$ and (iii) additional variables, to account for supply-side shocks which could distort the inflation-unemployment gap relationship, S_t.

Gordon (1997) models inflation expectations as being formed adaptively, i.e., based on realised outcomes. To ensure a vertical long-run Phillips curve, one can either impose that the sum of the coefficients in the $A(L)$ polynomial sum to unity, or alternatively estimate the equation using the change in the inflation rate, so that when the measure of real disequilibrium is zero and supply-side shocks are absent, the inflation rate is constant, as required by the NCIRU/NAIRU nomenclature. The unemployment gap is modelled as being non-linear. This issue is discussed in further detail below. Only the contemporaneous unemployment gap is included: models were estimated using lags of the unemployment gap but did not result in any significant improvement. Two supply-side variables are considered: import prices and energy. Only the import price variable is found to be significant.

$$p_t = A(L)p_t + g\left[\frac{U_t - U_t^*}{U_t}\right] + C(L)S_t \qquad (2)$$

The actual equation estimated is,

$$\Delta p_t = a(L)\Delta p_t + g\left[\frac{U_t - U_t^*}{U_t}\right] + c(L)\Delta S_t + e_t \qquad (3)$$

where,

$$e_t \sim N(0, H)$$

The unobservable NAIRU, U_t^*, is extracted from information contained in price data using the Kalman filter technique. To extract the NAIRU using the Kalman filter, it is necessary to model the evolution of the NAIRU.[19] The assumption here, as in other studies, is that the NAIRU evolves as a random walk reacting to shocks.

This yields,

$$U_t^* = U_{t-1}^* + h_t \qquad (4)$$

where,

$$h_t \sim N(0, Q)$$

Equations (3) and (4) are set in the state-space form that allows the Kalman filter to be applied. The Kalman filter is a recursive procedure for computing the optimal estimator of U_t^* at time *t*, based on information available at time *t*.

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[19] Appendix II contains a more detailed discussion of the Kalman filter technique. Alternatively see Hamilton (1994), Harvey (1989) or Harvey (1981) for a textbook treatment.

The extent to which the NAIRU is allowed to vary across time, Q, can be set either as part of the optimisation process itself, or is often set at an arbitrary value reflecting the priors of the researcher.[20] This issue is of crucial importance when calculating a time-varying NAIRU. There are two main approaches in the literature. The first is to arbitrarily impose a value that does not allow the NAIRU to vary too much, but allows it vary sufficiently to capture some of the underlying changes in unemployment. Gordon (1997, pg. 22) justifies his choice as it "results in a NAIRU series that exhibits substantial movements but just avoids sharp quarter to quarter zigzags". The second approach is to incorporate the choice of Q into the optimisation procedure. Unfortunately, this approach has come across two problems. (i) As Gordon (1997) highlights, in theory allowing Q to enter the optimisation procedure means that it will 'soak up' all the variance in the measurement equation. (ii) However, in practice, a different problem has arisen, if Q is allowed to enter the optimisation procedure the optimal value of Q frequently converges to zero. This latter problem has been noted by other authors, including Laubach (1997) and King *et al.* (1995). If Q converges to zero this implies that the NAIRU is constant and has not varied over time. This may reflect economic reality or may reflect misspecification in the model. A large number of models estimated for this paper suffered the same problem. Furthermore, when results from Gruen *et al.* (1999) were re-run using variants of their preferred model, a similar problem arose, despite the fact that the log likelihood behaved sensibly for their preferred model. This highlights the instability of the log likelihood function with respect to the model specification.

[20] The ratio Q/H is often referred to as the signal-to-noise ratio.

The approach in this paper, similar to Bank of England (1999), is to present a range of alternative NAIRU based on differing variability. Four alternative NAIRU are presented, setting Q = 0.0 (i.e., imposing a constant NAIRU), 0.1, 0.2 and 0.4.[21] The preferred choice is 0.2 as it allows for some variation in the estimated NAIRU but avoids jumps in the smoothed NAIRU estimates.

4. NAIRU ESTIMATION RESULTS

Baseline Model:

The initial model considered uses aggregate HICP inflation; assumes adaptive expectations and a non-linear unemployment gap; considers the Irish labour market; and, includes import prices.

The first results presented are for the model outlined above, where the dependent variable is change in aggregate HICP year-on-year inflation. As highlighted above, the degree to which the NAIRU is allowed to vary has a crucial role in the results. To illustrate this point, Figure 5 plots the log likelihood function for the basic model outlined above. As the concentrated log likelihood function is used, the optimum is where the function is minimised, which is when $\gamma^2 Q$ equals 6.25.[22] In this case, however, the value of Q essentially allows the NAIRU to fluctuate widely quarter-on-quarter 'soaking up' most of the unexplained residual in the

[21] To normalise the variance, H is set to unity. See Appendix II for details.

[22] The use of $\gamma^2 Q$ is made clear in Appendix II

measurement equation. This problem has been experienced in other studies, see, for example, Debelle and Vickery (1997). To get around this problem a range of arbitrarily imposed Q are considered. These should allow the NAIRU to fluctuate sufficiently to capture some of the underlying inflationary pressures, but should not allow it to fluctuate widely quarter-on-quarter.

FIGURE 5 - PLOT OF LOG LIKELIHOOD FUNCTION WITH RESPECT TO g^2Q

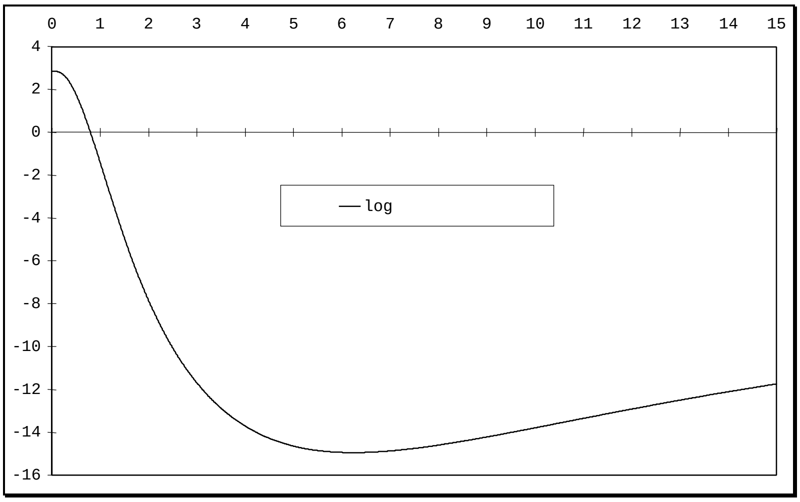
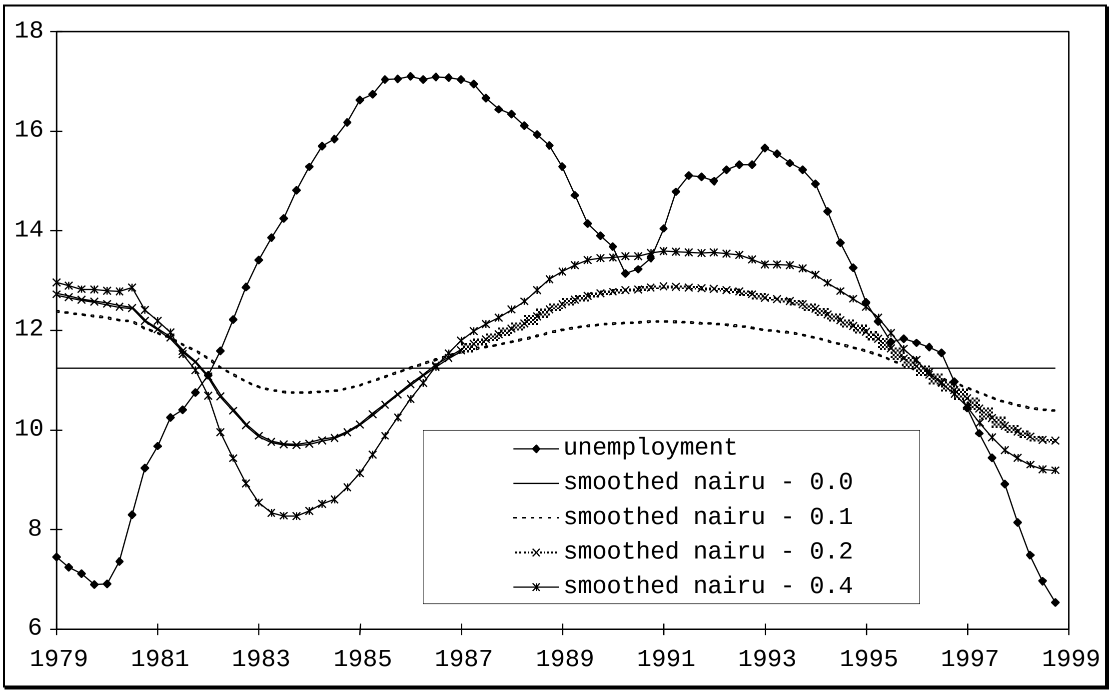


Figure 6 plots the estimated (smoothed) NAIRU using a range of alternative Q. Setting Q equal to zero imposes that the NAIRU is constant over the entire period. The estimated NAIRU for the other values of Q follow a similar trend over the period. The NAIRU is seen to be falling during the initial period. This may be the result of two factors. First, the model assumes adaptive expectations. Given that inflation was very volatile around this period, falling initially from 1976-1978 and then rising rapidly, perhaps adaptive expectations cannot accurately proxy inflation expectations at that time. Second, the choice of an initial value for the state vector (i.e., the estimated NAIRU at the start of the period) is crucial in Kalman filtering, as it is required to start the Kalman filter recursions. This issue is discussed in more detail in Appendix II.

FIGURE 6 - ESTIMATED NAIRU USING ALTERNATIVE Q (HICP MODEL)



The inflation volatility during the initial period combined with the indirect estimation method of the initial value for the NAIRU mean that the estimated NAIRU for the early period should be treated cautiously.[23] The preferred NAIRU estimate is the one that corresponds to Q equals to 0.2. It implies that γ^2Q approximately equals unity. Laxton *et al.* (1998) impose a value of unity when estimating the NAIRU across a range of countries, using a similar formulation to the one used here. It also results in a NAIRU, which, whilst changing across time, does not fluctuate widely

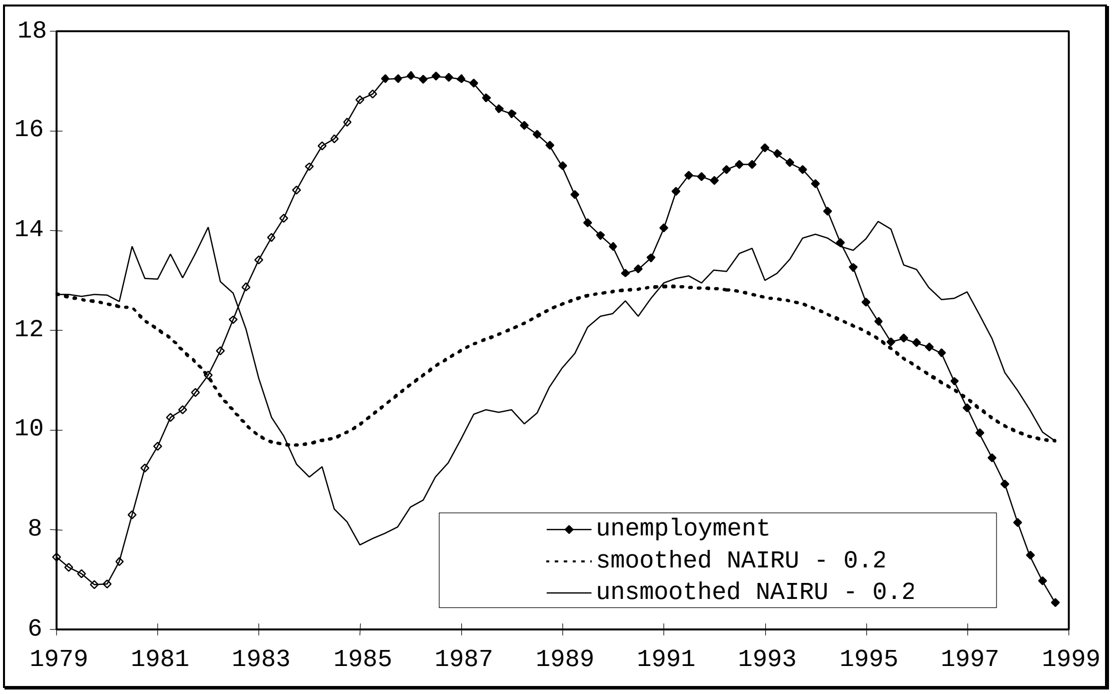
[23] Alternative approaches to the one used in this paper exist, e.g., the diffuse prior method. See Harvey (1989, Section 3.4.3).

quarter-on-quarter; neither does it reach values too low nor too high relative to the actual unemployment rate.

Figure 7 presents the unsmoothed (one-sided) and smoothed (two-sided) estimates of the NAIRU, imposing Q = 0.2. The unsmoothed estimate only uses information available at the time the estimate is constructed. This is the information available to the policy maker at the time the estimate is made. However, any estimates of the NAIRU made, for example in 1979, would incorporate information available prior to 1979. Thus, to focus on the unsmoothed estimates would be incorrect as we have set the sample period as 1979-1998.[24] The smoothed estimate, on the other hand, uses the entire sample of information. The smoothed estimates are, therefore, the optimal estimates of the state variable based on all the observations.

[24] 1979 was chosen as a starting date as it coincided with Ireland's entry to the European Monetary System (EMS), which also represented the break between sterling and the Irish pound.

FIGURE 7 - UNSMOOTHED AND SMOOTHED NAIRU ESTIMATES (Q = 0.2)



The smoothed NAIRU fell from approximately 12.5 per cent in 1979 to 10.0 per cent in 1981. This contrasts with the actual unemployment rate that fell slightly from 7.5 per cent to 7.0 per cent before rising sharply to 15 per cent by 1984. As stated above this could indicate problems with the estimation of the initial NAIRU and inflation expectations during the early period of the sample. The NAIRU then rises to reach 12.75 per cent in 1991. Since then the estimated NAIRU has fallen steadily to reach 10.0 per cent. Although the estimated NAIRU has fallen since 1991, it has not matched the fall in actual unemployment that was approximately 6.5 per cent by the end of 1998.

Table 2 presents the results from the estimation procedure. Despite uncertainty about the link between domestic demand and overall inflation in a small open economy, the estimated parameter on the unemployment gap is always the correct sign and always significant, even when the

NAIRU is constrained to be constant. As the NAIRU is allowed to fluctuate more, the coefficient on the unemployment gap becomes larger and more significant. The import deflator impacts positively on aggregate inflation, which is to be expected. Allowing Q to increase from zero to 0.2 has the effect of increasing the R^2 of the estimated Phillips curve from 0.52 to 0.62.[25]

[25] When the unemployment gap is omitted altogether, the R^2 is 0.41.

TABLE 2 - RESULTS FROM PHILLIPS CURVE ESTIMATION USING HICP INFLATION[26]

Q =	**0.0**		**0.1**		**0.2**		**0.4**	
Unemployment Gap	-1.80	(-4.3)	-2.15	(-5.4)	-2.42	(-6.4)	-2.61	(-7.6)
ΔInflation$_{-1}$	-0.12	(-1.2)	-0.16	(-1.7)	-0.18	(-2.0)	-0.21	(-2.5)
ΔInflation$_{-4}$	-0.48	(-5.3)	-0.50	(-5.7)	-0.52	(-6.2)	-0.54	(-6.9)
Δ(import-import$_{-4}$)$_{-1}$	0.07	(1.8)	0.06	(1.8)	0.06	(1.7)	0.06	(1.7)
Δ(import-import$_{-4}$)$_{-3}$	0.11	(3.1)	0.10	(3.1)	0.10	(3.1)	0.09	(3.2)
log likelihood		2.85		0.78		-1.98		-5.87
std error of est.		1.05		0.99		0.94		0.88
R^2		0.52		0.57		0.62		0.66
DW		1.6		1.6		1.7		1.9
Q(20-0)		53.8		40.5		32.1		28.2
significance		0.00		0.00		0.04		0.10
no. obs.		80		80		80		80
$\gamma^2 Q$		0.000		0.680		1.080		1.650

t-statistics in brackets

Services Inflation Model

As highlighted earlier, in a small open economy, aggregate inflation is driven to a large extent by external forces. In an attempt to extract a clearer 'signal' of domestic inflationary pressures from price data, a Phillips curve model using services inflation is also examined. As services are generally non-traded and include a high labour content, services

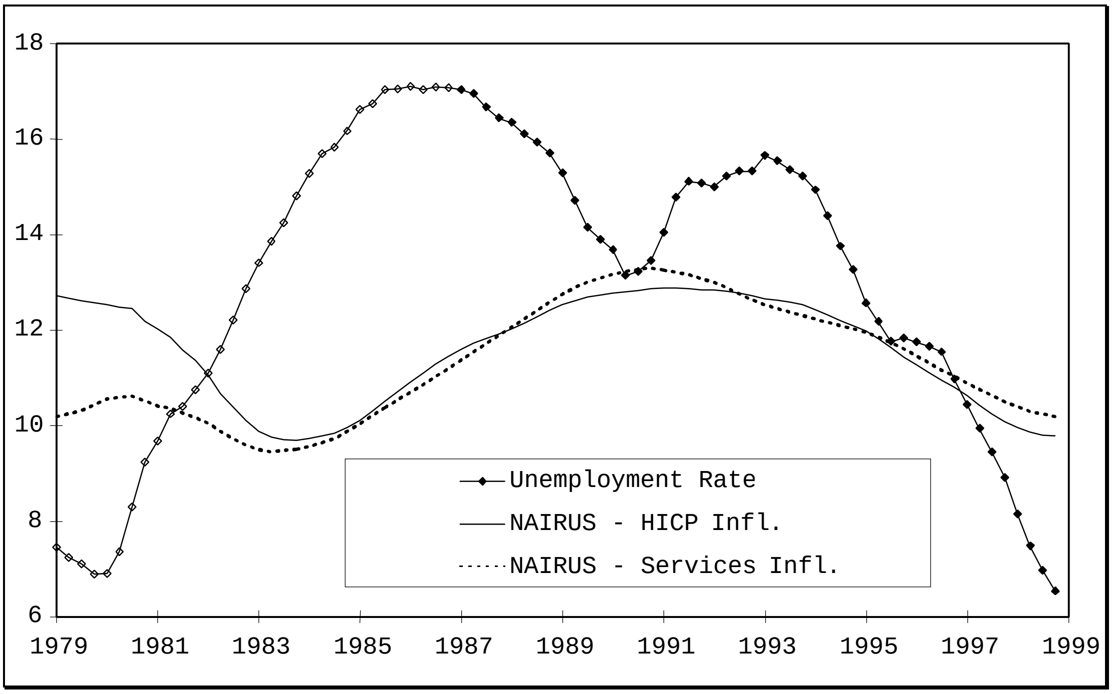
[26] In general the diagnostics of the estimated models are not ideal. This may be due, in part, to the fact that the unemployment gap is almost I(1), whereas the other variables in the model are I(0). The diagnostics problem is indicated by the Q statistic and is reflected in other diagnostics not reported here.

inflation should more accurately reflect domestic labour market tightness than aggregate inflation. However, services can contain a traded goods element and the trend in both series is quite similar.[27] An additional consideration arises in relation to the role of expectations. It is not immediately clear what the correct measure of inflation expectations should be in the services model. The assumption of adaptive expectations is continued here, using previous values of services inflation. The estimates of the NAIRU during the early period using services inflation appear more sensible than those obtained using aggregate inflation. However, over the remainder of the period, the trend in both NAIRU is largely similar.

The estimation results using services inflation are reproduced in Appendix III. These indicate that, the coefficient on the unemployment gap is correctly signed, significant, and is increasing in Q. The estimated coefficients on the unemployment gap are broadly similar to the aggregate HICP inflation model with slightly higher t-statistics, perhaps reflecting the clear signal from services price data. Allowing Q to increase from 0.0 to 0.2 increases the R^2 from 0.42 to 0.54. The R^2 excluding the unemployment gap is 0.22.

[27] Appendix I plots each of the inflation measures used in this paper.

FIGURE 8 - ESTIMATED NAIRU
USING AGGREGATE HICP INFLATION AND SERVICES INFLATION (Q = 0.2)

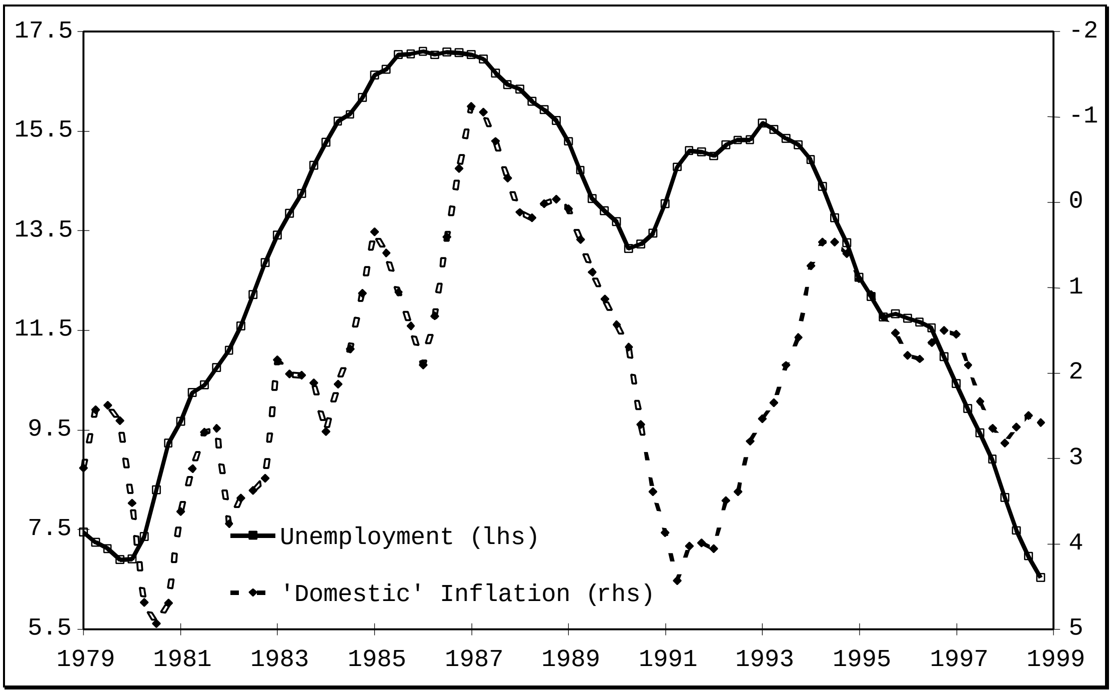


'Domestically Generated' Inflation Model

The results using services inflation show no significant difference compared to those using aggregate HICP inflation. This is not too surprising as when the two series are compared, the trend in each is broadly similar. As highlighted earlier, Kenny and McGettigan (1999) find that traded and non-traded goods prices are cointegrated. However, when the gap between the services inflation rate and the goods inflation rate is interpreted as 'domestically generated' inflation the picture changes considerably.

Figure 9 illustrates the relationship between 'domestically generated' inflation and unemployment. The 'domestically generated' inflation series is inverted and plotted on the right-hand axis to facilitate visual comparison with the unemployment series. The profile of both series is broadly similar, with the turning points in unemployment being matched by turning points in the 'domestically generated' inflation series at a lag of approximately 4 quarters. Although this is a purely graphical analysis, it may indicate that the current gap between services inflation and goods inflation will continue to grow for a number of quarters, even if the unemployment rate stabilises at current levels or reverses.[28] The large spike in the 'domestically generated' inflation series around 1991 is partially accounted for by a decrease in goods inflation as well as by an increase in services inflation.[29]

FIGURE 9 - 'DOMESTICALLY GENERATED' INFLATION AND UNEMPLOYMENT



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[28] The most recent data available (October 1999) indicate that year-on-year core services inflation was 6.1 per cent compared to core goods inflation of 1.1 per cent.

[29] However, an alternative explanation is possible, if the UK labour market is considered. The link with the UK labour market is discussed below.

Figure 10 plots the Phillips curve using ‘domestically generated’ inflation rather than aggregate HICP inflation as shown earlier. A Phillips curve type relationship appears to be much more evident from this formulation, i.e., there does appear to be a negative relationship between ‘domestically generated’ inflation and unemployment. There appears to have been a shift downwards in this curve between the early 1980s and the late 1990s. This shift may reflect a change in productivity differentials between the traded and non-traded sectors, or perhaps a change in pricing behaviour in the non-traded sector. The former explanation sits uneasily with the large increases in productivity experienced in the FDI sector. A change in expectations as shown in Figure 1 does not really make sense in this context as it is the gap between services and goods inflation that is being examined. Perhaps an increase in competition has altered price-setting behaviour in the non-traded sector.

FIGURE 10 - PHILLIPS CURVE USING 'DOMESTIC' INFLATION

The implications of an increase in the gap between services inflation and goods inflation depend on a number of factors. First, if the economy is in a floating exchange rate regime, then a falling exchange rate may counteract some of the competitiveness lost due to higher services inflation. In a fixed exchange rate regime, this cannot happen, and any adjustment must take place in the real economy. Relative prices must be forced down to a level whereby equilibrium is restored between the traded and non-traded sectors of the economy. In the presence of wage rigidity, this will occur mainly through a loss in competitiveness and an eventual downturn in the economy, until equilibrium relative prices are restored. Second, in equilibrium, it is not necessary that goods and services inflation be equal.[30] If, as is likely, productivity is higher in the traded (goods)

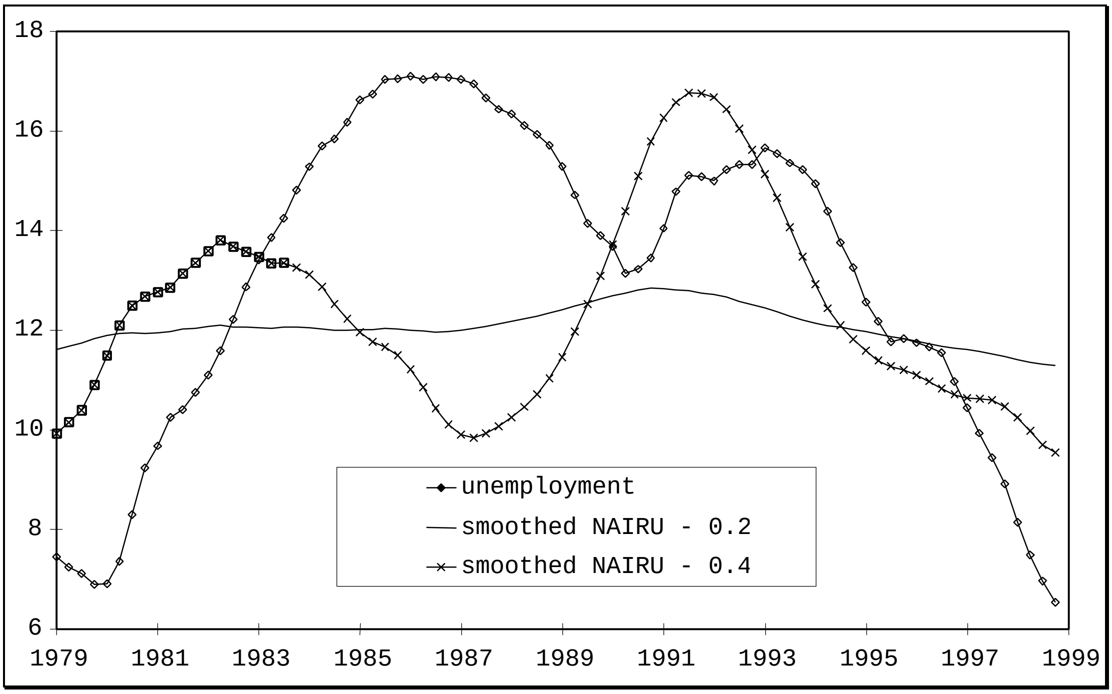
[30] Over the period 1979-1998, services inflation was, on average, approximately 2 per cent higher than goods inflation.

sector, then higher non-traded (services) inflation is consistent with the Balassa-Samuelson (BS) hypothesis. The BS hypothesis implies that higher productivity increases in the traded (goods) sector gives rise to higher wages increases in the traded sector, which permeate into the non-traded (services) sector, giving rise to higher services inflation as productivity increases in the services sector are unlikely to be sufficient to match those in the traded sector. However, provided excess services inflation does not outstrip this productivity differential then the resulting real exchange rate appreciation need not lead to a loss of competitiveness.

Thus, if the increase in domestic inflation is being driven by increased productivity, which could be highly correlated with output and employment, then it need not necessarily be a major source for concern. However, whilst productivity is undoubtedly correlated with the business cycle, it is unlikely that it is the only driving factor behind our measure of domestic inflation.

The results for the model using domestic inflation are reported in Appendix III. The estimated coefficient on the unemployment gap measure is generally lower than when aggregate HICP or service inflation are used. The exception to this is when the NAIRU is allowed vary more considerably (Q = 0.4). In this instance the coefficients of the model alter significantly. This instability is reflected in the log likelihood function, which rises until γ^2Q equals 2.25, falls slightly until γ^2Q equals 6.25 and then rises thereafter. Figure 11 plots the estimated NAIRU where Q equals 0.2 and 0.4. The profile of the two series is identical, although the latter NAIRU varies over a wider range. This plot illustrates a serious drawback with the Kalman filter approach. Given the instability of the log likelihood function, there is no real way of favouring one model over the other.

FIGURE 11 - ESTIMATED NAIRU USING DOMESTIC INFLATION



However, re-examining Figure 9 indicates that domestically generated inflation and actual unemployment co-move quite closely. This may indicate that the NAIRU is best captured by a relatively constant NAIRU.

Wage Inflation Model

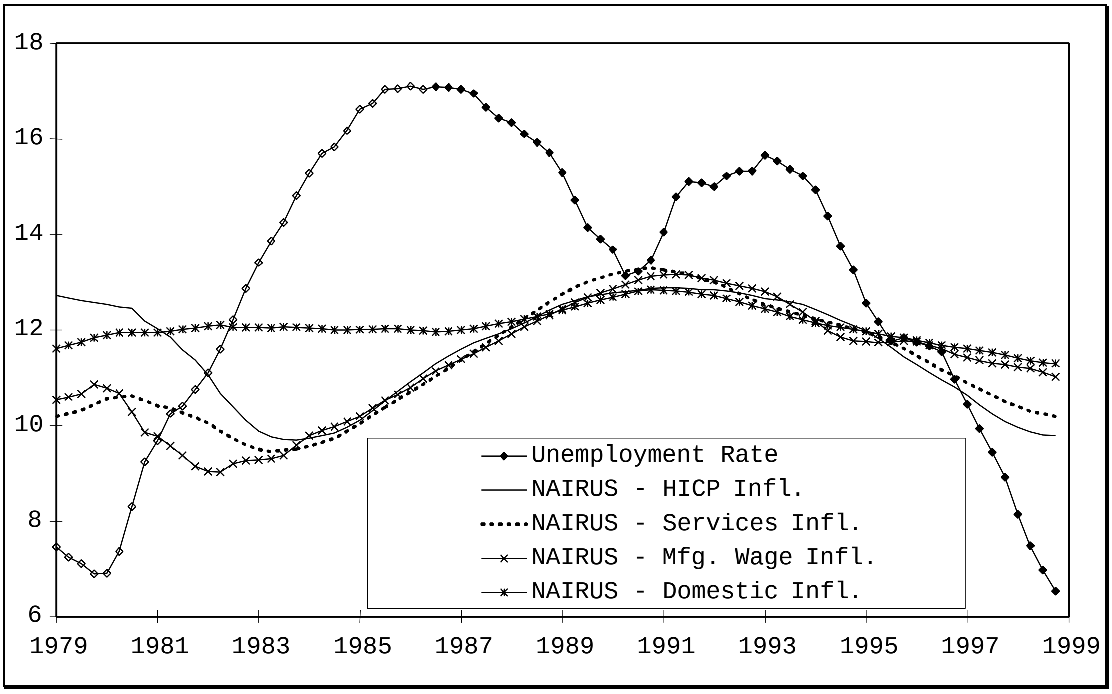
Whilst, using wage data may be preferable on theoretical grounds, as the Phillips curve effect is believed to work primarily through the labour market, price data are used more frequently. Gruen *et al.* (1999) estimate alternative Phillips curves for Australia using both wage and price data. They find that using wage inflation the coefficient on the estimated unemployment gap is larger and more statistically significant than when estimated using price inflation. Furthermore, the implied ratio of the variance of the measurement and state equations (Q/H) is more sensible for the wage model (1.45 for the price model compared to 0.06 for the wage model)

Wage data in Ireland present a number of problems. First, a consistent economy-wide wage series is not available at a quarterly frequency. Overall wage data are available from the national accounts but only at an annual frequency. Wage data are available at a higher frequency only for specific sectors, such as manufacturing, banking and insurance, and the public sector. Second, the advent of social partnership since the late-1980s obscures the relationship between labour market developments and wage dynamics. Each round of the social agreements has been negotiated approximately every three years. A similar problem was noted by Gruen *et al.* (1999) for Australia, although since the 1980s Australia has gone from a centralised bargaining system to a decentralised system. Social partnership requires the standard two party negotiating model such as that used by Layard *et al.* (1991), and Dombrecht and Moës (1997), whereby unions negotiate to maximise income of workers and firms seek to maximise profits with the outcome being determined by relative bargaining power, to be altered. Instead, a tripartite model must be considered which incorporates the government's social objective function and budget constraints, and the after-tax income of workers.

Given the lack of economy-wide wage data, this paper uses manufacturing wage data. The results from this model are presented in Appendix III. These results are broadly similar to the results obtained using aggregate HICP inflation and services inflation data. The coefficients on the unemployment gap are slightly larger than for the other two models, but the t-statistics are slightly lower. Unlike the other two models the concentrated log likelihood does not decrease as the permitted variance of the NAIRU, Q, increases. However, the standard error of the estimate does decrease and the R^2 increases as Q is allowed to increase.

Figure 12 plots the four alternative NAIRU using HICP, service, domestic and wage inflation. The trend for three of the series (HICP, service and wage inflation) is broadly similar, apart from the start and end of the sample period. This highlights a general problem with statistical filtering methods, be they univariate methods such as the Hodrick-Prescott filter or multivariate filters such as the Kalman filter. The trend for the NAIRU generated using domestic inflation is relatively similar to the other estimated NAIRU after 1988. However, prior to 1988, the trend in this series is much different. This may reflect the difficulty in capturing inflation expectations. The issue of measuring inflation expectations is addressed below.

FIGURE 12 - COMPARISON OF SMOOTHED NAIRU USING HICP, SERVICE, DOMESTIC AND WAGE INFLATION



5. ADDITIONAL ISSUES

5.1. Unemployment vs. Output Gap

Initial Phillips curve models examined the relationship between nominal wages and unemployment. However, many studies have also used output measures, such as GDP, as a measure of excess demand. The output gap enters in the same fashion as the unemployment gap. If actual output is thought to be above potential output then inflationary pressure exists. Unfortunately, in Ireland, there are well-documented problems with using output measures, given the importance of FDI. Even using GNP instead of GDP is unlikely to resolve these problems satisfactorily. The Bank of England (1999) reports using the unemployment gap when using wage inflation and the output gap when examining price inflation. In this paper only the unemployment gap is used.

5.2. Linear vs. Non-Linear Unemployment Gap[31]

Using a linear unemployment gap suffers from the drawback that it is only the absolute unemployment gap that matters. Thus, any given absolute unemployment gap has the same impact regardless of whether unemployment is high or low. On the other hand, using a non-linear unemployment gap has the attractive feature that has unemployment moves lower the impact of any given absolute gap is magnified.

A non-linear Phillips curve also implies that the impact of unemployment being below the NAIRU is stronger than the impact of unemployment being above the NAIRU. The insider-outsider model provides one rational for this hypothesis. If outsiders (the unemployed) are unable to exert an equilibrating influence on the labour market, due to union power, de-skilling or other similar arguments, then the disinflationary effect of excess unemployment is attenuated. However, if unemployment is below the NAIRU then the converse does not apply.

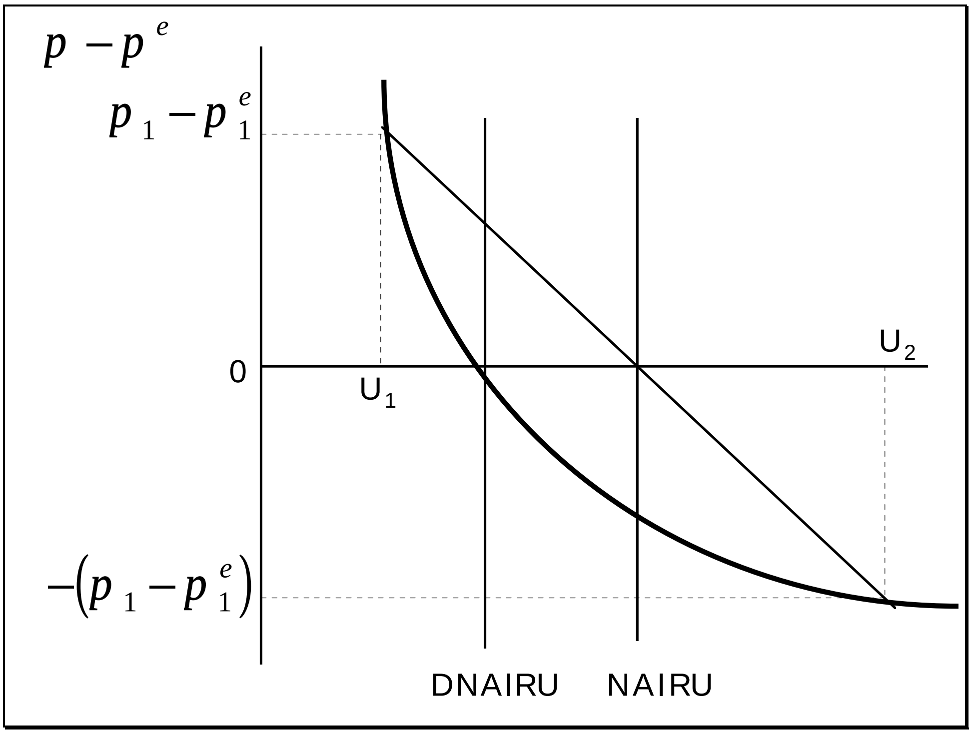
The evidence in the literature in support of either formulation is unclear. Turner (1995) for the G7 countries, Gruen *et al.* (1999) for Australia and Laxton *et al.* (1999) for the United States favour the non-linear framework. However, Gordon (1997) for the United States and Bank of England (1999) favour a linear unemployment gap. Indeed, Stiglitz (1997) even suggests that the Phillips curve could be concave, which, if true, would have significant implications for policy makers. In this case, the costs of overheating the economy are lower, and the costs of overcooling the economy are greater compared to the convex Phillips curve. Thus, policy should have an expansionary bias.

A drawback of a linear Phillips curve is that it implies no excess cost of volatility. Thus if unemployment is shocked symmetrically around the NAIRU there is no net output cost. In this case, policymakers should have an activist policy, as the costs of being above the NAIRU are no greater than the costs of being above the NAIRU. The benefit from reducing volatility may be seen in Figure 13, which shows a convex Phillips curve. In a deterministic world, the rate of unemployment consistent with inflation expectations is given by DNAIRU. However, in a stochastic world with shocks to the economy, the rate of unemployment will vary, for example, between U_1 and U_2, which implies that, in a stochastic world, the rate of unemployment consistent with non-accelerating inflation is given by NAIRU. Given convexity NAIRU always lies above DNAIRU. Reducing volatility will reduce the range U_1 to U_2 and will move NAIRU and DNAIRU closer together. As volatility approaches zero, the NAIRU and DNAIRU converge. Thus stabilisation policy is highly desirable within this framework.[32]

[31] See Debelle and Vickery (1997) for a more detailed discussion of this issue.

[32] Of course, the danger remains that misguided attempts at stabilisation could further increase volatility and thus further increase the gap between DNAIRU and NAIRU.

FIGURE 13 - A CONVEX PHILLIPS CURVE



The baseline model using a linear unemployment gap is estimated. The results indicate that the concentrated log likelihood is higher for the linear model than the linear model, which would indicate that the non-linear model should be preferred. The estimated (linear) NAIRU always lies above the estimated NAIRU derived from the non-linear model. This is consistent with theory, as in the non-linear framework actual unemployment can be further below the NAIRU than in the linear framework as the deflationary pressure is reduced the further unemployment is below the NAIRU. Similarly, in the non-linear framework, the further the NAIRU is above actual unemployment the stronger are the inflationary pressures.

5.3. *Inflation Expectations*

Modelling inflation expectations is problematic. A number of approaches are used in the literature. First, adaptive expectations may be assumed. This assumption is not ideal, as it implies that when inflation is falling (rising) that agents' expectations consistently over- (under-) estimate inflation. However, this approach is the most tractable in applied analysis. Furthermore, when expectations have been explicitly modelled, it is often shown that inflation expectations are essentially adaptive. Debelle and Vickery (1997, pg. 13) report for Australia, using inflation expectations extracted from bond yield data, that ".. for the most part inflation expectations are formed adaptively". Bakhshi and Yates (1999, pg. 5) in the United Kingdom conclude that "... measured expectations systematically overstate inflation". Second, inflation expectations may be modelled using information extracted from bond yields or other sources.[33] Such an approach is likely to be especially problematic in Ireland given the relative lack of depth in the Irish bond market. McGettigan (1995) found that the relatively illiquid nature of certain stocks meant that extracting information from bond prices was quite difficult. Third, survey data may provide a true picture of agent's inflation expectations. Unfortunately, no such survey data exist for Ireland. Fourth, rational expectations may be invoked and actual inflation outcomes may be substituted in place of inflation expectations. Roberts (1995) finds that actual future inflation outcomes are a worse proxy for inflation expectations than are survey data.

This paper, in common with many other studies (for example, Turner and Seghezza, 1999, Bank of England, 1999 and Gordon, 1997), assumes

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[33] For an example of this approach, see Debelle and Vickery (1997).

adaptive expectations. Debelle and Vickery (1997) note that, in common with an adaptive expectations framework, inflation expectations in Australia extracted from bond yields or survey data over-predicted Australian inflation when it was falling during most of the period during the 1980s and 1990s.

Two alternative measures of inflation expectations are considered. First, expectations of Irish inflation are extracted from Irish government bond yields and world bond yields using a method similar to Debelle and Vickery (1997). Second, an ARIMA model is used to forecast future inflation and thus provide a measure of inflation expectations. Both of these series are plotted in Appendix I. The ARIMA based forecasts follow very closely the actual inflation rate, whereas the bond yield data over-estimate inflation since 1984. However, this may reflect premia on Irish bonds rather than inflation expectations. This hypothesis is supported by the convergence in bond yield based expectations and actual inflation prior to EMU. Actual expected inflation is then proxied by a weighted average of inflation expectations based on one of the two methods above and historical inflation. Using the ARIMA model the weight is 0.65 on inflation expectations and 0.35 on historical inflation. Using bond yield model the weight is 0.15 on inflation expectations and 0.85 on historical inflation. The baseline model is then re-estimated with the addition of a variable, the gap between expected inflation and inflation lagged one period. If the coefficient on this variable is not significantly different from zero, this suggests that inflation expectations are essentially adaptive. If the coefficient is significantly different from zero, then inflation expectations need to be incorporated into the model.

The results indicate that the NAIRU based on ARIMA model inflation expectations follow the baseline model quite closely, and that the concentrated log likelihood is lower and the R^2 is higher for the ARIMA based model. However, the coefficient on the gap between expected inflation and historical inflation is the wrong sign, as a positive gap appears to reduce inflation. The model based on bond yield expectations also has a higher R^2 but in this case the coefficient on the gap between expected inflation and historical inflation is too large.

5.4. Supply-Side Variables

During the 1970s supply-side shocks, namely the oil crisis, resulted in the breakdown of the standard Phillips curve relationship. Rising unemployment and inflation were experienced simultaneously. Similarly, some commentators claim that the United States is currently benefiting from favourable supply-side shocks, to maintain low inflation despite historically low unemployment data. Supply-side variables examined in this paper include energy prices and import prices

(a) Energy prices: During the 1970s increasing energy prices gave rise to increased inflation in a time of rising unemployment. This was presented as a major factor in the poor performance of Phillips curve models during the 1970s. However, when energy prices are included in the models estimated in this paper, no significant impact is found.

(b) Import prices: Traded goods inflation in a small open economy such as Ireland is believed to be primarily determined by external developments in world prices and exchange rates. At present, due to weak price pressures internationally, traded goods inflation in Ireland has remained low, despite growing domestic demand. Import prices are found to be significant in the aggregate HICP and service inflation models. Although, when they are omitted from the model, the impact on the estimated NAIRU is relatively limited. The impact on the 'domestic inflation' model is relatively marginal. The positive impact on services inflation appears to be counteracted by the impact on goods inflation.

5.5. Speed Limit Effects

An additional consideration in many models contained in the literature is the inclusion of 'speed-limit' effects. The idea behind speed limit effects is that the real pressure exerted by unemployment depends not only on the level of unemployment but on the rate of change in unemployment. Thus, although unemployment may be at a high level, there is no real pressure if it has been at that level for some time as long as unemployment is not continuing to rise. In this scenario, as unemployment is not rising, insiders (those in employment) do not consider themselves under threat and 'outsiders' (the unemployed) are unable to exert pressure in the labour market due to human capital depletion arguments. To capture this effect the change in the unemployment rate is entered as an additional variable. However, when this variable was included, it was not found to be significant.

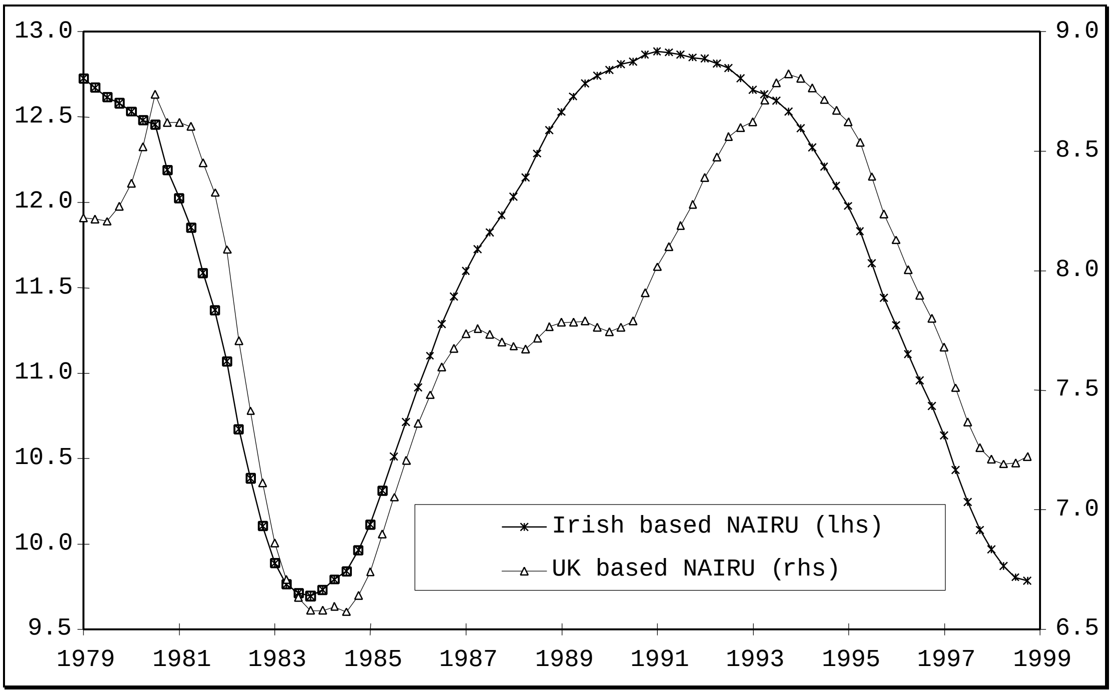
6. INCORPORATING THE UK LABOUR MARKET

In this section the relationship between the Irish and UK labour markets and its implications for Phillips curve analysis in Ireland is examined. A number of alternative issues are considered. First, does the gap between Irish and UK unemployment acts as an equilibrating relationship? In this case the Phillips curve is estimated defining the unemployment gap as the percentage gap between the Irish and UK unemployment rates. Second, does the UK labour market impart inflationary pressures on the Irish economy? In this scenario, Phillips curve analysis is carried out as above, except that the UK unemployment gap is hypothesised to impart inflationary pressures on the Irish economy. Third, does the influence of either labour market dominate the other and has there been any change in this relationship over time? To examine this Phillips curve models including both the Irish unemployment gap and the estimated unemployment gap obtained using UK unemployment are estimated. Recursive estimates are also carried out to see if the relative importance of either labour market has shifted over time.

A Phillips curve model was estimated using the gap between Irish and UK unemployment rates as a measure of the unemployment gap. Both a linear gap and a non-linear gap were estimated. However, in no case, was the unemployment gap measure found to be significant.

When the Phillips curve models are re-estimated using UK unemployment the results are quite striking. In all cases the coefficient on the unemployment gap is larger, with a higher t-statistic than the comparative model using Irish unemployment. Also the concentrated log likelihood is lower, suggesting the UK model be preferred. The profile of the estimated NAIRU is broadly similar however (Figure 14).

FIGURE 14 - COMPARISON OF ESTIMATED NAIRU FROM IRISH AND UK BASED MODELS (USING AGGREGATE HICP INFLATION - Q = 0.2)



Finally, a Phillips model incorporating two unemployment gaps based both on the Irish and UK labour markets was estimated. The results are presented in Table 3. This indicates that the UK model dominates the Irish model. In addition, Figure 15, which plots the recursive estimates, does not indicate that this effect has lessen in recent years.

TABLE 3 - PHILLIPS CURVE ESTIMATES USING IRISH AND UK UNEMPLOYMENT GAPS

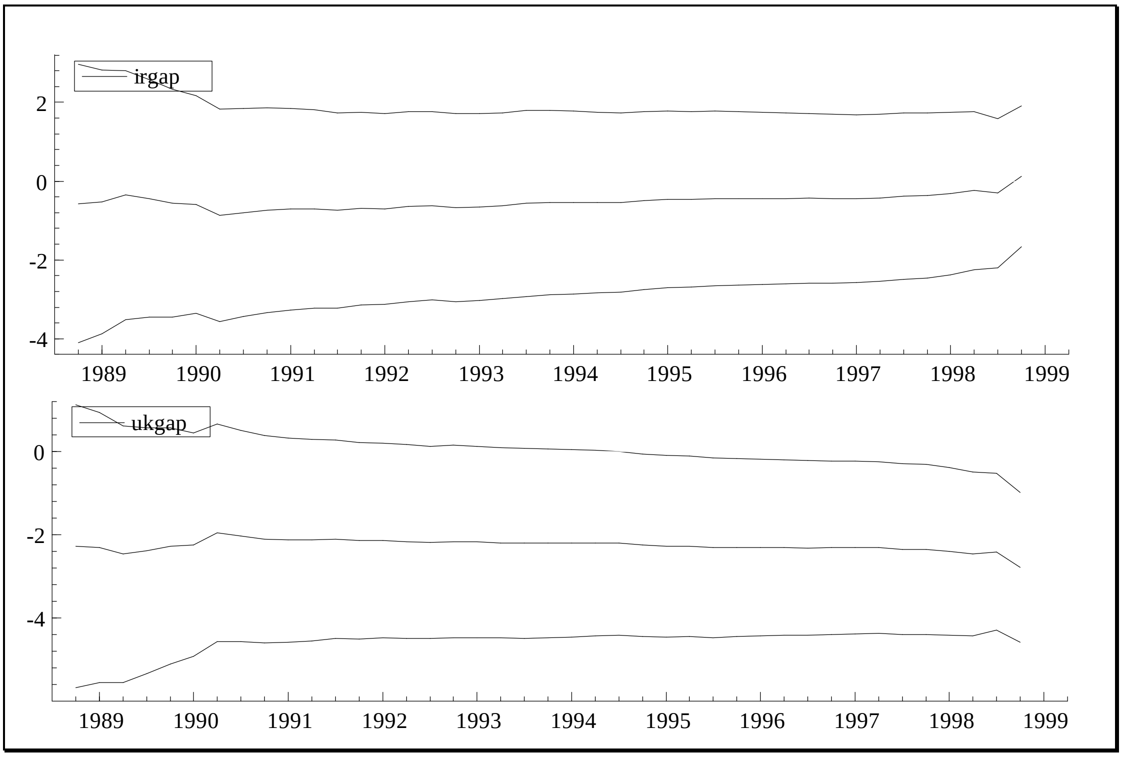
Modelling Δinfly by RLS
The present sample is: 1979 (1) to 1998 (4)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Δinfly_1	-0.22478	0.086863	-2.588	0.0116	0.0830
Δinfly_4	-0.50817	0.078639	-6.462	0.0000	0.3607
ΔΔimport_1	0.055497	0.033079	1.678	0.0976	0.0366
ΔΔimport_3	0.097597	0.029967	3.257	0.0017	0.1254
irgap	0.12082	0.89323	0.135	0.8928	0.0002
ukgap	-2.7826	0.89880	-3.096	0.0028	0.1147

R^2 = 0.661201 \sigma = 0.892735 DW = 1.89
* R^2 does NOT allow for the mean *
RSS = 58.97626165 for 6 variables and 80 observations

```
AR 1- 5 F( 5, 69) =      5.1569 [0.0004] **
ARCH 4  F( 4, 66) =      2.5604 [0.0465] *
Normality Chi^2(2)=      13.514 [0.0012] **
Xi^2    F(12, 61) =      2.3235 [0.0160] *
Xi*Xj   F(27, 46) =      4.3292 [0.0000] **
RESET   F( 1, 73) =      4.3614 [0.0402] *
```

FIGURE 15 - RECURSIVE ESTIMATES OF COEFFICIENTS ON IRISH AND UK UNEMPLOYMENT GAPS



7. CONCLUDING COMMENTS

In this paper we have attempted to extract information about the labour market using inflation data in a small open economy context. The difficulties in using Phillips curve analysis in a small open economy are highlighted. These are especially pronounced in Ireland, due to open product and labour markets. The impact of external forces on aggregate prices suggests that a measure of domestically generated inflation could yield additional information on domestic disequilibrium: information which in aggregate price inflation might be swamped by other external factors.

A strong relationship is seen to hold between 'domestically generated' inflation, defined as the gap between services inflation and goods inflation, and unemployment. When estimated within a Phillips curve type relationship the NAIRU generated from the domestically generated inflation measure appears to be relatively constant over time. However, this model suffers the drawback that both services and goods inflation are included in the dependent variable. This means that, holding services inflation constant, movements in goods inflation will cause our measure of domestically generated inflation to vary. A useful way to extend the analysis in this paper, would be to embed the relationship between domestically generated inflation and the labour market, within a system which ties down the long- and short-run dynamics of traded and non-traded inflation, rather than within the reduced-form Phillips curve framework as contained in this paper.

Although, labour market developments may only impact on the gap between services and goods inflation in the short-run, given fixed exchange rates within EMU it is relative movements in traded and non-traded inflation that will determine competitiveness and future economic performance. Thus the future evolution of 'domestically generated' inflation is of crucial importance to economic policy-makers.

The relationship between the Irish and UK labour markets is also considered. The influence of UK labour market developments on the Irish labour market is clearly evident. However, with the advent of EMU and the UK's non-participation a weakening of the connection between the Irish and UK labour markets may be witnessed.

APPENDIX I -
DATA SOURCES, CONSTRUCTION AND TIME SERIES PROPERTIES

INFLATION:

Aggregate HICP:

1997 - 1998: Data provided by the CSO
1979 - 1996: Constructed by the author using disaggregated Consumer Price Index (CPI) data provided by the CSO. See Meyler *et al.* (1998a) for more details.

Services

Constructed by the author using disaggregated CPI data provided by the CSO. Core services inflation is defined as the services component of the HICP excluding administered services, alcohol-related services and telecommunications services. See Meyler (1999) for more details.

Goods

Constructed by the author using disaggregated CPI data provided by the CSO. Core goods inflation is defined as the goods component of the HICP excluding unprocessed foods and energy goods.

Domestically Generated Inflation

Defined as the gap between core services inflation and core goods inflation

Inflation Expectations

Extracted from Bond Yields A rough approximation of Irish inflation expectations was extracted from Irish bond yields using the following methodology. First, world bond yields were proxied using a simple unweighted average of US, Japanese, UK and German long-term government bond yields. Second, real bond yields were estimated by subtracting an unweighted average of inflation rates in each country. Third, Irish inflation expectations were calculated by subtracting the estimated world real rate of return from the nominal yield on long-term Irish government bonds. All bond yield data and foreign prices were taken from the IMF IFS database.

ARIMA Model Forecasts An estimate of future inflation was constructed using ARIMA models of aggregate HICP inflation as described in Meyler *et al.* (1998b).

WAGES:

Manufacturing Wages

Data provided by the CSO. QIBQ051 - Quarterly Average Gross Earnings per Hour by All Industrial Workers. Total Manufacturing Industries. IR£

UNEMPLOYMENT AND EMPLOYMENT:

Overall Unemployment and Employment Data

Annual Data - Constructed from CSO Labour Force Survey (LFS, 1975-1997) and March-May Quarterly National Household Survey (QNHS, 1998 & 1999). Annual data calculated as 75 per cent of same year April data plus 25 per cent of following year's April data.

Interpolation Procedure - Annual data were interpolated to quarterly data using the Chow and Lin (1971) procedure in RATS. Live register data provided by the CSO were used to interpolate the annual data. Manufacturing employment data provided by the CSO were used to interpolate the annual data.

Unemployment Rate - Calculated as unemployment / (unemployment + employment)

Long-Term Unemployment Rate

Annual Data: 1988 - 1998 Constructed using the same methodology as for overall unemployment. Long-term unemployment is defined as greater than one year.

Quarterly Data: 1988 - 1998 Semi-annual data on the duration on unemployment from the live register was interpolated to quarterly using the Chow & Lin (1971) procedure. This series was then used to interpolate the annual data above.

Quarterly Data: 1980 - 1987 In the absence of data, the quarterly rate of long-term unemployment was constructed from semi-annual data on the duration of continuous registration on the live register and interpolated to quarterly data using the Distrib procedure in RATS. It is only since 1986 that the Live Register and Labour Force Survey have diverged significantly. Therefore use of live register data prior to 1988 should not present significant difficulties.

Quarterly Data: 1966 - 1979 In the absence of data, the quarterly rate of long-term unemployment was constructed from annual data on the duration of continuous registration on the live register and interpolated to quarterly data using the Distrib procedure in RATS. It is only since 1986 that the Live Register and the Labour Force Survey have diverged significantly. Therefore use of live register data prior to 1979 should not present any difficulties.

Short-Term Unemployment Rate

The short-term unemployment rate is defined as the overall unemployment rate less the long-term unemployment rate.

SUPPLY-SIDE VARIABLES:

Import Prices

Taken from CSO Trade Statistics.

Energy Prices

Taken from CSO Trade Statistics using SITC 333.

MISCELLANEOUS DATA:

UK Unemployment

Data provided by Ian Thompson, Bank of England. Data since mid-1984 are based on UK Labour Force Survey data. Prior to mid-1984, claimant count data are used but are chain-linked to the Labour Force Survey data.

SEASONAL ADJUSTMENT:

All data were seasonally adjusted where necessary using the Tramo-Seats algorithm developed by Gómez and Maravall (1998).

Figure 16 - Annual HICP, Services and Manufacturing Wages Inflation Plus Gap Between Services and Goods Inflation

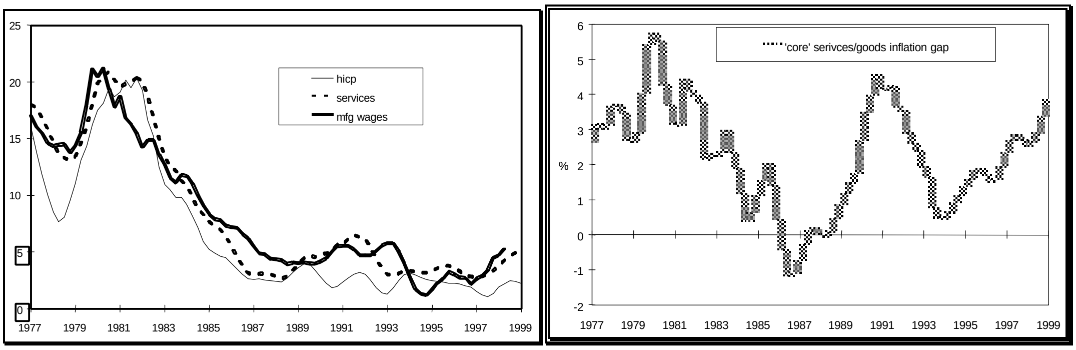
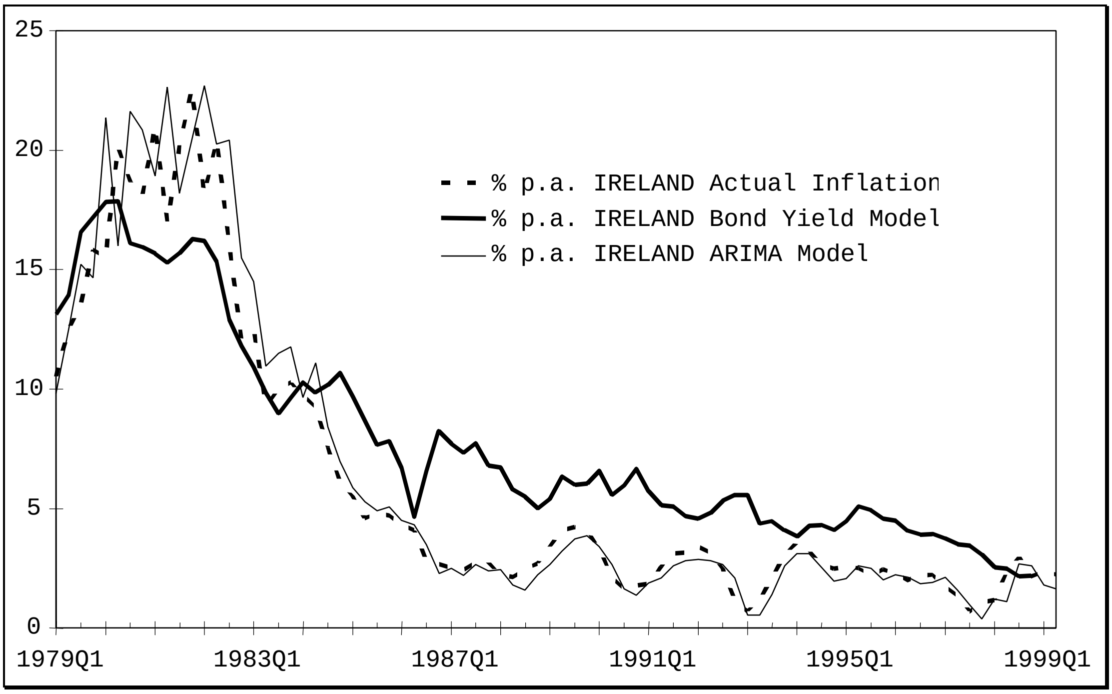


FIGURE 17 - ACTUAL INFLATION PLUS INFLATION EXPECTATIONS EXTRACTED FROM BOND YIELDS AND FROM ARIMA MODEL



TIME SERIES PROPERTIES

TABLE 4 - TIME SERIES PROPERTIES OF DATA SERIES[34]

	Level	n	Year-on-Year Change	n	Difference of YoY Change	n
HICP			-1.37	4	-3.65 *	3
Services			-1.90	4	-3.48 *	4
Services-Goods			-1.99	4	-5.72 *	3
Mfg Wages			-3.06 *	4	-7.62 *	3
Infl. Expns Extracted from Bond Yields			-2.24	0	-5.86 *	3
Infl. Expns Extracted from ARIMA Model			-1.85	4	-3.17 *	4
Unemployment	-1.76	1	-3.47 *	0		
UK Unemployment	-3.53 *	1	-3.39 *	2		
Irish/UK Unemployment Gap	-0.70	1	-3.02 *	1	-11.56 *	0
Import Prices			-2.90 *	1	-6.63 *	3
Energy Prices			-3.74 *	0	-7.25 *	4

[34] The table reports Augment Dickey Fuller (ADF) test statistics in addition to the number of lags of the first difference of the dependent variable added to the ADF regression. The number of lags added was determined by the Schwarz (SC) or Bayesian Information (BIC) Criterion. Only the unemployment data were tested using levels data. None of the ADF tests include a deterministic trend. * indicates that the null hypothesis of a unit root is rejected at the 95% level.

APPENDIX II - KALMAN FILTER

In this appendix the Kalman filter technique used to estimate the models incorporated in the paper is briefly outlined.[35] The methods used to estimate the parameters on the non-stochastic variables and the starting value for the state variable are explained. The issue of how to address the problem of determining the extent to which the NAIRU is allowed vary is also considered.[36]

To use the Kalman filter a model must be set up in the state-space form. In univariate state-space form a variable (inflation) is related to a state vector (the unobserved NAIRU) via a measurement equation (the Phillips curve). The measurement equation may be augmented by non-stochastic variables (such as inflation expectations and supply-side shocks). Equations (A1) and (A2) represent the Phillips curve model set up in state space form. The measurement equation (A1) relates inflation to the state vector (the unobserved NAIRU) and deterministic variables such as inflation expectations and supply-side shocks.

The basic model may be written as follows[37],

(A1) $$p_t = p_t^e + B(L)S_t + g\left[\frac{U_t - U_t^*}{U_t}\right] + e_t$$

Assuming adaptive expectations yields $p_t^e = A(L)p_t$

(A2) $$p_t = A(L)p_t + B(L)S_t + g\left[\frac{U_t - U_t^*}{U_t}\right] + e_t$$

Assume that the sum of the terms in *A(L)* equals unity, thus ensuring that when $U_t = U_t^*$ and supply-side shocks are absent, inflation remains constant. Supply shocks are entered in differenced form for time series reasons. This yields,

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[35] For a fuller discussion see Harvey (1989, Chapter 3).

[36] This is drawn from Gruen *et al.* (1999).

[37] The addition of lags of the estimated unemployment gap was considered, but they were found to be insignificant when added.

(A3) $$\Delta p_t = a(L)\Delta p_t + b(L)\Delta S_t + g\left[\frac{U_t - U_t^*}{U_t}\right] + e_t$$

(A4) $$\Delta p_t = a(L)\Delta p_t + b(L)\Delta S_t + g - \frac{1}{U_t} gU_t^* + e_t$$

or using Harvey's (1989, Chapter 3) notation

(A5) $$y_t = Z_t' a_t + X_t' d + e_t$$

where $y_t = \Delta p_t$

$a_t = gU_t^*$

$Z_t = -\frac{1}{U_t}$

$d' = [a(L), b(L), g]$

$X_t' = [\Delta p, \Delta s, 1]$

note $e_t \sim N(0, s^2 H)$

The reason for denoting the variance of e_t as $s^2 H$ rather than s_e^2 is outlined below.

The state equation specifies how the NAIRU evolves over time. In common with other studies a random walk specification is assumed.

(A6) $$U_t^* = U_{t-1}^* + h_t$$

or in Harvey's notation

(A7) $$a_t = Ta_{t-1} + h_t$$

where,

$h_t \sim (0, s^2 Q)$

$T \equiv 1$, this has important implications when estimating a starting value for the state vector.

note $gU_t^* = gU_{t-1}^* + gh_t$ implies $gh_t \sim N(0, g^2 s^2 Q)$

To operationalise the Kalman filter a starting value, α_0, for the state vector is required. This is necessary to start the Kalman filter recursions. with an initial estimate of the state vector. With this, the Kalman filter produces $E_0(\alpha_1)$ and then conditional on *H* and *Q*, the Kalman filter innovations can be produced and log likelihood calculated.. This paper uses the approach taken by Gruen *et al.* (1999), who concentrate out the initial starting value of the state vector, α_0, out of the log likelihood function.

Using the Kalman filter yields:

(A8) $$a_{t+1|t} = b_t a_{t|t-1} + K_t\left(y_t - x_t^{'}d\right)$$

where $K_t = P_{t|t-1}Z_t^{'}\left(Z_t P_{t|t-1}Z_t^{'} + H\right)^{-1}$ is the gain of the Kalman filter. $P_{t|t-1}$ is the variance of α conditional on past information (and is a function only of H and Q) and $b_t = 1 - Z_t K_t$.

Recursively solving equation (A8) yields

(A9) $$a_{t|t-1} = f_t a_{1|0} + s_{yt} - s_{xt}^{'} d$$

where

(A10) $$f_j = b_{j-1} f_{j-1}$$

(A11) $$s_{yj} = b_{j-1} s_{yj-1} + K_{j-1} y_{j-1}$$

(A12) $$s_{xj}^{'} = b_{j-1} s_{xj-1}^{'} + K_{j-1} x_{j-1}^{'}$$

where $\phi_0 = 1$, $s_{y1} = 0$ and $s_{x1} = 0$.

Combining (A5) and (A9) yields

(A13) $$\begin{aligned} e_t &= y_t - x_t^{'}d - Z_t^{'}\left(f_t a_{1|0} + s_{yt} - s_{xt}^{'}d\right) \\ &= y_t - Z_t^{'}s_{yt} - \left(x_t^{'} - Z_t^{'}s_{xt}^{'}\right) d - \left(Z_t^{'}f_t\right) a_{1|0} \end{aligned}$$

The maximum likelihood estimates of δ and $a_{1|0}$ may be computed by performing a weighted least squares regression of $y_t - Z_t^{'}s_{yt}$, against

$x_t - Z_t^{'} s_{xt}$ and $Z_t^{'} f_t$, where the weights are the inverse of the standard deviation of the innovations, the estimated variance of which F_t depends only on H and Q, where F_t equals $\left(Z_t P_{t|t-1} Z_t^{'} + H\right)$. σ^2 is concentrated out of the log likelihood function, see Harvey (1989, Section 3.4), and H is set to unity leaving the Q to determine the ratio of Q/H.

APPENDIX III - ADDITIONAL RESULTS

TABLE 5 - RESULTS FROM PHILLIPS CURVE ESTIMATION USING SERVICES INFLATION

Q =	0.0		0.1		0.2		0.4	
Unemployment Gap	-1.54	(-5.1)	-1.89	(-6.1)	-2.31	(-7.4)	-2.86	(-9.4)
ΔServ. $Infl_{t-4}$	-0.38	(-4.3)	-0.41	(-4.9)	-0.45	(-5.7)	-0.53	(-7.3)
$\Delta(import_t - import_{t-4})_{-2}$	0.07	(2.8)	0.07	(2.7)	0.06	(2.6)	0.05	(2.5)
log likelihood		-44.08		-45.16		-48.81		-56.18
std error of est.		0.77		0.74		0.69		0.61
R^2		0.42		0.47		0.54		0.64
DW		1.3		1.4		1.5		1.7
Q(20-0)		65.5		55.3		45.3		42.2
significance		0.00		0.00		0.00		0.00
no. obs.		80		80		80		80
$\gamma^2 Q$		0.000		0.600		1.035		1.810

TABLE 6 - RESULTS USING 'DOMESTICALLY GENERATED' INFLATION MEASURE

Q =	0.0		0.1		0.2		0.4	
Unemployment Gap	-0.92	(-2.3)	-1.01	(-2.4)	-1.14	(-2.6)	-4.03	(-5.9)
Domestic Inflation_{-1}	0.71	(9.3)	0.70	(-9.1)	0.69	(8.9)	0.41	(4.7)
$\Delta(\text{import}_t - \text{import}_{t-4})_{-2}$	0.07	(2.2)	0.07	(2.2)	0.07	(2.1)	0.06	(2.2)
$\Delta(\text{import}_t - \text{import}_{t-4})_{-2}$	-0.07	(-2.1)	-0.07	(-2.2)	-0.07	(-2.2)	-0.07	(-2.4)
log likelihood		-7.81		-6.67		-5.89		-3.76
std error of est.		0.98		0.97		0.97		0.84
R^2		0.65		0.65		0.65		0.74
DW		1.9		1.9		1.9		1.9
Q(20-0)		40.3		40.3		40.4		39.7
significance		0.00		0.00		0.00		0.01
no. obs.		80		80		80		80
$\gamma^2 Q$		0.000		0.320		0.510		2.550

TABLE 7 - RESULTS USING WAGE INFLATION

Q =	**0.0**		**0.1**		**0.2**		**0.4**	
Unemployment Gap	-2.02	(-3.3)	-2.38	(-3.8)	-2.63	(-4.1)	-2.91	(-4.6)
Δ Wage Infl.$_{-1}$	-0.35	(-4.0)	-4.3	(-4.3)	-0.38	(-4.5)	-0.40	(-4.7)
Δ Wage Infl.$_{-4}$	-0.49	(-5.6)	-5.8	(-5.8)	-0.50	(-5.9)	-0.50	(-6.1)
log likelihood		72.29		74.39		75.07		76.05
std error of est.		1.60		1.57		1.55		1.52
R^2		0.42		0.44		0.46		0.48
DW		2.0		2.0		2.1		2.1
Q(20-0)		43.5		48.1		52.8		58.8
significance		0.00		0.00		0.00		0.00
no. obs.		80		80		80		80
γ^2Q		0.000		0.750		1.170		1.850

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