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Abstract

A time-varying Phillips curve was estimated as a means to examine the changing nature of the negative relationship between wage inflation and the unemployment rate in Australia. The implied equilibrium unemployment rate was generated and the analysis showed the important role played by variations in the slope of the Phillips curve (and thus in real wage rigidity) in changing the equilibrium unemployment rate. The deviations of actuals from the estimated equilibrium unemployment rates also performed well as measures of inflationary pressures.

1 Introduction

In 1958 A.W.Phillips published his famous article "The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957" in which he documented the negative relation between money wage inflation and the unemployment rate. In 1959, when Phillips was on sabbatical leave in Australia at the University of Melbourne, he estimated his second "Phillips Curve" and once again established a negative relationship between changes in money wages and the unemployment rate, this time for Australia over the period 1947-1958.

Lipsey (1960, 1974), formalized the empirical relation examined by Phillips in terms of the reaction of (nominal) wages to the presence of excess demand for labour. Friedman (1968) and Phelps (1967, 1968) pointed out that it was real, not money, wages which varied to clear the labour market and derived the appropriate equilibrium condition. They also proposed an expectations-augmented Phillips Curve and argued that, since all expectations are fully realized in the long run, a 'natural rate of unemployment' will prevail. Parkin (1973) appears to have been the first to have estimated an expectations-augmented Phillips Curve for Australia, albeit with mixed results.

Since then, numerous Phillips Curves have been estimated. Amongst other developments since Phillips's original article, we have seen experimentation with different dependent variables - various rates of nominal wage growth, price inflation and the growth in unit labour costs (i.e., nominal wage divided by real output per unit of labour).[1] Increasingly elaborate specifications and econometric techniques have been applied to extract the Phillips curve and in particular the NAIRU (non-accelerating inflation rate of unemployment). More interestingly, with developments in econometric techniques, the NAIRU has been modelled as time varying (Debelle & Vickery (1998), Gruen, Pagan & Thompson (1999) and Kennedy, Luu, and Goldbloom (2008)). These models assume that the NAIRU evolves as a random walk.

[1] Recent summaries of studies for Australia can be found in Gruen, Pagan & Thompson (1999) and Borland & McDonald (2000).

In contrast to the approach which assumes that the NAIRU is a random walk, the aim of this paper is to estimate a Phillips curve which captures the evolution of labour market conditions and behaviours and to then infer the implied time varying equilibrium (natural) unemployment rate. In other words, we recognize that the natural rate of unemployment for the economy varies over time because labour market environments (for example industrial relation institutions) and labour market behaviours (for example degree of unionization) change over time. Since the sample period spans regimes with different policies and labour market reforms, the approach allows more naturally for the testing of time-varying behaviour including asymmetric wage responses to increases and decreases in unemployment. It also obviates the a priori assumption that the natural unemployment rate is a non-stationary series.

The research questions considered in the paper are motivated by the same concerns as those flagged by Stiglitz (1997). First, we aim to explain the variations in the equilibrium unemployment rate over time; second, we examine whether the deviations of actual unemployment rates from their equilibrium rates serve as robust indicators of inflationary pressures; and third, we examine whether the inflation unemployment trade-offs have played a role in the conduct of monetary policy in Australia.

The paper is organized as follows. Section 2 sets out the basic relationship between wages and unemployment and derives the implied time-varying equilibrium unemployment rate. Section 3 provides the empirical analysis and contains a comparison of the equilibrium rates genenerated in this paper with the NAIRUs generated for Australia. This section also discusses the evolution of the equilibrium rate of unemployment in the context of structural and policy changes in the Australian economy. Section 4 considers the relevance of unemployment gaps (deviations of actual unemployment rates from the derived equilibrium rates) in the inflation targeting monetary policy framework. Concluding remarks are in Section 5.

2 Wage Inflation and the Unemployment Rate

Utilizing the expectations-augmented Phillips curve, write the hypothesized relationship between wage inflation (w) and the unemployment rate (u) as:[2]

$$w_t = \gamma p_t^e + h_t + \alpha - \beta u_t + \varepsilon_t \tag{1}$$

where h_t is the rate of Harrod neutral technological progress (i.e., the equilibrium rate of growth in labour productivity), p_t^e is the expected rate of inflation, and α, γ and β are parameters.[3] Note the negative sign in front of the slope parameter.

The equilibrium rate of unemployment u^* is defined as the rate when expected inflation is equal to actual inflation and when the rate of growth in the real wage is equal to the rate of Harrod neutral technological progress:[4]

$$p^e = p \tag{2}$$

$$w - p - h = 0 \tag{3}$$

Setting γ to unity and imposing conditions (2) and (3) yields:

$$u^* = \frac{\alpha}{\beta}$$

This method yields a single unique equilibrium rate. Until recently the literature has assumed that the equilibrium rate of unemployment was constant over time (or, at best, subject to one or two discrete jumps). However, recognizing structural changes over time, Gruen, Pagan and Thompson (1999) suggested viewing the natural rate of unemployment as a random walk process and proposed a model where wages (and prices) react to the

[2] The unemployment rate can enter non-linearly. For example the equation might be written with $1/u$ on the RHS. Also many researchers include the change in the unemployment rate ($u_t - u_{t-1}$) as an additional explanatory variable.

[3] It is common in Australia to add import prices (Gruen, Pagan & Thompson (1999)), the terms of trade (Phillips (1959) and Wallis (1993)) or oil prices (Debelle & Vickery (1998)) and long-term unemployment and the replacement rate to the RHS of the equation.

[4] For simplicity we put aside the explicit modelling of changes in price-cost mark-ups. In our model, this appears as a change in α.

deviations of actual unemployment from the evolving natural rate. Their idea may be set up in the framework adopted in this paper as:[5]

$$\begin{aligned} w_t &= \gamma p_t^e + h_t - \beta(u_t - u_t^*) + \varepsilon_t \\ u_t^* &= u_{t-1}^* + \eta_t \end{aligned} \tag{4}$$

The first drawback of this approach is the assumption that the natural rate is inherently non-stationary. Many empirical studies have shown that, within the sample period examined, the actual unemployment rate may be viewed as a non-stationary series. But, this is not the same as assuming that, over the long run, the underlying natural rate is non-stationary.

The second weakness of this approach is the assumption that the behavioural parameters (in particular, β) in the labour market have remained fixed throughout the sample period. This is a strong assumption given the structural changes and policy reforms which have taken place in Australia, especially in the 1980's and 1990's.

An alternative approach to recover a time-varying equilibrium rate would be to estimate the model in (1) but with time-varying behavioural coefficients and to then extract the implied time varying unemployment rate. The model estimated in this paper allows for time variation in both the α and β parameters, and consequently time variation in the equilibrium rate of unemployment. The proposed model is given by:

$$w_t = p_t^e + h_t + \alpha_t - \beta_t u_t + \varepsilon_t \tag{5}$$

$$\alpha_t = \alpha_{t-1} + \eta_{1,t} \tag{6}$$

$$\beta_t = \beta_{t-1} + \eta_{2,t} \tag{7}$$

and the time-varying equilibrium rate is then:

$$u_t^* = \frac{\alpha_t}{\beta_t}.$$

This approach shows that variation in the equilibrium rate of unemploy-

[5]Note that we set $\alpha = 0$ to ensure that $u_t = u_t^*$ when $(w_t - p_t^e - h_t) = 0$.

ment can be attributed to two sources: those that effect the (semi-) elasticity[6] of nominal wage growth with respect to the unemployment rate (i.e., changes in the slope of the Phillips curve, β_t), and those which effect the rate of wage growth which would occur at any given rate of unemployment (i.e., changes in the intercept of the Phillips curve, α_t). Variations in these two coefficients over time are likely to have quite different origins, for example the slope of the curve reflects the degree of wage flexibility or wage responsiveness to excess demand in the labour market. One would imagine that this might have fallen over the sample period (and thus the curve becoming steeper) with the diminishing role of unions and the spread of enterprise bargaining. Earlier studies have focused on the intercept rather than the slope; the approach adopted in this paper assesses the relative contribution of changes in the intercept and changes in the slope to variations in the equilibrium rate of unemployment.

3 Empirical Analysis

3.1 Data

Average weekly earnings is the measure of money wages used here. The sample period is from 1960Q1 which is the earliest available quarterly data. The data for w_t is the annual change in average weekly earnings (persons) and u_t is the Australian unemployment rate over the period 1960Q1 to 2007Q4 ($T = 92$). Expected inflation is proxied by lagged actual p_{t-1}. The measure of productivity h_t is the 5-quarter moving average of GDP per employed person.

The unit root tests are shown in Table 1. The results of the well-known Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are corroborated by the robust Breitung Non Parametric (BNP) test (with null that the series has a unit root) and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (with null that the series is stationary). However, when the se-

[6] A "semi-elasticity" since it refers to the percentage change in nominal wages resulting from a 1 percentage point change in the unemployment rate.

ries were subjected to the Zivot-Andrews tests which allow for an alternative hypothesis of stationarity allowing for a break, we find that w_t, p_t and u_t can all be treated as stationary with a break. These tests find a break for w_t, p_t, sometime in the early 1970's, while the break for the unemployment series occurred sometime in the early 1990s.[7] Thus, *apriori,* the time series properties of the data generating process suggest the possibility of behavioural changes over time.

Table 1: Unit Root Tests*

variable	unit root tests				Zivot-Andrews^e		
	ADF^a	PP^b	BNP^c	KPSS^d	ZA1	ZA2	ZA3
w_t	−1.717	−2.915*	0.025	0.574*	−4.737	−4.826*	−5.973*
p_t	−2.073	−2.003	0.019	0.399*	−4.463	−4.758*	−5.509*
u_t	−1.969	−1.599	0.057	1.053*	−3.360	−4.527*	−4.689
h_t	−7.208*	−4.495*	0.005*	0.208	−	−	−
5% c.v.	−2.877	−2.877	0.010	0.463	−4.80	−4.42	−5.08

* Denotes significance at the 5% level

a: Augmented Dickey-Fuller unit root test with SIC optimal lag length

a: Phillips-Perron unit root test

c: Breitung non-parametric unit root test

d: Kwiatkowski, Phillips, Schmidt and Shin unit root test

e: Zivot-Andrews unit root test

Figure 1 shows a scatter plot of wage (and price) inflation and unemployment rates over the years 1960:1 to 2007:4. It is obvious that there is no simple inverse relationship between them - certainly not one that has been stable over time.

[7] This is consistent with the finding in Dixon, Freebairn and Lim (2007) that there was a sustained rise in the exit rate from the pool of unemployed relative to its entry rate in the early 1990s.

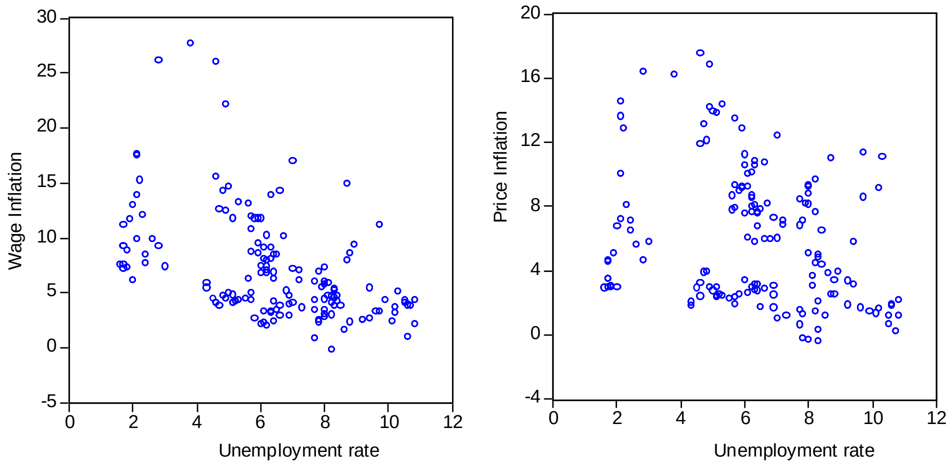

Figure 1: Scatter Plots

Rather than impose shifts and changes in the natural rate exogenously in an arbitrary fashion, we allow the relationship to evolve overtime in response to the policy changes, international shocks and other influences over the 5 decades in the sample.

3.2 Estimation

In the estimation, the model was changed by adding a lagged wage term to capture short run stickiness in adjustments:

$$\begin{aligned} w_t &= p_t^e + h_t + \alpha_t - \beta_t u_t + \varphi_t w_{t-1} + \varepsilon_t, & \varepsilon_t &\sim N(0, \sigma_\varepsilon^2) & (8) \\ \alpha_t &= \alpha_{t-1} + \eta_{1,t}, & \eta_{1,t} &\sim N(0, \sigma_{\eta 1}^2) & (9) \\ \beta_t &= \beta_{t-1} + \eta_{2,t}, & \eta_{2,t} &\sim N(0, \sigma_{\eta 2}^2) & (10) \\ \varphi_t &= \varphi_{t-1} + \eta_{3,t}, & \eta_{3,t} &\sim N(0, \sigma_{\eta 3}^2) & (11) \end{aligned}$$

Any error in the measurement of expected inflation p and technological progress h renders the equality in equation (3) void such that the dynamics of the wage rate w are not fully accounted for. In this respect, the inclusion of the parameter φ_t captures short-term dynamics in the path of w_t not adequately accounted for by the adopted proxies of expected inflation and technological progress. The condition (3) therefore becomes:

$$\varphi_t (L) w_t - p_t^e - h_t = 0 \quad (12)$$

where $\varphi_t (L) = 1 - \varphi_t L$, and L is the lag operator.

Before presenting the results for the time-varying model, we present the OLS results with heteroscedastic robust standard errors (in parenthesis):

$$\widehat{w}_t = p_{t-1} + h_t + \underset{(0.541)}{0.531} - \underset{(0.071)}{0.431} u_t + \underset{(0.059)}{0.281} w_{t-1}$$

The graph of recursive residuals which suggests possible changes in the early 1970's and mid 1980s is shown in Figure 2.

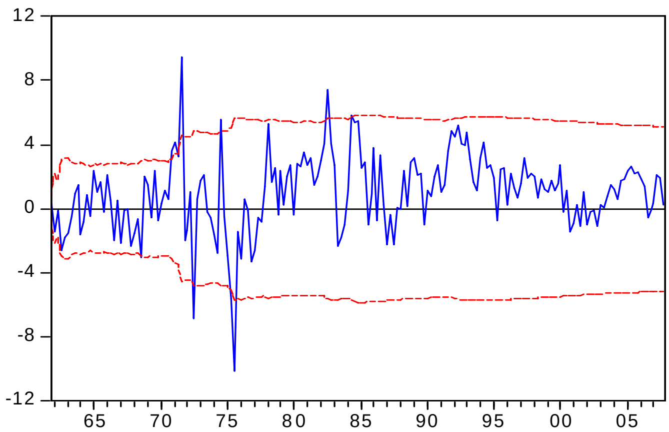

Figure 2: Recursive OLS Residuals with ± 2 s.e. upper and lower bounds

For the time-varying model, estimates of the parameter set $\left(\sigma_{\varepsilon}^2, \sigma_{\eta 1}^2, \sigma_{\eta 2}^2, \sigma_{\eta 3}^2\right)$ are obtained by maximizing the log-likelihood

$$L \propto -\frac{1}{2} \sum_t \left(\ln h_{t|t-1} + \frac{\left(w_t - w_{t|t-1}\right)^2}{h_{t|t-1}} \right). \quad (13)$$

The one-step ahead estimate prediction error, $w_t - w_{t|t-1}$, and its variance-covariance, $h_{t|t-1}$, are obtained using the Kalman filter. The parameter estimates (with standard errors in parentheses) are: $\sigma_{\varepsilon} = 0.851$ (0.017), $\sigma_{\eta,1} = 0.505$ (0.035), $\sigma_{\eta,2} = 0.099$ (0.016) and $\sigma_{\eta,3} = 0.181$ (0.021).[8] Figure 3 plots the time varying intercept α_t and slope β_t.

The estimates for $\sigma_{\eta,1}$ and $\sigma_{\eta,2}$ suggest significant time variation in the intercept α_t and slope β_t (sensitivity of the rate of change in wages to the unemployment rate u_t). Figure 3 shows that α_t rose significantly in the 1960's, but has varied less since the early 1970s while β_t rose to a peak in the mid 1980s, fell to its lowest value around the early 1990s, rose again and seems to have varied around unity since 2002.

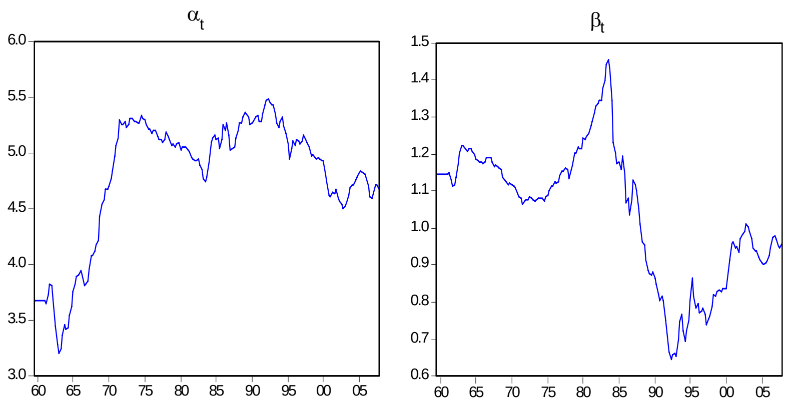

Figure 3: Time Varying Intercept, α_t and slope β_t (1960:1-2007:4)

3.3 Discussion of Results

We begin with a discussion of the new series for the equilibrium rate of unemployment, focussing on how it has evolved over time and how the results compare with results reported by other researchers. This series u_t^*, computed as α_t/β_t, together with the actual unemployment rate is shown in Figure 4.

[8]The model was also estimated subject to the addition of import prices with little change to the explanatory capacity of the model or the estimate of the natural rate of unemployment.

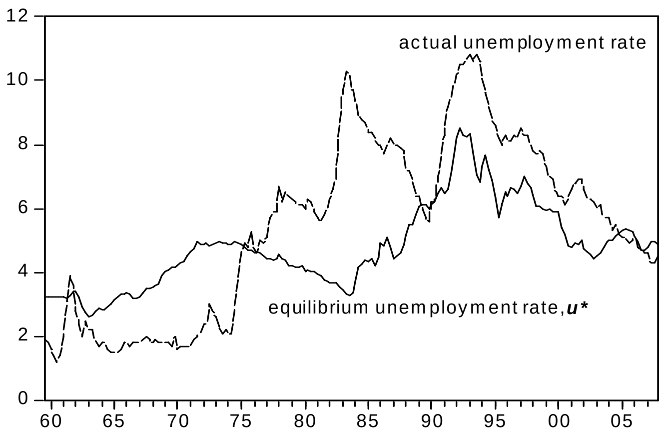

Figure 4: Actual and Time Varying Equilibrium Rate of Unemployment , α_t/β_t , (1960:1-2007:4)

The analysis shows that there was a fall in the equilibrium rate of unemployment from the start of the sample period when it was 3.2% to 2.6% in 1963. It then rose to 5.0% in 1971, fell to a low of 3.3% in 1983 before rising to a high of 8.5% in 1992. It then fell to 4.8% in 2001 and has fluctuated around this level during the 00s.

How does the equilibrium rate of unemployment computed in this paper compare with other studies? The u^* series computed here is different from early estimates which implicitly assume that β was constant and allowed only for shifts in α (see for examples, Crosby and Olekalns (1998)[9] and Downes and Bernie (1999)[10]). The analysis here shows large changes in **both** α and β, and casts doubt on these earlier studies.

There are three studies of inflation and unemployment in Australia which allow for time variation - Debelle and Vickery (1998) using data for the

[9] Crosby and Olekalns (1998, p125), using data for the period 1959 - 1997 estimate that the NAIRU rose in a series of discrete jumps. According to them, the NAIRU was 2.3% over the period 1959-1973, 5.04% over the period 1974-1984 and 9.18% over the period 1984-1997.

[10] Downes and Bernie (1999) estimate the NAIRU over the period 1971–1999 and find that there is a once and for all upwards shift in 1974 when it rose from 4.05% to 6.45% and then remained constant right through to 1999.

period 1959 - 1997[11]; Gruen, Pagan and Thompson (1999), using data for the period 1965–1997[12], and more recently, Kennedy et al (2008) who (inter alia) updates Gruen et al's estimates of the time-varying NAIRU from 1978 to mid 2007.

Debelle and Vickery put the NAIRU much higher in the 60s and 80s than the equilibrium rate u^* generated here, while the Gruen, Pagan and Thompson series is lower in the late 60s and early 70s, higher in the mid 70s through mid 80s and lower in the late 80s and early 90s than the equilibrium rate u^*. Kennedy et.el.'s NAIRU rose sharply up until the mid-1970s, declined gradually over the next 15 year, drifted upwards from 1990 until the early 2000s (although not reaching its 1974 peak), peaked at around 6 per cent in early 2000, then fell by 1.3 percentage points to around 4.7 per cent in recent times.

It is important to note at this juncture that the implied equilibrium unemployment rate is not identical to the NAIRU. The equilibrium rate of unemployment u^* calculated here is the rate when expected inflation is equal to actual inflation and when the real wage rate is equal to the Harrod neutral technological progress, while the NAIRU is the non-accelerating inflation rate of unemployment. Thus, there will be differences between the measures.

However, an intuitive understanding of the difference between the equilibrium unemployment rate with that generated using equation (4) which assumes that u_t^* is a random walk (the assumption underpinning the studies noted above) is shown in Figure 5. Both models are estimated on the same data set and hence are comparable. The main point to note is that both series have similar turning points, but that the random walk version overstates highs (around 1973 when inflation was high) and lows (around 1983, when

[11] Their one-sided NAIRU estimates from their (prefered) non-linear model rose during the first half of the 1970s, then remained at approximately 2 per cent through the 1960s, before rising to a level of around 6 per cent around the time of the sharp increase in real wages in 1974. After falling slightly during the rest of the 1970s, the estimate again increases at the turn of the decade. Thereafter, the estimate of the NAIRU fluctuates in the range between 5 and 8 per cent.

[12] Their two-sided NAIRU estimates from the W-curve (which seems to be their preferred model) rose steeply between 1967 and 1974 and then continued to rise but more slowly until the early 80s, then falling until 1986 after which it rises steadily through to the end of their sample period.

inflation dropped sharply), although post inflation targeting the two series are remarkably similar.

Another way to see the difference is to note that the model described in equation (5) can be rewritten as:

$$w_t = p_t^e + h_t - \beta_t(u_t - u_t^*) + \varepsilon_t \quad (14)$$

$$\beta_t u_t^* = \beta_{t-1} u_{t-1}^* + \eta_{1,t} \quad (15)$$

$$\beta_t = \beta_{t-1} + \eta_{2,t} \quad (16)$$

which differs from equation (4) in that the slope coefficient is time-varying. Assuming that β is a constant, then comparing (4) with (15) we that $\eta_t = \eta_{1,t}/\beta$. Thus, the more stable and closer β is to unity, the more u_t^* will behave like a random walk.

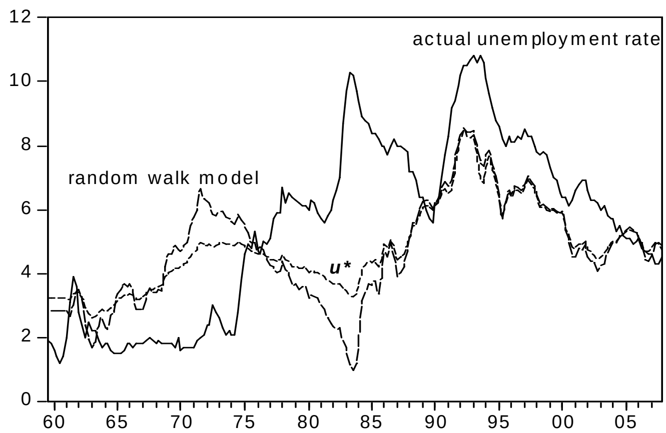

Figure 5: Plots of various rates of unemployment (1960:1-2007:4)

3.4 Relative contribution of α_t and β_t to u_t^*

Fundamental to the approach in the paper is the notion that variations in the equilibrium rate of unemployment can be attributed to two sources - those that effect the (semi-) elasticity of nominal wage growth with respect to the unemployment rate (i.e., changes in the (negative) slope of the Phillips curve, β) and those which effect the rate of wage growth which would occur at any given level of unemployment (i.e., changes in the intercept of the Phillips curve, α).

Values for α, β and u^* are given in Table 2 for the beginning and end of the sample period and at turning points of u^*. The table also includes the percentage changes between the turning points and between the last turning point and the end of the sample period.

Table 2 also contains information about the inverse of $1/\beta$, which is "the natural measure of wage rigidity as it is the extra unemployment which occurs in the face of a deflationary shock" (Grubb, et al, 1983, p 12f) where a real shock is one that "leads to a different equilibrium real wage - for example, a fall in productivity growth relative to trend or a shift in the terms of trade" (Coe, p. 115)). Thus the lower is β the greater is real wage rigidity (alternatively the lower is real wage flexibility, the greater the unemployment cost of real shocks).

Table 2: Values of α, β and u^*

	u^*	α	β	$1/\beta$
values at point in time				
1961:1	3.21	3.68	1.14	0.87
1963:1	2.62	3.20	1.22	0.82
1971:3	4.98	5.30	1.06	0.94
1983:3	3.26	4.75	1.45	0.69
1992:2	8.51	5.49	0.65	1.55
2002:4	4.44	4.50	1.01	0.99
2007:4	4.87	4.68	0.96	1.04
change over sub-samples				
1963:1-1971:3	90.48	65.78	−12.97	14.90
1971:3-1983:3	−34.50	−10.44	36.73	−26.86
1983:3-1992:2	160.50	15.59	−55.63	125.36
1992:2-2002:4	−47.76	−18.10	56.79	−36.22
2002:4-2007:4	9.69	4.06	−5.13	5.41

Before discussing the changes in α_t and β_t, it is appropriate at this juncture to first assess the relative importance of each in shaping the evolution of the equilibrium natural rate of unemployment. To gauge their relative contribution, consider a linearized version of the expression for u_t^*:

$$\log(u_t^*) = \log(\alpha_t) + \log(1/\beta_t)$$

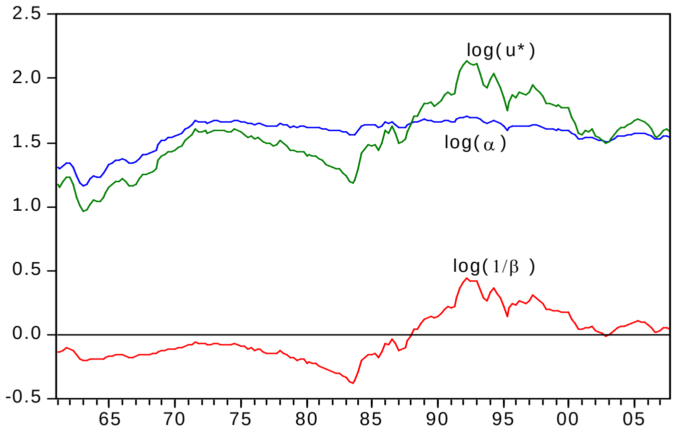

Figure 6: Relative Contributions of α_t, β_t to u_t^*

Figure 6 shows plots of $\log(u_t^*)$ and $\log(\alpha_t)$ and $\log(1/\beta_t)$. Changes in $\log(\alpha_t)$ played a significant role in raising the equilibrium rate in the 1960s and the early 1970s, but their contribution has been relatively stable since the early 1970s. The interesting point here is that declines in real wage rigidities lowered the equilibrium rate in the periods 1971-1983 and 1992-2002, while increases in real wage rigidities increased the equilibrium rate in the period 1983-1992. Additionally, it would appear that since 2000, both α_t and β_t (and thus u_t^*) have been relatively stable.

An alternative way to view the relative contribution is to consider deviations from the sample mean (assuming zero covariance between α_t, β_t):

$$
\begin{aligned}
u_t^* - \overline{u}_t^* &= \frac{\alpha_t}{\beta_t} - \frac{\overline{\alpha}}{\overline{\beta}} = \frac{\alpha_t\overline{\beta} - \overline{\beta}\overline{\alpha} + \overline{\beta}\overline{\alpha} - \overline{\alpha}\beta_t}{\overline{\beta}\beta_t} \\
&= \frac{\overline{\alpha}\overline{\beta}}{\overline{\beta}\beta_t}\left(\frac{(\alpha_t - \overline{\alpha})}{\overline{\alpha}}\right) - \frac{\overline{\alpha}\overline{\beta}}{\overline{\beta}\beta_t}\left(\frac{(\beta_t - \overline{\beta})}{\overline{\beta}}\right) \qquad (17)
\end{aligned}
$$

Figure 7 plots $(u_t^* - \overline{u}_t^*)$ as the sum of the term involving $(\alpha_t - \overline{\alpha})$ (in black) and the term involving $(\beta_t - \overline{\beta})$ (in red). One thing which is immediately apparent from the figure is that changes in the slope have been an important source of variation in the natural rate – this is especially evident in the period 1983–2001. Overall, we see the dominance of the term involving $(\beta_t - \overline{\beta})$ and its role in pulling the natural rate down over the period 1960-1970, and up over the period 1988-2000. Between 1975-1988 and since 2000, the effect due to $(\beta_t - \overline{\beta})$ has overwhelmed the effect due to $(\alpha_t - \overline{\alpha})$.

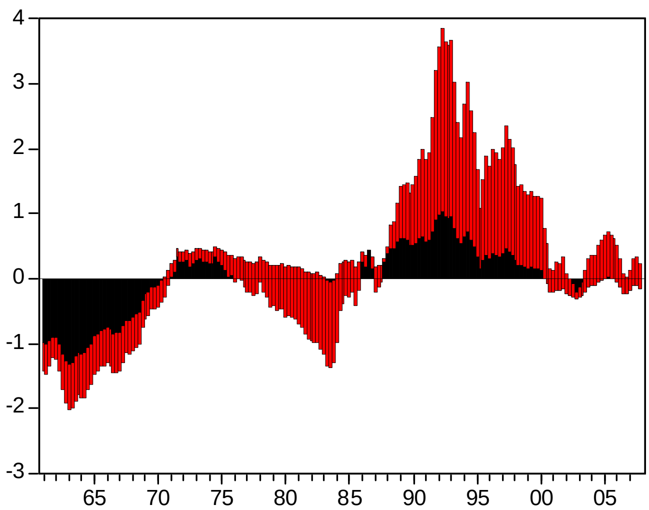

Figure 7: Contributions of $(\alpha_t - \overline{\alpha})$ and $(\beta_t - \overline{\beta})$ to $(u_t^* - \overline{u}_t^*)$

Taken together the finding on the importance of variations in β provides justification for the time-varying parameter approach which focuses on β as well as α as time-varying parameters. We turn now to some of the factors influencing the time-varying nature of α_t and β_t.

The parameter β is the (semi-) elasticity of nominal wage growth with respect to the unemployment rate. The results support a negative relationship between wage growth and unemployment throughout the period. It appears that wages exhibited the strongest sensitivity to unemployment in the early 1980s. Thereafter wage sensitivity to the unemployment rate fell to its lowest level around early-90s and it reached unity by end 2007.

From Table 2, we see that over the sample period, the trajectory of β_t was steepest over the period 1984-1993 and with noticeable rises in β_t (i.e., fall in real wage rigidity, $1/\beta$) before 1984 (from about 1971-1984) and after 1992 (from about 1992-2002). This is an interesting result, especially in light of the real-wage overhang 'debate' of the late 1970s. The analysis shows that real wage rigidity fell over the period 1974–1983 and that the degree of wage-rigidity then was low compared with the 90s and even today.[13]

The period 1983-1996 was the period of successive Accords between the Australian Labour party (ALP) and the ACTU (the political and industrial wing of the labour movement) during which unions agreed to moderate wage demands while the (ALP) government undertook to introduce a number of social and economic reforms. The degree of labour market regulation under the Accords changed over the thirteen years the ALP was in government. The initial emphasis was on limiting nominal wage increases with the aim of achieving sustained decreases in inflation with little or no increase in unemployment (Chapman, 1998). Over time, and especially after 1993 the industrial system became more directed to enterprise bargaining which "paved the way for more radical changes during the latter part of the 1990s, after Labor lost office" (Lansbury, 2002, p 31). These latter years marked a period of steady de-centralization and de-unionisation of the labour market.

In short, the variations in β, that have contributed to changes in the equilibrium unemployment rate appear to be the result of changes in labour

[13] This finding sheds new light on the recession of the early 90s, the 'recession we had to have'. Our series for real wage rigidity shows it to have been at the highest level at this time and this may go some way towards explaining how economic policy had such calamitous effects on the unemployment rate.

market regulation and institutions and their effect on promoting (or not, as the case may be) the degree of wage flexibility.

Figure 3 plots the time-varying intercepts. As noted earlier, variations in α captures information regarding the environment influencing the determination of Australian wages. Examples include: changes in market power (as in the price-cost mark-up), the level and eligibility requirements for social security benefits, structural changes in industrial relations, extent and effectiveness of labour market programs (for a summary of possible factors, see Borland & McDonald (2000)).

An important finding in this paper is that while α is higher at the end of the sample period compared to its value at the beginning of the sample period, the most significant (not only in terms of the size of the change in α but also in terms of the consequences for the equilibrium rate of unemployment) occurred in the period 1963-1971 when α rose by about 65%. This cannot be attributed to a rise in the unemployment benefits replacement rate as it was falling over the period and the other favorite culprit, long-term unemployment, was falling or stable over the period. It is likely that the rise in α over this period is related to structural and demographic changes occurring at the time and also to the dramatic rise in union militancy and thus bargaining power over the period (see Bean (1994, pp 579-591 and the references cited therein) for a discussion of the relationship between union militancy on the one hand and both the intercept in the wage setting equation and hysteresis, on the other).

4 Inflation and Unemployment

One motivation for re-visiting the Phillips curve is to consider the implication of the inflation unemployment trade-off in the conduct of monetary policy. In this section, we report on the performance of the $(u_t - u_t^*)$ series as a signal of inflationary pressure and provide a perspective on the role of the unemployment gap since the adoption of inflation targeting in 1993.

4.1 Inflationary Pressures

The u_t^* derived here may be interpreted as the underlying unemployment rate consistent with setting the 'right' wage, namely when the real wage is equal to a measure of productivity. According to the model, when actual u_t is less than u_t^* (the unemployment deviation terms, $u_t - u_t^*$, are negative) then in line with Phillips' original hypothesis on the relationship between wage inflation and labour conditions, wage inflation adjusts negatively to the deviation $u_t - u_t^*$ in proportion to the magnitude of β_t. Hence, this suggests that price inflation should be on the rise. Conversely, when actual u_t is greater than u_t^*, there is slack in the labour market and price inflation is unlikely to be on the rise.

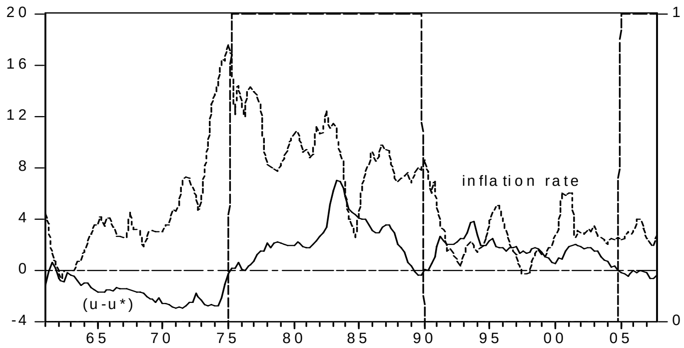

Figure 8: Deviations of unemployment rates ($u_t - u_t^*$) and inflation, 1960:1-2007:4

To check how well the equilibrium rate measure we have generated serves as a signal of rising inflationary pressures, in Figure 8, we plot the deviations of $(u - u^*)$ along with actual price inflation over the sample period. Over the period 1960-1975, when $(u - u^*) < 0$, inflation rose to a peak in 1975. From 1975 to 1996, when inflation was falling, $(u - u^*) > 0$. There was a short period when the GST was introduced when prices rose, and a short period 2001 - 2004 when prices fell. Since 2004 - the unemployment deviation terms, $u_t - u_t^*$, have been negative and Australia has been in an inflationary phase.

4.2 Inflation Targeting and the Unemployment Gap

In this section, we provide a graphical view about the practice of inflation targeting in Australia with respect to unemployment as well as estimate a probit model of a change in monetary policy expressed as a function of the inflation and unemployment gaps.

In Figure 9, the vertical axis shows the inflation gap (deviation of actual inflation from the mid-point of the target band of 2.5%), while the horizontal axis shows the unemployment gap (deviation of actual unemployment from the equilibrium rate, u^*). The top left hand quadrant shows the occasions when the inflation gaps were high and the unemployment gaps low, namely states of the economy when monetary tightenings (positive changes in the cash rate) were warranted. In contrast, the bottom right-hand quadrant shows the occasions when monetary loosenings (negative changes in the cash rate) were warranted as the inflation gaps were low and the unemployment gaps high. The number of points in the top right hand quadrant provides some indication of the priority given to keeping inflation low, despite the unemployment gap.

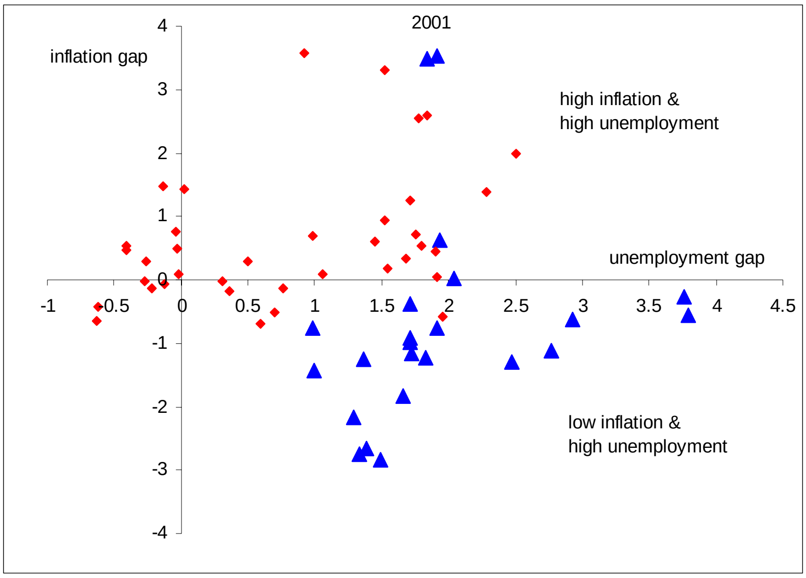

Figure 9: Inflation gap, Unemployment Gap and Changes in the Cash Rate (+ diamonds and - triangles), 1993:1-2007:4

The outliers are the blue triangles in the top right-hand-side quadrant. These occurred in 2001. As many commentators have pointed out (e.g. Bell, 2004, p.101 and p.132) the interest rate cuts in the lead up to the 2001 election are an anomaly.

4.3 Modelling the Probability of a Cash Rate Increase

A probit model was estimated to assess the probability of a tightening in monetary policy (increase in official cash rate) as a function of the inflation and unemployment gaps. The model takes the form:

$$\begin{aligned} \Pr(y_t &= 1|X_t) = \Phi\left(X_t'\delta\right) \\ X_t &= \{(\pi_t - 2.5), (u_t - u_t^*)\} \end{aligned}$$

where $y_t = 1$ indicates an increase in the cash rate, Φ is the cumulative standard normal distribution function, δ is a vector of parameters and X_t is the data set containing observations of the inflation gap $(\pi_t - 2.5)$ and the unemployment gap $(u_t - u_t^*)$. The estimated coefficient (standard error in parenthesis) for the inflation gap is 0.932 (0.272) while that for the unemployment gap is -0.952 (0.356). Both coefficients are of the correct sign and suggest that this particular measure of the unemployment gap contains useful information for understanding the practice of inflation targeting in Australia.

The results are presented graphically in Figure 10. As shown we see the drop in the probability of an interest rate rise as the unemployment gap becomes larger (actual u is above the equilibrium rate u^*) and the increase in the probability of an interest rate rise as the inflation gap increases. We also see the extent to which high unemployment gaps moderate a tightening policy.

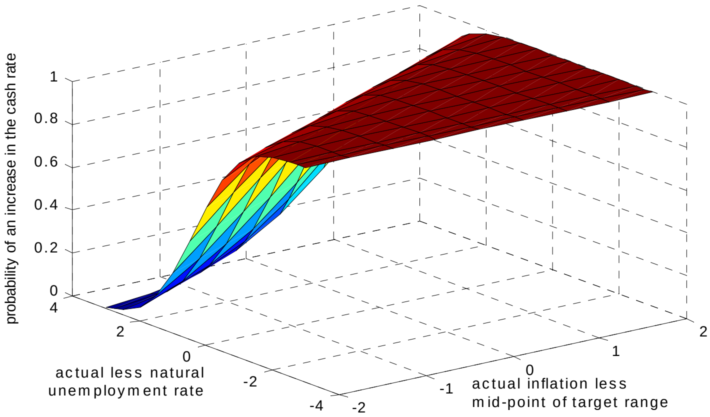

Figure 10: Probit Model

5 Concluding Remarks

The aim of the paper was to determine whether there was a negative relationship between wage inflation and the unemployment rate and how both the negative relationship and the equilibrium rate of unemployment have changed over time. To this end we estimated a time-varying Phillips curve for the period 1960:1-2007:4. A new series for the equilibrium rate of unemployment rate u^* was generated.

Three results followed from an analysis of the series. First, the analysis showed that, since 2001 the equilibrium unemployment rate u^* which is compatible with the condition - real wages equal productivity - is around 4.5%. Second, the analysis points to the major role played by the fall in wage rigidity, since 1993, in reducing the equilibrium unemployment rate.[14] Third,

[14]The success of inflation targeting (politically as well as in its role as a system of economic management) was clearly helped by the improvement in real wage flexibility (hence reduction in the real costs of unemployment). It suggests that the long boom (and the low unemployment associated with it) which followed the recession was not only due to the successful winding down of inflation expectations associated with the monetary policy of inflation targeting (see Macfarlane (2006)), it was also due to the reforms in the labour market under the Keating and Howard governments which markedly reduced real wage rigidity.

the approach yields the most timely measure of the inflation-unemployment trade-off. We find that the deviations of actual from the equilibrium unemployment rates (the unemployment gaps) performed remarkably well as measures of inflationary pressures.

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