Why has Australian Wages Growth Been so Low? A Phillips Curve Perspective

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Abstract

Wages growth in Australia has recently been the lowest in two decades. One possible explanation is a decline in the Non-Accelerating Inflation Rate of Unemployment (NAIRU). We examine this hypothesis by estimating a wage Phillips curve including a time-varying NAIRU. Our findings are: (i) the NAIRU has recently been around 5.5%, (ii) our approach increases the precision of the NAIRU estimates, (iii) low inflation expectations have been an important contributing factor, and (iv) the long-run annual wages growth is nearly 3%. We also find that the underutilisation rate suggests greater slack exists, but is less useful in explaining wage developments.

1 Introduction

A striking feature of the Australian economy in recent years has been low wages growth. The main measure of wages that policymakers and business economists focus on - the Wage Price Index (WPI) - has been at its lowest level since its inception two decades ago.

Low wages growth has important macroeconomic consequences. For example, it impedes the ability of the federal government to reduce the budget deficit as it suppresses income tax revenues. The outlook for wages growth was the most widely debated aspect of the macroeconomics forecasts underlying the recent 2017/18 Commonwealth Budget (see, for example, Daley (2017)). Another important macroeconomic consequence is that it may hamper the ability of households to service debt.

The Phillips curve framework is commonly used to interpret and model developments in wages. In a Phillips curve, the unemployment rate being above the Non-Accelerating Inflation Rate of Unemployment (NAIRU) will dampen wages growth. The NAIRU is unobserved and has to be estimated. The unemployment rate that has prevailed in recent years is not substantially above previous estimates of the NAIRU (e.g. Ballantyne, Voss & Jacobs (2014) and Bullen, Greenwell, Kouparitsas, Muller, O'Leary & Wilcox (2014)) or particularly elevated by historical standards. This raises the central research question addressed in this paper: does Australia's recent low wages growth indicate that the NAIRU has fallen and that there is considerable slack in the labour market?

Estimates of the NAIRU may be of interest for reasons beyond explaining low wages growth. One example is that they are a key input into production function-based estimates of the output gap (such as those constructed by the Congressional Budget Office in the United States), which can be used by policymakers as an input into the setting of monetary policy or the construction of cyclically-adjusted budget estimates.

To answer whether the NAIRU has fallen, and to ascertain the implications for wages growth, ideally we need a framework where: (i) the NAIRU is allowed to be time-varying, and (ii) wages data is used in its estimation. The most influential study of Phillips curves where a time-varying NAIRU is estimated is

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Gruen, Pagan & Thompson (1999); for example, an updated version is currently used at the Australian Treasury (Bullen *et al.* 2014). However, this study focuses on price and unit labour cost inflation, not wage inflation. A contribution of this paper is to demonstrate how one may build on the unit labour costs approach of Gruen *et al.* (1999) to estimate a Phillips curve for the WPI with a time-varying NAIRU.

The introduction of wages data into the estimation of the NAIRU may produce more precise estimates. There are, however, several complications that must be dealt with. These include the relatively limited availability of the WPI, and the uncertainty about the extent to which it is adjusted for changes in productivity. We demonstrate a simple approach to estimating a wage Phillips curve that handles both of these issues.

In recent years the underemployment rate - the share of the labour force that is employed but are working less hours than they desire - has increased to high levels by historical standards. This suggests there may be more slack in the labour market than is captured by focusing on the unemployment rate. In this paper we examine the implications of underemployment for growth in unit labour costs.

To preview our findings, we find that additionally using a wage Phillips curve produces estimates of the NAIRU currently being close to 5.5 per cent, moderately higher than those produced using an unit labour cost Phillips curve alone (4.75 per cent). As with the estimation of any latent variable, a sizable degree of uncertainty surrounds each of these estimates, particularly at the end of the estimation sample. Nevertheless, the wage Phillips curve considerably reduces this uncertainty. These estimates imply that currently little slack exists in the labour market. Important factors contributing to the low wages growth appear to be low inflation expectations, together with lower productivity growth. Model-averaging across several variants of the model yields a slightly lower NAIRU estimate of 5 per cent.

Our findings also shed light on the possible future behaviour of the WPI. They suggest that if labour productivity was to grow at its average rate since the late 1990s - the sample the WPI is available for - then in the long-run the WPI is likely to grow at nearly 3 per cent. This is considerably lower than the 3.75 per cent assumed in the 2017/18 Commonwealth Budget forecasts (Commonwealth of Australia 2017). As such, our findings suggest that budget repair may be a more protracted process than is currently forecast.

Broader measures of labour underutilisation are found to point to greater slack in the labour market than the unemployment rate suggests. However, in part reflecting the non-linearity in the unit labour cost Phillips curve, this greater slack has a similar dampening effect on unit labour costs growth as the conventional unemployment rate-based measure.

This paper is structured as follows. Section 2 provides an overview of the Gruen *et al.* (1999) methodology, which we build on in order to estimate the wage Phillips curve. Section 3 outlines the data used and their properties. Section 4 details our methodology, including how differing sample lengths and the uncertain degree to which the WPI is productivity-adjusted are addressed. Section 5 presents the estimates of the unit labour cost and wage Phillips curves and the NAIRU, together with their implications for long-run growth wages growth. Section 6 discusses results based on broader measures of labour underutilisation, and Section 7 discusses the sources of the recent low wages growth. Finally, Section 8 summarises the main conclusions of the paper.

2 Literature and Existing Methodology

The approach adopted in this paper is to build on the model of Gruen *et al.* (1999), which has been highly influential in the literature on Australian Phillips curves and in Australian policy institutions.[1]

There are several important aspects of the Phillips curve estimated by Gruen *et al.* (1999). The first is that they are expectations-augmented Phillips curves, where inflation expectations are modeled as a combination of both bond-market, which are possibly forward-looking, and lagged inflation and unit labour costs growth. Second, Phillips curves are estimated for both price and unit labour cost inflation. Unit labour costs are productivity-adjusted wages. In this paper we will focus primarily on the unit-labour costs Phillips curve, as we are intending to introduce a second measure of wages. Third, Gruen *et al.* (1999) estimate specifications where the NAIRU can vary over time. Given that our research question is whether the current low wages growth suggests the NAIRU has declined and slack exists in the labour market, accommodating a time-varying NAIRU is important.

The long-run Phillips curve is constrained to be vertical in the approach of Gruen *et al.* (1999). This essentially means that real unit labour costs are constant in the long run; a doubling in inflation

[1] Borland & McDonald (2000) provides an overview of Australian Phillips curve estimates. The working paper version of Gruen *et al.* (1999) includes an extensive discussion of the evolution of thought about the Phillips curve in Australia at the RBA.

expectations, for example, will eventually result in a doubling of nominal unit labour costs. It has the implication that a central bank cannot impact on the real economy in the long-run.

In recent years there has been research into the possibility that the short-run Phillips curve has flattened; see, for example Gillitzer & Simon (2015) and Kuttner & Robinson (2010). The Gruen *et al.* (1999) approach accommodates this to some extent by allowing the short-run Phillips curve to be non-linear. In particular, the specification allows, for example, a given increase in the unemployment rate to be more inflationary the further the unemployment rate is above the NAIRU. On the flip-side, it also means that fluctuations of the unemployment rate near the NAIRU have relatively little impact on inflation.[2] In summary, many of the properties of the Gruen *et al.* (1999) approach, such as allowing a time-varying NAIRU and the non-linear specification, combined with the wide usage by Australian policy institutions, make it an appropriate starting point for our analysis.

More precisely, the unit labour costs specification estimated by Gruen *et al.* (1999) is

$$\begin{aligned}\triangle_4 ulc_t - \triangle_4 p_{t-1} = \delta_1 \left(\pi_t^* - \triangle_4 p_{t-1}\right) + \delta_2 \frac{U_t - U_t^*}{U_t} + \delta_3 \frac{\triangle U_{t-1}}{U_t} + \delta_4 \left(\triangle_4 ulc_{t-1} - \triangle_4 p_{t-2}\right) + \\ \delta_5 \left(\triangle ulc_{t-1} - \triangle ulc_{t-4}\right) + e_t,\end{aligned} \tag{1}$$

where: Δ denotes the difference operator and Δ_4 the change over four quarters; ulc_t is nominal unit labour costs; π_t^* are bond-market inflation expectations; p_t are underlying consumer prices; U_t the unemployment rate; U_t^* the NAIRU and e_t the residual, where denotes $e_t \sim N(0, \sigma_1^2)$. Finally, $\delta_1, \delta_2, \ldots, \delta_5$ are the parameters.

The NAIRU is assumed to follow a unit root process:

$$U_t^* = U_{t-1}^* + v_t, \tag{2}$$

where $v_t \sim N(0, \sigma_v^2)$.

This is a convenient statistical approximation to the variation over time that may be evident over time in the NAIRU.

The properties described above are evident in Equations 1 and 2. In particular, the vertical long-run Phillips curve is the reason why many of the variables are specified as a deviation from lagged price or unit labour cost inflation. To see this, consider the economy in the long run, when: first, the unemployment rate is at the NAIRU; secondly, bond-market inflation expectations equal actual inflation; and thirdly, nominal unit labour costs growth is constant. In this case Equation 1 implies that nominal unit labour costs will be growing at the same rate as inflation. Alternatively, Equation 1 can be rearranged so that it is an expression for nominal unit labour costs growth; in this case the coefficients on the terms capturing expectations (bond-market inflation expectations and lagged unit labour cost and good inflation) will sum to one. This restriction is sometimes referred to as an "accelerationist" specification, although it should be noted that due to the inclusion of the bond-market term inflation expectations are partially forward looking. However, they are not constrained to be rational like in the New Keynesian Phillips curve.

More recently, Cusbert (2017) has extended the Gruen *et al.* (1999) framework to estimate both the price and unit labour cost Phillips curves jointly, which has similarities to the approach adopted in this paper. Cusbert (2017) finds that the NAIRU recently has been around 5 per cent, and has been drifting lower since the mid-1990s.

Alternative approaches exist. Lim, Dixon & Tsiaplias (2009) estimate an expectations augmented Phillips curve for Australia, however, they do this within a time-varying parameter framework. This has two potential advantages. First, the time-variation may be more appropriate than the non-linear specification used by Gruen *et al.* (1999). Second, the NAIRU in Lim *et al.* (2009) is not directly assumed to follow a random walk, although it is the ratio of two time-varying parameters which are assumed to. As technically the NAIRU should be bounded below by zero this could be desirable, although practically any model producing a negative NAIRU is likely to be misspecified. Bullen *et al.* (2014) report that their updated versions of Gruen *et al.* (1999) and Lim *et al.* (2009) deliver "...virtually identical" NAIRU estimates (p.16).

WPI-based Phillips curves have been estimated. Ballantyne *et al.* (2014) present wage Phillips curves, together with updated versions of Gruen *et al.* (1999). In the wage Phillips curves, however, the NAIRU is constant and a linear specification is used. Alternatively Rush & Jacobs (2015) estimate a WPI-based Phillips curve with a time-varying NAIRU, although the NAIRU is not estimated simultaneously, and

[2] For a discussion of the implications of a convex Phillips curve see Debelle & Vickery (1997).

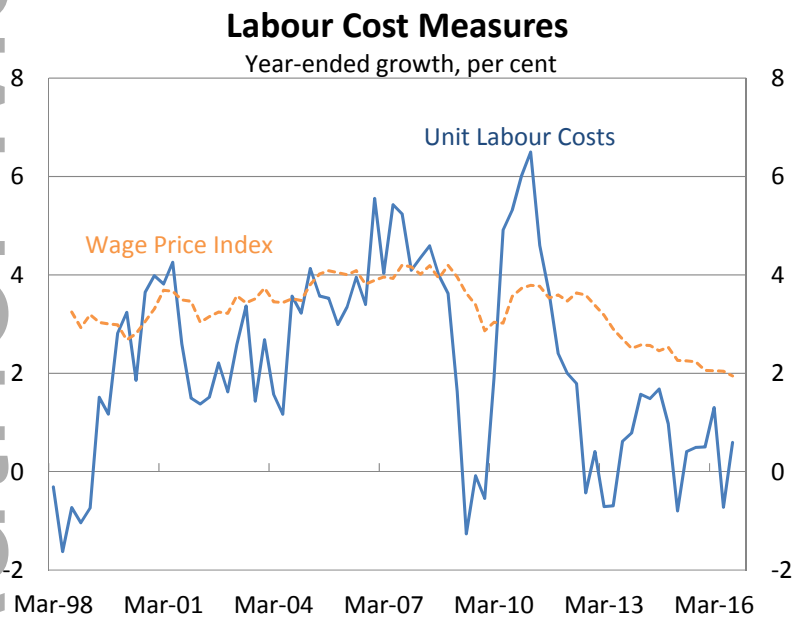
is instead taken from the updated Gruen *et al.* (1999) estimates in Ballantyne *et al.* (2014). Bishop & Cassidy (2017) update Ballantyne *et al.* (2014), using the NAIRU from Cusbert (2017).

Another dimension that has been examined in the literature is whether the deviation of the unemployment rate from the NAIRU - hereafter referred to as the unemployment gap - is a sufficient measure of slack or excess demand in the labour market. One reason why it may not be sufficient is that adjustment along the intensive margin is likely to be an important aspect of the Australian labour market today (see, for example, Bishop, Gustafsson & Plumb (2016)). Consequently, we explore several approaches to incorporating the underemployment rate into the Phillips curves. Borland (2011) models price Phillips curves that in addition to the unemployment rate include broader labour underutilisation variables, in order to capture variation in hours worked.[3] However, Borland (2011) assumes that the NAIRU is constant. An older literature exists examining alternative variables for capturing labour market slack - see, for example, Gregory (1986) and Dawkins & Wooden (1985); Borland & McDonald (2000) provide a summary.

3 Data

The focus of this paper is to estimate a Phillips curve for the WPI with a simultaneously estimated time-varying NAIRU. Why is this potentially useful or desirable? The WPI is the main measure followed by policymakers and market economists in assessing the state of the economy. This focus, in our opinion, is a result of it providing a clearer signal about wage developments and the state of the economy than wage bill-based measures. This reflects its construction. The WPI measures the wages for a given bundle of positions, analogous to the CPI, whereas wage bill-based measures will be affected by changes in the composition of employment in the economy (see Box D in Reserve Bank of Australia (2006)). Consequently, the WPI and unit labour costs are distinctly different wage measures. Empirically, growth in the WPI is considerably less volatile than unit labour costs (Figure 1).

Figure 1



A potential advantage of including the WPI into the NAIRU estimation is that the additional information may result in more precise estimates. Indeed we find this to be the case, although considerable uncertainty remains, particularly at the end of the sample.

The WPI, however, does have disadvantages. One is that it is only available for a relatively short

[3] See also Mitchell & Muysken (2008).

period of time, namely 1997:Q3 onwards.[4] This is in contrast to the long samples that have typically been used to estimate Phillips curves with a time-varying NAIRU for Australia.[5] This relatively short sample influences the methodology we use to estimate the wage Phillips curve. A second limitation of the WPI is that while it is constructed for a given group of positions, the extent to which it is productivity adjusted is not clear, unlike unit labour costs. This is another issue our methodology addresses.

The majority of the other data used in this paper - underlying consumer prices, bond-market inflation expectations, unemployment, labour productivity and import prices - are similar to those used by Gruen *et al.* (1999). Additionally, we use labour productivity and underemployment data; these are primarily based on Australian Bureau of Statistics releases (although we extend the latter back in history) and their sources are detailed in Appendix A. A volumes measure of labour underutilisation and an alternative measure of inflation expectations incorporating survey data were obtained from the Reserve Bank of Australia.

4 Method

We now explain how our methodology builds on that of Gruen *et al.* (1999) in order to estimate the wage Phillips curve with a time-varying NAIRU while addressing: (i) the short sample available for the WPI, and (ii) the uncertainty about the extent of productivity adjustment necessary for the WPI.

4.1 The Short Sample

Estimating models with a latent variable, such as the NAIRU, with maximum likelihood typically requires a longer time series of data than is available for the WPI. Our approach is to estimate the wage Phillips curve jointly with a unit labour cost Phillips curve. To be clear, while the two Phillips curves are estimated jointly, there is a common NAIRU, and the unit labour cost Phillips curve is estimated over a longer sample.

An alternative approach to dealing with the short sample would be to use a Bayesian framework with informative priors. The method adopted in this paper directly builds on the existing Australian literature estimating the NAIRU, which overwhelmingly uses maximum likelihood. We believe that exploring a Bayesian approach could be a productive area of future research; one possibility would be to adapt the recent highly flexible work of Chan, Clark & Koop (2018) to Australia.

Before turning to the specifics of how the WPI Phillips curve is incorporated, we first describe the unit labour cost Phillips curve.

4.1.1 The Unit Labour Cost Phillips Curve

Our preferred specification is:

$$\triangle rulc_t = \delta_1 \left(\pi_t^* - \triangle_4 p_{t-1}\right) + \delta_2 \frac{U_t - U_t^*}{U_t} + \delta_3 \frac{\triangle U_{t-1}}{U_t} + \delta_4 rulc_{t-1} + e_{1,t} \tag{3}$$

where $\triangle rulc_t = \triangle ulc_t - \triangle p_{t-1}$ and $e_{1,t}$ is normally distributed.

There are several aspects to note. First, the Phillips curve contains similar explanatory variables to Gruen *et al.* (1999), and these are often specified as deviations from lagged inflation in order to maintain the vertical long-run Phillips curve assumption. This assumption raises the possibility of a cointegrating relationship existing that includes both nominal unit labour costs and the price level; such a relationship is the basis of the mark-up of model of inflation (see, for example, de Brouwer & Ericsson (1998)). The mark-up model typically assumes that the CPI cointegrates with both unit labour costs and import prices, with their coefficients summing to 1, that is:

$$p_t = C + \beta ulc_t + (1 - \beta) pm_t + \epsilon_t, \tag{4}$$

where C is a constant and ϵ_t the long-run disequilbrium. However, we found little evidence of such a cointegrating relationship and therefore it is not included; this was also found by Gruen *et al.* (1999).

[4] Another disadvantage is that it does not capture some cyclical developments. Reserve Bank of Australia (2006) cites the example regarding increased rates of promotion during a cyclical upturn not being captured.

[5] For example, Gruen *et al.* (1999) use the sample 1965:Q3 to 1997:Q4.

A second aspect of our specification is that unlike Gruen *et al.* (1999) and Ballantyne *et al.* (2014) this equation is for quarterly, rather than year-ended, real unit labour costs growth.[6] Cusbert (2017) also estimates a Phillips curve for quarterly unit labour costs growth. Third, this unit labour cost Phillips curve, Equation 3, is non-linear. Gruen *et al.* (1999) demonstrate how it can be accommodated in a linear state-space model and therefore estimated with maximum likelihood and the Kalman filter, which we outline below.[7]

4.1.2 Incorporating the Non-linearity

The general formulation of the state-space representation is that the unit labour cost Phillips curve, Equation 3, will be the measurement equation, and the state equation, which describes the evolution of the NAIRU, is a slightly modified version of Equation 2 in order to take account of the non-linearity. More precisely, the case where the unemployment gap enters the Phillips curve contemporaneously will be:

$$y_t = x_t'\alpha + H_t z_t + \epsilon_t \tag{5}$$

$$z_t = z_{t-1} + \zeta_t \tag{6}$$

where Equation 5 is the measurement equation and Equation 6 is the state equation.[8] y_t is the observed variable; x_t the covariates with parameters α; z_t the latent state and H_t a pre-determined, possibly time-varying parameter, and ϵ_t the shock. z_t is the latent state, whose evolution is governed by Equation 6 and is driven by the innovations ζ_t. To see how this accommodates the non-linear unit labour cost Phillips curve, let the Phillips curve be the measurement equation, so y_t is the dependent variable and $x_t'\alpha$ the explanatory variables and coefficients other than the non-linear unemployment-gap term, $\gamma\frac{U_t - U_t^*}{U_t}$. Note that $\gamma\frac{U_t - U_t^*}{U_t}$ equals $\gamma - \gamma\frac{U_t^*}{U_t}$, and consequently if a constant term is added to $x_t'\alpha$, and $H_t = \frac{1}{U_t}$, then the latent process z_t represents $-\gamma U_t^*$, from which the estimates of the NAIRU can be obtained.

4.1.3 Incorporating the Wage Phillips Curve

Generalising the model to handle multiple Phillips curves is straightforward. Denoting items relating to the unit labour cost Phillips curve with a subscript 1 and the WPI Phillips curve 2, the generalisation mostly involves redefining variables, such as y_t, to be a vector containing the dependent variable for both equations. A complication is that the latent process involves the slope of the first Phillips curve, γ_1, and consequently the corresponding element of the matrix H_t for the second equation must include a normalisation. Specifically, the term is $\frac{\gamma_2}{\gamma_1 U_t}$, where γ_2 is the slope of the wage Phillips curve. The state space therefore is

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} x_{1t}' & 0 \\ 0 & x_{2t}' \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \frac{1}{U_t} \\ \frac{\gamma_2}{\gamma_1 U_t} \end{bmatrix} z_t + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix} \tag{7}$$

$$z_t = z_{t-1} + \zeta_t \tag{8}$$

where the x_t include a constant and $z_t \equiv -\gamma_1 U_t^*$.

We allow the errors in the two Phillips curves to potentially be correlated.

4.1.4 Differing Data Availability

Addressing the limited availability of the WPI requires a further slight modification to the measurement equations, which is a common way to handle missing data. Let W_t be a time-varying matrix and T_0 be when the WPI data becomes available. Then

$$W_t \equiv \begin{cases} \begin{bmatrix} 1 & 0 \end{bmatrix} & \text{if } t < T_0, \\ I_2 & \text{otherwise.} \end{cases}$$

Pre-multiplying Equation 7 by W_t effectively drops the WPI equation when the data are unavailable. The standard recursions for the Kalman filter are otherwise unaffected by the introduction of W_t.[9]

[6] Using year-ended growth creates the possibility of a moving-average process in the residuals. See Connolly (2016) and the references therein for a further discussion.

[7] Debelle & Vickery (1997) also estimate non-linear Phillips curves using the Kalman filter.

[8] For an overview of state-space models and the Kalman filter see Harvey (1991).

[9] The long and short samples used are 1966:Q1 and 1998:Q1 to 2016:Q3, respectively.

4.2 Adjusting for Productivity and the WPI Equation

The general structure of the WPI equation is similar to that for unit labour costs, Equation 3. For example, it includes bond-market inflation expectations, speed-limit terms, allows for a non-linear relationship and many of the variables are expressed as a gap. The main difference is the treatment of productivity.

4.2.1 Adjusting for Productivity

In most macroeconomic models a key determinant of real wages growth is productivity growth. The WPI is intended to be a pure price measure of labour - that is, to not be influenced by changes in the quality of labour. The Australian Bureau of Statistics, however, acknowledges that constructing such a measure is difficult to do in practice (see Australian Bureau of Statistics (2012), p24). Consequently, it is unclear to what extent developments in the WPI reflect productivity, unlike growth in unit labour costs, where by definition it is explicitly controlled for.

To account for the influence of productivity growth, we introduce contemporaneous and lagged productivity growth as explanatory variables in the Phillips curve. To be clear, the long-run Phillips curve is still assumed to be vertical - a doubling in inflationary expectations will result in a doubling of nominal wages growth - but in the long-run real wages growth will be determined by productivity growth.

We also explored a second way of accounting for the impact of productivity, motivated by the possibility that cointegration between real wages and productivity exists. Based on the mark-up model of inflation we investigated a specification of the form:

$$wpi_t = C + p_t + \alpha lp_t + \frac{(\beta - 1)}{\beta}(pm_t - p_t) + \epsilon_t, \tag{9}$$

where we have essentially normalised Equation 4 on unit labour costs, and introduced the parameter α to capture the long-run elasticity of the real WPI with respect to labour productivity. While there was greater evidence of cointegration than in the unit labour costs case, it was also rejected at conventional levels of significance.

4.2.2 The WPI Equation

In summary, the equation for the WPI we estimate is:

$$\begin{aligned} \triangle rwpi_t &= \alpha_1(\pi^*_t - \triangle_4 p_{t-1}) + \alpha_2 \frac{U_t - U^*_t}{U_t} + \alpha_3 \frac{\triangle U_{t-1}}{U_t} + \alpha_4 \triangle lp_t \\ &\quad + \alpha_5 \frac{\triangle U_{t-2}}{U_{t-1}} + \alpha_6 \triangle rwpi_{t-1} + \alpha_7(\pi^*_{t-1} - \triangle_4 p_{t-2}) + \alpha_8 \triangle lp_{t-1} \\ &\quad + \alpha_9 \frac{\triangle U_{t-3}}{U_{t-2}} + \alpha_{10} \triangle lp_{t-3} + e_{2,t} \end{aligned} \tag{10}$$

where $rwpi_t \equiv wpi_t - p_{t-1}$.

Apart from the inclusion of the labour productivity term, the other noticeable difference compared to the unit labour cost Phillips curve is that a greater role was found for speed-limit terms. The innovations in the two Phillips curves, Equations 3 and 10, are allowed to potentially be correlated and it is assumed they follow a multivariate normal distribution.

5 Unemployment Rate-Based Results

5.1 Parameter Estimates

5.1.1 Unit Labour Cost Phillips curve

Table 1 presents the parameter estimates of the unit labour cost Phillips curve, both when it is estimated alone and when it is estimated jointly with the wage Phillips curve.[10]

There are several noteworthy aspects of these parameter estimates. First, in general there is little difference in the parameter estimates; the most sizable change is that the magnitude of the speed limit term, δ_3, decreases in the two-equation model. The proportion of the variation in unit labour costs growth

[10] We treat the initial value of the state, namely the scaled NAIRU, as an estimated parameter. Plots of the actual and fitted values are presented in Appendix C.

explained is surprisingly higher in the two-equation model, so the joint estimation approach does not appear to sacrifice fit. Second, the key parameter, δ_2, is the slope of the Phillips curve, and is correctly signed (negative) and highly significant. Finally, while the coefficient on the forward-looking inflation expectations terms in each model is significant, expectations appear to be largely backward looking.

Table 1: Parameter Estimates
Unit Labour Cost Phillips Curve

	Separate		Joint	
	Coefficient	Std Err	Coefficient	Std Err
z_0	6.33 **	2.58	3.77 **	1.64
δ_1	0.12 **	0.06	0.11 **	0.05
δ_2	−1.74 ***	0.59	−1.64 ***	0.48
δ_3	−6.52 ***	1.84	−5.84 ***	1.79
δ_4	−0.11	0.07	−0.13 *	0.08
σ_1	1.24 ***	0.07	1.27 ***	0.07
σ_v	0.62 **	0.25	0.46 ***	0.12
R^2	0.13		0.19	

*, **, *** Denotes significance at the 10, 5 and 1% levels.

5.1.2 Wage Phillips Curve

The parameter estimates of the wage Phillips curve are presented in Table 2. α_2, the slope of the Phillips curve is negative, and significantly different from zero at the 12 per cent level. Speed-limit terms appear to be very important for wages growth, as does productivity growth. In common with the unit labour cost Phillips curve, inflation expectations appear to be mainly backward looking. The correlation between the residuals in both equations is found to be slight, and insignificantly different from zero.

Table 2: Parameter Estimates
Wage Price Index Phillips Curve

	Coefficient	Std Err
α_1	0.17 *	0.09
α_2	−0.45	0.28
α_3	−3.00 **	1.13
α_4	0.13 ***	0.04
α_5	−1.08	1.16
α_6	−0.24 **	0.12
α_7	−0.15 *	0.08
α_8	0.12 ***	0.05
α_9	−2.85 **	1.09
α_{10}	0.06	0.05
σ_{12}	0.00	0.15
σ_2	0.10	0.07
R^2	0.15	

*, **, *** Denotes significance at 10, 5 and 1% levels.

5.1.3 Implications for Long-run Wages Growth

In the model, long-run real wages growth is anchored by productivity growth. The coefficients in Table 2 imply that the long-run elasticity of real wages to labour productivity growth is 0.26.[11]

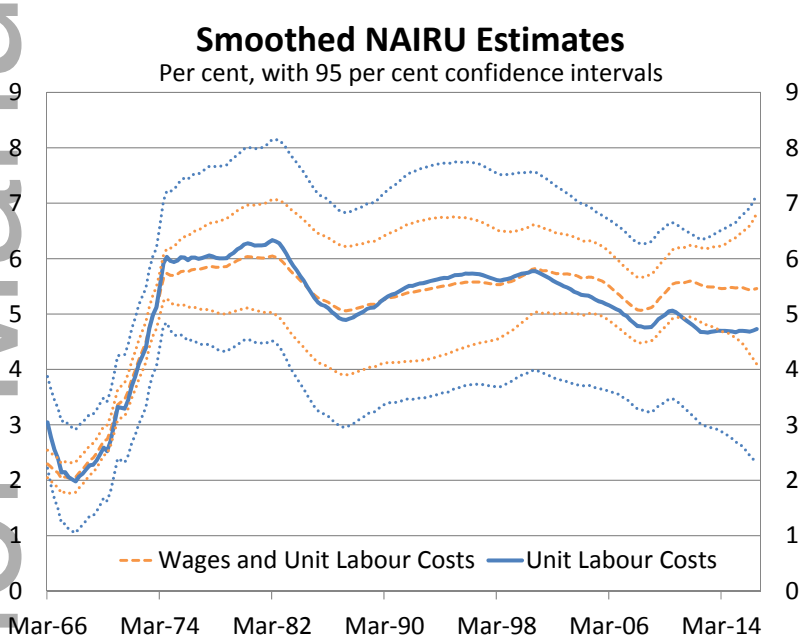
[11] This is calculated as $(\alpha_4 + \alpha_8 + \alpha_{10}) / (1 - \alpha_6)$.

The outlook for year-ended nominal wages growth in the long-run, assuming inflation is at the mid-point of the Reserve Bank of Australia's inflation target, depends on the outlook for labour productivity growth. If the average labour productivity growth which occurred over the estimation sample of the wage Phillips curve was to reoccur, namely 1.4 per cent, then the implied nominal wage growth is approximately 2.9 per cent. This is lower than the 3.75 per cent assumed in the 2017/18 Budget (Commonwealth of Australia 2017). One aspect to note is that while Australia experienced strong productivity growth during the 1990s, only the latter is included in the estimation sample. Average productivity growth over a shorter period, for example from 2005 onwards, implies long-run wages growth which is only slightly weaker, namely 2.8 per cent.

5.2 NAIRU Estimates

The estimation approach in this paper - namely maximum likelihood and the Kalman filter - produces two estimates of the NAIRU. The first, known as one-sided or filtered estimates, at time t uses information available from the start of the sample until period t. Alternatively, the two-sided or smoothed estimates use the whole sample, that is, at time t they use not only past and contemporaneous information, but also future information. Since they use all the available information these are our best estimates of the NAIRU at any given time, and thus are what we focus on (Figure 2).

Figure 2



The two models produce highly correlated estimates of the NAIRU. This is to be expected; for much of the sample the unit labour cost Phillips curve is the only one in both models, although as shown above its parameterisation differs. Also to be expected is that it is the period at the end of the sample when the two estimates differ the most - this is when both Phillips curves are included in the two-equation model, but also there is the greatest uncertainty about the NAIRU as less future information is available. A noticeable characteristic is that the NAIRU from the two-equation model exhibits less variation than that from the unit labour cost Phillips curve alone. It also points to the NAIRU currently being higher, namely closer to 5.5 per cent, rather than 4.75 per cent (Figure 2).

Incorporating wages data into the estimation, by producing a higher NAIRU, suggests that there is currently less slack in the labour market than when unit labour costs alone are used, as demonstrated by the unemployment gap, namely the deviation of the unemployment rate from the NAIRU. Indeed, the two-equation model suggests that little slack presently exists (Figure 3). An important aspect to note is that, while closely related, this is not the driving variable in the Phillips curve, rather it is its numerator. We return to this distinction later in our discussion of underutilisation-based measures of labour market slack.

Figure 3

Finally, considerable uncertainty surrounds any time-varying estimate of the NAIRU. The uncertainty can be both statistical and about the specification of the true model, a point also discussed by Ballantyne *et al.* (2014). Focussing on the former, this uncertainty is likely to be particularly pronounced at the end of the estimation sample, when little or no future information can be used in the smoothed estimates. We find that the introduction of the wage Phillips curve reduces the standard error for the most recent period by around one fifth, which is evident from the tighter 95 per cent confidence intervals in Figure 2. Surprisingly the standard error is also reduced earlier in the sample, before the wages data becomes available, although by a smaller magnitude. Once again, this reflects the two-sided nature of the smoothed estimates. Intuitively, if we are more certain about the latter period, and when the NAIRU earlier in the sample is estimated these future values are used, then the precision of the early estimates will also increase.

5.3 Sensitivity Analysis

We explore three variations to the above analysis. First, the previous results assume that the Phillips curve is non-linear. However, reflecting that the WPI is only available for a short sample which excludes the high inflation period of the early and mid-1970s, it is possible that a linear wage Phillips curve is more appropriate. When estimating this model we maintain the non-linearity in the unit labour cost Phillips curve, reflecting that it is estimated over the longer sample. A second variant is prompted by Bishop & Cassidy (2017), who include the unemployment gap with a one period lag in the wage Phillips curve.

In the final variant we assess the sensitivity of the results to using an alternative inflation expectations series. Many past Australian studies, such as Gruen *et al.* (1999), use a bonds market-based measure, which we have followed. However, recent Reserve Bank of Australia studies (namely Bishop & Cassidy (2017) and Cusbert (2017)) have instead adopted a constructed series that incorporates information from the available survey-based inflation expectations measures from 1985 onwards (due to data availability), together with a bond-market series. As some policymakers have referred to this measure recently, it is the most relevant alternative to examine. A noticeable difference between the two series is that the measure incorporating survey-based information is considerably smoother, particularly during the inflation-targeting period (Figure B.1 in Appendix B). An example is the second half of 1994, a period in which monetary policy was tightened despite the previous deep recession; using the new measure the pick up in inflation expectations is muted. Similarly, in the period prior to the Global Financial Crisis it suggests inflation expectations increased much more moderately.

The implications of these variants of the model are detailed in Appendix B. In brief, for the parameters

of the unit labour costs Phillips curves the implications generally are small. Most notably, the slope of the Phillips curve is steeper when the unemployment gap is lagged, but the fit of the equation worsens. The alternative measure of inflation expectations improves the fit of the model.

Turning to the wage Phillips curve, lagging the unemployment gap has a larger impact on the parameters than assuming a linear relationship, but in both variations the slope of the Phillips curve decreases considerably in size and significance. Alternatively, using the measure of inflation expectations which incorporates survey data, the Phillips curve becomes slightly steeper and more significant. The fit of the equation also decreases, albeit marginally. A similar estimate of the long-run elasticity of real wages with respect to labour productivity is obtained (0.25).

These alternative specifications tend to lower the NAIRU estimates at the end of the sample to varying degrees (see Figure B.2). The smallest difference is for the Phillips curves with the alternative inflation expectations series, although for much of the sample it is half a percentage point or more higher. The linear wage Phillips curve estimates the NAIRU to currently be 5 per cent. The largest difference to the baseline occurs with the lagged unemployment gap, in which case the NAIRU is estimated to have fallen throughout the 2000s, before stabilising in recent years at less than 4.5 per cent. Correspondingly, the latter suggests that there is greater slack presently in the labour market, although its significance in influencing wages is considerably lower. The precision of the current NAIRU estimates of all of these models is greater than those from just using the unit labour cost Phillips curve alone (see Figure B.3); those with the alternative inflation expectations are slightly more precise than the baseline model.

In summary, two of the plausible alternative specifications of the wage Phillips curve produce lower, but also less useful, estimates of the current NAIRU. The alternative specification that appears most useful is using the inflation expectations measure constructed by the Reserve Bank of Australia, which suggests a very similar value for the current NAIRU. It is apparent that the model is sensitive to small variations; this characteristic was also noted of the Gruen *et al.* (1999) specifications in Ballantyne *et al.* (2014). One approach to handling uncertainty about the true specification is to average the models. We do so using two simple approaches, namely weighting each equally, or inversely proportional to the standard error. The resulting NAIRU estimates are similar and suggest it is currently around 5 per cent.

6 Incorporating Labour Underemployment

We build on the previous models in order to consider broader measures of labour slack by replacing the unemployment rate in the models with the underutilisation rate. The underutilisation rate is defined as the sum of those who are unemployed or underemployed as a share of the labour force; in other words, this is a heads-based, rather than volume, measure. This approach was motivated by the unemployment and underutilisation rate moving similarly over a sizable part of the sample (Figure 4). We then considered small variations to these specifications. The resulting unit labour cost Phillips curve is:

$$\triangle rulc_t = \delta_1 \left(\pi_t^* - \triangle_4 p_{t-1}\right) + \delta_2 \frac{UU_t - UU_t^*}{UU_t} + \delta_3 \frac{\triangle UU_{t-1}}{UU_t} + \delta_4 \triangle rulc_{t-1} + e_{1,t}, \tag{11}$$

where UU_t denotes the underutilisation rate, and its trend, UU_t^*, is assumed to follow a random walk, analogous to the NAIRU. We were unable to find a specification of the WPI Phillips curve where the coefficient on the underutilisation rate was significantly different from zero; it tended to be very small in magnitude.

The parameter estimates of the unit labour cost Phillips curve based on the underutilisation rate, which are shown in Table 5, are in general similar to those of the unemployment-based curve.[12] However, the standard deviation of the innovations to (scaled) latent trend underutilisation rate are more than twice the magnitude of those for the NAIRU, and the fit of the curve decreases slightly.

A possibile reason for the insignificance of the underutilisation rate in the WPI curve is that it assumes both underemployment and unemployment have the same consequences for wages. To account for this we also investigated adding the first difference of the underemployment rate (and lags) and gaps constructed using a Beveridge-Nelson filter to the unemployment rate-based Phillips curves. However, these terms also were not significantly different from zero. A third approach tried was to introduce a second latent process as the trend underemployment rate, but this also proved unsuccessful. In general, it was difficult to find a wage Phillips curve where underemployment or underutilisation-based gaps were significant.

[12] The sample is 1967:Q3 to 2016:Q3.

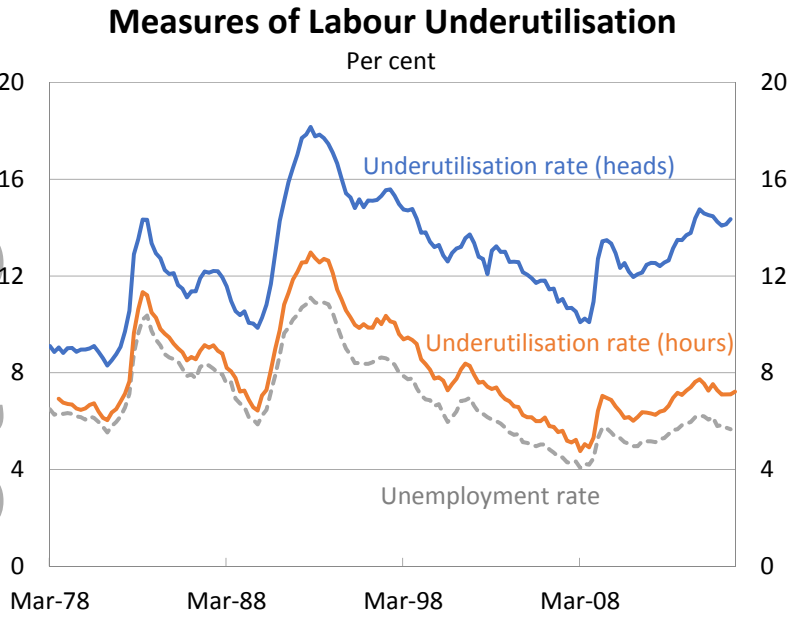
Table 5: Parameter Estimates
Unit Labour Cost Phillips Curve

	Unemployment		Underutilisation	
	Coefficient	Std Err	Coefficient	Std Err
z_0	6.33 **	2.58	4.20 ***	4.20
δ_1	0.12 **	0.06	0.17 ***	0.08
δ_2	−1.74 ***	0.59	−2.13 ***	0.86
δ_3	−6.52 ***	1.84	−6.56 ***	2.34
δ_4	−0.11	0.07	−0.12 ***	0.23
σ_1	1.24 ***	0.07	1.23 ***	0.09
σ_v	0.62 **	0.25	1.58 ***	1.03
R^2	0.13		0.11	

*, **, *** Denotes significance at the 10, 5 and 1% levels.

A potential criticism of this analysis is that it is simply due to the wrong underutilisation rate being focused on; in particular, a volumes-based measure should be used. Such a measure not only captures the number of people who are underemployed, but the number of hours that they would prefer to work. While this is intuitively appealing, the two measures have moved dramatically differently in recent years, with the large pick up in underutilisation evident in the heads-based measure being much more muted in the volume series (Figure 4). Consequently, the correlation with the unemployment rate is far greater for the volumes measure - from 1978:Q3 onwards it is 0.98, compared with 0.64. Essentially, if the volumes measure of underutilisation is the most appropriate measure, then the unemployment rate will be a good proxy.[13]

Figure 4



[13]The measure presented was constructed by the RBA. An alternative series compiled by the Department of Employment over the same sample displays only a marginally smaller correlation (0.94).

6.1 Trend Underutilisation Rate Estimates

Returning to the heads-based measure, we focus on the estimates of the trend underutilisation rate from the unit labour cost Phillips curve alone. In recent years the trend underutilisation rate has been gradually drifting upwards, and is presently around 11.75 per cent (Figure 5). This implies a considerably greater amount of slack - around 2.5 per cent - than the unemployment-based estimates (Figure 6). The trend underutilisation rate is imprecisely estimated, particularly for the most recent period.

Figure 5

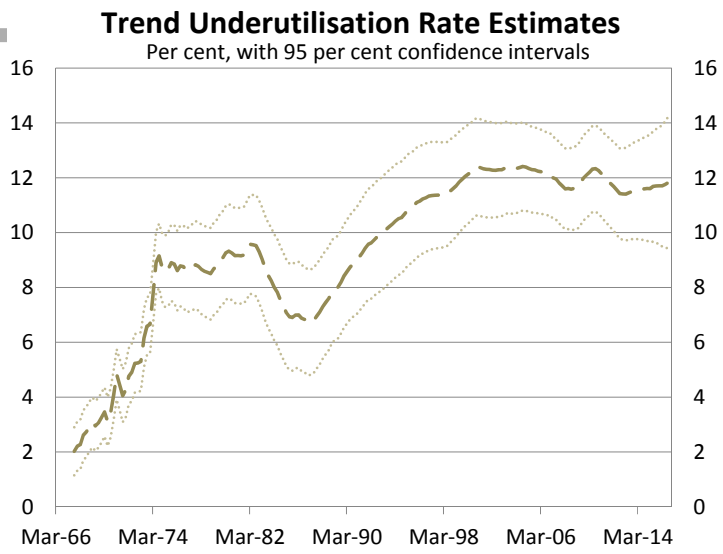
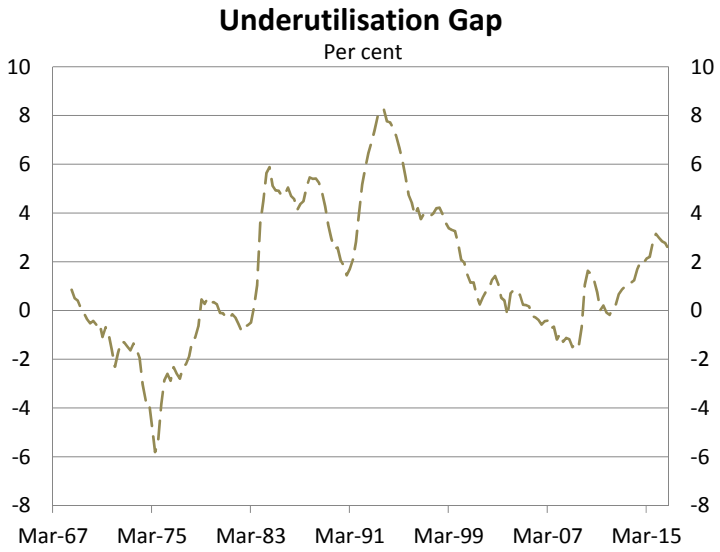
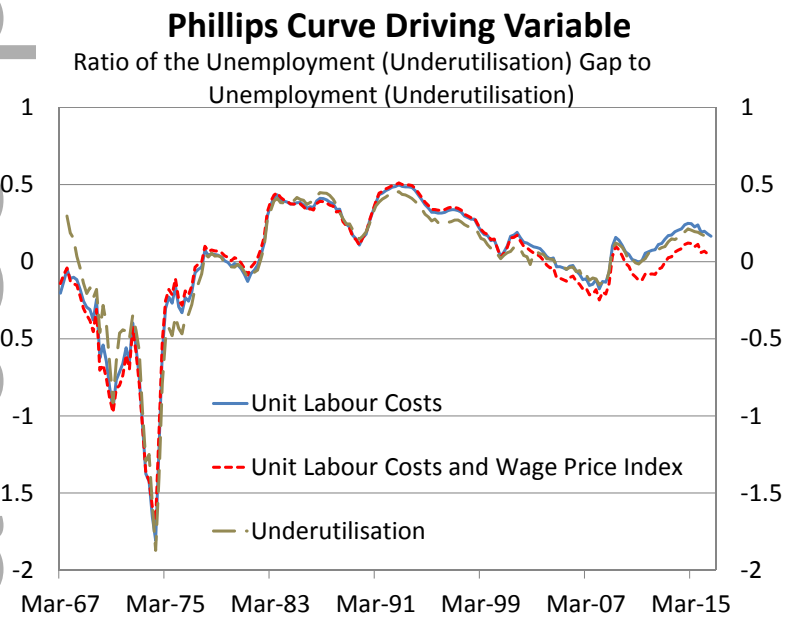


Figure 6



But what does this mean for unit labour costs growth? Recall that the Phillips curves are non-linear, and the driving variable is the unemployment (underutilisation) gap divided by the unemployment (underutilisation) rate. Consequently, while the underutilisation gap is more sizable than the unemployment gap, when it is taken into account that the underutilisation rate itself also is much higher, the divergence is greatly diminished. Furthermore, it is comparable to that obtained from the unit labour costs estimated with the unemployment rate (Figure 7).

Figure 7



7 What is Contributing to Low Wages Growth?

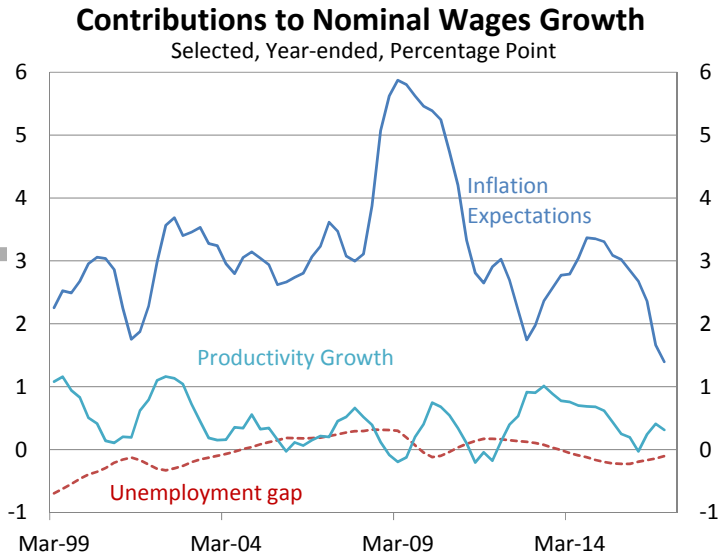
Our main research question was to determine whether the low wages growth over recent years has meant that the NAIRU has moved lower and that significant slack exists in the labour market. We have found little evidence that such slack exists. What then, has been determining the low wages growth? Many reasons have been suggested - see Bishop & Cassidy (2017) for an overview. Our model suggests that, from the perspective of a Phillips curve, two factors have been particularly important (Figure 8).[14] First, the contribution from inflation expectations to nominal wages growth has fallen considerably. While explaining why inflation expectations have fallen is beyond the scope of our model, international factors may well be important - trade-weighted inflation of Australia's trading partners fell, and crude oil prices declined noticeably. Overall, it appears that low nominal wages growth is partially a result of the low inflation environment.

The second important factor contributing to low wages has been a slowing in labour productivity growth, in year-ended terms it decreased from around 3 per cent in 2012 to being slightly negative in late 2015. More recently there has been some improvement in labour productivity growth, which may support wages growth.

Labour market slack currently is weighing on wages growth, but only to a small extent. This is simply a reflection that, based on our estimates of the NAIRU, currently only a small amount of slack exists in the labour market, rather than that it is irrelevant for wages. While for most of the estimation sample of the wage Phillips curve the contribution of the unemployment gap is small, it is worth remembering that despite the two financial crises during this period Australia did not experience a recession and the unemployment rate never reached 8 per cent. Indeed, it was highest early in the sample when the unemployment gap subtracted around 0.75 percentage points from wages growth.

[14] These contributions are calculated by rearranging the WPI equation to be an expression for nominal wages growth. The inflation expectations contribution is the sum of those from the bond-market, lagged wages growth and inflation. For clarity they are presented on a year-ended basis.

Figure 8



The most promising alternative model from those considered above was that which used the measure of inflation expectations which incorporated survey-based information. The finding that low inflation expectations have been an important factor contributing to the recent low wages growth is robust to using this alternative measure (Figure B.4). This occurs despite the alternative series being more stable as it is only one component of inflation expectations in the model, the others being lags of wages growth and inflation.

8 Conclusions

Low wages growth has been one of the defining characteristics of the Australian economy in recent years. Understanding its sources is important because it may be informative about whether it will persist. Such low wages growth not only has implications for household behaviour but makes fiscal consolidation difficult. It is also surprising as the unemployment rate has not been high by historical standards. Viewed through a Phillips curve, this raises the possibility that the NAIRU has fallen. This paper demonstrates a framework in which this possibility and its implications for the main wage series of interest to policymakers and business economists, namely the Wage Price Index, can be assessed. Our framework accommodates several important characteristics of the WPI, such as its limited availability and the uncertain degree of productivity adjustment.

We have found the NAIRU to have been broadly unchanged in recent years at around 5.5 per cent, which implies that little slack exists in the labour market. While a considerable degree of uncertainty surrounds these figures - as is typical of time-varying estimates of a latent variable at the end of the sample - our approach has substantially reduced this uncertainty. Different specifications of the Phillips curves yield differing estimates of the NAIRU, but averages of these are just slightly lower - around 5 per cent - and therefore suggest that only a modest amount of labour market slack exists. Low inflation expectations and labour productivity growth alternatively appear to have been the primary factors contributing to the low wages growth.

One possibility is that the unemployment rate is an imperfect measure of the state of the labour market. This may well be true, but the heads-based measure of labour underutilisation does not appear to be particularly useful for understanding developments in the WPI, whereas it has more relevance for unit labour costs growth. Alternatively, the volumes (hours) measure of underutilisation co-moves so strongly with the unemployment rate that inferences based on either series are likely to be similar.

Finally, our analysis provides guidance on how to interpret the WPI. In particular, it appears that the long-run elasticity of the WPI with respect to labour productivity growth is around 0.26. The long-run growth rate of the WPI was found to be nearly 3 per cent, considerably lower than the 3.75 per cent built into the most recent Commonwealth Budget forecasts. This suggests that fiscal consolidation may well be a more protracted process than the 2017/18 Budget forecasts indicate.

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Appendix A Data

All data are quarterly and seasonally adjusted. Most of the data were obtained from the websites of Australian Bureau Statistics (ABS) and the Reserve Bank of Australia (RBA).

Unemployment, Underutilisation and Underemployment Rates

Unemployment rate is a measure of proportion of unemployed persons in the labour force, while underemployment rate is defined as the number of underemployed persons as a proportion of the total labour force. The heads-based underutilisation rate is the sum of the underemployment rate and unemployment rate. All measures are obtained from ABS (ABS Cat. No. 6202.0, Table 22: Underutilised Persons by Age and Sex). The unemployment rate, prior to the September quarter 1978, were obtained from the Modellers' Database (ABS Cat. No. 1364.0.15.003, Table 10: NIF Labour Market - Seasonally Adjusted ('000)). For the underemployment rate, prior to the September quarter 1978, we estimate the quarterly rates in two steps. First, we use Scanit software from AmsterCHEM to obtain a series of annual estimates from ABS 6426.0. Second, we interpolate the annual estimates into quarterly series.

The volumes-based underutilisation rate was provided as a special request from the RBA. It was presented in Reserve Bank of Australia (2017). The second measure also referred to was constructed by the Department of Employment and provided as a special request; see Connolly (2013).

Underlying Consumer Prices

Underlying consumer price index is downloaded from the RBA's website (www.rba.gov.au/statistics/tables /inflation-expectations). Prior to June 1982, the underlying consumer price index is spliced with the series from Gruen *et al.* (1999).

Wage Price Index

Total hourly rates of pay excluding bonuses for Private and Public (ABS Cat. No. 6345.0 Table 1. Total Hourly Rates of Pay Excluding Bonuses). The WPI was first published in the September quarter 1997.

Unit Labour Costs

Unit labour costs is a ratio wages per person to non-farm productivity per person. From September quarter 1985, we source the unit labour costs from the national accounts (ABS Cat. No. 5206.0, Table 42: Unit Labour Costs). Similar to Gruen *et al.* (1999), prior to 1985, the measure is constructed from average weekly earning per full-time adult and productivity per person, which is the ratio of chain volume measures non-farm GDP (ABS Cat. No. 5206.0,Table 24. Selected Analytical Series) to non-farm total employment (ABS Cat. No. 1364.0.15.003, Table 10:NIF Labour Market - Seasonally Adjusted ('000)).

Inflation Expectations

Bond-market inflation expectations is from Gruen *et al.* (1999) until March 1989; thereafter it is from the RBA Bulletin statistical table 'Inflation Expectations – G3' (www.rba.gov.au/statistics/tables/).

The alternative measure which additionally incorporates information from survey-based measures was provided as a special request from the RBA. It was used in Cusbert (2017) and Bishop & Cassidy (2017).

Labour Productivity

Labour productivity is non-farm labour productivity per hour. This series can be obtained from the RBA Bulletin statistical table 'Labour Costs and Productivity – H4' (www.rba.gov.au/statistics/tables/).

Appendix B Sensitivity Analysis

Figure B.1

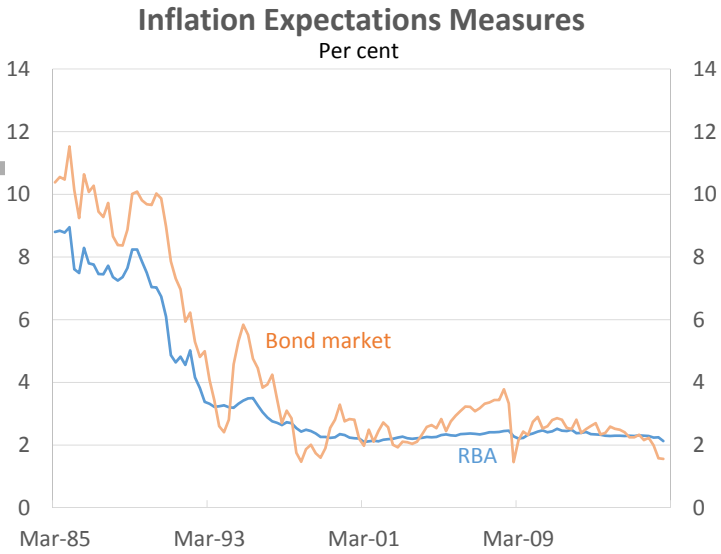


Table B.1: Parameter Estimates

Unit Labour Cost Phillips Curve

	Joint		**Linear WPI**		**Lagged**		**Inflation Expectations**	
	Coefficient	Std Err	Coefficient	Std Err	Coefficient	Std Err	Coefficient	Std Err
z_0	3.77 **	1.64	3.69 **	1.64	4.48 **	1.64	3.92 **	1.65
δ_1	0.11 **	0.05	0.11 **	0.05	0.17 ***	0.05	0.12 **	0.05
δ_2	−1.64 ***	0.48	−1.60 ***	0.48	−1.98 ***	0.48	−1.55 ***	0.46
δ_3	−5.84 ***	1.79	−5.91 ***	1.79	−3.75 **	1.79	−5.50 ***	1.83
δ_4	−0.13 *	0.08	−0.13 *	0.08	−0.25 ***	0.08	−0.13 *	0.07
σ_1^2	1.27 ***	0.07	1.27 ***	0.07	1.28 ***	0.07	1.27 ***	0.07
σ_v	0.46 ***	0.12	0.18 **	0.12	0.56 ***	0.12	0.45 ***	0.12
R^2	0.19		0.21		0.13		0.32	

*, **, *** Denotes significance at the 10, 5 and 1% levels.

Table B.2: Parameter Estimates

Wage Price Index Phillips Curve

	Joint		Linear WPI		Lagged		Inflation Expectations	
	Coefficient	Std Err	Coefficient	Std Err	Coefficient	Std Err	Coefficient	Std Err
α_1	0.17 *	0.09	0.15 *	0.09	0.19 **	0.09	0.48 ***	0.12
α_2	−0.45	0.28	−0.06	0.05	−0.03	0.24	−0.50 *	0.28
α_3	−3.00 **	1.13	−3.05 ***	1.14	−2.07 *	1.16	−2.34 **	1.10
α_4	0.13 ***	0.04	0.13 ***	0.04	0.12 **	0.04	0.12 ***	0.04
α_5	−1.08	1.16	−1.12	1.16	−2.92 **	1.12	−0.53	1.13
α_6	−0.24 **	0.12	−0.23 *	0.11	−0.25 **	0.12	−0.22 **	0.11
α_7	−0.15 *	0.08	−0.14	0.08	−0.16 *	0.08	−0.42 ***	0.12
α_8	0.12 ***	0.05	0.13 **	0.05	0.08 *	0.05	0.11 **	0.04
α_9	−2.85 **	1.09	−2.95 **	1.12	−0.61	1.01	−3.38 ***	1.07
α_{10}	0.06	0.05	0.06	0.05	0.06	0.05	0.08 *	0.04
σ_{12}	0.00	0.15	0.00	0.15	0.00	0.16	0.00	0.15
σ_2	0.10	0.07	0.10	0.07	0.15 **	0.06	0.08	0.06
R^2	0.15		0.15		0.13		0.14	

*, **, *** Denotes significance at the 10, 5 and 1% levels.

Figure B.2

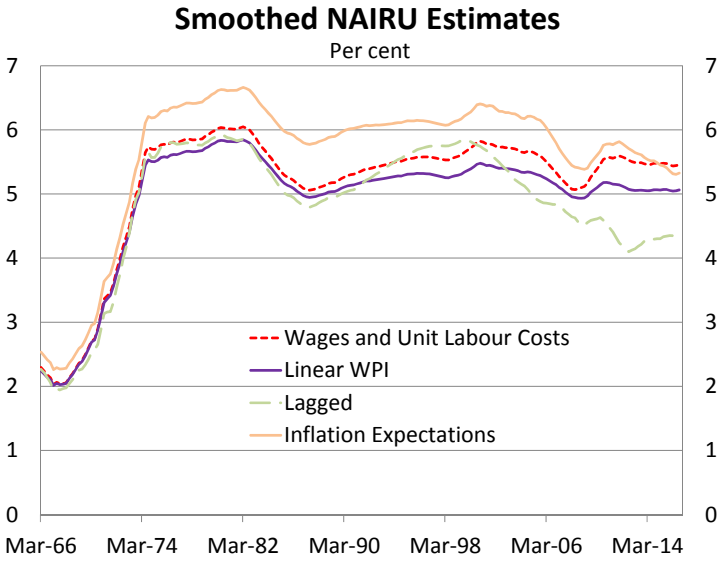


Figure B.3

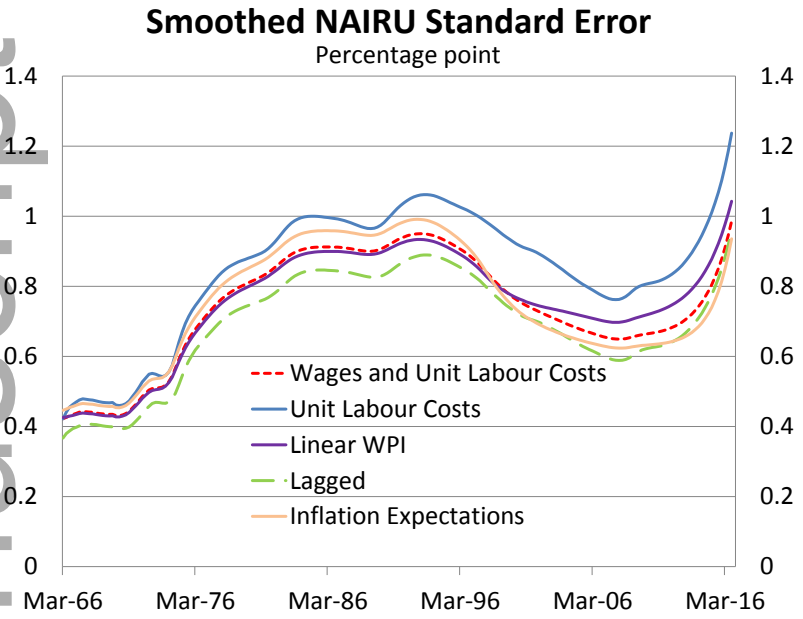
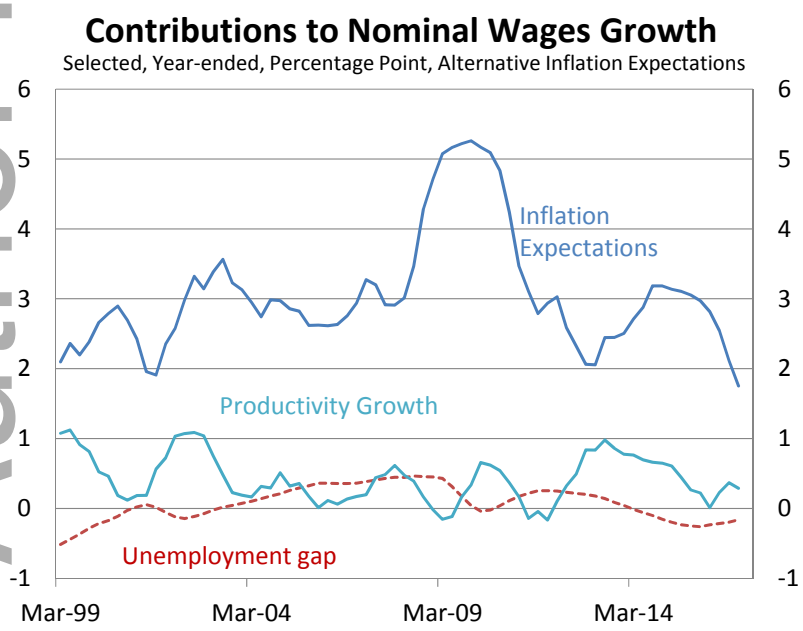


Figure B.4



Appendix C Actual and Fitted Values

Figure C.1

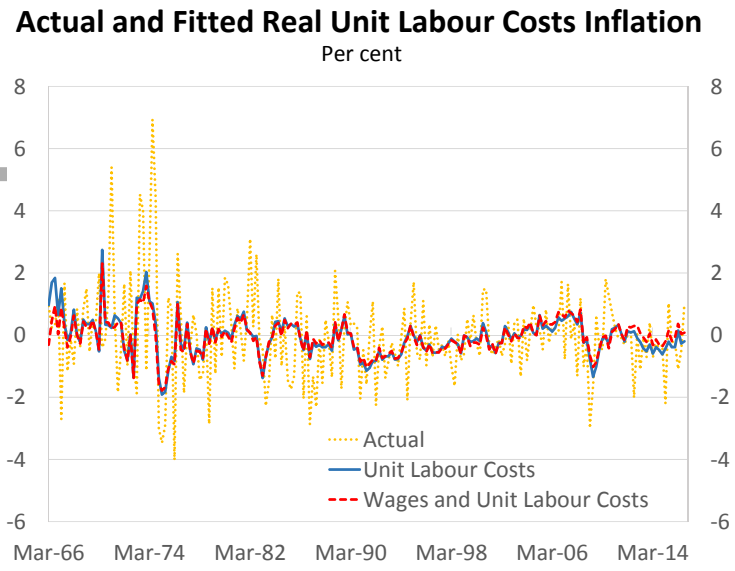


Figure C.2

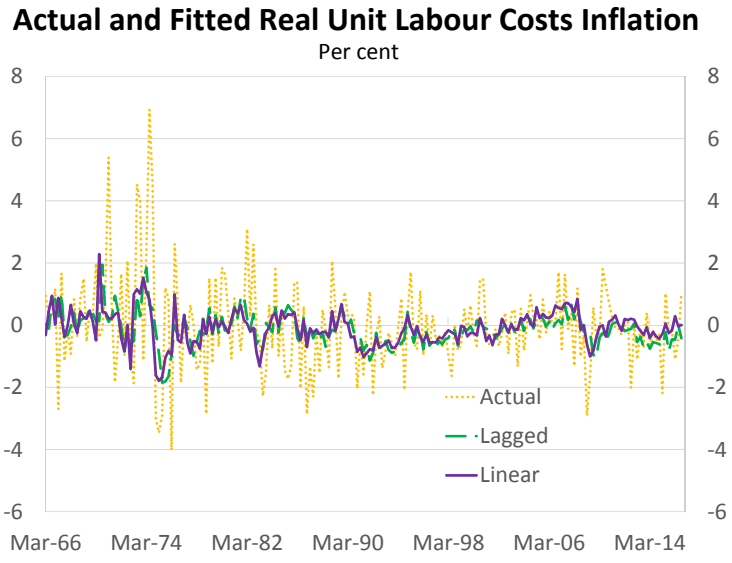


Figure C.3

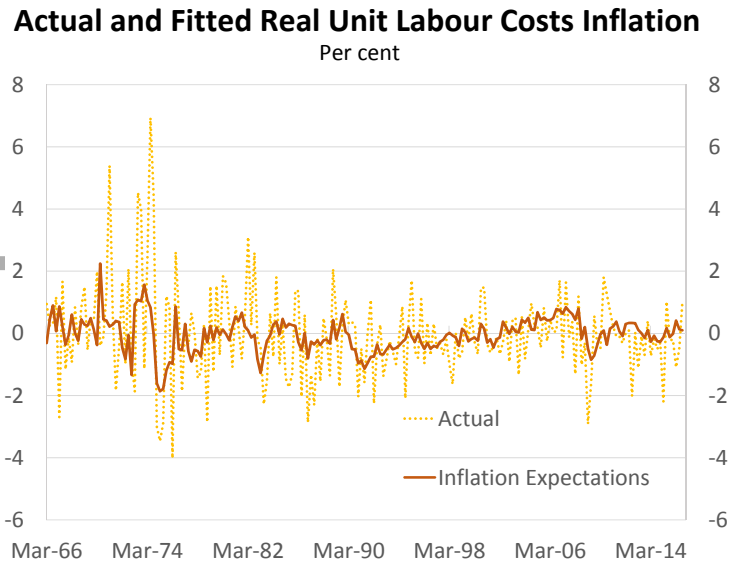


Figure C.4

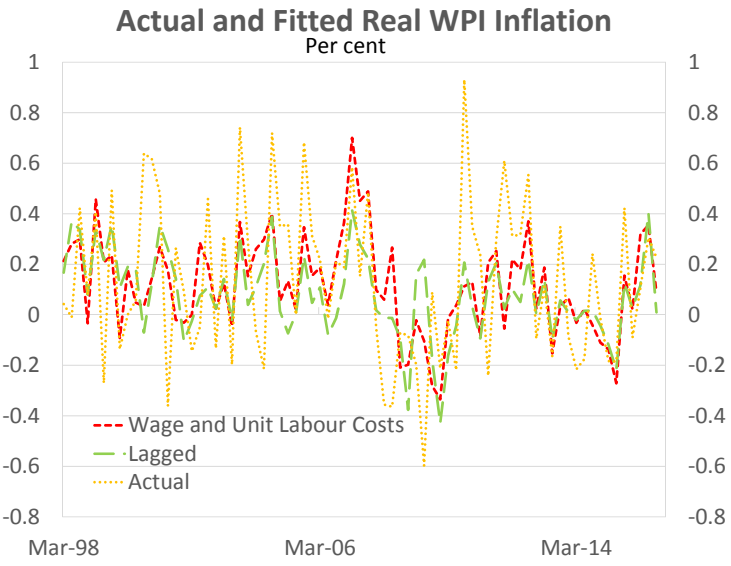


Figure C.5

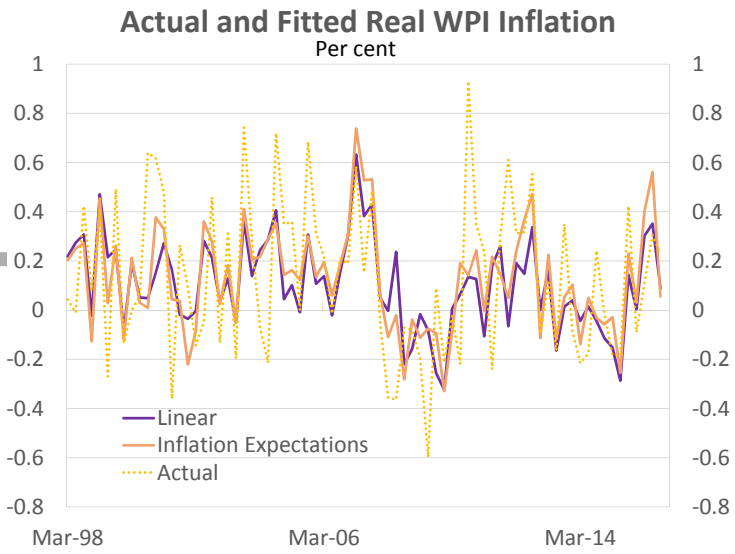


Figure C.6