The Effects of Excess Labour Supply and Excess Labour Demand on Australian Wages

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Abstract:
Econometric estimation of what determines wages in Australia is important for macroeconomic modelling (such as for the FoCUS macroeconomic model which is used for policy and scenario analysis in the Department of Employment), for monetary and fiscal policy, for setting of the minimum wage and for labour market policies.

With sophisticated models of the labour market, such as those in Connolly (1999a) and Stacey and Downes (1995), it is possible for excess labour supply (in the form of unemployment, underemployment and/or hidden unemployment) and excess labour demand (in the form of job vacancies) to co-exist and to have separate and differential effects on wages. Estimates of these separate effects are presented in this paper.

This is done in the framework of an expectations-augmented wage Phillips curve. However, unlike some Australian applications (such as Ballantyne, De Voss and Jacobs 2014) where in some of their estimated equations the inflationary expectations coefficient is assumed to be one and a Non-Accelerating Wage Rate of Unemployment (NAWRU) is imposed on the estimated equation, careful testing is conducted in this analysis to determine whether or not a NAWRU is likely to be present. This follows the work of Connolly (2008 and 2001) who showed that when corrections are made for analytical flaws, the inflationary expectations coefficient is likely to be less than one and a NAWRU is unlikely to be present.

Before regression analysis is conducted, the orders of integration (or stationarity) and cointegration of the dependent and explanatory variables are tested. The results of this testing are that the average Australian wage and its explanatory variables are likely to be integrated of the first order and cointegrated with each other. A set of wage equations is then estimated, taking account of these results. Other relevant explanatory variables are included, such as those relating to institutional factors, the share of teenagers in total employment and short-term temporary entrants to Australia. Excess labour demand is indeed estimated to have a differential effect from excess labour supply on the average wage.

* This paper reflects the author's views and does not necessarily represent those of the Department of Employment or the Australian Government. The author would like to thank other members of the Labour Economics Section at the Department of Employment for their assistance with this research.

I. *Introduction*

Econometric estimation of what determines wages in Australia at the aggregate level is important for macroeconomic modelling (such as for the FoCUS macroeconomic model which is used for policy and scenario analysis in the Department of Employment - see Connolly 2011 for an overview of this model), for monetary and fiscal policy, for setting of the minimum wage and for labour market policies. In this regard, one of the purposes of this analysis is to provide better information to the Department of Employment on what determines the average wage, to assist it in preparing the Australian Government Submission to the Annual Wage Review.

With sophisticated models of the labour market, such as those in Connolly (1999a) and Stacey and Downes (1995), it is possible for excess labour supply (in the form of unemployment, underemployment and/or hidden unemployment) and excess labour demand (in the form of job vacancies) to co-exist and to have separate and differential effects on wages. Estimates of these separate effects are presented in this paper.

This is done in the framework of an expectations-augmented wage Phillips curve. However, unlike some Australian applications (such as Ballantyne, De Voss and Jacobs 2014) where in some of their estimated equations the inflationary expectations coefficient is assumed to be one and a Non-Accelerating Wage Rate of Unemployment (NAWRU) is imposed on the estimated equation, careful testing is conducted in this analysis to determine whether or not a NAWRU is likely to be present. This follows the work of Connolly (2008 and 2001) who showed that when corrections are made for analytical flaws, the inflationary expectations coefficient is likely to be less than one and a NAWRU is unlikely to be present. This is in addition to the analyses of Connolly (1999b) and Mitchell and Muysken (2002) who showed that a NAWRU or a Non Accelerating Inflation Rate of Unemployment (NAIRU) was unlikely to be present, even when the expectations-augmented Phillips curve was estimated with a functional form that was likely to bias the inflationary expectations coefficient upwards towards one when the true coefficient was less than one.

Another estimate of the wage equation for Australia, not based on the expectations-augmented wage Phillips curve, is also examined in the current research project. This is the estimate of Karanassou and Sala (2010), who applied the Chain Reaction Theory model of the labour market to Australia.

Before regression analysis is conducted, the orders of integration (or stationarity) and cointegration of the dependent and explanatory variables are tested. The results of this testing are used in setting the functional form of the equations that are estimated. These estimates are presented in Section V. Other relevant explanatory variables are included in this set of equations, such as those relating to institutional factors, the share of teenagers in total employment and short-term temporary entrants to Australia who are likely to be employed.

A conclusion is then presented, including an assessment of whether excess labour demand is indeed estimated to have a differential effect on the average wage, compared with excess labour supply.

II. Previous Econometric Analysis of the Determinants of Wage and Price Inflation in Australia

Much of the previous econometric analysis of the determinants of aggregate wage and price inflation in Australia has been conducted using the framework of the expectations-augmented wage Phillips curve.

The Phillips Curve is named after Phillips (1958), who postulated a negative relationship between wage changes and the unemployment rate. In the 1960s and early 1970s it was noticed (particularly by Friedman 1968 as cited in Gruen, Pagan and Thompson 1999) that the relationship between wages and unemployment also depended on expectations about wage and price inflation, and it was appeared that a reduction in the rate of unemployment below a particular level would not only lead to an initial acceleration in wages and prices, but that the increased inflation rate would then increase the expected inflation rate. This led to the expectations-augmented Phillips Curve, where explanatory variables representing expectations of wage or price inflation were added to the Phillips Curve.

If an initial increase in inflation that arises from a low unemployment rate leads to a one-for-one increase in the expected inflation rate (i.e., if the inflationary expectations coefficient is one), then a reduction in the unemployment rate below a certain level would then lead to a permanent acceleration in wages or prices (and an increase in the unemployment rate above a certain level would lead to a permanent deceleration in wages or prices). If both of these factors are present (i.e., the unemployment rate (or a similar variable representing labour market capacity) has a significant negative effect on wage changes <u>and</u> this effect results in an inflationary expectations coefficient of at least 1.0), then a so-called Non-Accelerating Inflation Rate of Unemployment (NAIRU) [1] is present if the dependent variable is a change in prices, or a Non-Accelerating Wage Rate of Unemployment (NAWRU) is present if the dependent variable is a change in wages.

Connolly (2008 and 2001) reviewed most of the econometric analysis of the wage-setting equation conducted in Australia up to the time of release of these two research papers. He found that there was highly unlikely to be a NAIRU or NAWRU in Australia. These were some of the key reasons why:

- Many of the previous analysts had used a functional form for the Phillips Curve (with the dependent variable being a change over four quarters in wages or prices and the inflationary expectations variable being a change over four quarters in wages or prices, lagged by one quarter) which led to an upwards bias in their estimates of the inflationary expectations coefficient.

- Even where some analysts, such as Connolly (1999b) and Mitchell and Muysken (2002) had used this biassed functional form, they had estimated that the inflationary expectations coefficient was significantly less than one.

[1] Of course, as many people have pointed out, the term, 'NAIRU', is a misnomer because it is not inflation that would be accelerating but the natural logarithm of the price level. For the sake of brevity, the term 'natural logarithm' is abbreviated to 'logarithm', 'log' or 'Ln', depending on the space available, in the rest of this paper.

- Where the lagged dependent variable is used as a component (or all) of the inflationary expectations coefficient, its estimate was sometimes biassed upwards as a result of effects identified by Achen (2001). These effects arise where the explanatory variables are trended and the error terms (in an equation where the dependent variable is excluded) are positively autocorrelated.

- Some of the previous analysts had incorrectly used or interpreted the results of using prospective or 'forward-looking' inflationary expectations coefficients or had incorrectly counted the coefficients of exogenous variables (such as world prices, as used by Parkin (1973), or import prices as used by Ryder (2007)) as part of the inflationary expectations coefficient for determining whether or not a 'NAIRU' or NAWRU is present.

- The orders of integration or stationarity of prices or wages (or unit labour costs) and their explanatory variables (the unemployment rate, prospective inflationary expectations variables, etc) were not consistent with the presence of a 'NAIRU' or NAWRU. In order for a NAIRU or NAWRU to be present, the price variable must be integrated of the second order or I(2) and the unemployment rate must be stationary. However, previous researchers have sometimes estimated the price variable to have an order of integration less than two but the unemployment rate to be I(1) instead of being stationary. In other cases, researchers had not conducted sufficient statistical testing to determine whether a 'NAIRU' or NAWRU is present. A prime instance of this is that Gruen, Pagan and Thompson (1999, Appendix C) tested whether the accelerations of the underlying CPI and the unit labour cost index were integrated, that is, they tested whether the underlying CPI and the unit labour cost index were I(3) versus the alternative of I(2), but they did not test whether the degree of integration was lower than I(2).

Key econometric analyses on aggregate wage determination in Australia since Connolly (2008) conducted his review of Australian wage-setting research in mid-2008 will now be examined in the light of the discussion above.

Mitchell and Muysken (2008) estimated expectations-augmented price Phillips curves for Australia and tested out various specifications of unemployment and underemployment as their variables for labour-market capacity. Their dependent variable was the change over four quarters in the logarithm of prices and their key variable for the inflationary expectations coefficient was the dependent variable, lagged only one quarter. All of their estimated coefficients for this variable were numerically less than one.

As shown in Connolly (2008), under this circumstance, this specification biases up the estimation of the inflationary expectations coefficient up towards one. Despite this, most of their estimates of this variable were significantly less than one (using the standard rule of thumb of two standard errors above the coefficient estimate for the upper bound of the 95 per cent confidence interval). The authors compounded the existing problem of overlapping of components of the dependent and lagged dependent variables by conducting a so-called 'NAIRU' test where they also included the change over four quarters in the logarithm of prices, lagged two, three and four quarters. Apart from the last term, these additional variables would have added more components of the dependent variable to the estimated inflationary expectations coefficient and (potentially at least) biassed it even more severely upwards towards one. Mitchell and Muysken (2008) estimated that their 'NAIRU' test showed that their estimate was 'homogenous' or that the sum of their (upwardly biassed) lagged dependent variables was not significantly different from one. This is unsurprising, given that their specification severely biasses the estimate of the inflationary expectations coefficient towards one.

The valuable contribution from Mitchell and Muysken (2008) was not their estimate of the inflationary expectations coefficient but rather their finding that underemployment has a significant negative effect on the price inflation rate in Australia. What's more, of the equations that they estimated, the version with the highest explanatory power (as measured by the Adjusted R-squared statistic) also had a significant negative effect from the short-term unemployment rate gap (the difference between actual and trend short-term (less than 12 months) unemployment rates).

Lim, Dixon and Tsiaplis (2009) estimated that the ‘NAIRU’ varied through time and rose from around 4½ per cent in 2007 to 5 per cent in 2008. However, their analysis was flawed because they did not analyse whether the inflationary expectations coefficient was less than one, and whether a ‘NAIRU’ was actually present, but instead imposed an inflationary expectations coefficient of one[2].

Guichard and Rusticelli (2011) estimated expectations-augmented Phillips curves for most OECD countries, including Australia, taking account of possible changes after the Global Financial Crisis, which worsened in late 2008. For Australia, the dependent variable was the quarterly percentage change in the headline CPI inflation rates (for some other OECD countries, it was the core CPI inflation rate). They included three lags of the dependent variable for Australia and the estimated coefficients were -0.81, -0.54 and -0.27 respectively. The sum of the three coefficients is -1.62. Each of the individual coefficients was significantly different from zero. Clearly, the inflationary expectations coefficient is not only significantly less than one, it would also be significantly be less than zero. Despite the authors' claim in the title of their paper that they were "Reassessing the NAIRUs after the Crisis", their estimates of the inflationary expectations coefficient for Australia (and incidentally every other OECD country which they estimated and reported in Table 1 on pages 13 and 14 of their paper) implied that a NAIRU was not present. While for Australia (and some other OECD countries), the unemployment rate gap had a negative association with the CPI inflation rate, this is insufficient to prove that a 'NAIRU' is present.

[2] This critique of the analysis conducted by Lim, Dixon and Tsiaplis (2009) was also made in Connolly (2011a).

Norman and Richards (2012) estimated ten separate single equations for the determinants of the consumer price inflation rate for Australia (five for headline inflation and five for underlying inflation). Six of these were Phillips curves, two were mark-up models and the other two were a variant of the mark-up model called the distributed lag model. In only one of these (the Hybrid New Keynesian Phillips Curve for the underlying inflation rate) was the inflationary expectations coefficient not significantly different from one. However, this equation does not fit all the criteria for being considered a NAIRU-style equation, because the estimated coefficient for the output gap, which was used instead of the unemployment rate as the measure of economic capacity constraints, was not significantly different from zero. Further, this equation had substantially lower explanatory power than the other four alternatives for the underlying inflation rate.

Bullen, Greenwell, Kouparitsas, Muller, O'Leary and Wilcox (2014) estimated an expectations-augmented wage-style Phillips Curve for Australia. It was wage-style in that their dependent variable was a real unit labour cost index, and not the nominal wage as in conventional wage Phillips curves (the real unit labour cost index is the nominal wage deflated by both labour productivity and an aggregate price index). Their dependent variable was a change over four quarters in the real unit labour cost index. Their inflationary expectations coefficients had three components: inflationary expectations from the bond market (in real terms); the change in the real unit labour cost index over four quarters, lagged one quarter; and the difference between the change in the nominal unit labour cost index one quarter ago and the change in the nominal unit labour cost index four quarters ago. The variable they used to convert from nominal to real terms was the price deflator for Gross National Expenditure. Their variable for labour market capacity was the proportional difference between the actual unemployment rate (lagged one quarter) and the equilibrium unemployment rate. The coefficient on this variable was estimated to be negative and significantly different from zero (in other words, unemployment rates higher (or lower) than the equilibrium rate were followed by lower (or higher) real unit labour costs). They estimated their equation with Kalman filtering, which allowed for time-varying levels of the equilibrium unemployment rate.

They also described this equilibrium unemployment rate as a trend unemployment rate and they stated that this is "commonly referred to as the non-accelerating inflation rate of unemployment (NAIRU)."

Their estimated equilibrium unemployment rate was around 5 per cent in the December quarter 2013, which was the end of their sample period. However, their equilibrium unemployment rate does not appear to fulfil all the criteria for strictly being classified as a 'NAIRU', because an unbiassed estimate of the sum of their inflationary expectations coefficients is calculated (see Appendix A) to be highly likely to have been less than one. Notably, the second component of the inflationary expectations coefficient in their Wage Phillips Curve equation is a four-quarterly change in a dependent variable which is lagged one quarter. As shown by Connolly (2008), this specification biasses the estimate of the inflationary expectations coefficient towards one[3], and the further away the estimate is from one, the larger the bias is. However, the situation is more complex than this, since the dependent variable is in real terms and there are three components of the inflationary expectations coefficient, with two of these being in real terms and the third being in nominal terms. These complexities are analysed in Appendix A. A range of estimates of the sum of the inflationary expectations coefficients is generated, with the lowest of these being -0.6 for the sum of the direct inflationary expectations coefficients (working through lagged quarterly changes in wages and assuming no flow-on effects on prices or inflationary expectations in the bond market) and the highest of these being +0.55 (assuming full flow-on effects on prices and inflationary expectations in the bond market).

Ballantyne, De Voss, and Jacobs (2014) estimated a variety of expectations-augmented Phillips curves for Australia. They used several dependent variables, including wages, prices and unit labour costs. They estimated their wage and price Phillips curves at both the State/Territory and national levels. With some of the equations, they imposed an inflationary expectations coefficient of one and claimed to have estimated a 'NAIRU'. With their more innovative and interesting equations, however, their dependent variables were quarterly wage or price inflation rates, they didn't impose an inflationary expectations coefficient of one (or even report the coefficients on their inflationary expectations variables in the research article), didn't include any lagged dependent variables, and used various components of the unemployment rate as explanatory variables.

They disaggregated unemployment according to the observable characteristics of the unemployed into frictional, structural and cyclical components. One of these disaggregations was by reason of unemployment (former workers, those who had never worked before, retrenchees). This was similar to Connolly (2011) with his measure of the Observable Structural and Frictional Unemployment Rate (or OSFUR). Other disaggregations were by duration of unemployment and by the perceived reasons for unemployment[4].

[3] That is, unless the unbiassed estimate is 1.0.

[4] which they obtained from the survey used to produce the ABS publication, *Job Search Experience, Australia*, ABS Cat. No. 6222.0; while this publication is no longer produced by the ABS, much of the information from it for 2014 was released in the ABS publication, *Persons Not In the Labour Force, Underemployed Workers and Job Search Experience, Australia, February 2014*, ABS Cat. No. 6226.0.55.001; and the ABS intends to continue to release annual statistics on the perceived reasons for unemployment in the release relating to its supplementary Labour Force survey titled Participation, Job Search and Mobility.

In terms of duration of unemployment, they found that medium-term unemployment (which they defined as 1-12 months), which was more likely to represent cyclical unemployment, had a stronger and more statistically significant negative effect on price and wage inflation than short-term unemployment (up to one month's unemployment, which is more likely to represent frictional unemployment), while long-term unemployment (12 months and longer, which is more likely to represent structural unemployment) was estimated to have almost no effect on price and wage inflation.

When they disaggregated unemployment by reasons for unemployment, they found that those who had become unemployed involuntarily during the last two years (for reasons such as retrenchment) had the strongest downward effect of all the groups of reasons on both wage and price inflation. Those who had become unemployed 'voluntarily' (for reasons such as leaving their job because of unsatisfactory work arrangements) had the second-strongest downward effect of all the groups of reasons on both wage and price inflation, although this effect was not statistically significant on price inflation. Former workers (unemployed people who had not worked for at least the last two years) and unemployed people who had never worked before had no statistically significant effect on wage or price inflation.

They were unable to obtain reliable estimates of the effects of categories of perceived barriers of unemployed people on price or wage inflation, probably because data on these categories are only available on an annual basis.

Gillitzer and Simon (2015) estimated an expectations-augmented price Phillips curve for Australia with the gap between the actual unemployment rate and the equilibrium unemployment rate (which they estimated in their equation) being their key measure of the output gap. They imposed an inflationary expectations coefficient of one without testing whether it was significantly less than one. They also didn’t examine the stationarity or integration properties of their variables. They estimated their equation using Kalman filtering, which allowed for time-varying coefficients.

Gillitzer (2015) estimated an expectations-augmented price Phillips curve for Australia with the output gap measured as the difference between actual real GDP and trend real GDP, where the latter was estimated using a one-sided Hodrick-Prescott filter. He did this to test some advanced versions of the Phillips Curve (the Sticky Information Phillips Curve and the New Keynesian Phillips Curve) for their applicability to Australia. As he did not include the unemployment rate in his equations, his results can't be used to provide evidence about whether there is or isn't a 'NAIRU' in Australia. His dependent variable was the quarterly CPI inflation rate (the headline measure for some equations and the underlying measure for others). In a small number of his equations, he included a lagged dependent variable (i.e., CPI inflation rate lagged one quarter) and estimated the coefficient of this variable to be close to zero. He also included a wide range of explanatory variables for inflationary expectations (from the RBA's forecasts, from Consensus forecasts or econometrically estimated), alternative sample periods, alternative specifications for the coefficients (some linear, some non-linear and so not able to be used directly to determine whether the inflationary expectations coefficient is less than one), and alternative timing of the forming of expectations (concurrent or lagged). Corresponding with this, he estimated a wide range of coefficients for these inflationary expectations coefficients. While some of these were not significantly less than one, others were, while still others contained estimates that were so imprecise that they were not significantly different from either zero or one.

Jacobs and Rush (2015) estimated an expectations-augmented wage Phillips curve for Australia. Their dependent variable was the quarterly percentage change in the ABS private-sector *Wage Price Index*[5]. Their inflationary expectations coefficients were inflationary expectations from the bond market, with lags of one, two and three quarters. A similar explanatory variable was the quarterly percentage change in the GDP price deflator, lagged one quarter. Even if all four of these variables are summed up to give an overall inflationary expectations coefficient (which is likely to be invalid for reasons given in Connolly 2008 and 2001), it would be less than one because the sum of these coefficients is 0.15.

Their labour market capacity variable was a so-called 'NAIRU Gap'. It was measured as the difference between the actual quarterly unemployment rate and the 'NAIRU' estimated by Ballantyne, Jacobs and De Voss (2014). However, as previously pointed out in this review of the literature, they imposed an inflationary expectations coefficient of one in order to estimate their 'NAIRU'. They included this 'NAIRU' gap variable with lags of one and two quarters. Their estimated coefficients were 0.07 and -0.11 respectively, with neither of these coefficients being significantly different from zero at the one per cent level of significance (they did not provide any additional statistical information in their paper to enable readers to determine whether these coefficients would have been statistically significant at a less precise level). The positive sign on the first coefficient is contrary to expectations and the sum of the two coefficients is around -0.04, which is numerically very small. For example, these coefficients imply that if the actual unemployment rate remains one percentage point below the 'NAIRU' for at least two quarters, the quarterly wage inflation rate would have risen by only 0.04 per cent in the long run. This is abstracting from additional effects that may arise through other explanatory variables. In particular, another explanatory variable is the quarterly change in the unemployment rate, lagged one quarter. The estimated coefficient for this variable is -0.39, indicating that the effect through this 'speed hump' variable is around ten times as large as the long-term effect through the 'NAIRU' gap. Also, there is another potential effect through a possible influence of the unemployment rate on the inflationary expectations coefficients or the GDP price deflator, but as previously mentioned, the sum of the coefficients on these four variables was only 0.15.

The IMF (2015a, p.30) claim to have forecast that Australia’s ‘NAIRU’ will be 5.6 per cent in 2016 and 2017 and 5.7 per cent in 2018, 2019 and 2020. The author of the IMF’s article states (on p. 31) that the IMF’s ‘NAIRU’ or equilibrium unemployment rate was estimated with the IMF’s Multivariate Filter or MVF model, which is “a statistical (Kalman) filter model that uses information from actual growth, inflation, and unemployment to estimate the output gap, potential growth, and equilibrium unemployment…”. Although how the IMF estimated the equilibrium unemployment rate (‘NAIRU’) for Australia is not explained in this paper, it appears to be explained in the April 2015 *World Economic Outlook* by the IMF (2015b, p. 72) as being estimated using an expectations-augmented Phillips curve with the inflationary expectations coefficient set to be equal to one. There was no justification provided in this paper for this assumption, nor any evidence in either paper that the unemployment rate gap has a significant negative effect on the inflation rate in Australia in their estimated equation.

[5] ABS Cat. No. 6345.0.

Karanassou and Sala (2010), found evidence against the presence of a 'NAIRU' or a ‘natural’ rate of unemployment in Australia using a model of the Australian labour market that they constructed based on the Chain Reaction Theory (this is an innovative alternative to the usual framework of the expectations-augmented wage Phillips curve). They concluded (p. 207) that lagged adjustment processes, spillovers from one part of the labour market or economy to another, and differential growth rates in the capital stock, the working-age population and other economic and labour market variables imply that “...actual unemployment does not gravitate towards its natural rate in the long-run.” The explanatory variables in their aggregate wage-setting equation were the lagged level and change in wages (with the estimates implying that the inflationary expectations coefficient is likely to be less than one[6]), current and lagged changes in the unemployment rate, the capital-employment ratio, social security benefits as a percentage of GDP, household direct taxes as a percentage of GDP, and dummy variables for the wage breakout in 1974-75 and the Prices and Incomes Accord which lasted from the mid-1980s to the mid-1990s. With the Three-stage Least Squares estimate of their equation, they estimated that all of the explanatory variables were statistically significant (the lagged change in the unemployment rate at the ten per cent level and all the others at higher levels of precision) and all had the expected sign (where a particular sign was expected).

Karanassou and Sala (2010) justified using the capital-employment ratio in their wage-setting equation because it was a measure of capital deepening and stated that it commonly proxies labour productivity. They estimated an elasticity of +0.25 on the capital-employment ratio and found that their estimate was statistically significant at a high level of probability.

In the current analysis, a more sophisticated measure of capital deepening is used: the ratio of aggregate hours worked to the capital stock. This is largely the inverse of the capital-employment ratio, but more sophisticated in the sense that aggregate hours worked is a more comprehensive measure of labour input to production than employment.

The key conclusion from this review of the literature is that there is very little evidence that Australia genuinely has a 'NAIRU' or a NAWRU. Where a 'NAIRU' or NAWRU has claimed to be estimated, either an inflationary expectations coefficient of one has been imposed on the equation or the relationship between the inflation rate and labour market capacity has been called a 'NAIRU' or a NAWRU even though the unbiassed estimates of the true inflationary expectations coefficients are almost always less than one. Accordingly, an inflationary expectations coefficient of one is not imposed on the specification used for the econometric estimation in this current analysis. Also, stringent measures are taken to reduce biasses in the estimate of the inflationary expectations coefficient. The dependent variable is expressed as a quarterly change, not a change over four quarters. Prospective measures of inflationary expectations, such as inflationary expectations from the bond market, are not included as explanatory variables. Further, steps are also taken to reduce the potential bias in estimates of the lagged dependent variable arising from 'Achen' effects. In particular, the methods of Wilkins (2013) are used to reduce this potential bias. Wilkins (2013) devised a method for separating the unbiassed estimate of the coefficient of the lagged dependent variable from the estimate of the first-order autoregressive error term.

[6] Indeed, Karanassou and Sala (2010, p. 196) stated that their persistence coefficient (for the effect of the lagged level of wages on the current wage level) "...is rather low at 0.25...reflecting the quick adjustment to shocks that characterise the Anglo-Saxon labour markets."

III. Selection of Variables

In this Section, the selection of both the dependent and the explanatory variables is described.

III.i Dependent Variable

The criteria for the choice of an Australian wage series to be the most suitable dependent variable for this analysis are that it should be:

- Available on a quarterly basis. This is because many of the explanatory variables, such as ABS job vacancies, series constructed from the ABS quarterly *National Accounts*[7], and the ABS consumer price index, are available on a quarterly basis (but not on a more frequent basis such as monthly). This criterion rules out annual wage series (such as from the ABS's *Characteristics of Employment* release[8]) and biennial wage series (such as from the ABS's *Employee Earnings and Hours* release[9]). It also counts against series from the ABS's *Average Weekly Earnings* release (ABS Cat No. 6302.0), which were available on a quarterly basis until mid-2012, but since then have only been collected and released biannually.

- A consistent data series, available for a sufficiently long time. Ideally, it should be available back before the informal inflation-targetting regime was instituted by the RBA in 1993 (so that the results are not vulnerable to criticism that they would be affected by the 'Lucas critique', which is explained in Lucas (1976), that there might have been a NAWRU before the inflation-targetting regime, but the introduction of inflation targetting anchored inflationary expectations so that a NAWRU was no longer observable) and back to times when Australia had technical economic recessions (i.e., back to at least 1991) so that the results are robust to both good and bad economic conditions. This criterion tends to count against data from the ABS's *Wage Price Index* release[10], which has only been collected and released by the ABS since the September quarter 1997.

These criteria and the availability of data mean that the clear choice as the most suitable dependent variable is:

- Average Non-farm Earnings on a National Accounts basis (AENA). The weekly series from the ABS [NIF-10S] *Modellers' Database*[11] is chosen because it is available for a longer time period than the quarterly series from the ABS quarterly *National Accounts*[12], which is only available from the March quarter 1978. The preferred series is shown in Figure 1.

[7] ABS Cat. No. 5206.0.

[8] ABS Cat. No. 6333.0. In order to construct an annual wage series, data for August 2014 from this series would need to be spliced with data from one of its predecessor publications titled *Employee Earnings, Benefits and Trade Union Membership* (ABS Cat. No. 6310.0).

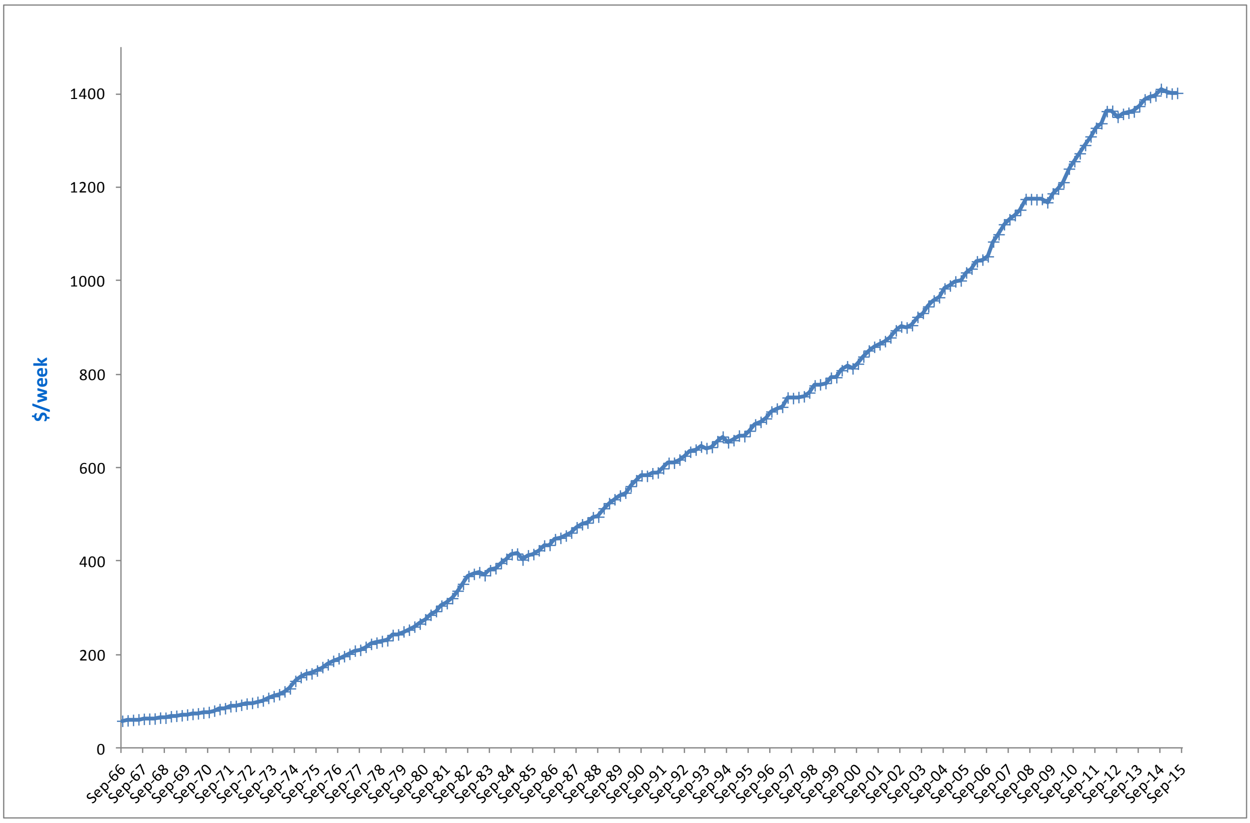
[9] ABS Cat. No. 6306.0.

[10] ABS Cat. No. 6345.0.

[11] ABS Cat No. 1364.0.15.003.

[12] ABS Cat No. 5206.0.

Figure 1: **Average Non-farm Earnings on a National Accounts basis**



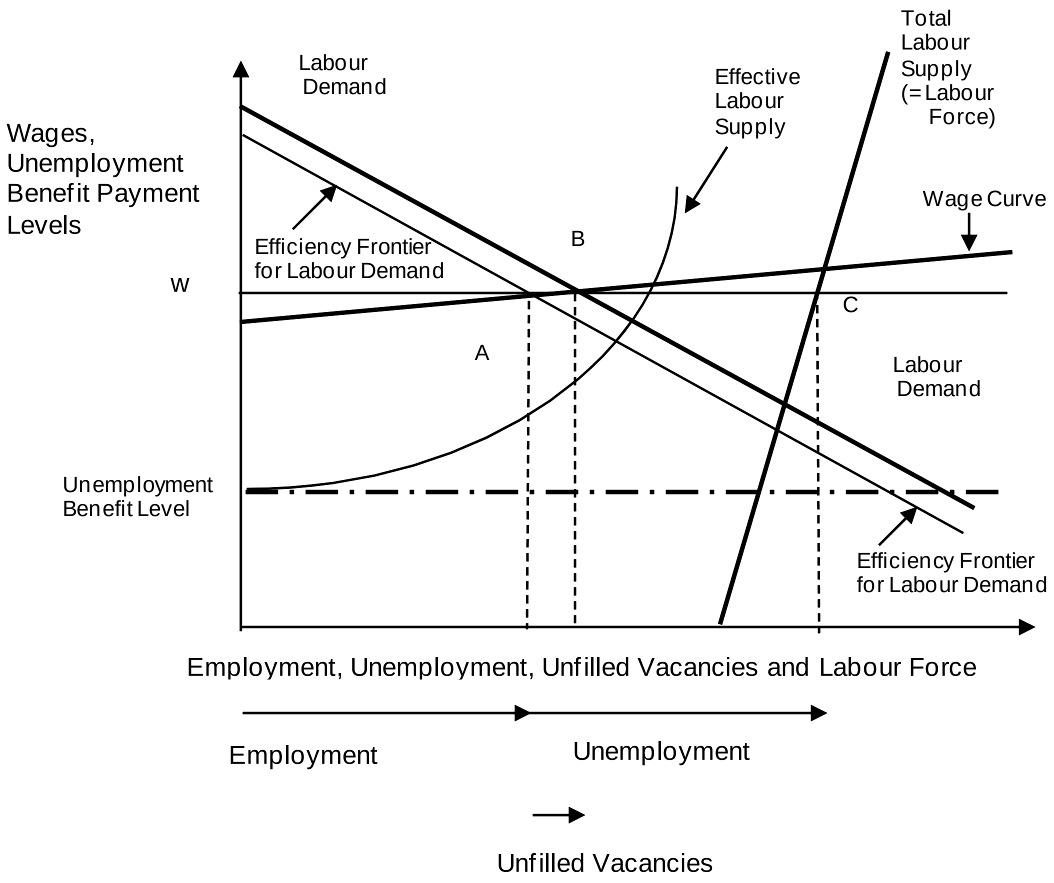
Source: ABS [NIF-10S] *Modellers' Database*, ABS Cat No. 1364.0.15.003. These figures are in $/week, current prices (i.e, nominal), seasonally adjusted terms.

In general, this series evolves fairly smoothly, but is subject to wage breakouts at times, such as in the mid-1970s and early 1980s following the first and second oil price booms. It also appears that there could have been minor wage breakouts just before and in the initial recovery just after the initial stage of the Global Recession (i.e., in 2007 and from mid-2009 through early 2012 respectively). Its rate of change tends to stall (or even become negative) in economic recessions and other downturns, such as in the early-mid 1980s, the early 1990s and the initial stages of the Global Recession in 2008-09.

III.ii Excess Labour Supply and Excess Labour Demand

Connolly (1999a) provided a model of the labour market in which there was the simultaneous presence of both excess labour demand (in the form of job vacancies) and excess labour supply (in the form of unemployment, but it is also possible to have excess labour supply in the forms of underemployment and hidden unemployment, or marginal attachment to the labour force). Figure 2 is taken from this analysis. This represents the usual state of the Australian labour market since the mid-1970s where there has been usually been excess labour supply and the wage (in a given quarter) is determined by the intersection of the labour demand curve and the wage-setting curve.

Figure 2: **Depiction of the Labour Market with Excess Effective Supply: Employment, Unemployment, Wages and Unfilled Vacancies**



The short-term equilibrium in the labour market is represented in Figure 2 above. There are two labour supply curves: a total labour supply curve, which determines the labour force participation rate, and an effective labour supply curve, which represents the fact that not everyone in the labour force is effective at a particular point in time in obtaining and retaining employment (for various reasons such as they are structurally unemployed or there is little financial incentive for them to search actively for work if the wage they could earn is low relative to the unemployment allowance payment rate). There are also two labour demand curves: a total labour demand curve and an efficiency frontier for labour (arising from job mismatch and frictional effects and the time taken to fill job vacancies). The fifth and final curve in this model is a Wage Curve (otherwise known as a wage-setting curve), which captures institutional effects on wage determination and the effects of the interaction of the other curves in the labour market. This is the curve that is being estimated in the current analysis.

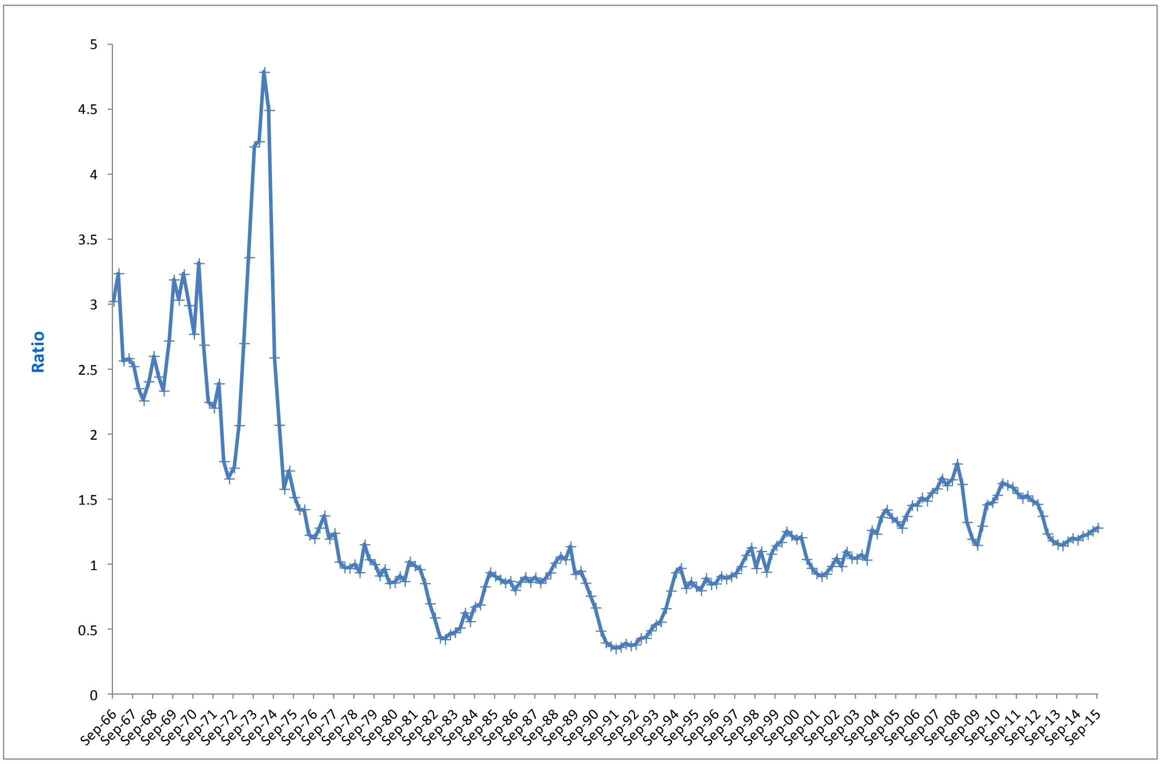
In the situation shown in Figure 2 of excess labour supply, the level of employment (on the horizontal axis) and the wage ('w' on the vertical axis) are determined by the intersection of the efficiency frontier for labour demand and the wage-setting curve (point A). Job vacancies are determined by the difference between total labour demand and the efficiency frontier for labour demand (point B minus point A). The labour force is determined by the total labour supply at wage 'w' (point C). Unemployment is equal to the difference between points A and C.

Figure 2 represents a snapshot of the labour market at a point in time. Over time, each of these five curves shifts in response to changes in the factors which determine labour demand, labour supply, prices and wages. Also, if there is a sizable increase in labour demand and/or a sizable decrease in labour supply, it is possible for employment to be determined by insufficient effective labour supply, instead of insufficient effective labour demand as shown in Figure 2 above.

This means that over time, both excess labour demand, in the form of job vacancies, and excess labour supply, in the form of unemployment and underemployment, can have separate effects on the average wage. It is also possible for there to be different time lags for the effects of excess labour supply and demand on the average wage.

The variable used for excess labour demand in the econometric analysis is the ratio of ABS Job Vacancies to the ABS Labour Force and it is shown in Figure 3. The ABS Job Vacancies series is chosen because it is the longest running, consistently defined and comprehensive series available. That is, when a gap of five quarters, for August 2008 through August 2009 when the ABS did not collect and release this series as a cost-saving measure, is filled in using the methods of Connolly and Tang (2011c)[13] and when the extended series (from the ABS Modellers' Database[14] is used, where more recent data from surveys of employers are spliced with earlier data from the Commonwealth Employment Service). It is more consistency defined and comprehensive because it is less affected by changes in job vacancy filling methods (such as from newspapers to the internet) than other methods.

Figure 3: **ABS Job Vacancy/Labour Force Ratio**



Sources: see Appendix B.

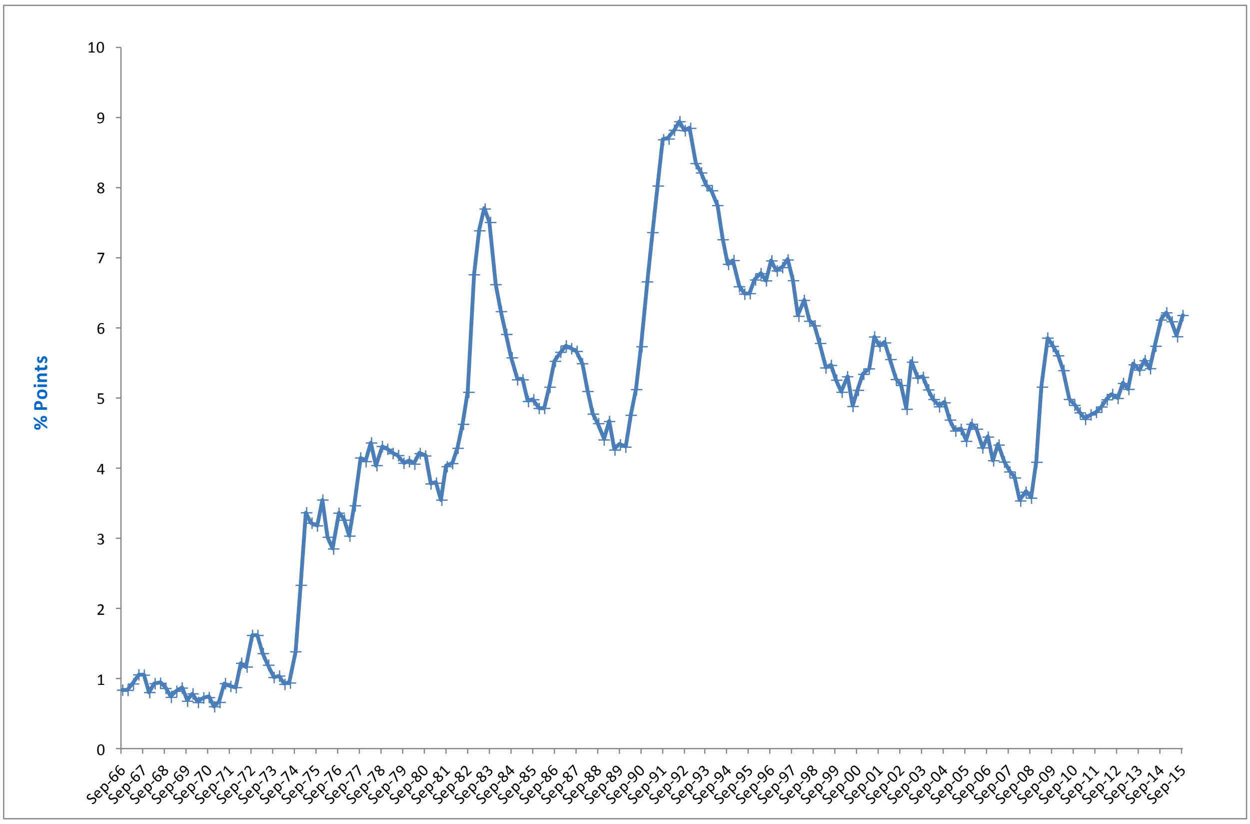
[13] Connolly and Tang (2011) econometrically estimated what ABS Job Vacancies would have been during this time as a function of ANZ total job advertisements and the Westpac/Melbourne Institute Leading Index of Economic Activity.

[14] ABS Cat No. 1364.0.15.003.

As shown in Figure 3, the job vacancy rate was substantially higher up until the mid-1970s than at any time since. It fell to very low levels in the recessions of the early-mid 1980s and the early 1990s. It was estimated to fall sharply during the Global Recession of 2008-09 by Connolly and Tang (2011), but then recovered sharply. Since then, it has fallen to around of the level of the Global Recession, then recovered slowly.

The variable used to represent excess labour supply in the econometric analysis is the cyclical component of the volume labour force underutilisation rate; that is, the difference, or gap, between the total volume labour force underutilisation rate and the Structural and Frictional Volume Underutilisation Rate, or SAFVUR, as defined and explained in Connolly (2013). This measure is in volume rather than headcount terms. In other words, it is in terms of potential hours of work lost through labour underutilisation, where labour underutilisation is the combination of unemployment and underemployment. The SAFVUR is composed of structural unemployment (unemployed people who are former workers (i.e., have not worked for at least two years) or who have never worked before), frictionally unemployed labour market insiders (people unemployed for less than one month who are not structurally unemployed) and people who are structurally or frictionally underemployed (The structural and frictional volume underemployment rate is assumed to be constant at 0.4 per cent, based on the occurrence of a rate as low as this on numerous occasions pre-1978). This gap is shown in Figure 4.

Figure 4: **Volume Labour Force Underutilisation Gap**



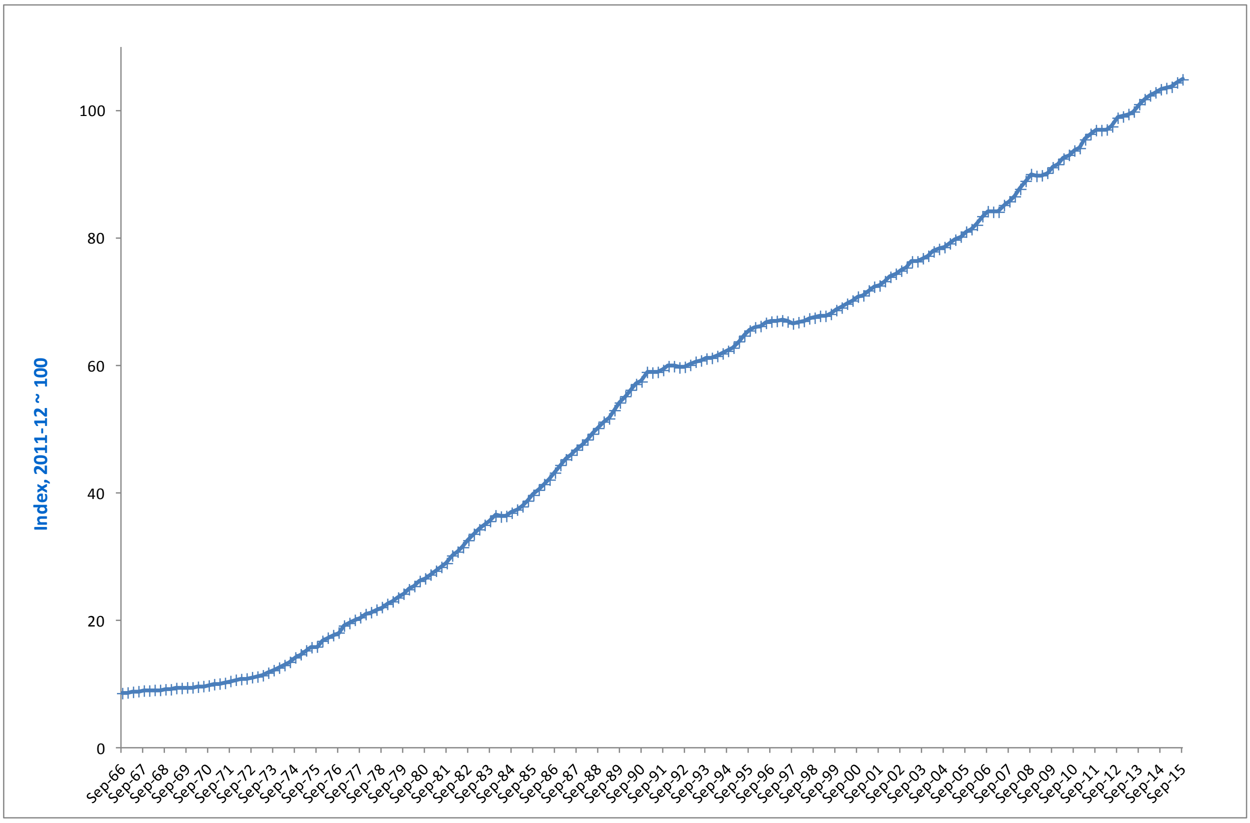
Sources: see Appendix B.

The Volume Labour Force Underutilisation Gap was very low (below two percentage points) between mid-1966 and the mid-1970s. It rose sharply in late 1974 and early 1975, following the first oil price crisis to around three percentage points and has not (yet at least) been back down below this level since then. It rose sharply in the recessions of the early-mid 1980s and early 1990s and the initial stage of the Global Recession (in 2008-09). After rising sharply in recessions, it has usually taken a lot longer time to get down to the level it was before the recession. In the case of the Global Recession, after an initial recovery, it has since risen to a level that in August 2015, was higher than the peak in the initial aftermath of the Global Recession.

III.iii Price Variables

At first glance, the price variable likely to have the most important influence on Australian wages is consumer prices, as measured in the Consumer Price Index (CPI). This is especially so as Award wages have been indexed, or partly indexed, to the CPI at various times over the last 50 years or so. The version of the CPI that is used for the econometric work is the headline, or overall, CPI, adjusted for the introduction of A New Tax System in the September quarter 2000 (which involved a change from wholesale taxes to the Goods and Services Tax) by removing its estimated effect (an increase in the CPI of around 2.9 per cent). The reason for removing this effect is that wage earners were informed well in advance of the introduction of the New Tax System and its effect on after-tax earnings was offset by reductions in income taxes on individuals. The time series of this version of the CPI is shown in Figure 5.

Figure 5: **CPI, Adjusted for the Introduction of A New Tax System**

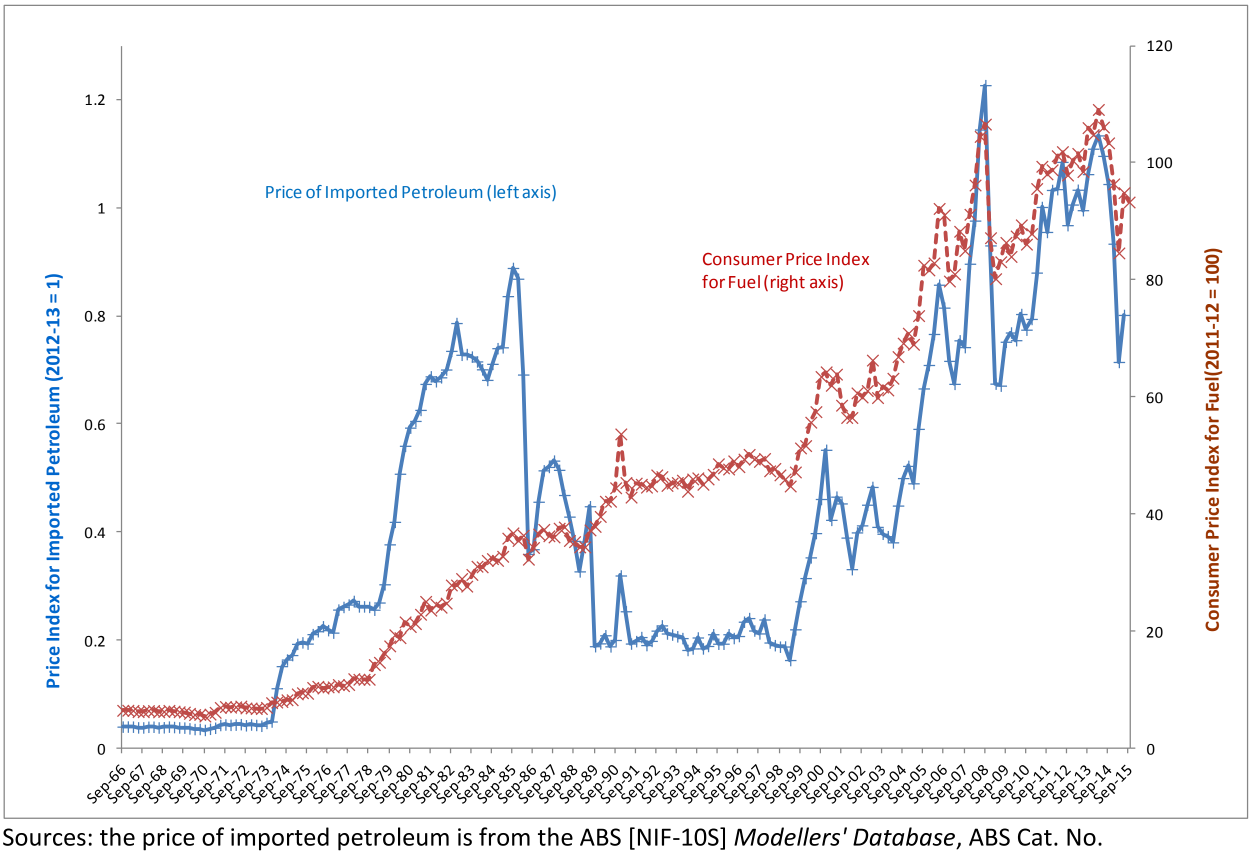


Source: Based on ABS (2015), *Consumer Price Index, Australia, September quarter 2015*, ABS Cat. No. 6401.0: All Groups CPI (headline CPI), adjusted for the introduction of A New Tax System in September quarter 2000 by reducing the level of the adjusted CPI by around 2.9 per cent.

The CPI rose slowly in the mid-1960s through to the early 1970s, rose rapidly from then through the 1980s, then rose slowly again from the 1990s onwards.

Another set of price variables which are likely to have an important effect on wages are fuel prices. Two alternative fuel prices were considered: the fuel component of the CPI and the price of imported petrol (from the ABS [NIF-10S] *Modellers' Database*). The former only goes back to 1972 and was spliced with the latter variable to extend the series back before then. The fuel component of the CPI represents the cost to wage earners of travelling to work. If this is higher, then wages are expected to be higher, because wage earners would expect a higher wage to compensate them for the higher costs of travelling to work. The price of imported petrol is a proxy for this (as shown in Figure 6, both series were highly positively correlated with each other from the start of the 1990s) and also represents the cost of fuel as an energy input to production (which is more likely to be a substitute for than a complement with labour). In addition, particularly around the times of the first and second oil price crises (in the early-mid 1970s and then again in the early 1980s), wage-earners could have formed their expectations of what would happen in the near future to their costs of travelling to work based on world oil prices and their flow-on effects on the price of imported petroleum and based their wage bargaining positions on these, rather than on the actual retail cost of fuel (there was substantial regulation of the retail price of fuel in the 1960s, 1970s and 1980s). Each of these three reasons mean that a higher cost of imported petrol should be followed by higher wages.

Figure 6: **Price of Imported Petroleum and Consumer Price Index for Fuel in Australia**

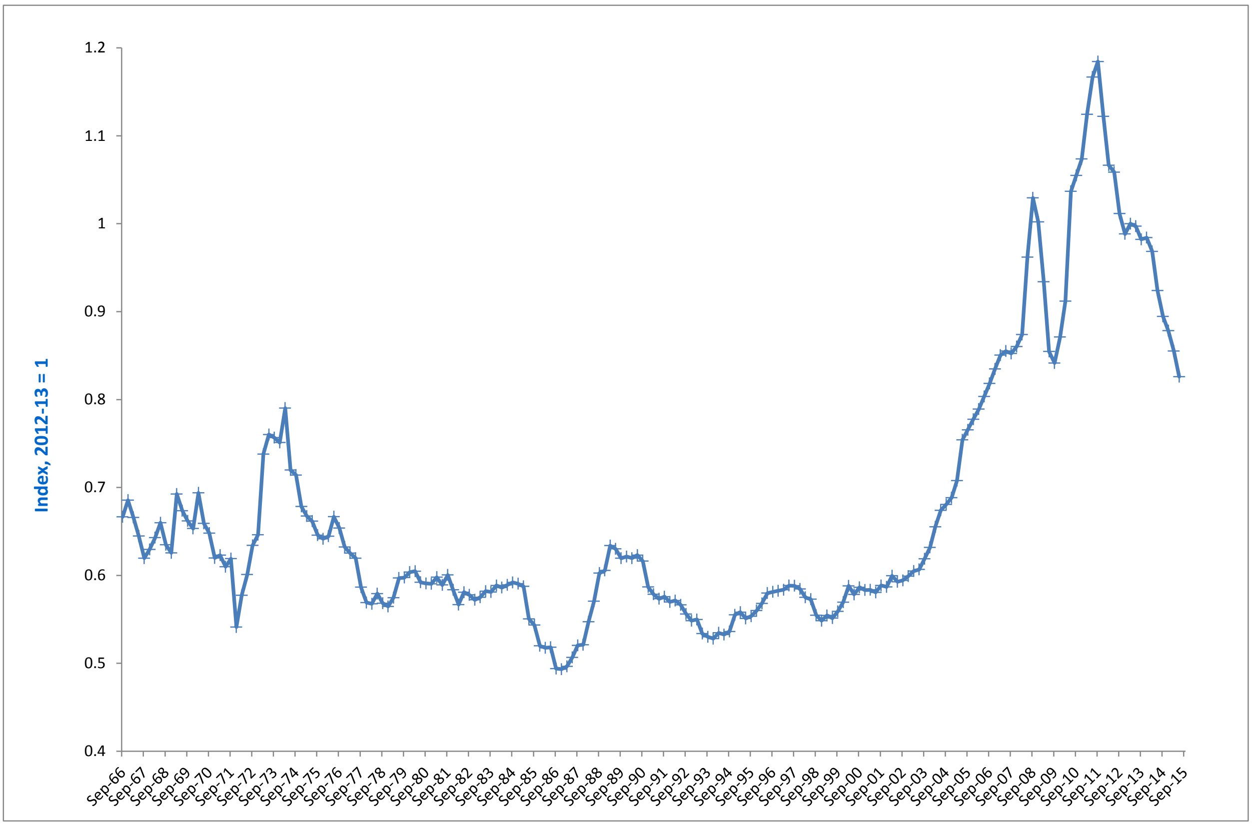


Sources: the price of imported petroleum is from the ABS [NIF-10S] *Modellers' Database*, ABS Cat. No. 1364.0.15.003, while the CPI for fuel is from ABS (2015), *Consumer Price Index, Australia, September quarter 2015*, ABS Cat. No. 6401.0.

The effects of the first and second oil price crises (in the early-mid 1970s and then again in the early 1980s) on the price of imported petroleum can clearly be seen in Figure 6 (in the solid blue line). The effects of these crises on the retail price of fuel were substantially muted, mainly because the retail price of fuel was more highly regulated than at present. Since the start of the 1990s, the closer relationship between these two fuel price series can clearly be seen in Figure 6.

Another set of prices that are likely to affect Australian wages is the ratio of the export price to the import price, otherwise known as the Terms of Trade, which is shown in Figure 7. The expected effect on the average wage is positive, as a higher output price in export industries, especially in Mining during the commodity price boom of the 2000s and early 2010s, is likely to have increased the average wage as the Mining industry, and industries associated with it such as the Construction industry, bid up wages to attract suitable labour.

Figure 7: **The Terms of Trade (Ratio of Export to Import Price) in Australia**



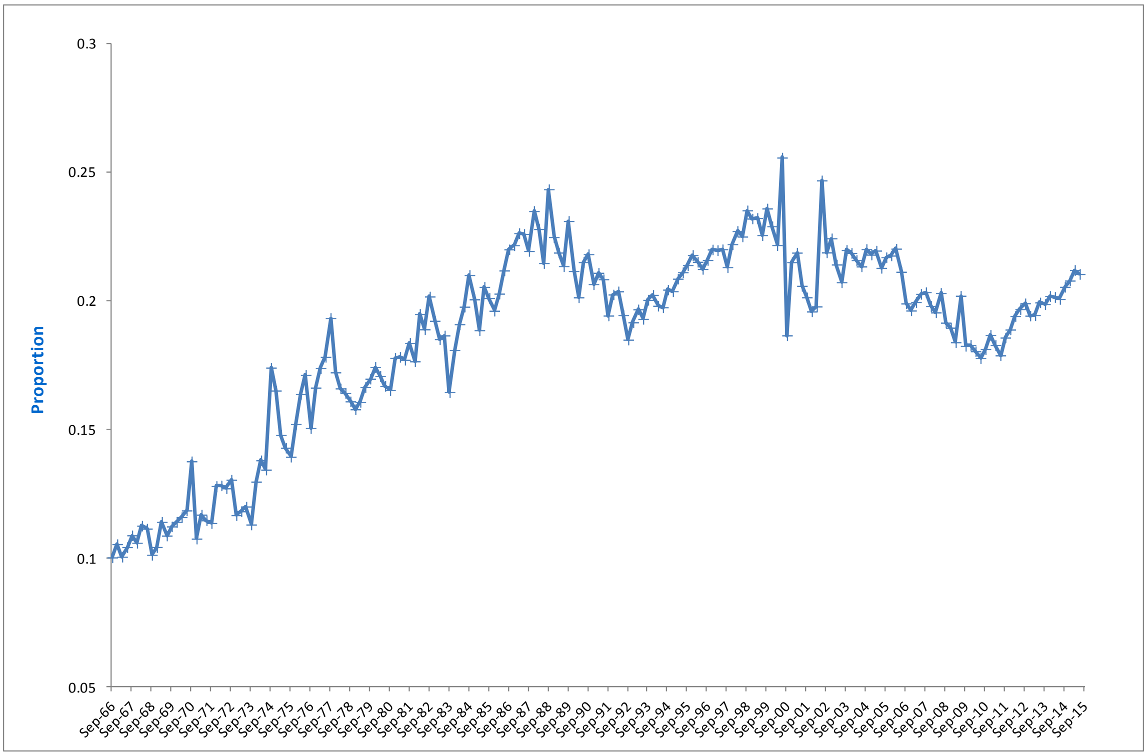
Source: calculated from seasonally adjusted data on GDP price deflators for exports and imports of goods and services from ABS (2015), *Australian National Accounts: Income, Expenditure and Product, September quarter 2015*, ABS Cat. No. 5206.0.

As can be seen from Figure 7, the minerals and energy commodity price boom, which started around 2003 and started to end in the September quarter 2011, pushed up the Terms of Trade enormously and put upward pressure on wages, especially in the Mining industry, but also in industries associated with Mining, which put upward pressure on the average wage. The Terms of Trade peaked just before the Global Recession began (around the time that Lehmann Brothers collapsed in the USA in September 2008), then fell sharply in the initial stages of the Global Recession. It then rose sharply in the initial recovery from the Global Recession (boosted by the positive effects of economic stimulus programmes in Australia, China (Australia's main export destination) and other countries on the demand for iron ore, coal and other commodities). After peaking in the September quarter 2011, it has fallen sharply, reflecting slower economic growth and a shift from investment and exports towards domestic consumption in China and increased supply of iron ore, oil, gas and other mineral and energy commodities.

III.iv Income Tax Rates

In conducting wage bargaining, employees (and/or their wage-bargaining agents, such as trade unions) are likely to be most interested in their net pay after income tax, otherwise known as their take-home pay, rather than their gross wage. Therefore, it is probable that a higher rate of income tax would be likely to induce them to bid for higher wages (conversely, a lower income-tax rate may mean that they are less strident in their claims for higher wages). To the extent that they are successful in their attempts to maintain or improve their net pay after tax, we would expect a positive relationship between income tax rates and average earnings. The average income tax rate is shown in Figure 8.

Figure 8: **The Average Income Tax Rate on Individuals in Australia**



Source: calculated from seasonally adjusted data on income taxes paid by households as a proportion of Compensation of Employees and Gross Mixed Income from ABS (2015), *Australian National Accounts: Income, Expenditure and Product, September quarter 2015*, ABS Cat. No. 5206.0.

As can be seen from Figure 8, the average income tax rate rose from the mid-1960s through to the mid-1980s. It then fell until the September quarter 1992. This was partly in association with the Prices and Incomes Accord, where workers traded off a slower rate of wage growth for reductions in income tax rates and improvements in the 'social wage' (such as social assistance benefits for families). The average tax rate then rose for the rest of the 1990s (the Prices and Incomes Accord ended with a change of government of the Commonwealth of Australia in 1996). The average tax rate was reduced sharply in the September quarter 2000. This was due to the introduction of A New Tax System, where a lower income tax rate for individuals (i.e., direct tax) was implemented in exchange for the bringing-in of the Goods and Services Tax (which involved a higher indirect tax rate, even after taking account of the fact that the Goods and Services Tax, which is a tax on value added, replaced wholesales sales taxes). This reduction in the average tax rate was, however, fairly short-lived. After rising over the next year, the average tax rate fell over the rest of the 2000s, but then has risen slowly in the 2010s.

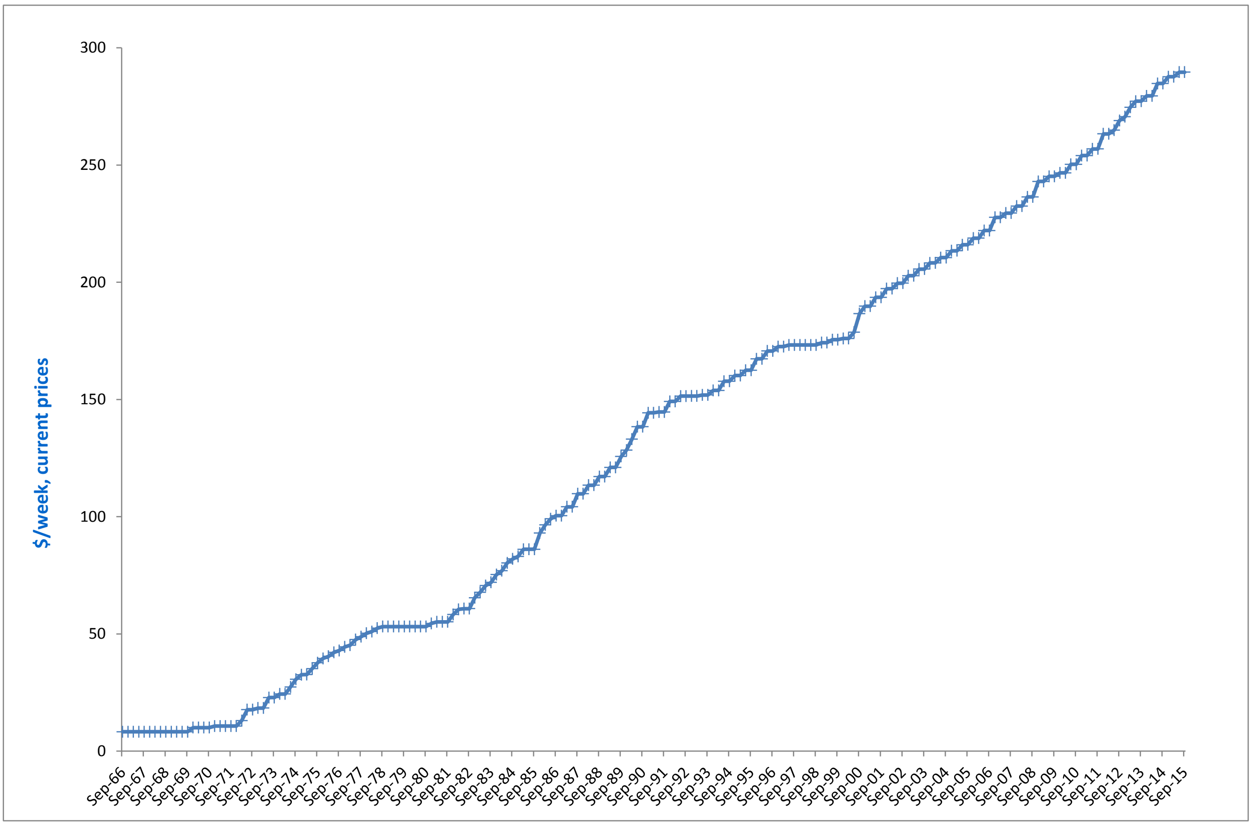
Another notable thing about the average tax rate shown in Figure 8 is that it is very volatile, which means that it may be hard to estimate its influence accurately in econometric estimation. One reason for this volatility is that the denominator is the sum of the Compensation of Employees and Gross Mixed Income (also known as the combination of Gross Operating Surplus and the Compensation of Employees for unincorporated enterprises). Gross Mixed Income is a volatile series, as a substantial amount of it is generated in Agriculture, Forestry and Fishing, which is subject to volatility through weather conditions, variable prices and costs and pests and diseases.

III.v Unemployment Allowance Payment Rate

A higher unemployment allowance payment rate is expected to lead to a higher average wage. In the model of the labour market shown in Figure 2, the unemployment allowance payment rate forms the base for the effective labour supply curve. This means that a higher unemployment allowance payment rate puts upward pressure on the average wage to create the financial incentive for people to search actively for work and to retain work when they find it (and to reduce the flow-on to unemployment). The standardised unemployment allowance payment rate is shown in Figure 9.

While the unemployment allowance payment rate is currently indexed to the headline CPI, this hasn’t always occurred in the past and there were periods in the late 1960s and the late 1970s when it was kept unchanged in nominal terms for well over a year on each occasion. Conversely, there have been times, such as in the early 1970s, when it has been increased at a much higher rate than the CPI inflation rate.

Figure 9: **Unemployment Allowance Payment Rate, Australia**



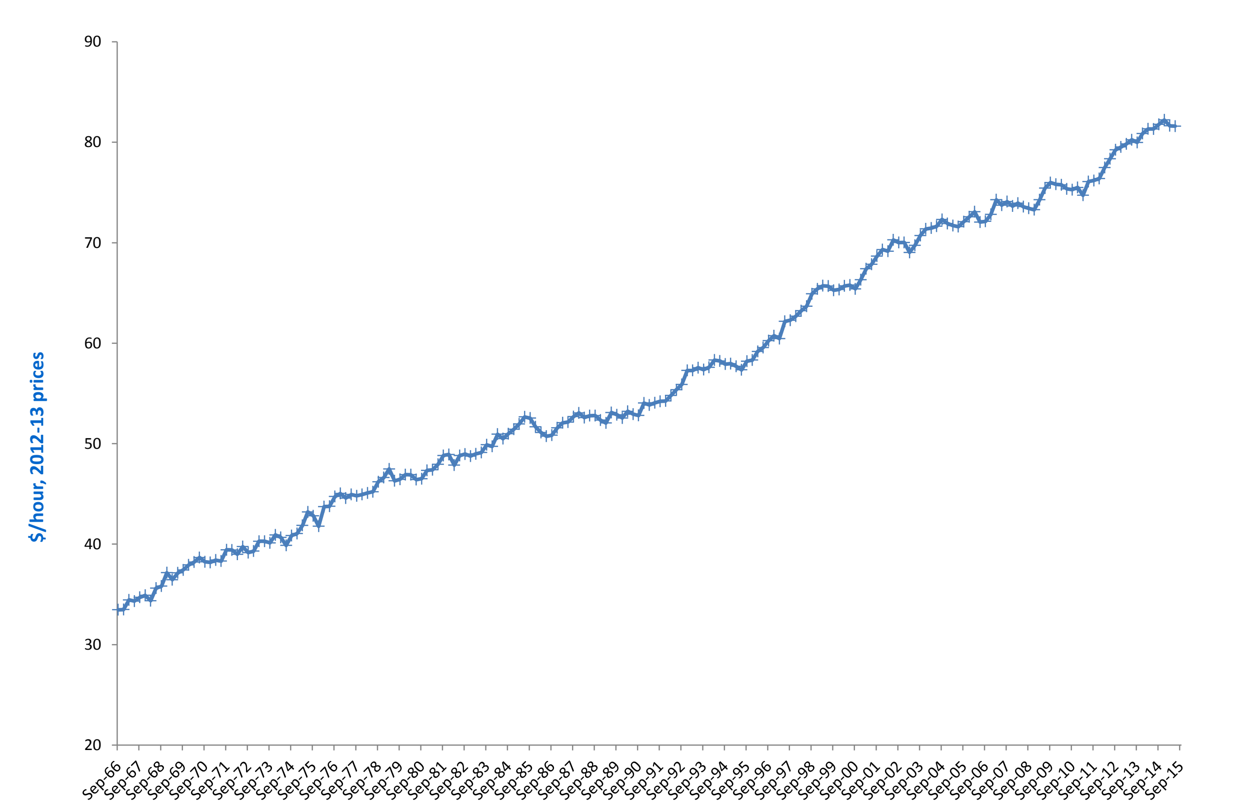
Sources and notes: The standardised unemployment allowance payment rate is the maximum rate of Newstart Allowance (or equivalent unemployment allowance payments before Newstart Allowance) for a single person with no dependants, who's aged 22-59 years (21-59 years until June 2012), plus one third of the maximum rental assistance payment. It is in original terms and current prices (i.e., nominal terms). Statistics are obtained from DHS, *A Guide to Australian Government payments* and DSS, *Guide to Social Security Law*.

III.vi Labour Productivity and its Drivers

The benefits of higher labour productivity are likely to be shared between labour (in the form of higher wages) and capital (in the form of higher profits). However, the ABS estimate of labour productivity (particularly on a quarterly basis and in seasonally adjusted terms) is volatile from quarter to quarter (as shown in Figure 10) and the estimates in the ABS's quarterly *National Accounts*[15] are often revised in subsequent quarters.

[15] ABS Cat. No. 5206.0.

Figure 10: **Economy-wide Labour Productivity, Australia**

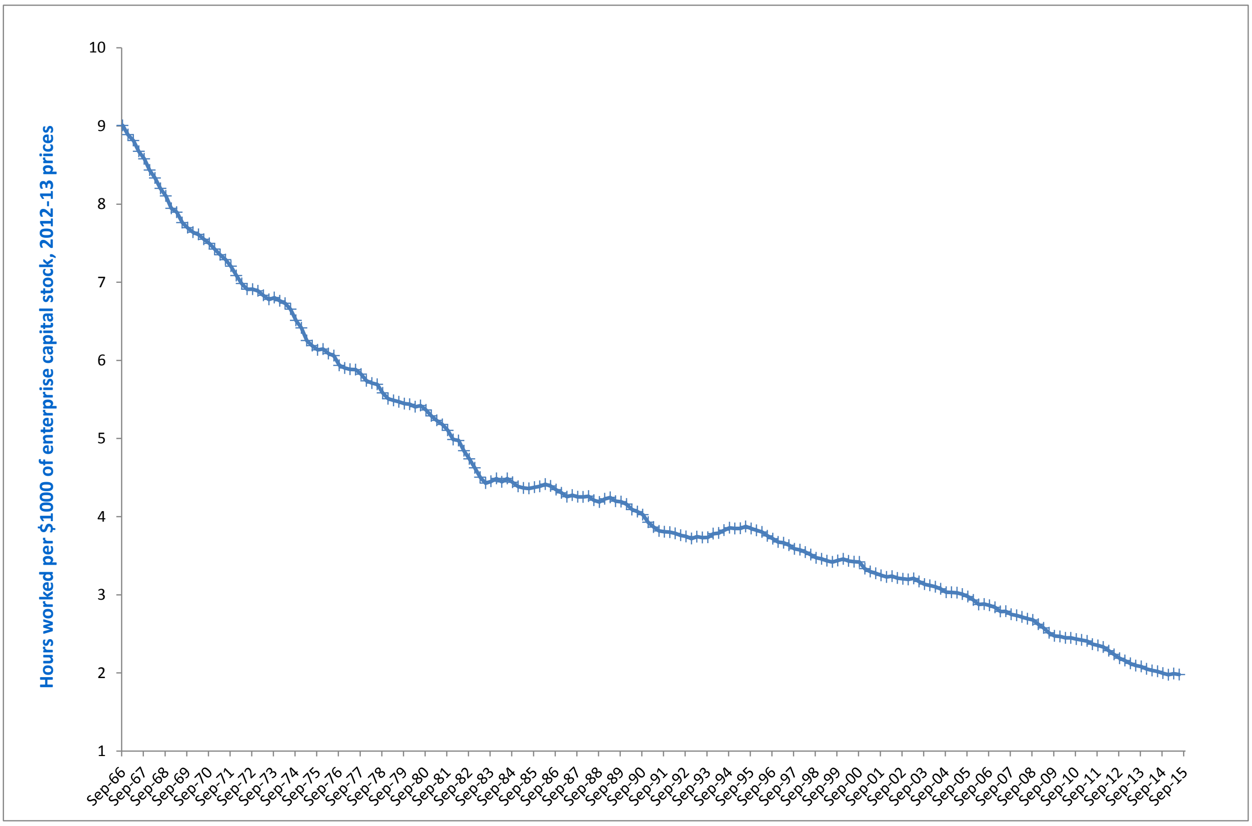


Source: calculated from Real GDP from ABS (2015), *Australian National Accounts: Income, Expenditure and Product, September quarter 2015*, ABS Cat. No. 5206.0, divided by aggregate hours worked from ABS (2015), Labour Force, *Australia, September 2015*, ABS Cat. No. 6202.0 (this series is spliced with another series from the ABS Labour Force Survey based on average hours worked in the reference week for the Labour Force Survey, before 1979).

Also, in terms of enterprise and individual bargaining, workers may not have a good estimate of how much Gross Value Added they generate per hour they work, while many firms wouldn't measure their labour productivity on a quarterly basis. Instead, firms and workers may base their bargaining over the distribution of the share of the fruits of labour productivity on more tangible measures, particularly capital deepening, the level of skills (or educational qualifications) held by workers and wage-setting arrangements relating to productivity (i.e., enterprise and registered individual workplace agreements).

In contrast to Karanassou and Sala (2010), who used the capital-employment ratio as their measure of capital deepening in their wage-setting equation, in the current analysis, a more sophisticated measure of capital deepening is used. This is the ratio of aggregate hours worked to the capital stock. This is largely the inverse of the capital-employment ratio, but more sophisticated in the sense that aggregate hours worked is a more comprehensive measure of labour input to production than employment. This series is shown in Figure 11.

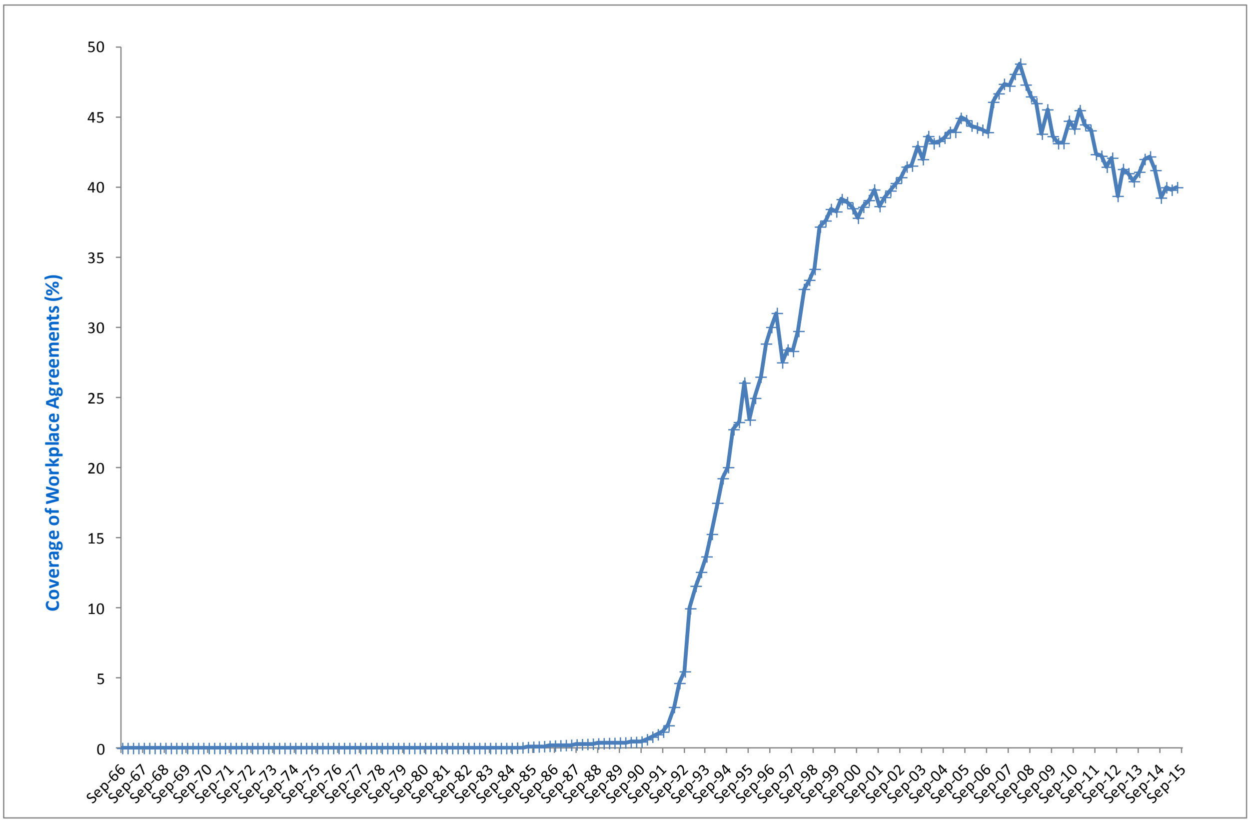
Figure 11: **Labour/Capital Ratio, Australia**



Source: Labour Inputs are measured as aggregate hours worked from ABS (2015), Labour Force, *Australia, September 2015*, ABS Cat. No. 6202.0 (this series is spliced with another series from the ABS Labour Force Survey based on average hours worked in the reference week for the Labour Force Survey, before 1979). This is divided by the real capital stock in private and public enterprises, which up to June quarter 2014 is interpolated from data in ABS (2014), *Annual System of National Accounts, 2013-14*, ABS Cat. No. 5204.0. From the September quarter 2014, this variable is extrapolated, using on investment in enterprises from ABS (2015), *Australian National Accounts: Income, Expenditure and Product, June quarter 2015*, ABS Cat. No. 5206.0 (and assuming that depreciation rates remain the same as in 2013-14).

Another productivity-linked variable that is likely to have had a significant effect on wages is the percentage of employees covered by workplace agreements (enterprise agreements and registered individual agreements). Connolly, Trott and Li (2012) estimated that the workplace agreements coverage had a significant, positive and lagged effect on labour productivity (real GDP per hour worked) in Australia. This variable is also likely to have a positive effect on wages, but the effect is likely to be immediate or with a short lag (of a quarter or two), given that employees would receive a wage rise when their enterprise or individual agreement comes into effect, but it is likely to take longer before the productivity benefits of these workplace agreements fully materialise. The evolution of this variable is shown in Figure 12. While Federal enterprise agreements started in 1991, this variable also includes enterprise and registered individual agreements in State and Territory jurisdictions and so has small positive values before 1991. The coverage of workplace agreements rose sharply in the 1990s, then rose more slowly in the early and mid-2000s before peaking at almost 50 per cent in early 2008, but has since fallen by almost 10 percentage points.

Figure 12: **Coverage of Workplace Agreements, Australia**

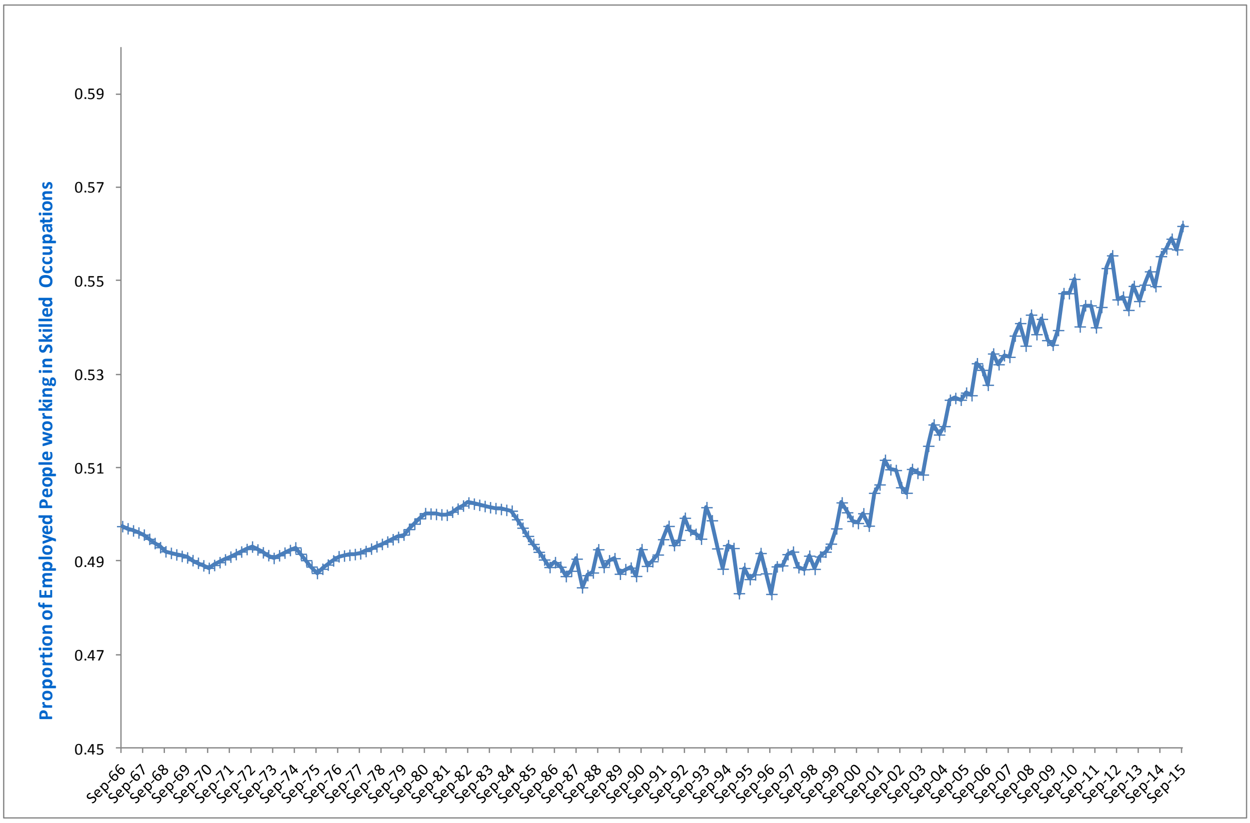


Sources: constructed from various sources using the methods explained in Connolly, Trott and Li (2012).

A third productivity-linked variable which is likely to have had a significant effect on wages is the proportion of employed people who work in skilled occupations. Connolly, Trott and Li (2012) estimated that this share had a significant and positive effect on labour productivity (real GDP per hour worked) in Australia. This variable is also likely to have a positive effect on wages. There have also been many other Australian labour market analyses (too numerous to cite individually) that have shown a positive effect of skills (or skilled occupations) on wages.

The movements in this variable are shown in Figure 13. The share of workers in skilled occupations remained fairly stable at just below 50 per cent from the mid-1960s through to the mid-1990s. From the mid-1960s through the mid-1980s, the data shown in Figure 13 are interpolated annual data (the ABS only published these data for August of each year during this period); from the mid-1980s onwards, the data are available for the middle month of each quarter. This is why the data in Figure 13 are smoother up until the mid-1980s. From the mid-1990s until the September quarter 2015, the share of workers in skilled occupations has risen fairly smoothly and steadily, reaching 56 per cent in the September quarter 2015.

Figure 13: **Proportion of Employed People Working in Skilled Occupations, Australia**



Sources: constructed from data on employment by occupation from the ABS Labour Force Survey using the methods explained in Connolly, Trott and Li (2012), with skilled occupations consisting of Managers, Professionals, Associate Professionals and Technicians and Trade Workers (or equivalent occupational groupings before the current ANZSCO occupational classification was introduced.

III.vii Institutional Factors

Analysts of Australian wage-setting outcomes have long considered institutional factors to be important drivers of wage determination in this country. For example, Karanassou and Sala (2010), included dummy variables for the wage breakout in 1974-75 and the Prices and Incomes Accord which lasted from the mid-1980s to the mid-1990s as explanatory variables in their econometric estimation of the Australian wage-setting equation.

In common with that study, a dummy variable for the Prices and Incomes Accord is included in the present analysis. For the effect on the quarterly change in the logarithm of the average wage, this variable, called $ACCORD_t$, is set equal to one from the December quarter 1983 through the March quarter 1996; and set equal to zero at other times. For the effect on the level of the logarithm of the average wage, it is defined as follows:

$$SACCORD_t = SACCORD_{t-1} + ACCORD_t \qquad (1)$$

Where:

the subscript, t, stands for the time period in quarters and
$SACCORD_{t-1}$ is initially set equal to zero.

In other words, this variable is the sum or accumulation of the effects of the Prices and Incomes Accord on the quarterly rate of change of the average wage.

In order to explore the relationship with the findings of Karanassou and Sala (2010), a dummy variable for the wage breakout in 1974-75 was included in some non-preferred equations in the current analysis. The results were not worth reporting (they appear to have been dominated by other developments at the time such as the effects of the first world oil price shock), but are available from the author.

However, in terms of wage breakouts, a dummy variable was included for the combined effects of the wage breakout in the early 1980s and the subsequent wage freeze in response to it. For the effect on the quarterly change in the logarithm of the average wage, this variable is defined as follows:

$$WBKOFRZ_t = \begin{cases} 1 & \text{from December quarter 1981 through September quarter 1982;} \\ -1 & \text{from December quarter 1982 through September quarter 1983; and} \\ 0 & \text{at other times} \end{cases} \tag{2}$$

For the effect on the level of the logarithm of the average wage, a cumulative or summation variable is defined (similarly to what is done with the Accord dummy variable) as follows:

$$SWBKOFRZ_t = SWBKOFRZ_{t-1} + WBKOFRZ_t \tag{3}$$

Where:

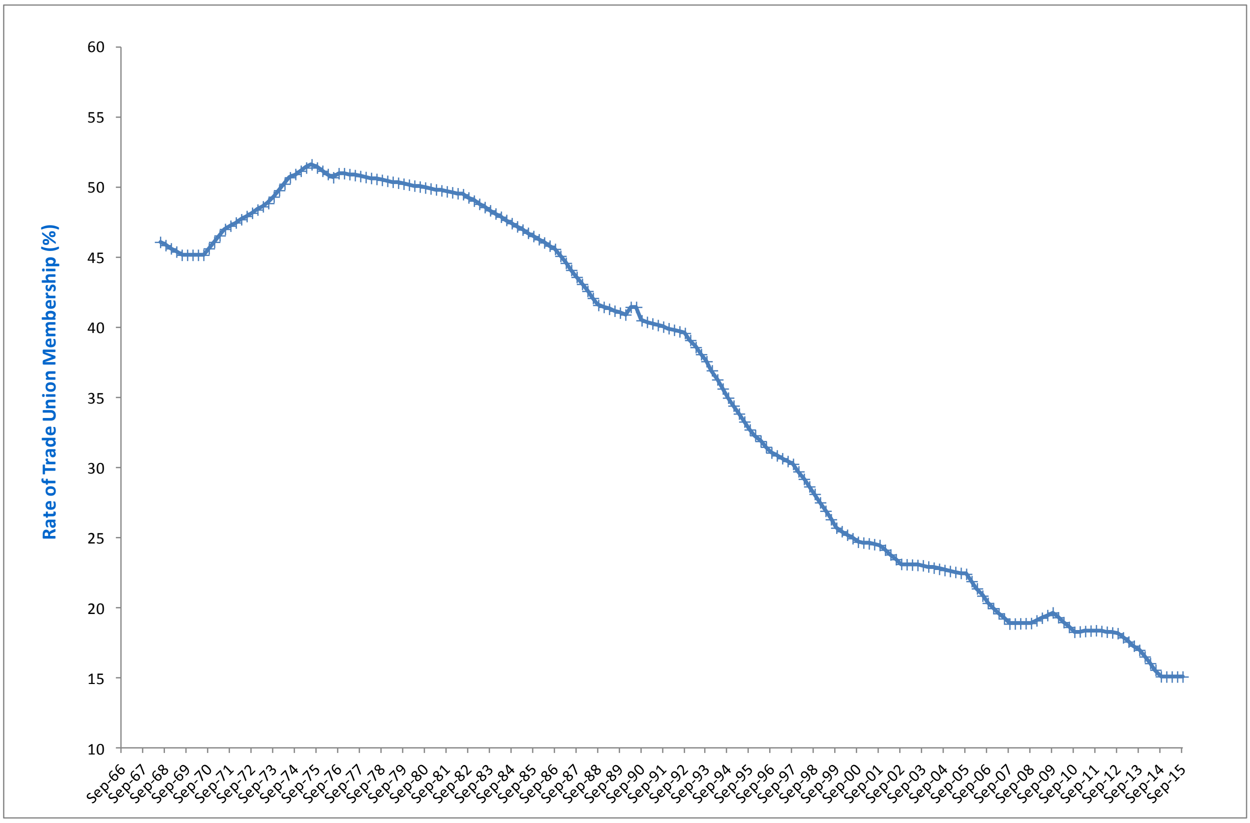
the subscript, t, stands for the time period in quarters and

$SWBKOFRZ_{t-1}$ is initially set equal to zero.

One of the explanatory variables that has already been explained (in the subsection on productivity in this paper) is that for the coverage of workplace agreements. This variable is strongly affected by institutional factors (indeed, a decentralisation of institutional wage-setting arrangements away from the Award system was needed to bring it into existence).

The final institutional factor that was considered for inclusion as an explanatory variable is the Trade Union Membership Rate, shown in Figure 14. This rate rose in the early 1970s, peaked at 51.6 per cent in mid-1975 and has fallen almost continuously since then to its present level of 15.1 per cent.

Figure 14: **Trade Union Membership Rate, Australia**



Sources: interpolated from annual data in relevant ABS supplementary surveys to the Labour Force Survey, including *Characteristics of Employment* (ABS Cat. No. 6333.0) for 2015; and *Employee Earnings, Benefits and Trade Union Membership* (ABS Cat. No. 6310.0) beforehand. Before 1976, the statistics from the TRYM model variable, RUM, for the Rate of Union Membership, are discounted by 7.8 per cent. This is done to correct for the effects of double-counting where people are members of more than one union, and also unfinancial memberships, in the TRYM series which is compiled from Trade Union records. This is consistent with the methods explained in Leigh (2005).

III.viii Average Hours Worked per Week

Since the average wage series used for the dependent variable in this analysis is expressed in dollars per week, the average hours worked per week should theoretically have a positive, and almost a one-for-one effect on the average wage. This is assuming that workers receive a constant pay rate in dollars per hour worked. If, however, they don't get fully compensated for working longer hours per week, the coefficient could be less than one. Empirically, the estimated coefficient could be less than one, and even statistically insignificant, as a result of measurement issues. The data for average non-farm wages comes from the ABS quarterly *National Accounts*[16], while the data for average hours worked per week by employees (for all industries including farming), while it is provided in the ABS *Modellers' Database*[17], is calculated from data from the ABS Labour Force Survey. The different sources and coverage of the data on wages versus hours could reduce the estimated relationship between these two series.

[16] ABS Cat. No. 5206.0.

[17] ABS Cat No. 1364.0.15.003.

The time series for average hours worked per week is shown in Figure 15. Weekly working hours dropped sharply between early 1974 and early 1977, stabilised between then and the late 1990s, and then have been falling slowly since then. A key explanation for the long-term decline in weekly working hours is the long-term upward movement in the share of employment held by part-time workers.

Figure 15: **Average Hours Worked per Week by Employees, Australia**

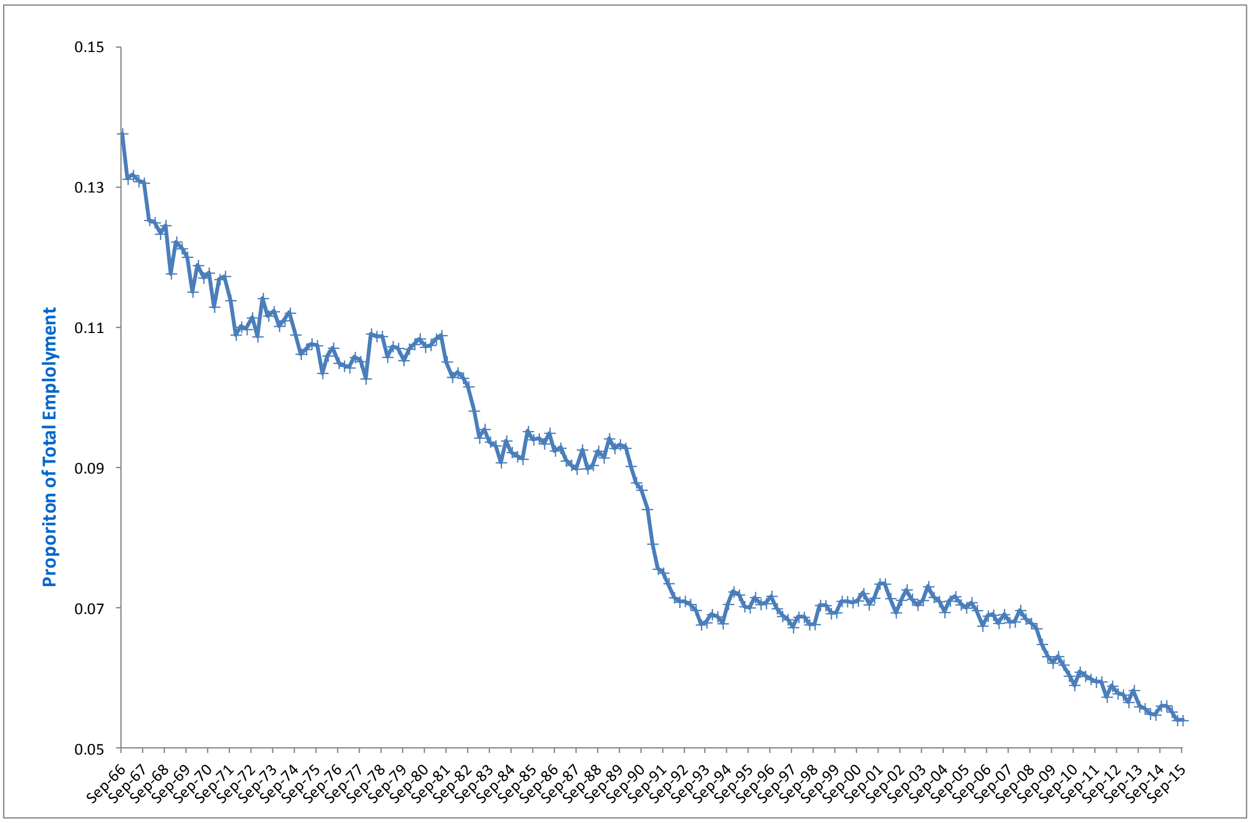
Source: NIF-10S model component of the ABS *Modeller's Database*, ABS Cat No. 1364.0.15.003.

III.ix Compositional Factors

The average wage series used in the econometric analysis is subject to variation arising from several compositional factors, since it is averaged across wages for juniors and adults, men and women, full-time and part-time workers, all industries except farming and almost all occupations.

A key source of compositional variation in the average wage series is the share of employment held by teenagers (15-19 years), which is shown in Figure 16. There is a close correspondence between being a teenage worker and receiving junior rates of pay, which are substantially below adult rates of pay, especially for workers aged 15 and 16 years. In addition to junior rates of pay, teenagers also receive lower wages because they have less workforce experience and lower levels of education, skills and qualifications than adults, on average. As shown in Figure 16, the share of employment held by teenagers has fallen by two thirds between 1966 and 2015. This fall has not been uniform, since the share has fallen sharply during and shortly after economic recessions and other economic downturns such as the Global Recession of 2008-09.

Figure 16: **Share of Total Employment held by Teenagers, Australia**



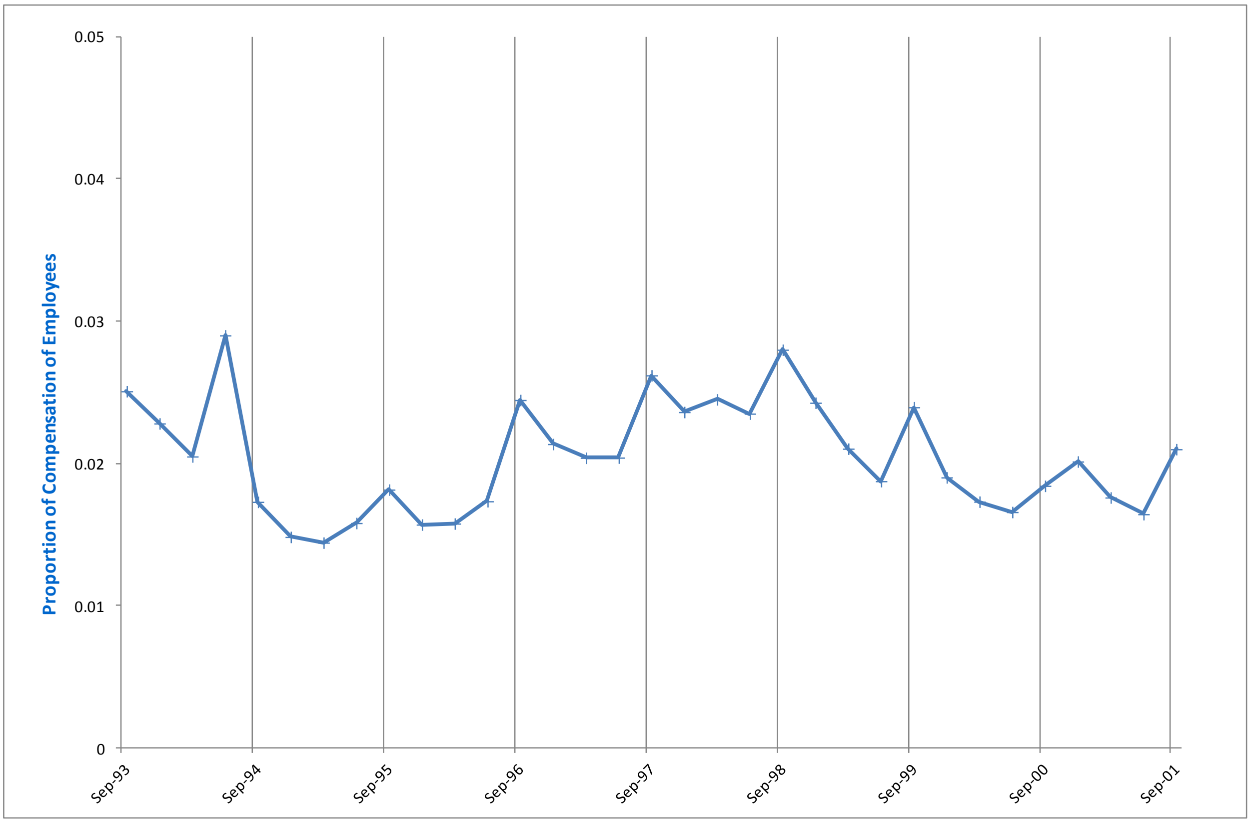
Source: calculated from data from the ABS detailed Labour Force Survey (ABS Cat. No. 6291.0.55.001 and predecessor publications), adjusted for ABS Labour Force Survey redefinitions using the methods explained in Connolly (2008).

III.x Redundancy Pay

Redundancy pay is included in the *National Accounts* measure of average earnings which is used as the dependent variable in the current analysis, but is not included in most of the alternative Australian wage series, such as the *Wage Price Index* and *Average Weekly Earnings* series.

The ABS published the redundancy pay statistics in the quarterly National Accounts from September quarter 1993 through September quarter 2001 (but not before or after this). This series, expressed as a proportion of Compensation of Employees, is shown in Figure 17. The redundancy pay series was only released by the ABS in original form, and a seasonal pattern is apparent in Figure 17, with a peak in the September quarters of most years and low points in the March and June quarters of most years. Redundancy pay ranged between 1½ and 3 per cent of Compensation of Employees over this period. It was high in 1993 in the aftermath of the recession of the early 1990s and fell in 1994 and early 1995 in accord with the improvement in the labour market. However, after this period it appears not to have as strong a relationship with labour market conditions after then. For example, it had a trough in the June quarter 2001, even though labour market conditions weren't especially strong at this time. In general however, this proportion appears to be mildly countercyclical.

Figure 17: **Redundancy Pay as a Share of Compensation of Employees, Australia**



Source: ABS (various dates), *Australian National Accounts: Income, Expenditure and Product,* ABS Cat. No. 5206.0.

The ABS series for Redundancy Pay that was published in the quarterly *National Accounts* is too short to be used in the current econometric analysis. It would also be unfeasible to find a variable that would comprehensively proxy for it, because the amount of redundancy pay is not perfectly correlated with the state of the labour market (as discussed above). It also depends on redundancies in the public sector and industry restructuring (brought on by changes in tariff rates and other trade protection measures by industry, technical developments and changes in international competitiveness).

III.xi Short-term Temporary Entrants

Short-term Temporary Entrants to Australia with working rights can and are employed in Australia, but are not counted as part of the labour force by the ABS. To be counted in the labour force, a person has to be part of the Estimated Resident Population. To be in this count, a person has to have resided in Australia for at least 12 out of the last 16 months. For the purposes of this analysis, short-term temporary entrants are defined as people who have come from overseas to live in Australia who don't fulfil the residency requirements to be counted as part of the Estimated Resident Population.

Connolly, Medina and O'Regan (2015) derived an estimate of the number of short-term temporary entrants to Australia who are likely to be employed. They used this in their attempt to reconcile the difference between the estimate of the number of people employed (in all industries except Finance and Insurance Services) in the Labour Force Survey and business-survey data.

To do this, they used data from the ABS publication, *Overseas Arrivals and Departures* (ABS Cat. No. 3401.0) for short-term overseas arrivals (i.e., people who stated on their arrival cards that they fill out for the Department of Immigration and Border Protection that they intend to stay in Australia for less than one year) for Employment, Business and Education/Study purposes, with different assumptions about length of stay in Australia and percentage working for each of these three categories.

The same method was used in the current analysis to extend the series from Connolly, Medina and O'Regan (2015) to the latest available quarter. For the purposes of the current analysis, the estimated number of short-term overseas arrivals who are employed was converted to a share of the extended employment base (i.e., by including employed short-term overseas arrivals on the denominator for this calculation), using the following formula:

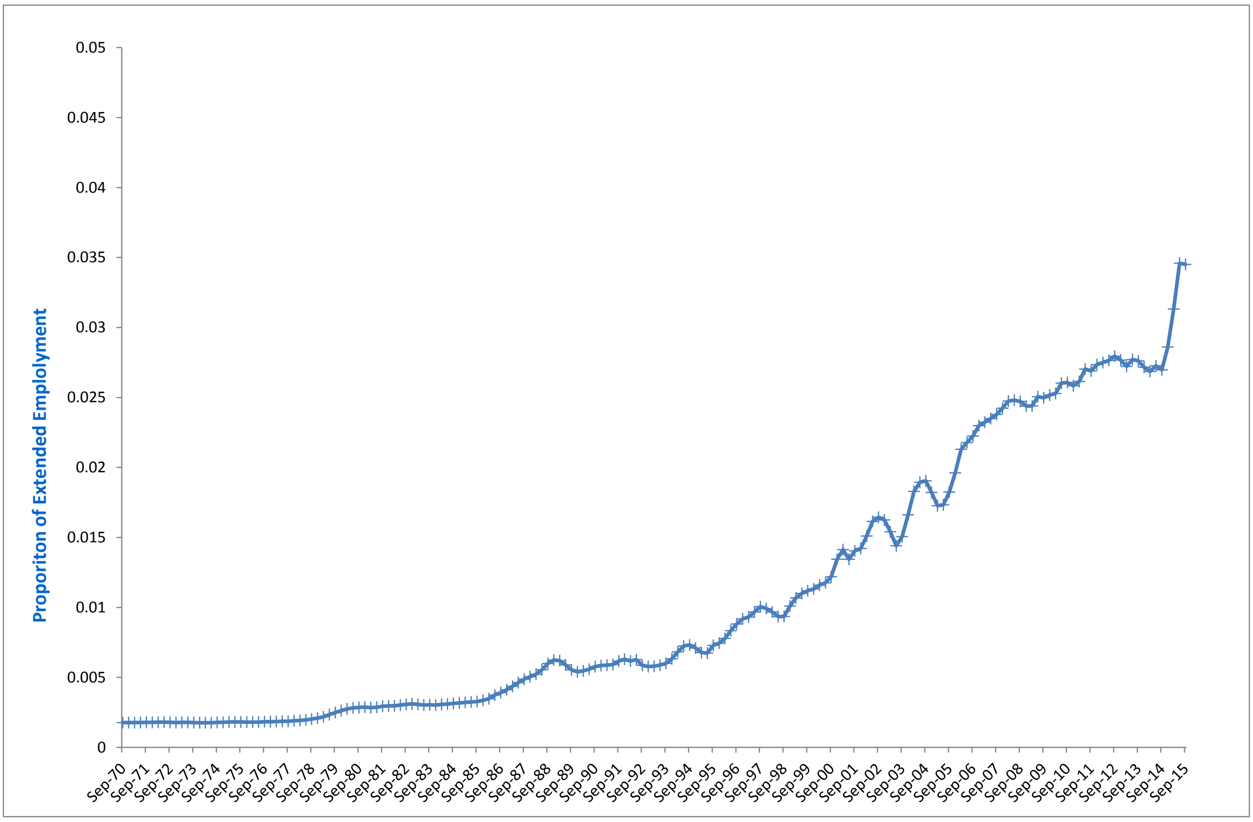
$$SSTOAEM_t = STOAEM_t /(STOAEM_t + EM_t) \qquad (4)$$

Where:

$SSTOAEM_t$ is the Share of Short-term Overseas Arrivals who are Employed (i.e., the proportion of Extended Employment)
$STOAEM_t$ is the number of Short-term Overseas Arrivals who are Employed
EM_t is Total Employment (for the Estimated Resident Population of Australia) and the subscript, t, stands for the time period in quarters.

This share is shown in Figure 18.

Figure 18: **Short-term Overseas Arrivals as a Proportion of Extended Employment, Australia**



Sources: ABS (2016), *Overseas Arrivals and Departures, Australia, Nov 2015* (and previous issues), ABS Cat. No. 3401.0, for short-term overseas arrivals and ABS (2016), *Labour Force, Australia, Detailed – Electronic Delivery, Dec 2015*, ABS Cat. No. 6291.0.55.001, (and previous issues and versions of this publication) for total employment.

As shown in Figure 18, the share of short-term overseas arrivals in employment was very low up until the mid-1980s when it started to increase. It fell back after the recession of the early 1990s, but then rose sharply from the mid-1990s until the onset of the Global Recession in 2008. This rise wasn't monotonic (i.e., continuous) during this period, however, when there was a setback to the growth rate it was quickly reversed. Following the onset of the Global Recession in 2008, the growth rate levelled off for several years, but it has risen sharply in late 2014 and throughout 2015.

IV. Stationarity of the Average Wages and its Explanatory Variables

As mentioned previously by Lewis and MacDonald (1993), Crosby and Olekalns (1998) and Connolly (1999b, 2001 and 2008) among others, for the 'NAWRU' or 'NAIRU' to exist, there has to be a stationary relationship between the unemployment rate and the acceleration in wages, prices or unit labour costs, i.e., the change in the change in the "price" variable. This implies that the "price" variable needs to be integrated of the second order {I(2)} and that the unemployment rate (or an alternative variable representing labour market capacity) needs to be stationary {I(0)} for the relationship to hold.

Such testing has previously been conducted, including by the authors cited in the paragraph above (see Connolly 2008 for a summary of these results) and the general consensus of results among the analysts who conducted comprehensive testing[18] is that both the "price" variables (consumer price index, wages or unit labour costs) and the labour market capacity variables (generally the unemployment rate) are likely to be I(1). This implies that a 'NAIRU' or a NAWRU is unlikely to be present.

However, it has been around seven years since the results of such testing were reported in Connolly (2008) and so it was considered worthwhile, for the sake of completeness, to update this testing. Accordingly, testing of the orders of integration or stationarity for both the dependent variable (the logarithm of the average wage) and the explanatory variables was conducted. This testing was done both under the null hypothesis of stationarity (the KPSS test, named after Kwiatowski, Phillips, Schmidt, and Shin 1992) and integration (the (Augmented Dickey-Fuller and weighted symmetric tau tests). This was done because the results from tests such as the Augmented Dickey Fuller test conducted using solely the null hypothesis of integration can be lacking in power. In addition, testing for cointegration among the dependent and explanatory variables was also conducted.

[18] Gruen, Pagan and Thompson (1999, Appendix C) tested whether the accelerations of the underlying CPI and the unit labour cost index were integrated, that is, they tested whether the underlying CPI and the unit labour cost index were I(3) versus the alternative of I(2). Their estimation results implied that the logarithms of these variables were not I(3), but they did not test whether the degree of integration was lower than I(2). In other words, their integration tests were not comprehensive enough to determine whether or not a 'NAIRU' or 'NAWRU' was likely to be present.

Results of these tests are shown in Appendix C. The key point of these results is that they are basically the same as those of previous testing by Australian analysts who did comprehensive testing of the order of integration of relevant variables. The average wage, the labour market capacity variables (i.e., both the volume labour force underutilisation gap and the job vacancy rate) and other explanatory variables are highly likely to be integrated of the first order; that is, I(1). This implies that a 'NAIRU' or 'NAWRU' is highly unlikely to be present in Australia. Additionally, the levels of the dependent and explanatory variables are likely to be cointegrated with each other.

V Econometric Estimates of the Wage Equation

Since the dependent variable and its explanatory variables were shown in Appendix C to be I(1) and cointegrated with each other, the Engle-Granger two-stage estimation procedure is a suitable estimation procedure. More sophisticated estimation techniques, such as Johansen-Juselius matrix estimation procedures were not used, because some of the explanatory variables were lagged for longer than one year (and so would be lagged endogenous variables if not exogenous), others were genuinely exogenous (such as the dummy variables for institutional factors), and because there are potential estimation problems with the matrix methods (there are substantially more lagged dependent variables, which can compound potential biasses in the estimates).

The Engle-Granger two-stage estimation procedure consists of two equations. In the first, the levels (some of which are in logarithms) of the dependent and explanatory variables are included and estimated. In the second stage, quarterly changes in the variables are used, but the lagged error term (also known as the residual) from the first stage (levels) equation is included as another explanatory variable. If this variable is significant and negative, this implies that there is a co-integrating relationship between the dependent and explanatory variables (this would confirm the results of the cointegration test reported in Appendix C).

Since the second-stage equation is a quarterly change in the logarithm of the AENA wage, it is also an equation for the rate of change in wages. Accordingly, additional examination of the inflationary expectations coefficient is conducted with this equation, to determine whether this coefficient is significantly lower than one, which would provide further evidence that a NAWRU is unlikely to be present in Australia.

V.i Long-run results

The results of the preferred version of the first-stage equation for the logarithm of the average wage (on a *National Accounts* basis) are as shown in equation (5) below.

$$\ln(AENA)_t = \underset{(11.05)}{2.95} + \underset{(15.67)}{0.651} * \ln(CPI)_{t-1} + \underset{(3.01)}{0.0165} * \ln(PMP)_{t-2} + \underset{(4.45)}{0.0742} * \ln(ToT)_{t-3}$$

$$- \underset{(-3.30)}{0.00673} * VLFUG_t + \underset{(2.61)}{0.00793} * JV_{t-4} - \underset{(-3.50)}{3.70} * SSTOAEM_t$$

$$- \underset{(-4.57)}{0.0887} * L/K_t + \underset{(2.49)}{0.738} * SEMSKILL_{t-1} + \underset{(10.89)}{0.00412} * PECIA_t$$

$$+ \underset{(3.77)}{0.0754} * \ln(UAPR)_t + \underset{(1.71)}{0.0466} * \ln(UAPR)_{t-3} + \underset{(4.39)}{0.103} * \ln(UAPR)_{t-5}$$

$$+ \underset{(8.68)}{0.0224} * SWBKOFRZ_t - \underset{(-3.85)}{0.00308} * SACCORD_t - \underset{(-2.46)}{1.483} * SEM1519_t \qquad (5)$$

Sample Range: 1970Q3 to 2015Q2 (180 observations); F-statistic = 37,258;
Durbin-Watson Statistic = 0.91; Standard error of regression = 0.0141;
Mean of dependent variable = 6.25; Standard deviation of dependent variable = 0.788;
R-squared = 0.9997; Adjusted R-squared = 0.9997;
Condition(X) number = 1,072.
Figures in parentheses underneath the coefficients are t-statistics, and the subscript, t, refers to the time period (in quarters).

where:
$\ln(AENA)_t$ is the logarithm of Average Earnings on a National Accounts basis;
$\ln(CPI)_t$ is the logarithm of the Consumer Price Index (adjusted for the effects of the introduction of A New Tax System);
$\ln(PMP)_t$ is the logarithm of the Price Index for Imported Petroleum;
$\ln(ToT)_t$ is the logarithm of the Terms of Trade;
$VLFUG_t$ is the Volume Labour Force Underutilisation Gap;
JV_t is the ABS Job Vacancy/Labour Force Ratio;
$SSTOAEM_t$ is Short-term Overseas Arrivals (who are employed) as a Proportion of Extended Employment;
L/K_t is the Labour/Capital Ratio;
$SEMSKILL_t$ is the share of employed people who are skilled;
$PECIA_t$ is the percentage of employees who are covered by Enterprise or Registered Individual Agreements;
$\ln(UAPR)_t$ is the logarithm of the Unemployment Allowance Payment Rate;
$SWBKOFRZ_t$ is a dummy variable for the wage breakout and the following wage freeze; of the early-mid 1980s;
$SACCORD_t$ is a dummy variable for the Prices and Incomes Accord; and
$SEM1519_t$ is the share of employed people who are aged 15-19 years.

The overall level of explanation is very high, as indicated by the Adjusted R-squared statistic of almost one, particularly as many of the explanatory variables are lagged and a time period of almost 45 years is covered by the sample used for equation (5).

Some of the proposed explanatory variables in Section III, including the tax rate on individuals, the Trade Union Membership Rate and the Average Hours Worked per Week by Employees, were not statistically significant in earlier versions of this equation and so were not included in the preferred version. A possible reason why they may not have been significant is that there was severe collinearity among the explanatory variables, as indicated by the Condition(X) number of 1,072.

The low value of the Durbin-Watson statistic is expected, given the autoregressive nature of the dependent variable.

The coefficients of all of the explanatory variables had the expected sign and all of them appeared to be statistically significant (one at the 10 per cent level and all the rest at higher levels of precision). In terms of statistical significance, the t-statistics are only indicative, because, on the one hand, the severe multicollinearity tends to reduce the t-statistics, but on the other hand, the low value of the Durbin-Watson statistic tends to raise the t-statistics.

In the long term, around 65 per cent of the variation in consumer prices is estimated to flow through to a movement in the average wage in the same direction. This coefficient is significantly greater than zero, but also significantly less than one, implying that increases in consumer prices have not flowed fully into increases in the average wage, on average, over the last 45 years.

The responsiveness to other price-related variables was much less than this. Indeed, the elasticity with respect to the price of imported petroleum was only 0.0165, implying that wages only changed by around two per cent of the change in the price of imported petroleum, in the long term. There are several explanations for this very low elasticity, including the very high variability in the price of imported petroleum and that much of the variation in the price of imported petroleum does not flow on directly, immediately or fully to the retail price of automotive fuel (particularly in the early years of the sample period when there was more regulation of the automotive fuel market in Australia). The elasticity of the average wage with respect to the Terms of Trade was also estimated to be low at 0.0742, implying that wages only changed by around seven per cent of the change in the Terms of Trade, in the long term. In the long term, the average wage is estimated to rise by around 22 per cent of the increase in the unemployment allowance payment rate.

An increase (or decrease) in the volume labour force underutilisation gap of one percentage point is estimated to be associated with an decrease (or increase) in the average wage of 0.7 per cent, in the long term. An increase (or decrease) in the job vacancy rate of one percentage point is estimated to be associated with an increase (or decrease) in the average wage of 0.8 per cent, in the long run. A one per cent increase (or decrease) in the share of short-term temporary entrants in expanded employment is estimated to be associated with a fall (or rise) in the average wage of 0.04 per cent. While this response is very inelastic, it should be borne in mind that there is substantial variation in the share of short-term temporary entrants in expanded employment (as shown in Figure 18) and that this share has risen from well under one per cent to well over three per cent during the sample period (i.e., it has risen by hundreds of per cent during this time).

A one per cent increase (or decrease) in the Labour/Capital Ratio is estimated to be associated with a decrease (or increase) in the average wage of 0.37 per cent, in the long term. A one per cent increase (or decrease) in the share of skilled workers in employment is estimated to be associated with an increase (or decrease) in the average wage of 0.37 per cent, in the long term. It is interesting to see that both of these explanatory variables have the same long-term elasticity, especially as both of these are related to the effect of labour productivity on wages. The third explanatory variable related to this effect relates to the coverage of Workplace Agreements. A one percentage point increase in this coverage is estimated to increase the average wage by 0.4 per cent in the long term.

A one per cent increase (or decrease) in the share of teenagers in employment is estimated to be associated with a decrease (or an increase) in the average wage of 0.12 per cent, in the long term.

V.ii Short-term results

The error correction equation or short-term or second-stage regression, describes the short run dynamics of the system whilst it is in a disequilibrium state. In this equation, the quarterly change in the logarithm of the average wage is the dependent variable, and quarterly changes in the explanatory variables from the levels equation are used as explanatory variables. Another explanatory variable is the one-quarter lagged residuals from the first-stage (levels) regression. If this variable is negative and significant, this indicates that there is a cointegrating relationship between the dependent and explanatory variables. A negative sign is expected because if the relationship moves away from equilibrium, it is expected to move in the opposite direction in the following quarters to move back towards equilibrium. Results for the preferred short-term equation are shown in equation (6) below.

$$\begin{aligned}
\Delta(\mathrm{Ln}(\mathrm{AENA}))_t = {} & \underset{(0.65)}{0.00105} - \underset{(-6.92)}{0.435} * \mathrm{Residual}_{t-1} + \underset{(3.30)}{0.206} * \Delta(\mathrm{Ln}(\mathrm{AENA}))_{t-1} + \underset{(2.24)}{0.143} * \Delta(\mathrm{Ln}(\mathrm{AENA}))_{t-2} \\
& + \underset{(4.20)}{0.370} * \Delta(\mathrm{Ln}(\mathrm{CPI}))_{t-4} + \underset{(2.30)}{0.0121} * \Delta(\mathrm{Ln}(\mathrm{PMP}))_{t-2} \\
& - \underset{(-2.24)}{0.00600} * \Delta(\mathrm{VLFUG})_t - \underset{(-2.46)}{0.00665} * \Delta(\mathrm{VLFUG})_{t-1} + \underset{(1.98)}{0.00721} * \Delta(\mathrm{JV})_{t-3} \\
& - \underset{(-2.26)}{0.0672} * \Delta(L/K)_t + \underset{(1.98)}{0.0446} * \Delta(L/K)_{t-4} + \underset{(2.68)}{0.00219} * \Delta(\mathrm{PECIA})_t \\
& + \underset{(3.04)}{0.0683} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_t + \underset{(3.48)}{0.0768} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_{t-3} + \underset{(3.79)}{0.0794} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_{t-5} \\
& + \underset{(4.88)}{0.0180} * \mathrm{WBKOFRZ}_t - \underset{(-2.38)}{0.00453} * \mathrm{ACCORD}_t - \underset{(-2.69)}{1.261} * \Delta(\mathrm{SEM1519})_t \qquad (6)
\end{aligned}$$

Sample Range: 1970Q2 to 2015Q2 (181 observations); F-statistic = 18.6;
Durbin-Watson Statistic = 2.07; Durbin's h (alternative) statistic = 0.93;
Standard error of regression = 0.00982;
Mean of dependent variable = 0.0162; Standard deviation of dependent variable = 0.0160;
R-squared = 0.6593; Adjusted R-squared = 0.6238;
Condition(X) number = 6.5.
Figures in parentheses underneath the coefficients are t-statistics, the symbol, Δ, refers to a quarterly change in a variable and the subscript, t, refers to the time period (in quarters).

where:
$Residual_t$ is the residual from equation (5); i.e., the error-correction term; and
other variables are as described after equation (5).

The error-correction equation in first differences is consistent with theory, in the fact that there is a tendency for the system to return to equilibrium when there is a shock that moves the system away from long-term equilibrium (as defined by the variables specified and coefficients estimated for the preferred version in Table 1). This is captured by the error correction term. If the system is out of equilibrium, the difference equation result is that approximately two-fifths of the deviation from long-run trend will be corrected in the next quarter (shown by the negative and statistically significant coefficient on the residual for the first difference). There would, of course, be further corrections from this term in subsequent quarters. This implies a rapid adjustment back to equilibrium. Most of the first differences of the variables included in the level equations are significant in the difference equations at the five per cent level, and therefore, have a role to play in the short-run dynamics of the system.

Apart from the constant term, the coefficients of all of the explanatory variables in the preferred equation were statistically significant at the five per cent level (or higher levels of precision). All had the same sign as in the long-term equation, except for the Labour/Capital Ratio lagged four quarters, which had the opposite sign both to the variable in the long-term equation and the contemporaneous variable in the quarterly change equation.

Three of the variables in the long-term equation had statistically insignificant coefficients in initial versions of the error-correction equation and so were not included in the preferred version. The first of these was the Terms of Trade. As previously mentioned, this variable is very volatile and so it is not too surprising that this variable is insignificant in quarterly change form. The second is Short-term Overseas Arrivals (who are employed) as a Proportion of Extended Employment. This variable is estimated based on several assumptions about the percentages of short-term temporary entrants in three categories who are employed, since there are no official statistics on those who are actually working. In this circumstance, it is not surprising that it is insignificant in the error-correction equation. The third is the share of employed people who are skilled. Up until mid-1986, the variable for this share was constructed through the interpolation of annual data and so did not contain the actual quarterly changes in this share. Even when actual quarterly data are available after mid-1986, there is substantial volatility from quarter to quarter, as shown in Figure 13, partly due to sampling error in the ABS Labour Force Survey. Also, there might not be an immediate and entirely consistent effect of skills on quarterly changes in the average wage every quarter, even though there is a significant effect in the long term, as shown in equation (5).

The Adjusted R-squared value of around 0.62 was considered to be quite acceptable, especially considering that equations with quarterly changes as the dependent and explanatory variables almost universally have lower Adjusted R-squared statistics than levels equations for the same model. The Durbin-Watson statistic was very close to two and the Durbin's h statistic was not significantly different from zero, indicating that autocorrelation (or other statistical problems such as incorrect specification of dynamics) is unlikely to be a significant problem with the equation. The low Condition(X) number indicates that multicollinearity is unlikely to be problematic.

An important issue in the analysis of wage growth in Australia has been the stability of the relationships and whether there are structural changes in these relationships that are not addressed in the estimated equation. For instance, Jacobs and Rush (2015) concluded that not all of the recent decline in wage growth in Australia was explained in their wage-growth equation. An analysis of the stability of the relationships in equation (6) is provided in Appendix D. The consensus from the results in this Appendix from both the diagnostic tests and an examination of the time series of the residuals is that there is unlikely to be a serious problem with structural breaks in the equation, especially in the recent past.

The direct inflationary expectations coefficient estimated in equation (6) is 0.35. This is obtained by summing the coefficients of the lagged dependent variables (i.e., the dependent variable, lagged by one and two quarters). Clearly, this is well below one, as would be required for a NAWRU to be present.

A version of the equation for the quarterly rate of change in the average wage was estimated with an extra two lags on the dependent variable (i.e., there were four lags on the quarterly wage change), for the sake of completeness. A Wald test (conducted using the ANALYZ command in TSP International) was conducted to determine whether the sum of all four of the coefficients on the lagged dependent variable were equal to one (as would be required for a NAWRU to be present). This hypothesis was rejected at the 0.1 per cent probability level. Even when the extra two lags of the dependent variable (i.e, for the third and fourth quarterly lag) were added to the equation, the sum of the coefficients was still 0.35 (partly because the estimated coefficient on the dependent variable, lagged four quarters, is negative, although it is not statistically significantly different from zero).

An overall inflationary expectations coefficient could be calculated by also including the indirect effect on the average wage through the consumer price index. To do this properly, one would have to estimate the coefficient for the effect of the quarterly rate of change in the average wage on the quarterly rate of change in the consumer price index (this could be a separate research project) and use this information to adjust (by applying a weight to) the estimated coefficient on the consumer price index in equation (6). A simplifying assumption, which would lead to an overestimate of the overall inflationary expectations coefficient, would be to assume that there was a one-for-one flow on from changes in the average wage to changes in the consumer price index. If the coefficient of 0.370 on the quarterly rate of change in the consumer price index (lagged four quarters) was used to represent this simplified estimate of the effect, the overall inflationary expectations coefficient would be 0.72. Another Wald test was conducted to examine whether this simplified estimate of the overall inflationary expectations coefficient was significantly different from one. This was also found to be the case, at the one per cent probability level.

In a preliminary version of the equation for the quarterly rate of change in the average wage, the first four lagged values of the rate of change of the consumer price index were included as explanatory variables, but the only one that was estimated to be statistically significant was the one that was lagged four quarters and so this is the only one that was retained in the preferred version of the equation.

The short-term elasticity of the average wage with respect to the price of imported petroleum was estimated to be very inelastic at 0.012, implying that the average wage only rises by around one per cent of the rise in the price of imported petroleum, in the short term. While somewhat higher than this, the corresponding long-term elasticity is also very low, for reasons explained in the previous sub-section of this paper.

The short-term elasticity of the average wage to the unemployment allowance payment rate is estimated to be the same as the corresponding long-term elasticity; i.e, the wage is estimated to rise by around 22 per cent of the increase in unemployment allowance payment rate. While still constituting a short-term elasticity, this response is spread out over five quarters.

Changes in the volume labour force underutilisation gap were estimated to have a significant downward effect on the quarterly rate of change of the average wage, both in the same quarter and with a lag of one quarter (in addition to the effect arising in adjusting to equilibrium through the lagged error term from the long-term equation). A reduction (or increase) in the volume labour force underutilisation gap of one percentage point is estimated to raise (or lower) the quarterly rate of change of the average wage by 1.3 per cent, in the short term. This short-term effect is estimated to be around twice as large as the long-term effect. Several other researchers who have estimated the determinants of Australian wages have also found large short-term effects of excess labour market supply on the average wage, generally describing these as 'speed-limit effects'. The most recent such analysis was that by Jacobs and Rush (2015), who estimated that the quarterly change in the unemployment rate (lagged one quarter, which was their 'speed-limit effect') had a much larger effect on the quarterly rate of change of the private-sector Wage Price Index for Australia than their long-term labour market capacity variable (which they described as a 'NAIRU gap').

Changes in the job vacancy rate (representing excess labour demand) were estimated to have a significant upward effect on the quarterly rate of change of the average wage, but with a longer lag (three quarters of a year) than for the volume labour force underutilisation gap (representing excess labour supply). Moreover, the short-term effect of excess labour demand was not estimated to be as strong as the short-term effect of excess labour supply. A reduction (or increase) in the job vacancy rate of one percentage point is estimated to lower (or raise) the quarterly rate of change of the average wage by 0.7 per cent, in the short term. This short-term effect is estimated to be around the same as the long-term effect.

A one per cent increase (or decrease) in the Labour/Capital Ratio is associated with a 0.28 per cent decrease (or increase) in the average wage in the same quarter, but this short-term effect is mostly reversed four quarters later.

A one per cent increase (or decrease) in the share of teenagers in employment is associated with a 0.10 per cent decrease (or increase) in the average wage in the same quarter. This short-term elasticity is just below the long-term elasticity, indicating that most of the effect of the share of teenagers in employment occurs contemporaneously.

The Wage Breakout and Wage Freeze of the early-mid-1980s were estimated to have a strong and statistically upward, then downward, effect on the quarterly rate of change of the average wage. The Prices and Incomes Accord was estimated to have a significant downward effect, while the percentage of employees covered by Workplace Agreements was estimated to have a significant upward effect, on the quarterly rate of change of the average wage. These statistically significant estimates provide evidence that institutional factors are important in Australian wage determination in both the short and long terms.

One potential problem with including a lagged dependent variable in an econometrically estimated equation (as was done in equation 6) is that it can, under some circumstances, bias the estimate of the coefficient of the lagged dependent variable upward, and of the remaining explanatory variables downward, in the equation. As previously mentioned in Section II of this paper, this effect was explained by Achen (2001). This bias could lead to an upward bias to the estimate of the inflationary expectations coefficient and could even lead to a wrong conclusion about the presence of a 'NAIRU' or a NAWRU (Connolly 2008). Achen (2001) warned against using lagged dependent variables in equations under these conditions.

Wilkins (2013) showed that under fairly general assumptions, these potential biases can be reduced by adding additional lags of the dependent variable and explanatory variables in the estimated equation. The Wilkins (2013) approach was used and an appropriate equation was estimated, using the Nonlinear Least Squares regression method, with a constant term and the explanatory variables used for equation (6). The estimate using this approach is explained in detail in Appendix E. The coefficient on the lagged dependent variable (which is also the direct inflationary expectations coefficient) using this method is estimated to be the same as the direct inflationary expectations coefficient in the preferred short-term equation (i.e., the sum of the coefficients of the two lagged dependent variables in equation 6). The estimated direct inflationary expectations coefficient using the Wilkins method is significantly different from one, providing further evidence that a NAWRU is unlikely to be present.

VII Discussion and Conclusions

The analysis for this report has revealed that a ‘NAWRU’ is highly unlikely to be present in Australia for the following reasons:

1. The orders of integration and stationarity in the average wage, in labour market capacity variables and in other explanatory variables relating to the average wage in Australia are not consistent with the presence of a NAWRU. These variables were found to be I(1), but for a NAWRU to be present the average wage would have had to have been I(2) and the unemployment rate (or other labour market capacity variables used instead of it) would have had to have been I(0) or stationary. This assessment of the orders of integration was supported by the regression analysis, where the estimate that the coefficient of the lagged residual term from the equilibrium equation (equation 5) in the second-stage equation (equation 6) was significantly less than zero provides confirmatory evidence that the average wage and its explanatory variables are I(1) and that there is a cointegrating relationship among them.

2. The inflationary expectations coefficient was estimated to be well below one in the econometric analysis conducted for this paper. The direct inflationary expectations coefficient was estimated to be around 0.35, with the same estimate obtained through two different estimation techniques. Even taking account of an overestimate of the indirect inflationary expectations coefficient arising through changes in the Consumer Price Index, the overall inflationary expectations coefficient is also estimated to be substantially less than one at 0.72. In statistical testing, all of these estimates were found to be significantly different from one.
3. In other recent analyses of wage setting in Australia, the analysts who hadn't constrained the inflationary expectations coefficient to be one (notably Guichard and Rusticelli (2011), Bullen et al (2014) and Jacobs and Rush (2015)) had estimated that this coefficient was less than one (especially when account is taken of an upward bias in the estimate of the inflationary expectations coefficient in the case of Bullen et al (2014)).

The absence of a NAWRU might have implications for aggregate monetary and fiscal policies. The perceived presence of a 'NAIRU' or NAWRU is used to justify tight monetary and fiscal policies on the basis that loose monetary or fiscal policies would only lead to a short-term reduction in the unemployment rate if it is already around or below the 'NAIRU' or NAWRU but would lead to a permanently rising inflation rate. However, if there is no 'NAIRU' or NAWRU, then it is harder to justify tight fiscal and monetary policies or for pre-empting even small potential rises in inflation. There might, however, be other justifications, such as the possible effect of high inflation on international competitiveness or on the quality of investment.

The absence of a NAWRU also has implications for macroeconomic and general equilibrium modelling and long-term projections. Use of macroeconomic models such as Outlook Economics' AUS-M model, which contain a 'NAIRU' or a NAWRU could lead to an overprediction of the unemployment rate in simulations where there is downward pressure on the unemployment rate. It is possible that more realistic results could be obtained from a macroeconomic model such as the FoCUS model (outlined in Connolly 2011) which contains the set of equations for the average wage presented in this paper. There are also implications for long-run projections, such as those for population ageing contained in various versions of the *Intergenerational Report* or many conducted with computable general equilibrium models such as the Victoria University of Technology models, that are based on assumptions about a 'NAIRU' or a 'sustainable minimum unemployment rate'. The main implication is that they might overestimate the scope for further reductions in the unemployment rate to contribute to solving the problem at hand (such as potential shortfalls in labour supply arising from population ageing).

It should be borne in mind that although in this analysis a NAWRU was not found to be present in Australia, a negative relationship between excess labour supply and the average wage was found. Further, a reduction in excess labour supply was found to have effects on the average wage that persisted beyond the initial effect, working through the inflationary expectations coefficient and movements towards the long-term equilibrium relationship between excess labour supply and the average wage. While these effects were found to be persistent, they were not found to be permanent, in the sense that the inflationary expectations coefficient was estimated to be substantially less than one.

Excess labour supply (in the form of the volume labour force underutilisation gap) was estimated to have differential effects on the average wage from excess labour demand (in the form of the job vacancy rate). The effect of excess labour supply was estimated to be stronger in the short term and to affect the average wage with a shorter lag.

Labour supply in the form of short-term temporary entrants who are estimated to be working in Australia (and not counted as being employed by the ABS in its Labour Force Survey because they are not counted as part of the Estimated Resident Population) was also estimated to have a negative effect on the average wage in the long term.

Compositional effects in the labour market were also estimated to be important, with the average wage rising with the share of skilled people in employment, but falling with the share of teenagers in employment.

As has been found with several other studies, institutional effects were found to be significant in this analysis. These were a wage breakout in the early 1980s, which was associated with a decentralisation of wage setting, a subsequent wage freeze in the mid-1980s, the Prices and Incomes Accord, which operated from the mid-1980s through to the mid-1990s and the percentage of employees covered by Workplace Agreements (Enterprise Agreements and Registered Individual Agreements).

Three separate explanatory variables which have a positive effect on labour productivity (as found in Connolly, Trott and Li 2012) were estimated in this analysis to have a positive and statistically significant association with the average wage. These were the share of employed people who are skilled, the percentage of employees covered by Workplace Agreements and the capital stock (however, since the variable relating to the capital stock was entered in inverse form in this analysis as the Labour/Capital Ratio, the estimated coefficients were negative). These responses are as expected and the finding about the effect of the Labour/Capital Ratio is consistent with the results of Karanassou and Sala (2010). It is interesting, however, to consider the findings of this paper in combination with those of Connolly, Trott and Li (2012) in relation to the percentage of employees covered by Workplace Agreements. This coverage ratio increases both labour productivity and the average wage, but it is estimated to have a rapid effect on the average wage (as estimated in the current analysis) but a lagged effect on labour productivity (as estimated in Connolly, Trott and Li 2012).

The findings in the current analysis are useful for informing one of the key contemporary questions about wage setting in Australia. In an article in the RBA's *Bulletin* in mid-2015, Jacobs and Rush asked (through the title of their paper): "Why Is Wage Growth So Low?" They attempted to explain the answer to their own question through their analytical work, finding that the fall in the wage growth rate in recent years is partly explained through an increase in the unemployment rate, a fall in the growth rate of the price deflator for GDP and (to a much smaller extent) from a fall in inflationary expectations. However, there was also a sizable component of the fall in wage growth that could not be explained through their economic analysis.

The analysis conducted for the current paper provides three additional key reasons why wage growth has been so low over recent years:

1. The underemployment rate has been rising. Jacobs and Rush (2015) only took account of the unemployment rate in their analysis, but in the current analysis, both unemployment and underemployment are combined in a consistent manner to form the volume of the labour force that is underutilised. As shown in Figure 4, the volume labour force underutilisation gap has risen by around 2½ percentage points, between just before the Global Financial Crisis worsened in September 2008 and late 2015. A substantial proportion of this increase has been from underemployment. The headline underemployment rate has risen from 5.9 per cent in August 2008 to 8.5 per cent in August 2015[19].
2. There has been a rapid increase in the share of short-term temporary entrants (who are unlikely to be counted by the ABS in Labour Force statistics) in the expanded employment base (as shown in Figure 18). This share has risen from around 2½ per cent in the September quarter 2008 to around 3½ per cent in the September quarter 2015.
3. There has been a shift in employee coverage away from Workplace Agreements (Enterprise Agreements and Registered Individual Agreements) since early 2008 (as shown in Figure 12). Some of this shift has been to the Award System (as calculated from the ABS publication, *Employee Earnings and Hours*[20], the percentage of employees who had their wages set by Awards only rose from 15.2 per cent in May 2010 to 18.8 per cent in May 2014).

In addition to assist in explaining why wage growth has been so low in recent years, the inclusion of explanatory variables relating to these three reasons also assists in the formulation of an econometric estimate for the quarterly rate of change in the average wage which is stable through time (i.e., not seriously affected by a quantified structural break over a long sample period of around 45 years). In addition to being stable through time, the set of estimated equations was acceptable in other respects. Almost all of the variation in the logarithm of the average wage was explained in the preferred long-term equation (equation 5). Around 62 per cent of the variation in the quarterly rate of change in the average wage was explained in the preferred short-term regression analysis (equation 6). This much lower level of explanatory power is to be expected, since the average wage on a *National Accounts* basis is highly variable from quarter to quarter.

[19] Source: ABS (2016), *Labour Force, Australia, December 2015*, ABS Cat. No. 6202.0, spreadsheet 22 (6202022.xls). Data quoted are in seasonally adjusted terms.

[20] ABS Cat. No. 6306.0.

Appendix A:

ESTIMATE OF THE INFLATIONARY EXPECTATIONS COEFFICIENTS IN THE WAGE-STYLE PHILLIPS CURVE ESTIMATED BY AUTHORS FROM TREASURY IN 2014

Bullen, Greenwell, Kouparitsas, Muller, O'Leary and Wilcox (2014) estimated an expectations-augmented wage-style Phillips Curve for Australia. It was wage-style in that their dependent variable was a real unit labour cost index, and not the nominal wage as in conventional wage Phillips curves (the real unit labour cost index is the nominal wage deflated by both labour productivity and an aggregate price index). Their dependent variable was a change over four quarters in the real unit labour cost index. Their inflationary expectations coefficients had three components: inflationary expectations from the bond market (in real terms); the change in the real unit labour cost index over four quarters, lagged one quarter; and the difference between the change in the nominal unit labour cost index one quarter ago and the change in the nominal unit labour cost index four quarters ago. Their variable for labour market capacity was the proportional difference between the actual unemployment rate (lagged one quarter) and the equilibrium unemployment rate. The coefficient on this variable was estimated to be negative and significantly different from zero (in other words, unemployment rates higher (or lower) than the equilibrium rate were followed by lower (or higher) real labour costs). They estimated their equation with Kalman filtering, which allowed for time-varying coefficients for the variable for the equilibrium unemployment rate.

Their estimated equation[21] is:

$$\begin{aligned} &\Delta_4\, w_t - \Delta_4\, q_t - \Delta_4\, pgne_{t-1} \\ &\quad = \beta_1 * (\pi^e_t - \Delta_4\, pgne_{t-1}) + \kappa * (U_{t-1} - U^T_t)/U_{t-1} \\ &\quad\quad + \beta_2 * (\Delta_4\, w_{t-1} - \Delta_4\, q_{t-1} - \Delta_4\, pgne_{t-2}) \\ &\quad\quad + \beta_3 * [\Delta\, w_{t-1} - \Delta\, q_{t-1} - (\Delta\, w_{t-4} - \Delta\, q_{t-4})] + \varepsilon_{wt} \qquad \text{(A.1)} \end{aligned}$$

Where: Δ stands for the change over one quarter;
Δ_4 stands for the change over four quarters;
w_t stands for the natural logarithm of the hourly wage rate;
q_t stands for the natural logarithm of labour productivity;
$pgne_t$ stands for the natural logarithm of the price deflator for Gross National Expenditure;
π^e_t stands for inflationary expectations from the bond market (in nominal terms);
U_t stands for the actual Unemployment Rate;
U^T_t stands for the trend (or equilibrium) Unemployment Rate;
β_1, κ, β_2 and β_3 are coefficients which were estimated by Bullen et al (2014) using the Maximum Likelihood estimation technique;
ε_{wt} stands for the residual in the estimated wage equation; and
t stands for the time period in quarters.

[21] This is the specification of equation (28) on page 9 of Bullen et al (2014).

On the right side of right side of equation (A.1), the first term represents Real Bond Market Inflationary Expectations; the second term represents the effect of the unemployment rate gap; the third term is the dependent variable, lagged only one quarter (meaning that three quarterly changes in real unit labour costs are included on both the left and the right sides of this equation); the fourth term is the difference between the first lag and the fourth lags in the quarterly changes in the logarithm of the Nominal Unit Labour Cost index and the final term is a residual (or error term).

As shown in Connolly (2008, Appendix A), an upward bias in the estimate of the inflationary expectations coefficient arises through the use of the third term on the right side of equation (A.1) above (that is, unless the coefficient estimate for this variable is 1.00, which it wasn't in Bullen et al (2014), who estimated it to be around 0.60[22]).

The upward bias arises because the unbiassed specification of this version of the wage Phillips curve would have the quarterly change in Real Unit Labour Costs as the dependent variable and four quarterly lags of this variable on the right side of the equation (i.e., t-1, t-2, t-3 and t-4). In contrast, the specification in equation (A.1) means that three-quarters of the movement in the dependent variable is automatically included in the second variable in equation (A.1), regardless of whether or not movements in the unemployment rate have any effect on quarterly changes in Real Unit Labour Costs (or wages, prices or nominal unit labour costs, depending on which measure of inflation is chosen). Indeed, Connolly (2008) showed that if the unbiassed estimate of the inflationary expectations coefficient is zero, this specification would result in an estimate of the inflationary expectations coefficient of three-quarters (i.e., 0.75). He also gave a proof of the bias and pointed out that use of this functional form also implied other restrictions on the coefficients of the lagged quarterly changes in the dependent variable, which may or may not be valid (i.e., this is an empirical question, which can only be answered by estimating the equation in unbiased form). His estimate of the potential bias[23] induced by the use of this functional form is:

$$\text{Bias} = 3 - 3 * \phi_4 \tag{A.2}$$

where φ_4 is the coefficient on the four-quarterly change in the dependent variable, lagged one quarter. This is equal to β_2 in equation (A.1).

This means that the upward bias in the estimate of the inflationary expectations coefficient for the logarithm of the real unit labour cost (assuming that there are no biases in the other coefficients) in the equation estimated by Bullen et al (2014) is:

$$\text{Bias} = 3 - 3 * 0.60 = +1.20 \tag{A.3}$$

[22] The estimation results for the Wage Phillips Curve in Bullen et al (2014) are contained in Table 3 on page 15 of their paper. These coefficient estimates are rounded in this Appendix for ease of reading.

[23] This "potential bias" becomes an actual bias unless the true inflationary expectations coefficient is 1.00 or unless there are other components of the inflationary expectations coefficient contained in the Phillips Curve that exactly offset this potential bias. In other words, this "potential bias" is likely to become an actual bias much of the time.

On the assumption that the other two components of the inflationary expectations coefficient in equation (A.1) are unbiassed[24], the unbiassed estimate of the sum of the components of the inflationary expectations coefficient for the quarterly change in the logarithm of the real unit labour cost, for the equation estimated by Bullen et al (2014) is:

$$0.15 + 0.60 - 1.20 + 0.15 = -0.30 \qquad \text{(A.4)}$$

However, further analysis is required to determine the unbiassed estimates of the inflationary expectations coefficients for wages and prices, as opposed to real unit labour costs. In addition, the estimate in equation (A.4) is a simplification, because the fourth term on the right side of equation (A.1) is a difference in nominal unit labour costs, not real unit labour costs.

In order to simplify the exposition of the algebra used to determine the unbiassed estimates of these coefficients, the explanatory variables that are not related to prices or wages are combined into one variable, defined as follows:

$$Z_t = \Delta_4\, q_t + \kappa * (U_{t-1} - U^T_t)/U_{t-1} - \beta_2 * \Delta_4\, q_{t-1} - \beta_3 * (\Delta\, q_{t-1} - \Delta\, q_{t-4}) \qquad \text{(A.5)}$$

Applying equation (A.5) to equation (A.1) means that it can be simplified as follows:

$$\begin{aligned} &\Delta_4\, w_t - \Delta_4\, pgne_{t-1} \\ &\quad = \beta_1 * (\pi^e_t - \Delta_4\, pgne_{t-1}) + \beta_2 * (\Delta_4\, w_{t-1} - \Delta_4\, pgne_{t-2}) \\ &\quad\ + \beta_3 * (\Delta\, w_{t-1} - \Delta\, w_{t-4}) + Z_t + \varepsilon_{wt} \end{aligned} \qquad \text{(A.6)}$$

Next, the variables in four-quarterly changes are converted into their four quarterly changes, using the following two formulae:

$$\Delta_4\, w_t = \Delta\, w_t + \Delta\, w_{t-1} + \Delta\, w_{t-2} + \Delta\, w_{t-3} \qquad \text{(A.7)}$$

and

$$\Delta_4\, pgne_t = \Delta\, pgne_t + \Delta\, pgne_{t-1} + \Delta\, pgne_{t-2} + \Delta\, pgne_{t-3} \qquad \text{(A.8)}$$

Applying (A.7) and (A.8) to (A.6) and adding $\Delta_4\, pgne_{t-1}$ to both the left and right sides of the resulting equation yields:

$$\begin{aligned} &\Delta\, w_t + \Delta\, w_{t-1} + \Delta\, w_{t-2} + \Delta\, w_{t-3} = \\ &\quad \Delta\, pgne_{t-1} + \Delta\, pgne_{t-2} + \Delta\, pgne_{t-3} + \Delta\, pgne_{t-4} \\ &\quad + \beta_1 * [\pi^e_t - (\Delta\, pgne_{t-1} + \Delta\, pgne_{t-2} + \Delta\, pgne_{t-3} + \Delta\, pgne_{t-4})] \\ &\quad + \beta_2 * [\Delta\, w_{t-1} + \Delta\, w_{t-2} + \Delta\, w_{t-3} + \Delta\, w_{t-4} - (\Delta\, pgne_{t-2} + \Delta\, pgne_{t-3} + \Delta\, pgne_{t-4} + \Delta\, pgne_{t-5})] \\ &\quad + \beta_3 * (\Delta\, w_{t-1} - \Delta\, w_{t-4}) + Z_t + \varepsilon_{wt} \end{aligned} \qquad \text{(A.9)}$$

[24] As shown in Connolly (2008 and 2001), the use of prospective or 'forward-looking' measures of inflationary expectations, such as the inflationary expectations variable from the bond market used by Bullen et al (2014) can also induce an upward bias in the relevant inflationary expectations coefficient for determining whether or not a 'NAIRU' is present. This is for a number of reasons, including that much of the movement in such variables is as a result of exogenous influences, such as world oil prices.

Rearranging the variables in equation (A.9) so that they are expressed in terms of their effects on the quarterly change in the logarithm of the hourly wage rate yields the following equation:

$$\begin{aligned}
\Delta w_t = {} & (\beta_2 + \beta_3 - 1) * \Delta w_{t-1} + (\beta_2 - 1) * \Delta w_{t-2} + (\beta_2 - 1) * \Delta w_{t-3} + (\beta_2 - \beta_3) * \Delta w_{t-4} \\
& + (1 - \beta_1) * \Delta pgne_{t-1} + (1 - \beta_1 - \beta_2) * \Delta pgne_{t-2} + (1 - \beta_1 - \beta_2) * \Delta pgne_{t-3} \\
& + (1 - \beta_1 - \beta_2) * \Delta pgne_{t-4} - \beta_2 * \Delta pgne_{t-5} \\
& + \beta_1 * \pi^e_t \\
& + Z_t + \varepsilon_{wt} \qquad \text{(A.10)}
\end{aligned}$$

The coefficients on the top line of the right side of equation (A.10) represent the direct inflationary expectations coefficients, working through the lagged quarterly changes in the logarithm of wages. The coefficients on the next two lines on the right side of equation (A.10) represent the indirect inflationary expectations coefficients, working through the lagged quarterly changes in the logarithm of prices. The coefficient on the second-bottom line on the right side of equation (A.10) represents the indirect inflationary expectations coefficient, working through inflationary expectations in the bond market.

Bullen et al (2014) estimated that the β coefficients were, in rounded terms: $\beta_1 = 0.15$; $\beta_2 = 0.60$; and $\beta_3 = 0.15$. Applying these estimates results in the following equation:

$$\begin{aligned}
\Delta w_t = {} & -0.25 * \Delta w_{t-1} - 0.40 * \Delta w_{t-2} - 0.40 * \Delta w_{t-3} + 0.45 * \Delta w_{t-4} \\
& + 0.85 * \Delta pgne_{t-1} + 0.25 * \Delta pgne_{t-2} + 0.25 * \Delta pgne_{t-3} \\
& + 0.25 * \Delta pgne_{t-4} - 0.60 * \Delta pgne_{t-5} \\
& + 0.15 * \pi^e_t \\
& + Z_t + \varepsilon_{wt} \qquad \text{(A.11)}
\end{aligned}$$

The sum of direct inflationary expectations coefficients, working through lagged changes in the logarithm of wages, is -0.60. If changes in wages brought about through changes in the unemployment rate gap had no effect on changes in the logarithm of the price deflator for Gross National Expenditure or on inflationary expectations in the bond market, then this would also be the total sum of inflationary expectations coefficients.

The sum of indirect inflationary expectations coefficients working through lagged changes in the logarithm of the price deflator for Gross National Expenditure, is 1.00. If a one-for-one flow-on from changes in the logarithm of wages to changes in the logarithm of this price is assumed, then the contribution to the sum of total inflationary expectations coefficients would also be 1.00. The indirect inflationary expectations coefficient, working through inflationary expectations in the bond market, is 0.15. If it is also assumed that movements in the unemployment rate gap are reflected fully in inflationary expectations in the bond market, then this would also be counted as part of the total sum of inflationary expectations coefficients. Under these assumptions, the total sum of direct and indirect inflationary expectations coefficients is -0.60 + 1.00 + 0.15 = 0.55. While positive, this is well below one.

Bullen et al (2014), assume that "the price of output sold domestically is assumed to be determined endogenously via a constant percentage mark-up over nominal unit labour costs (i.e., wages per unit of labour productivity)". This is presented algebraically in equation 31 in their paper as follows:

$pd_t = \mu + (w_t - q_t)$ (A.12)

where pd_t is the logarithm of the price of output sold domestically;
μ is the constant percentage mark-up between the logarithm of nominal unit labour costs and the logarithm of the price of output sold domestically; and
w_t and q_t are as previously explained.

For a given level of labour productivity, this assumption imposes a one-for-one link between the logarithm of the wage and the logarithm of the price of output sold domestically. It is apparent from equations 30, 31 and 36 of Bullen et al (2014) and the descriptions about them in this paper that the "price of output sold domestically" actually refers to the price of domestic output sold domestically. The relationship between this price and the price deflator for Gross National Expenditure is explained in equation (36) of Bullen et al (2014) using the following formula:

$PGNE_t = [PD_t * D_t + PM_t * M_t]/GNE_t$ (A.13)

Where $PGNE_t$ is the price deflator for Gross National Expenditure;
PD_t is the price deflator for output sold domestically;
D_t the volume of output sold domestically;
PM_t is the price deflator for imports;
M_t is the volume of imports; and
GNE_t is the volume of Gross National Expenditure.

Bullen et al (2014) assume that the price of imports is unaffected by changes in wages which lead to changes in nominal unit labour costs (this is apparent from examining equations 33, 34 and 35 in their paper). This implies (through equation A.13) that a change in the hourly wage rate is likely to have a dampened effect on the price deflator for GNE (i.e., the coefficient is likely to be less than 1.00), because it only affects the price of domestically produced and consumed output and doesn't affect the price of imports.

If, say, one assumes that the logarithm of the price deflator for GNE varies according to the following formula:

$pgne_t = pd_t * D_t/GNE_t$ (A.14)

and one approximates D_t as GNE_t minus M_t then this would give this dampened effect. Over recent years, this ratio has been fairly stable at around 0.80 (in other words, the volume of imports of goods and services is around 20 per cent of the volume of Gross National Expenditure[25]). Applying these assumptions would lower the sum of indirect inflationary expectations coefficients working through lagged changes in the price deflator for Gross National Expenditure from 1.00 to 0.80. Assuming full flow-through to the inflationary expectations coefficient in the bond market, it would also reduce the sum of all inflationary expectations coefficients from 0.55 to 0.35.

[25] These ratios were calculated from seasonally adjusted data from Spreadsheet 2 (5206002.xls) from ABS (2016), *Australian National Accounts: Income, Expenditure and Product, December quarter 2015*, ABS Cat. No. 5206.0.

APPENDIX B

DATA SOURCES AND METHODS

The data sources and methods used for the variables in the quantitative analysis are explained here, for variables which are more complex and haven't been fully explained in the main body of this paper. Except where otherwise mentioned, the series in this Appendix are in seasonally adjusted terms.

Job Vacancy Rate

The Job Vacancy Rate is calculated as the ratio of ABS Job Vacancies to the ABS Labour Force, expressed as a percentage. The data for ABS Job Vacancies generally come from various issues of the ABS publication, *Job Vacancies, Australia* (ABS Cat. No. 6354.0) and relate to the number of job vacancies available for immediate filling in the middle month of each quarter. There was a recent period, from August 2008 through August 2009, when the ABS did not collect and release this series. For this period, the econometric estimates of Connolly and Tang (2011) are used. Connolly and Tang estimated an econometric relationship between ABS Job Vacancies (as the dependent variable) and ANZ total Job Advertisements and the previous version of the Westpac-Melbourne Institute Leading Index of Economic Activity, then used this relationship to estimate what ABS Job Vacancies would have been during this period. A continuous series for ABS Job Vacancies going back to August 1966 is constructed by splicing the data from the ABS survey of employers with data from the TRYM model data base on the ABS *Modellers' Database* (ABS Cat. No. 1364.0.15.003), which is based on CES job vacancies. The data for the ABS Labour Force is based on that in ABS (2016), *Labour Force, Australia, Detailed – Electronic Delivery, Dec 2015* (ABS Cat. No. 6291.0.55.001), with adjustments for ABS Labour Force Survey redefinitions using the methods explained in Connolly (2008).

Volume Labour Force Underutilisation Gap

The Volume Labour Force Underutilisation Gap is constructed from ABS Labour Force Survey data[26] using the methods explained in Connolly (2013 and 2011). It is constructed as the difference (in percentage points) between the total volume of labour force underutilisation (i.e., the difference between potential hours worked and actual hours worked) and the structural and frictional component of the volume of labour force underutilisation. In turn, this component is composed as follows:

- Structural unemployment is composed of unemployed people who are former workers (i.e., they have not worked for at least the last two years) or who have never worked before.

- Frictional unemployment is composed of unemployed people who are not structurally unemployed who have been unemployed for less than four weeks.

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[26] Most of the data used to construct the Volume Labour Force Underutilisation Gap is obtainable from ABS (2016), *Labour Force, Australia, Detailed – Electronic Delivery, Dec 2015* (ABS Cat. No. 6291.0.55.001, and previous issues and versions of this publication). However, some of the data comes from detailed unpublished ABS Labour Force Survey data on reasons for unemployment which the Department of Employment purchases from the ABS.

- The structural/frictional volume underemployment rate is assumed to be 0.4 per cent of potential hours worked, because this is the minimum volume underemployment rate reached in the very tight labour market conditions of the early-mid 1970s (apart from a very small number of observations below this level).

APPENDIX C

TESTS FOR STATIONARITY AND INTEGRATION OF THE AVERAGE WAGE AND ITS DETERMINANTS

In this appendix, the results of tests for stationarity (KPSS tests, based on the work of Kwiatowski, Phillips, Schmidt, and Shin 1992) or integration (Weighted Symmetric (tau) and Augmented Dickey Fuller tests) of the logarithm of the AENA wage and its determinants are presented. Since the issue of whether these variables are integrated or stationary is a crucial determining factor in deciding whether a 'NAWRU' is present, it was considered important to test the degree of integration from the perspective of null hypothesis that the variables are stationary (using the KPSS) test versus the null hypothesis that the variables are integrated (using the Weighted Symmetric (tau) and Augmented Dickey Fuller tests), especially as it is well known that the Augmented Dickey Fuller test can lack power to distinguish whether the variable actually has a unit root in some cases. Results of the KPSS tests for stationarity are shown in Table C.1, while the results for the Weighted Symmetric (tau) and Augmented Dickey Fuller tests are shown in Table C.2.

Table C.1: **KPSS tests for the Logarithms of the AENA Wage and its determinants**.

Variable	**H_0: Stationarity around mean**		**H_0: Stationarity around trend**		**Conclusion**
	Test Statistic (ε_μ)	Probability of rejecting H_0	Test Statistic (ε_τ)	Probability of rejecting H_0	
ln($AENA_t$)	1.982	>0.99	0.459	>0.99	Integrated
Δ (ln($AENA_t$))	1.327	>0.99	0.184	$0.975<\varepsilon_\tau<0.99$	Borderline between being integrated and being stationary around trend
$VLFUG_t$	0.773	>0.99	0.395	>0.99	Integrated
Δ ($VLFUG_t$)	0.137	<0.90	0.044	<0.90	Stationary
ABS Job Vacancy $Rate_t$	0.460	$0.90<\varepsilon_\mu<0.95$	0.365	>0.99	Borderline between being integrated and being stationary around mean
Δ (ABS Job Vacancy $Rate_t$)	0.142	<0.90	0.039	<0.90	Stationary
Ln(CPI_t)	1.950	>0.99	0.503	>0.99	Integrated
Δ (ln(CPI_t))	1.398	>0.99	0.153	$0.95<\varepsilon_\tau<0.975$	Borderline between being integrated and being stationary around trend

Note: results are for a lag of 9 quarters on the autocorrelated error term in the KPSS test. AENA refers to Average Earnings on a National Accounts basis while $VLFUG_t$ refers to the volume labour force underutilisation gap. The following sample period was used: 1970Q2 to 2015Q2.

Table C.1 (continued): **KPSS tests for the Logarithm of the AENA Wage and its determinants**.

Variable	**H_0: Stationarity around mean**		**H_0: Stationarity around trend**		**Conclusion**
	Test Statistic (ε_μ)	Probability of rejecting H_0	Test Statistic (ε_τ)	Probability of rejecting H_0	
Labour-Capital $Ratio_t$	1.994	>0.99	0.413	>0.99	Integrated
Δ (Labour-Capital $Ratio_t$)	0.787	>0.99	0.194	$0.975<\varepsilon_\tau<0.99$	Borderline between being integrated and being stationary around trend
$PECIA_t$	1.898	>0.99	0.286	>0.99	Integrated
Δ ($PECIA_t$)	0.281	<0.90	0.271	>0.99	Stationary around mean
Ln(Price of Imported $Petrol_t$)	0.922	>0.99	0.208	$0.975<\varepsilon_\tau<0.99$	Borderline between being integrated and being stationary around trend
Δ (Ln(Price of Imported $Petrol_t$))	0.227	<0.90	0.137	$0.90<\varepsilon_\tau<0.95$	Stationary
Ln(ToT_t)	0.988	>0.99	0.434	>0.99	Integrated
Δ (Ln(ToT_t))	0.142	<0.90	0.067	<0.90	Stationary
Ln($UAPR_t$)	1.895	>0.99	0.440	>0.99	Integrated
Δ (ln($UAPR_t$))	0.951	>0.99	0.132	$0.90<\varepsilon_\tau<0.95$	Borderline between being integrated and being stationary around trend
Employment Share of Short-term Temporary $Entrants_t$	1.898	>0.99	0.512	>0.99	Integrated
Δ (Employment Share of Short-term Temporary $Entrants_t$)	0.912	>0.99	0.046	<0.90	Stationary around trend
Teenage Employment $Share_t$	2.010	>0.99	0.255	>0.99	Integrated
Δ (Teenage Employment $Share_t$)	0.058	<0.90	0.052	<0.90	Stationary

Note: results are for a lag of 9 quarters on the autocorrelated error term in the KPSS test. PECIA refers to the percentage of employees covered by Collective and Individual [workplace] Agreements; while UAPR refers to the Unemployment Allowance Payment Rate. The following sample period was used: 1970Q2 to 2015Q2.

Table C.2: **Augmented Dickey Fuller and Weighted Symmetric (tau) tests for unit roots in the Logarithm of the AENA Wage and its determinants**

Variable	Weighted Symmetric (tau) tests: Coefficient on lagged dependent variable	Weighted Symmetric (tau) tests: Probability of failing to reject H_0 of a unit root	Augmented Dickey Fuller Tests: Coefficient on lagged dependent variable	Augmented Dickey Fuller Tests: Probability of failing to reject H_0 of a unit root	**Conclusion**
$\ln(AENA_t)$	1.018	>0.999	0.963	0.000	Possibly not integrated
$\Delta \ln(AENA_t)$	0.441	0.008	0.503	0.046	Not integrated
$VLFUG_t$	0.972	0.797	0.963	0.426	Integrated
$\Delta (VLFUG_t)$	0.280	<0.001	0.283	<0.001	Not integrated
ABS Job Vacancy $Rate_t$	0.952	0.796	0.937	0.268	Integrated
Δ (ABS Job Vacancy $Rate_t$)	-0.291	<0.001	-0.698	<0.001	Not integrated
$Ln(CPI_t)$	1.009	1.000	0.990	0.049	Probably Integrated
$\Delta Ln(CPI_t)$	0.635	0.014	0.593	0.006	Not integrated
Labour-Capital $Ratio_t$	1.008	1.000	0.978	0.175	Integrated
Δ (Labour-Capital $Ratio_t$)	0.464	<0.001	0.460	<0.001	Not integrated
$PECIA_t$	0.990	0.970	0.982	0.630	Integrated
$\Delta (PECIA_t)$	0.660	0.281	0.674	0.420	Integrated
Ln(Price of Imported $Petrol_t$)	0.975	0.926	0.950	0.263	Integrated
Δ (Ln(Price of Imported $Petrol_t$))	0.088	0.001	0.090	0.002	Not integrated
$Ln(ToT_t)$	0.974	0.755	0.974	0.660	Integrated
$\Delta (Ln(ToT_t))$	0.360	0.093	0.335	<0.001	Not integrated
$Ln(UAPR_t)$	1.009	1.000	0.987	0.703	Integrated
$\Delta (Ln(UAPR_t))$	0.421	0.006	0.679	0.077	Not integrated
Employment Share of Short-term Temporary $Entrants_t$	1.009	1.000	0.998	0.991	Integrated
Δ (Employment Share of Short-term Temporary $Entrants_t$)	0.045	0.001	0.130	0.074	Not integrated
Teenage Employment $Share_t$	0.940	0.279	0.949	0.540	Integrated
Δ (Teenage Employment $Share_t$)	-0.008	0.007	0.063	0.002	Not integrated

Note: results are for lags of up to 11 quarters on the autocorrelated error term for the statistical tests. The explanation of the mnemonics for the variables is provided in the footnotes under Table C.1. The following sample period was used: 1970Q2 to 2015Q2 (or the longest available subsample within this period).

The general result of these tests are that the dependent and explanatory variables are integrated of the first order; that is, I(1). With the dependent variable (the logarithm of Average Earnings on a National Accounts basis), there is the possibility that it is integrated of a higher order than I(1) on the basis of the KPSS test. On the other hand, there are indications that it is stationary on the basis of the result of the Augmented Dickey-Fuller test. On balance, it is classed as I(1). Some of the explanatory variables also appear to be borderline between being I(1) and being integrated of a higher order on the basis of the KPSS test, but these would be classed as I(1) on the basis of both the Augmented Dickey-Fuller and Weighted Symmetric tau tests.

On the basis that the variables are highly probable to be I(1), an Engle-Granger (tau) cointegration test was conducted between the dependent and an expanded set of explanatory variables. Two additional explanatory variables were initially included in the set of probable explanators of wages and so were included in this test, but were not found to be statistically insignificant in later econometric analysis. These were the logarithm of the Pay as You Go tax rate on individual incomes and the logarithm of the average hours worked by employees per week.

The result of the cointegration test was an α coefficient of 0.522 at an optimal lag of five quarters, with at tau statistic of -5.00. While it is not feasible to calculate a probability for this test because there are too many explanatory variables, it is likely to indicate that the explanatory variables are cointegrated with the dependent variable.

APPENDIX D

AN ANALYSIS OF THE STABILITY OF THE PREFERRED EQUATION FOR THE RATE OF CHANGE OF THE AVERAGE WAGE

In this Appendix, an analysis of the stability of the preferred equation for the rate of change of the average wage (i.e., equation 6 in the main body of this paper) is conducted. This analysis consists of diagnostic tests for structural change in the coefficients and/or the residuals of the equation and a graphical analysis of the time series of the residuals from this equation.

<u>Diagnostic tests</u>

The results of diagnostic tests for structural change in equation (6) in the main body of this paper are as follows:

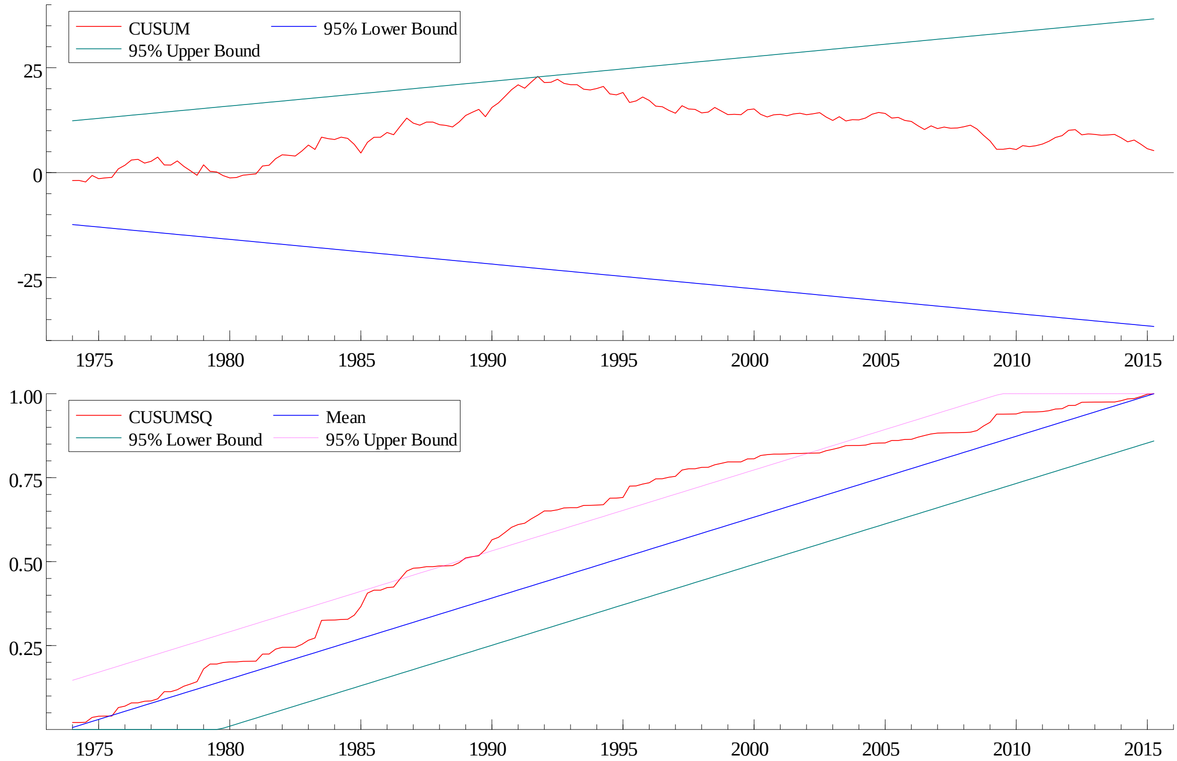
Autoregressive Conditional Heteroscedasticity (ARCH) test = 0.737 [0.391]
Cumulative Sum of Residuals (CuSum) test = 0.953 * [0.048]
Cumulative Sum of Squares of Residuals (CuSumSq) test = 0.211 ** [0.001]
Chow test = 0.730 [0.776]
Chow heteroscedasticity robustness (Chow het. rob.) test = 1.755 * [0.036]

where the figures in square brackets are the probabilities of not rejecting the null hypothesis for each test, which is generally that there is no statistical problem in the equation; * denotes statistically significant at the five per cent level and ** denotes statistically significant at the one per cent level.

There is no evidence of instability in the equation using the classical test for structural change in equations, the Chow test. Neither is there any evidence of a problem with the ARCH test, although this is not purely a test for structural change (instead, the presence of autoregressive conditional heteroscedasticity might be a sign that heteroscedasticity and not structural changes in the relationship is responsible for this statistical problem).

The CuSum test is marginally statistically significant (i.e., just under the five per cent level). However, an examination of the time series of the cumulative sum of residuals (shown in Figure D.1) reveals that this series only just exceeds the upper bound for the test once (around the time of the recession of the early 1990s), and doesn't exceed the lower bound at all, during the whole sample period of around 45 years. Over the last five years, the cumulative sum of residuals has been very close to zero. Hence, if there was a statistical problem signalled by this test, it took place around a quarter of a century ago and there is negligible evidence that it is still a problem. The CuSumSq test is statistically significant, but since this is a test of the sum of the squares of the residuals, it is more of a test of heteroscedasticity (since it is closely related to the variance of the residuals and not the level of the residuals) than of structural change in the equation. This is consistent with the Chow heteroscedasticity robustness test, which although statistically significant, could easily be a sign of heteroscedasticity in the equation and not instability of the parameters. However, other statistical tests for heteroscedasticity were mixed (the Lagrange Multiplier test was significant, while the White test was insignificant).

Figure D.1: **Time Series of the Cumulative Sum (CuSum) and Cumulative Sum of Squares (CuSumSq) of Residuals from the Preferred Equation for the Rate of Change in the Average Wage**

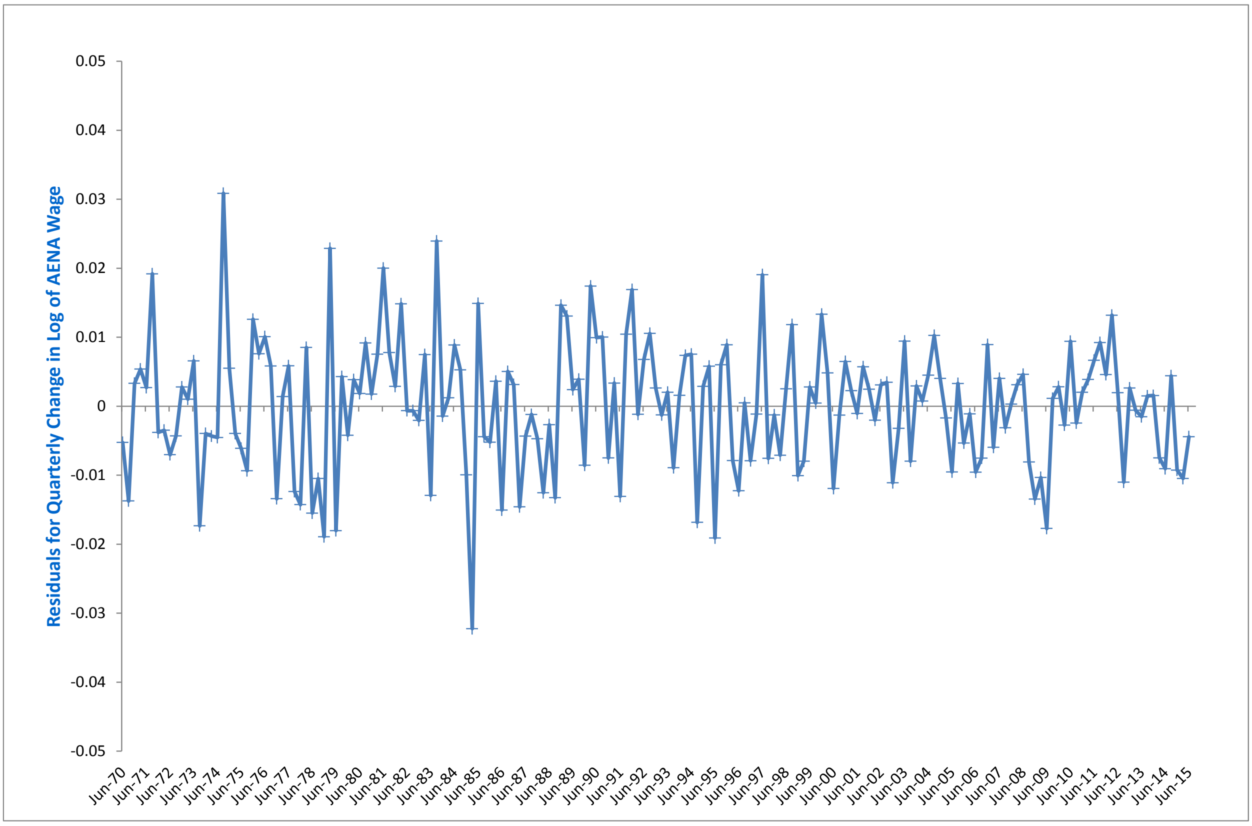


Source: Results of the preferred regression (equation 6 in the main body of this paper) for the quarterly rate of change in the average wage, from the TSP 5.1/OxMetrics 6 computer programme.

Plot of Residuals

A time series of the residuals from equation (6) in the main body of this paper is provided in Figure D.2.

Figure D.2: **Residuals from the Preferred Equation for the Rate of Change in the Average Wage**



Source: residuals from equation (6) in the main body of this paper, estimated using the OLS technique in TSP International Version 5.1 (Hall and Cummins 2009).

Graphically, there is little evidence of serious problems with the time series of residuals apparent in Figure D.1. Notably, there is also only weak evidence of recent structural changes in the relationship between the average wage and its explanatory variables. Some, but not all of the residuals in the latest year and a half are negative (indicating that the quarterly rate of change in the average wage is lower than predicted through the preferred equation) but even then the magnitude of these residuals is similar to the average throughout the sample period.

<u>Summary</u>

The consensus from the results from both the diagnostic tests and an examination of the time series of the residuals is that there is unlikely to be a serious problem with structural breaks in the equation, especially in the recent past and especially when account is taken of the circumstances under which there was some evidence of a possible previous structural break (the recession of the early 1990s differed in several ways from previous recessions).

APPENDIX E

ECONOMETRIC ESTIMATE OF THE EQUATION FOR THE QUARTERLY RATE OF CHANGE IN THE AVERAGE WAGE USING THE WILKINS (2013) METHOD

As mentioned in the main body of this paper, the Wilkins (2013) method enables analysts to substantially reduce the 'Achen' effects (upward bias in the estimate of the coefficient of the lagged dependent variable and downward bias in the estimate of the coefficients of the other explanatory variables). This is done through the addition of an additional lag on the dependent variable and the explanatory variables that, in effect, enables the researcher to separate the coefficient of the lagged dependent variable from the effect of the first-order autocorrelated error term. This method was performed on a version of the preferred equation for the quarterly rate of change in the average wage (i.e., a version of equation (6) in the main body of this paper). One difference from the preferred version in equation (6) is that only one lag of the dependent variable was specified for the equation estimated here, for the purpose of tractability. The equation was estimated using Non-linear Least Squares in TSP International Version 5.1 (Hall and Cummins 2009), with results as follows:

$$
\begin{aligned}
\Delta(\mathrm{Ln}(\mathrm{AENA}))_t = \; & \underset{(0.33)}{0.000560} - \underset{(-6.21)}{0.347} * \mathrm{Residual}_{t-1} + \underset{(4.59)}{0.354} * \Delta(\mathrm{Ln}(\mathrm{AENA}))_{t-1} - \underset{(-2.65)}{0.282} * e_{t-1} \\
& + \underset{(4.67)}{0.382} * \Delta(\mathrm{Ln}(\mathrm{CPI}))_{t-4} + \underset{(2.59)}{0.0129} * \Delta(\mathrm{Ln}(\mathrm{PMP}))_{t-2} \\
& - \underset{(-2.25)}{0.00621} * \Delta(\mathrm{VLFUG})_t - \underset{(-2.19)}{0.00625} * \Delta(\mathrm{VLFUG})_{t-1} + \underset{(2.21)}{0.00763} * \Delta(\mathrm{JV})_{t-3} \\
& - \underset{(-2.63)}{0.0746} * \Delta(\mathrm{L/K})_t + \underset{(1.33)}{0.0290} * \Delta(\mathrm{L/K})_{t-4} + \underset{(2.46)}{0.00196} * \Delta(\mathrm{PECIA})_t \\
& + \underset{(2.81)}{0.0607} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_t + \underset{(3.41)}{0.0713} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_{t-3} + \underset{(3.40)}{0.0705} * \Delta(\mathrm{Ln}(\mathrm{UAPR}))_{t-5} \\
& + \underset{(5.18)}{0.0164} * \mathrm{WBKOFRZ}_t - \underset{(-2.34)}{0.00380} * \mathrm{ACCORD}_t - \underset{(-2.35)}{1.150} * \Delta(\mathrm{SEM1519})_t \qquad \text{(E.1)}
\end{aligned}
$$

Sample Range: 1970Q4 to 2015Q2 (180 observations);
Durbin-Watson Statistic = 2.00;
Standard error of regression = 0.00987;
Mean of dependent variable = 0.0162; Standard deviation of dependent variable = 0.0161;
R-squared = 0.6578; Adjusted R-squared = 0.6219.
Figures in parentheses underneath the coefficients are t-statistics, the symbol, Δ, refers to a quarterly change in a variable and the subscript, t, refers to the time period (in quarters).

where:
$\mathrm{Residual}_t$ is the residual from equation (5); i.e., the error-correction term;
e_{t-1} is the first-order autoregressive error term; and
other variables are as described after equation (5).

The coefficient on the lagged dependent variable (which is also the direct inflationary expectations coefficient) is estimated to be 0.354. This is the same as the direct inflationary expectations coefficient in the preferred short-term equation (equation 6 in the main body of this paper). This coefficient is significantly different from one, providing further evidence that a NAWRU is unlikely to be present.

The first-order autoregressive error term is estimated to be significantly less than one, implying negative autocorrelation. Other coefficient estimates and the overall explanatory power of the equation (as shown by the Adjusted R-squared statistic) are similar to those in the preferred equation.

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