AUSTRALIAN WAGE AND PRICE INFLATION: 1971-1994

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ABSTRACT

This paper estimates an imperfect competition model of price and wage adjustment for Australia. The results suggest the Australian economy can be characterised as one where firms are trying to achieve their desired long-run income share while workers are primarily concerned with maintaining their real wage.

The estimation of the price-wage model is complicated by two problems; namely the substantial and persistent changes in income shares and the changing means in the inflation series over the sample. The first problem was overcome by extending the estimation period to include the wage shocks in the early 1970s which allows the income shares to be characterised as stationary. The second problem was addressed by imposing a restriction to the wage equation. This allowed a range of possible steady state inflation rates in the model over the estimated sample.

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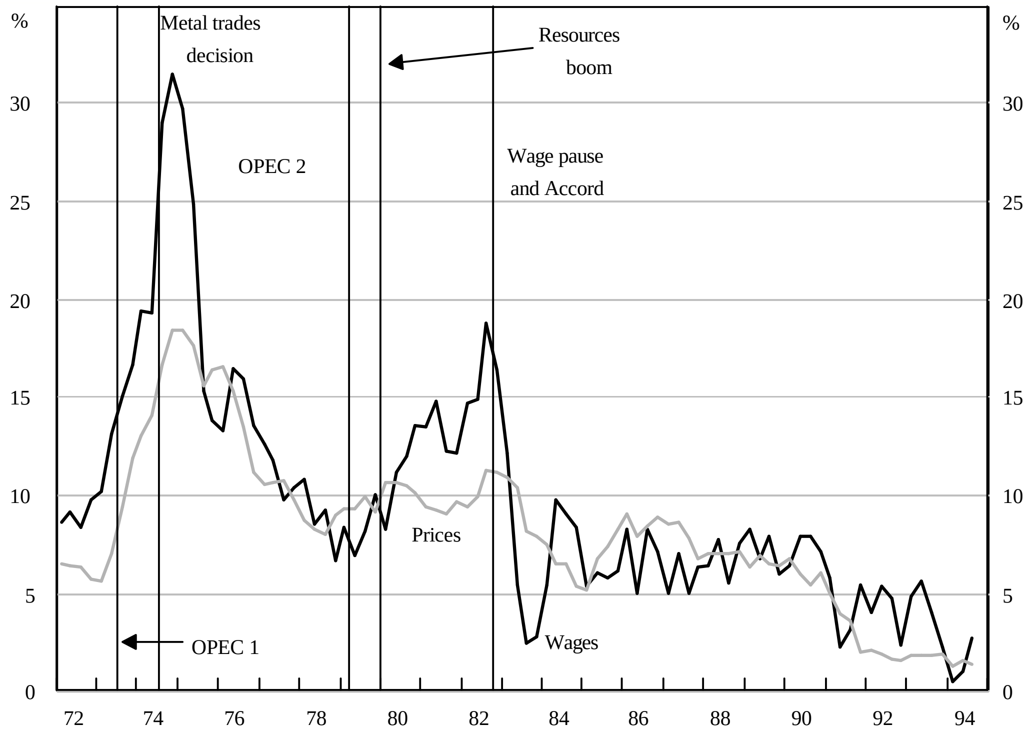
1. INTRODUCTION

Australian wage and price inflation has varied widely over the past 25 years displaying a number of distinct inflationary periods. Figure 1 shows that following low inflation in the early 1970s, inflation rose substantially with the first oil price shock (OPEC 1) and successive wage shocks. Inflation rose again in the late 1970s and early 1980s with the minerals wage boom and second oil price shock (OPEC 2) before moderating through the 1980s. During the recession beginning in 1989/90 inflation declined to rates not seen since the beginning of the period.

Figure 1: Wage and Price Inflation[(a)]

(Four quarter ended)

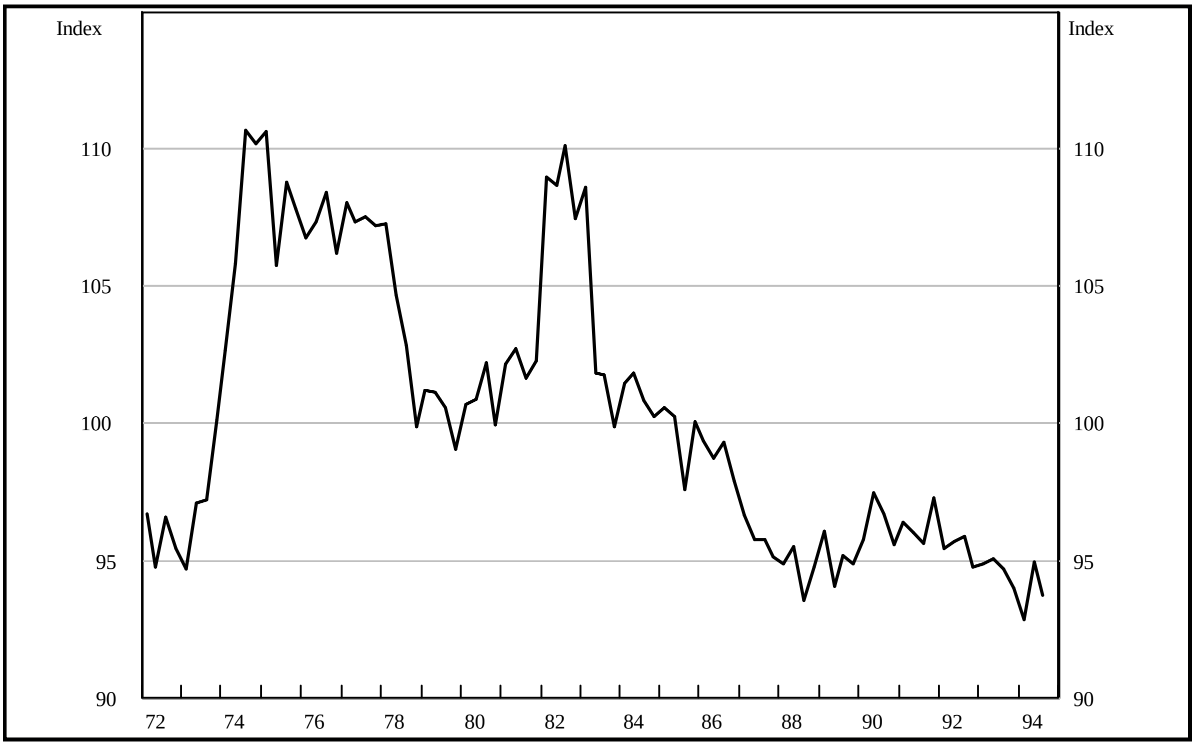


Note: (a) Prices are the consumption deflator and wages are average non-farm wages measured on a national accounts basis.

The evidence of distinctly different inflationary periods is consistent with standard macroeconomic models where economies can experience any value of inflation in the steady state. This implies that in a statistical sense inflation can exhibit changes in its mean between periods. The changing means is the first complication encountered when estimating price and wage equations.

Attempts to estimate price and wage equations for Australia are also complicated by the large and persistent changes in the income shares of firms and labour over the past 25 years. In Figure 2 we see the wage shocks of the early 1970s led to

Figure 2: Labour's Income Share[(a)]



Note: (a) Labour's share of income is measured as non-farm unit labour costs on a national accounts basis divided by the consumption deflator at factor cost. The period average of the index is 100.

large increases in labour's income share. The increased income share persisted well above its pre-shock levels until the late 1980s. If we assume in the long run that labour and firms receive constant income shares then the large change in income shares during the 1970s and 1980s may be characterised in one of two ways. This period may represent very slow price adjustment in response to wage shocks. Alternatively, the persistently high labour income share may reflect a temporary higher equilibrium. Difficulty arises with both interpretations. The former conflicts with casual observation of the speedy adjustment of firms to cost increases while the latter is difficult to support theoretically.

This paper estimates price and wage equations for Australia. In doing so we highlight a number of the methodological and empirical problems associated with their estimation and we offer solutions to the two problems identified above: that of changing income shares and the changing means of wage and price inflation.

The remainder of this paper is in three sections. The next section sets out an imperfect competition model and uses this model to explain the changed relationship between labour's income share and unemployment over the past 25 years. A simple two-equation imperfect competition model is then solved to determine the form of the long-run price equation. This model is used to highlight the identification problems associated with estimating price and wage equations. Section 3 estimates two price and wage systems using quarterly Australian data for the period March 1971 to September 1994. The first system displays a unique rate of inflation in the steady state and, therefore, is inconsistent with standard macroeconomic models. Applying a restriction to the wage equation, the system is re-estimated in a form which avoids this inconsistency. Section 4 concludes.

2. IMPERFECT COMPETITION MODEL OF INFLATION

The large and persistent fluctuations in labour's income share can be explained by adjustment costs and real wage rigidities within a neoclassical model with price-taking firms. In this model the real wage remained high relative to productivity following the 1974 wage shocks, raising labour's income share and increasing unemployment.[1] Eventually the real wage was driven down relative to productivity by the higher unemployment and labour's income share returned to its pre-shock level. The fact that unemployment did not simultaneously return to its pre-shock level implies the story is more complicated. One explanation is that the observed unemployment was voluntary or frictional and there was no involuntary

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1 The result that high real wages increase labour's income share is not straight-forward. High real wages reduce labour input relative to capital and raise the marginal product of labour. Depending on the size of the increase in average productivity, labour's income share may rise or fall. Given that wage shocks appear to raise labour's income share for a considerable time it would appear that the increase in productivity does not match the rise in real wages, at least not in the short to medium term.

unemployment. Casual observation suggests this is incorrect. A second explanation is that labour supply increased during the adjustment and that the existing real wage and labour's income share were still too high compared with their full employment values. While this may be true there seems little obvious market driven pressure to further lower real wages at present.[2]

Modelling the Australian economy using a price taking model is inconsistent with the observation that firms appear to set prices and that labour market outcomes are the result of collective bargaining between labour and firms (or possibly labour, the government and firms). It may be more appropriate, therefore, to model Australian wage and price inflation within an imperfect competition model.

In the 'standard' imperfect competition model firms maximise profits by holding a desired markup of price on wages.[3] This implies they hold a desired real wage. Simultaneously, labour's desired real wage is a decreasing function of the level of unemployment since the bargaining position of labour deteriorates as unemployment rises. In the long run, the *desires* of labour must be consistent with those of firms and this is achieved by changes in the level of unemployment. When the desires of labour and firms are consistent, inflation is stable and the corresponding level of unemployment is termed the non-accelerating inflation rate of unemployment (NAIRU). Away from the NAIRU the desires of firms and labour are not consistent and one or both parties are disappointed with the outcome. In this version of the model, the disappointment is due to the mistaken price expectations of firms and labour which result from unexpected changes in the rate of inflation.

An explanation of the shifts in Australian income shares within an imperfect competition model is set out in Figure 3. It is assumed that labour productivity is constant and equal to 1. It is also assumed that the labour force is fixed so that unemployment U can be shown on the horizontal axis along with employment L.[4]

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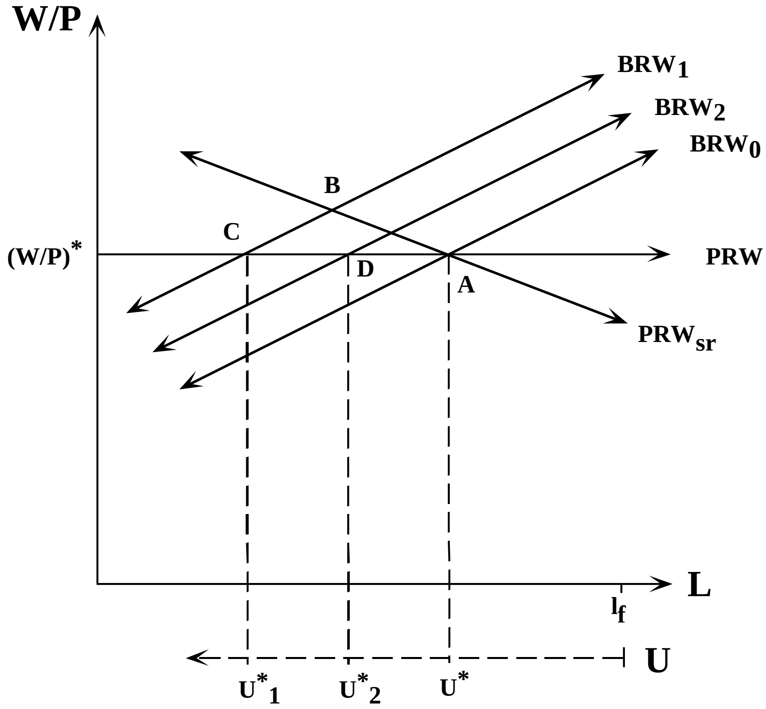
2 For a comprehensive survey on the interrelationship between unemployment, Phillips curves and real wages, see Bean (1994).

3 The 'standard' model is that of the Layard/Nickell tradition. For a detailed exposition, see Layard, Nickell and Jackman (1991) or Carlin and Soskice (1990).

4 These simplifications allow the story to be told in two dimensions on a diagram. With steady state growth in productivity, the curves are simultaneously shifting upwards. Another result of the simplification of constant labour productivity is that increases in the real wage correspond to increases in labour's share of income.

The horizontal product real wage (PRW) curve is the firm's desired real wage. While there is no consensus as to how imperfectly competitive firms adjust prices, there is general agreement that in the long run the markup of price on wages is constant and, therefore, the PRW is constant.[5] The curves marked BRW are the desired real wage which labour bargains for. The BRW curves slope upward to reflect the improved bargaining position of labour as unemployment falls.

Figure 3: The Imperfect Competition Model of the Real Wage



At A the real wage desires of labour and firms are matched by an unemployment rate of U^* and inflation is stable. Wage shocks such as those in the early 1970s would lead to the BRW_0 curve shifting to BRW_1 where each level of unemployment is associated with a higher desired real wage. Due to adjustment costs, the firm's desired short-run PRW curve is downward sloping and the economy initially shifts to B where there is a higher real wage and labour's share of income as well as

5 Normal cost markup and kinked demand curve models suggest the price level is largely insensitive to demand fluctuations. See Hall and Hitch (1939), Sweezy (1939), Layard *et al.* (1991), Carlin and Soskice (1990), Coutts *et al.* (1978), Tobin (1972), Bils (1987).

higher unemployment.[6] In the long run the economy will eventually shift to C with even higher unemployment but with the real wage returning to its long-run level $(W/P)^*$. If before adjustment is complete the economy experiences a wage shock, such as associated with the wage pause and the Accord, the desired real wage curve of labour will shift down to BRW_2 and the economy moves towards D.

In this model the real wage and labour's income share eventually return to their long-run level. The higher level of unemployment reflects the fact that labour's real wage demands are still greater at each level of unemployment than before the initial shock. In the new long run, the real wage demands of labour just balance those of profit maximising firms. For the economy to return to A the demands of labour would have to be reduced further shifting the BRW curve back to BRW_0 which implies a period of adjustment where the real wage is below its long-run level.

In this simple imperfect competition model, short-run deviations in real wages from their long-run level are due to mistaken price expectations and adjustment costs. However, if these are the only causes of the fluctuations in the real wage then the adjustment appears slow. The increase in real wages relative to productivity following the 1974 wage shocks lasted around 12 years and it took nearly two business cycles before firms and labour corrected their mistaken price expectations and the wages share returned to its pre-shock level.

Despite this issue the imperfect competition model of inflation is used to derive a simple markup model of prices for a closed economy.[7] We can write the firm's desired markup as:

$$p - w = b_0 - b_1 U - b_2 \Delta U + b_3 z_p - b_4 \left(p - p^e\right) - b_5 f \qquad (1)$$

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6 In the short run firms may not fully pass on cost increases into prices for a number of reasons including menu costs and contracts. The reasons are loosely collected under the heading of 'adjustment costs'.

7 See Appendix A for a more detailed working of this model.

and labour's desired real wage as:

$$w - p = \gamma_0 - \gamma_1 U - \gamma_2 \Delta U + \gamma_3 z_w - \gamma_4 \left(p - p^e\right) + \gamma_5 f \qquad (2)$$

where p, p^e, w, U and f are prices, expected prices, wages, the unemployment rate and productivity respectively and the lower case variables are in logs. All coefficients in equations (1) and (2) are positive. The variables z_w and z_p capture shifts in the bargaining position of labour and firms respectively.[8] For labour, z_w includes unemployment benefits, tax rates, and measures of labour market skill mismatch. Similarly for firms, z_p includes measures of the firm's competitive environment or monopoly power, indirect taxes, and non-labour input costs including oil prices. The unemployment term in the firm's desired markup equation is simply an output measure using Okun's law. If the desired markup is independent of the level of demand then $b_1 = 0$.

These two equations represent the desired claims of firms and labour on the real output of the economy. By design the *ex post* real wage of labour must always be equivalent to the inverse of the firms markup. We can, therefore, eliminate the real wage from (1) and (2) to provide an expression for the unemployment rate. Alternatively, we can eliminate the unemployment rate to provide an expression for the real wage:

$$w - p = \frac{1}{\gamma_1 + b_1}\left[\begin{array}{l} b_1 \gamma_0 - b_0 \gamma_1 + (b_2 \gamma_1 - b_1 \gamma_2)\Delta U + b_1 \gamma_3 z_w \\ - b_3 \gamma_1 z_p + (b_4 \gamma_1 - b_1 \gamma_4)\left(p - p^e\right) + (b_5 \gamma_1 + b_1 \gamma_5) f \end{array}\right] \qquad (3)$$

Defining the long run by setting $\Delta U = 0$ and $p = p^e$ then the long-run real wage is:

$$(w - p)^* = \frac{1}{\gamma_1 + b_1}\left[b_1 \gamma_0 - b_0 \gamma_1 + b_1 \gamma_3 z_w - b_3 \gamma_1 z_p + (b_5 \gamma_1 + b_1 \gamma_5) f\right] \qquad (4)$$

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8 For a detailed discussion of the theory underlying these shift variables see Layard, Nickell and Jackman (1991) or for a simple taxonomy of explanations see Coulton and Cromb (1994).

Therefore, the long-run real wage and markup are functions of productivity. Furthermore, if firms price independently of demand as in Figure 3 then the real wage in the long run is independent of wage pressures shocks z_w. In contrast, changes in the competitive environment captured by z_p do affect the long-run real wage.

Two issues concerning this model should be raised. First, for labour and firms to maintain stable income shares in the long run and for these shares not to continually rise or fall with trend productivity, the coefficient on productivity in the long-run real wage equation $\left(\dfrac{b_5 g_1 + b_1 g_5}{g_1 + b_1}\right)$ must equal unity. This condition is met if $b_5 = 1$ and $g_5 = 1$.[9] However, if firms price independently of demand and maximise profits (which implies $b_5 = 1$) then this condition will hold irrespective of g_5. In the general case when $b_1 \neq 0$ the impact of productivity on labour's real wage desires is important. Feedback mechanisms through the impact of persistent unemployment on the aspirations of labour could lead the above coefficient on productivity to equal unity in the long run. However, there is no *a priori* reason why this condition should be met in the short run.[10]

The second issue is whether the model as outlined in equations (1) and (2) is identified.[11] If the equations represent the bargaining behaviour of labour and firms then it can be expected that the variables which impact on the bargaining behaviour of one group will automatically impact on the other. For example, union strength will not only affect labour's bargaining position but also how firms conduct negotiations with labour. In this case z_w and z_p enter both the price and wage equations and the model is not identified.

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9 This is the equivalent to assuming linear homogeneity between prices and unit labour costs.

10 The basing of labour's wage claims on past rather than present productivity is sometimes referred to as real wage persistence. Many studies have highlighted the persistently high growth in labour's desired real wages as a major explanation of European unemployment following the slowdown in productivity growth after OPEC 1. See Bruno and Sachs (1985), Grubb, Jackman and Layard (1983).

11 The model is not identified if adding a multiple of one equation to the other leaves the form of the equation unchanged. A number of authors, including Manning (1994), have raised doubts as to whether the imperfect competition model is identified.

3. ESTIMATION OF THE PRICE AND WAGE EQUATIONS

3.1 The Long-Run Price Equation

Following from the imperfect competition model outlined above, we propose in our price and wage model that firms desire a constant ratio of price on unit costs in the long run with short-run deviations in the ratio the result of shocks and the economic cycle. Assuming that demand does not impact on prices in the long run (i.e. $b_1 = 0$) and the competitive environment is unchanged then the long-run real wage equation (4) can be interpreted as a simple markup model where prices P are a constant multiple Q of unit costs. For an open economy, these costs include import prices and the long-run price equation can be written as:

$$P = Q\left(\frac{W}{\Phi}\right)^{b} P_M^{1-b} \tag{5}$$

where W/Φ is unit labour costs with W the average compensation per employee, Φ labour productivity and P_M is the price per unit of imports. The coefficients b and $1 - b$ are the long-run price elasticities with respect to unit labour costs and import prices respectively. Long-run homogeneity is imposed with these coefficients summing to unity.

Before we estimate price and wage equations we need to analyse the impact of import prices on the domestic price level. In addition, two issues raised above need be addressed: how to model the large and persistent changes in income shares which have occurred over the past 25 years; and whether or not separate price and wage equations exist. Each of these issues is dealt with in turn before we proceed to estimate the price and wage equations.

3.1.1 The impact of import prices on the domestic price level

Defining the markup as the ratio of price to unit labour costs (equivalent to the inverse of labour’s income share), equation (5) can be rearranged to show that the markup is dependent in the long run on the relative price of imports and unit labour costs $\left(P_M \middle/ \frac{W}{\Phi} \right)$ which we loosely characterise as the real exchange rate (RER):[12]

$$Markup = \frac{P\Phi}{W} = Q\,(RER)^{1-b} \tag{6}$$

Permanent movements in the real exchange rate will result in a shift in the markup and, equivalently, in a shift in labour's long-run income share. Factor shares of income are, therefore, not necessarily stationary (or constant in the long run) but depend on the behaviour of the real exchange rate.

Figure 4: The 'Real Exchange Rate'

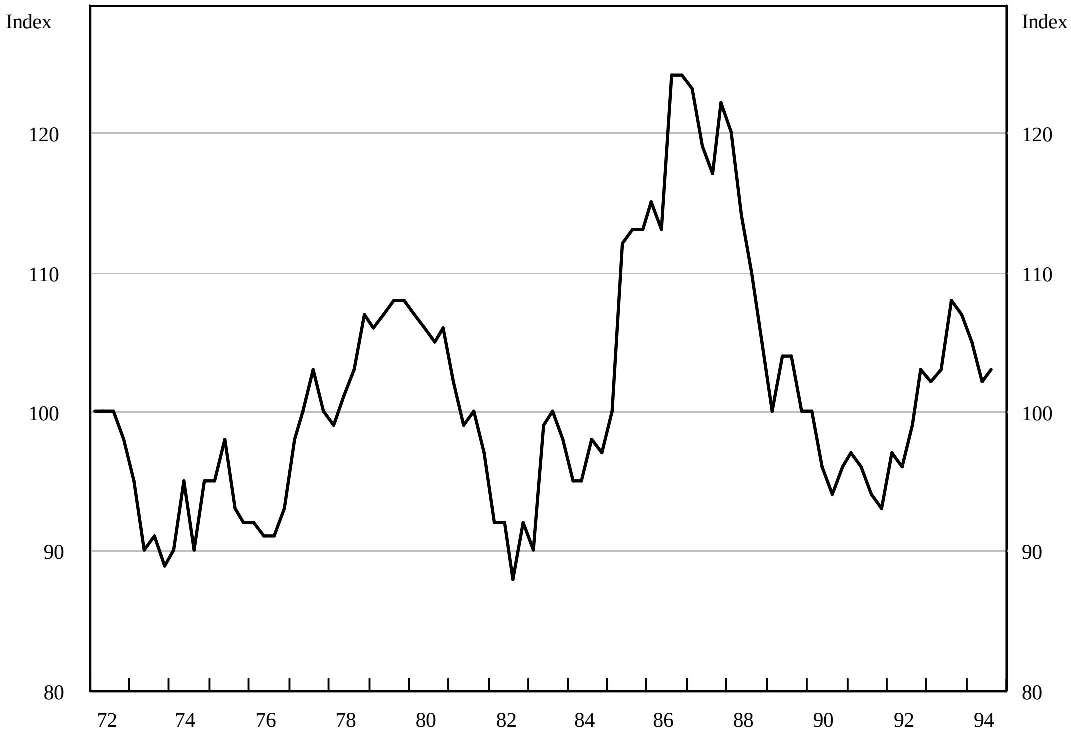

Figure 4 illustrates the real exchange rate as defined above where a rise represents a real depreciation. It is clear that the exchange rate experiences prolonged deviations from its mean level exhibiting cycles of around ten years. Yet it also appears that it

12 This definition of the real exchange rate may not be as 'loose' as first thought. It is similar to the measure of the relative price of traded and non-traded goods used by Swan (1963) in his classic article.

reverts to its mean in the long run.[13] This suggests that shocks to the real exchange rate should have no *permanent* effect on the markup and labour's share of income but can exert an important influence on income shares and prices for an extended period of time. If the defined real exchange rate is indeed stationary, there must exist a second long-run relationship between import prices and unit labour costs. This relationship is not formally modelled in this paper.

3.1.2 Modelling Australia’s changing income shares

In the ten years following the wage shocks in the early 1970s labour’s income share was on average around $6^1/_2$ per cent higher than during the four years prior to the wage shocks (see Figure 2). With the wage restraint associated with the wages pause and the Accord, labour's income share is now not substantially different from its pre-shock level.

This persistent movement in labour's income share suggests long cycles in the relationship between real wages and productivity though labour's income share appears mean reverting over the sample considered.[14] However, over shorter samples, the mean reverting (or stationary) characteristics of the series are not revealed and the long-run relationship which is identified may be erroneous. By choosing the starting period for the estimation prior to the 1974 wage shocks, labour’s income share is mean reverting in a statistical sense and this allows a ‘correct’ characterisation of the long run. While a number of characterisations of the persistent movement in income shares are possible we have chosen the ‘slow adjustment to shocks’ option. In addition, although the relationship between real wages and productivity was subject to a series of potential shocks, the econometric results which follow suggest that OPEC 1 in 1973 and the metal trades decision in 1974 are the only shocks necessary for understanding the observed disequilibrium in income shares.

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13 Although the graphical evidence of stationarity of the real exchange rate is apparent in Figure 4 the statistical evidence is less clear. The augmented Dickey-Fuller (ADF) (Said and Dickey (1984)) and the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests provide conflicting results. See Appendix B. While using a different measure of the real exchange rate, Gruen and Shuetrim (1994) support the finding of stationarity.

14 The KPSS test and graphical analysis support the view that labour’s income share is stationary. However, the ADF test contradicts this result. See Appendix B and Figure 2.

3.1.3 Identification and the imperfect competition model

Whether or not the wage and price equations of the imperfect competition model are identified was raised in Section 2. In order to estimate separate wage and price equations, variables are required which only appear in one of these equations. Unfortunately, these variables are difficult to discover. Possible candidates, such as unemployment benefits, union strength, and strike activity are themselves endogenous variables and in a bargaining model will impact directly on the behaviour of both labour and firms.

Manning (1994) considers the identification problem and points out that the usual practice is to add dynamics to the model and omit one or more variables (or lags thereof) in one of the equations. This will *technically* identify the equations so that the system can be estimated but fails to identify the economically important variables which separate the demand and supply curves in the wage-price decision. However, we find that it is prices and not wages which respond to deviations from the long-run markup and this identifies the wage and price equations in an important way.[15] The estimated model describes a world where firms respond to disequilibria from the long-run markup by adjusting their price (possibly because they set prices after wage costs are known) and labour responds to past inflation and labour market conditions.[16] We believe that this model is a reasonable representation of the Australian economy.

3.2 The Price and Wage System

The estimation of the price and wage system is based on a vector error correction version of equation (6). The price equation is shown as equation (7) and incorporates inflationary pressures from petrol prices and the business cycle. Also

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15 The impact of disequilibrium from the long-run markup on prices and wages was investigated within the Johansen framework. It was found that the speed of adjustment coefficient was significant in the price equation yet insignificantly different from zero in the wage equation. See Johansen (1991).

16 This result is not always found. Franz and Gordon (1993) find disequilibria in the markup impacts on price but not wage adjustment for the US. In contrast, Franz and Gordon (1993) using German data and Cozier (1991) using Canadian data find the reverse relationship exists. Mehra (1993) using US data finds conflicting results depending on whether prices are measured by the GDP deflator or CPI.

included is the real exchange rate which is considered exogenous for the purpose of estimation.[17] As noted earlier, the inclusion of a real exchange rate variable implies a long-run relationship between prices, unit labour costs and import prices.

$$\begin{aligned}\Delta p_t^{fc} = {} & g_0 + \sum f_{1,i} \Delta p_{t-1}^{fc} + \sum f_{2,i} \Delta ulc_{t-i} + f_3 \hat{y}_{t-1} + \sum f_{4,i} \Delta \hat{y}_{t-i} \\ & + \sum f_{5,i} \Delta p_{mt-i} + \sum f_{6,i} \Delta pet_{t-i} + g_1 rer_{t-1} + g_2 p_{t-1}^{fc} + g_3 ulc_{t-1}\end{aligned} \tag{7}$$

where:

- p^{fc} private consumption deflator at factor cost;[18]
- ulc Treasury's national accounts measure of non-farm unit labour costs;
- $\hat{y}$ output gap measured as the log of the ratio of actual to potential non-farm output;
- rer real exchange rate;
- p_m import price deflator; and
- pet petrol prices.

The output gap measure is constructed using potential output as used in the 1994 Reserve Bank Annual Report (Wilkinson 1994) and is defined as the ratio of actual to potential output with an index value of 100 representing full capacity.

The wage equation is shown in equation (8) and relates changes in wages to past changes in both wages and prices as well as labour market pressures with the latter captured by the unemployment rate and strikes.[19, 20]

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17 The price equation is similar to that estimated by de Brouwer and Ericsson (1995) but excludes the level of petrol prices in the long-run relationship.

18 The indirect tax rate was calculated as non-farm indirect taxes plus subsidies as a proportion of non-farm GDP at factor cost. To provide a price series at factor cost the consumption deflator was divided by 1 plus the indirect tax rate.

$$\Delta w_t = l_0 + \sum j_{1,i}\Delta w_{t-i} + \sum j_{2,i}\Delta p_{t-i} + j_3 IU_{t-1} + \sum j_{4,i}\Delta IU_{t-i} + \sum j_{5,i} stks_{t-i} + l_1 rer_{t-1} + l_2 p_{t-1} + l_3 ulc_{t-1} \tag{8}$$

where:

- w average non-farm wages measured on a national accounts basis;
- p private consumption deflator at market prices;
- IU inside unemployment defined as the unemployed with at least 2 weeks of full time work in the past 2 years taken as a percentage of employment plus insider unemployment; and
- $stks$ strikes measured as working days lost as a proportion of employed full and part-time persons.

The standard unemployment rate is a poor measure of labour market pressure because it has suffered structural shifts since the early 1970s. Inside unemployment is a better measure since it does not exhibit these structural shifts and can simply be interpreted as those actively seeking employment with up to date employment skills. Unfortunately, this series begins in March 1979 while the wage and price equations should be estimated from before the wage shocks in the early 1970s to ensure that income shares are stationary. The unemployment gap ratio, however, can be produced for the entire estimation period but has no clear economic interpretation.[21]

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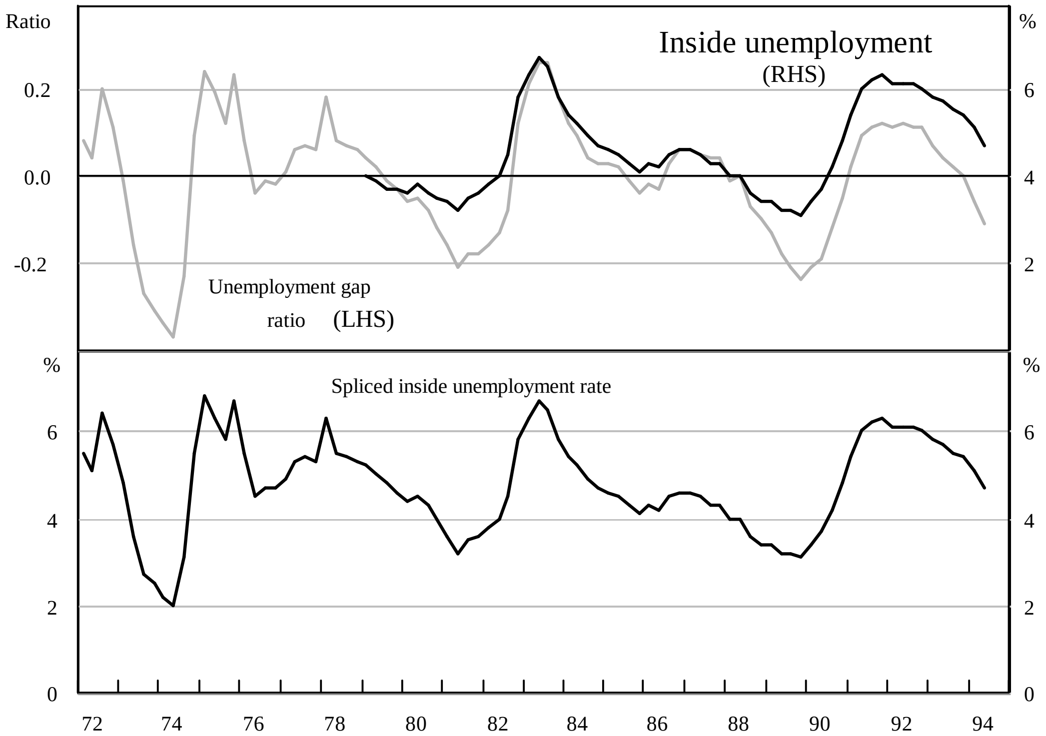
19 Unemployment benefits were also investigated as a source of inflationary pressure. Unfortunately this series does not exist prior to December 1976. The variable was included in a number of forms to reflect its possible role as a measure of the opportunity cost of work or leisure but remained insignificant over the shorter sample from December 1976.

20 For a survey of work on Australian wage equations see Lewis and MacDonald (1993).

21 The unemployment gap ratio is defined as the difference (or gap) between actual unemployment and unemployment ‘smoothed’ by a Hodrick Prescott filter divided by smoothed unemployment. The scaling of the unemployment gap by smoothed unemployment was thought necessary as the structural shifts impact on the unemployment gap as well as the level of unemployment. This can easily be observed during the three recessions in the sample. These recessions are of roughly similar size but the unemployment gap in the 1974/75

Both these series are presented in the top panel of Figure 5. Over the most recent period, the unemployment gap ratio closely tracks the inside unemployment rate, and can, therefore, be considered a proxy for inside unemployment. This information is utilised to construct an 'inside unemployment' or 'labour market pressure' series for the entire sample period.[22] This new labour market pressure variable is illustrated in the bottom panel of Figure 5.

Figure 5: Measures of Labour Market Pressure



Prior to estimation, the time series properties of the data were considered using the augmented Dickey-Fuller tests along with the test proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992) and the results are reported in Appendix B. These

recession is very small in absolute terms compared with the following two recessions. It appears, therefore, that the unemployment gap not only depends on the business cycle but is also related to the level of unemployment.

22 The spliced inside unemployment rate was obtained by first estimating the relationship between inside unemployment and the unemployment gap ratio for the period from 1979:Q1 to 1994:Q2 as a simple distributed lag model. Back-casts of inside unemployment are then produced for the period prior to 1981:Q2 and finally this new series is spliced with the actual inside unemployment data.

tests generally suggest that, for the sample considered, the level of prices, wages and unit labour costs contain unit roots and the remaining exogenous variables are best characterised as stationary.

From equation (6) it is expected that prices and unit labour costs will move one-for-one in the long run.[23] The long-run relationship between prices and unit labour costs was investigated using the Johansen (1988), Phillips and Hansen (1990) and unrestricted error correction techniques. In all cases it was found that the normalised long-run coefficient on unit labour costs was insignificantly different from unity and that prices and unit labour costs are cointegrated. These results, therefore, strongly support the view that the markup is stationary over the sample and that there is full pass-through of unit labour costs into prices in the long run.

A theoretically correct systems approach to estimating the price and wage equations would allow for the non-stationary characteristics of the data. The Johansen (1988) vector error correction estimation is one such approach. This procedure however has a number of well known drawbacks. In particular, the estimation requires the same variables to enter each regression of the system.

An alternative approach which overcomes some of the drawbacks is to estimate the wage and price system using the seemingly unrelated regressions (SUR) technique. Because the statistical properties of a SUR with non-stationary variables are unknown, the markup and the real exchange rate were used in the SUR estimation as they are stationary. Comparison of the results from a system estimated by the Johansen technique with one estimated using the SUR technique indicates that the SUR technique does not provide economically different coefficients but generates an improved fit.

The results of the SUR estimation of the wage and price system are reported in the first two columns of Table 1 where insignificant variables were excluded after joint and individual tests of their significance. In order to allow for the expected very fast pass through of cost increases into prices, the contemporaneous change in unit

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23 This result is expected given that the real exchange rate is stationary and enters as a separate and exogenous variable. An alternative modelling strategy is to introduce import prices as a separate variable in which case we expect the sum of the coefficients on unit labour costs and import prices to be unity.

labour costs is included in the inflation equation and the system is estimated using three stage least squares.

Since the markup does not enter the wage equation, the estimates suggest that prices, and not wages, respond to a disequilibrium in the markup.[24] The coefficient on the markup in Table 1 is significant and represents the speed of adjustment to deviations from the long-run markup. It is almost 14% per quarter and this implies that half of the adjustment to the long run is achieved in the first 4 to 5 quarters.[25]

The real exchange rate has a significant impact on inflation. Depreciations in the real exchange rate (i.e. rises in rer) lead to an increase in the rate of inflation but a fall in the real wage relative to productivity. Changes in the real exchange rate often persist for a number of years (see Figure 4) and over this time have had a sizeable effect on inflation.[26] While this is clearly relevant to the setting of policy, the impact eventually disappears as the real exchange rate returns to its long-run value.

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24 The null hypothesis that the speed of adjustment coefficient in the wage equation is zero was tested within the Johansen framework. The likelihood ratio test statistic is $c_1^2 = 0.56$ $(\text{Prob. value} = 0.46)$ and the null hypothesis is not rejected at the 5% level of significance. This suggests that if the price equation described the full set of the parameters of interest, wages could be described as weakly exogenous and a single equation approach pursued for modelling inflation. Since it remains the objective of this paper to estimate both wage and price equations, a systems approach was preferred.

25 The median lag is calculated as $-\log 2 / \log(1+g) = 4.7$ where $g = -0.137$ is the speed of adjustment coefficient.

26 An equivalent representation of the long-run relationship relates prices to unit labour costs and import prices as in equation (5). Rearranging the estimates in Table 1, the implied long run in this form is $\text{price} = 0.76\ \text{unit labour costs} + 0.24\ \text{import prices}$. This implies that a 10 per cent increase in import prices will eventually increase the price level by 2.4 per cent given the level of unit labour costs. These long-run coefficients may be interpreted as the response of prices to changes in costs if the real exchange rate were not to adjust back to its pre-shock level.

Table 1: Prices and Wages Model (1972:Q2-1994:Q3)

	Unrestricted		Restricted(a)	
Dependent variable	$\Delta\ prices_t^{(b)}$	$\Delta\ wages_t$	$\Delta\ prices_t^{(b)}$	$\Delta\ wages_t$
Constant	0.322**	0.006*	0.318**	0.002
	(0.058)	(0.003)	(0.058)	(0.001)
June & Sept 1973 dummy	0.016**		0.015**	
	(0.005)		(0.005)	
September 1974 dummy		0.069**		0.065**
		(0.012)		(0.012)
$\Delta\ prices_{t-1}^{(b)}$	-0.293*	0.821**	-0.318**	1.000
	(0.116)	(0.124)	(0.115)	
$\Delta\ unit\ labour\ costs_t$	0.424**		0.421**	
	(0.061)		(0.061)	
$\Delta\ unit\ labour\ costs_{t-1}$	0.140**		0.140**	
	(0.040)		(0.040)	
$\Delta\ petrol\ prices_t$	0.034**		0.034**	
	(0.013)		(0.013)	
Δ inside unemployment $_{t-1}$		- 0.556*		- 0.610**
		(0.224)		(0.221)
strikes$_{t-1}^{(c)}$		0.038*		0.034
		(0.019)		(0.018)
$markup_{t-1}$	-0.137**		-0.135**	
	(0.022)		(0.021)	
$real\ exchange\ rate_{t-1}$	0.033**		0.032**	
	(0.010)		(0.010)	
R^2	0.61	0.56	0.62	0.55
Standard error of eqn.	0.75%	1.23%	0.74%	1.25%
DW	1.96	1.99	1.93	2.01

Notes: (a) The null hypothesis that the coefficient on lagged prices in the wage equation is insignificantly different from one is not rejected at the 5% level of significance. $\left[c_1 = 2.10 \{\text{Prob. value} = 0.15\}\right]$

(b) Prices are measured at factor cost in the price equation and at market prices in the wage equation.

(c) Strikes are adjusted for a shift in the mean in the March quarter, 1983.

The standard errors are in brackets and * (**) denote significance at the 5% (1%) level.

Variables in logs are in italics.

Two measures of capacity utilisation are used in the price and wage system. The first is the potential output gap which is found not to significantly explain price inflation conditional on unit labour costs.[27] This result conforms with the general view that firms do not 'price to demand' and the markup is independent of the business cycle given the level of costs.[28] The second measure is inside unemployment. Interestingly, it is changes and not the level of inside unemployment which significantly impact on wage inflation even though this measure of labour market conditions already incorporates some form of hysteresis in the labour market by excluding the long-term unemployed from affecting the wage outcome.[29] In addition, the strikes variable is significant in the wage equation with the expected positive sign.

A number of dummies were incorporated in the initial estimation to capture the sometimes erratic nature of the wage process and the possible non-linear response of firms to surges in wages and costs. Somewhat surprisingly, dummies to capture the mining wage boom, OPEC 2, the wage pause and the Accord were all insignificant. Two dummies remain in the final specification and capture the turbulence of the years surrounding OPEC 1. In the price equation the June and September 1973 dummy has a positive impact on prices. This implies that prices rose by more than the model would otherwise predict. However, even given the increased price response of firms, the price rises were not sufficient to fully absorb the cost increases in the period and the markup fell.

The second dummy appears in the wage equation and coincides with the timing of the Metal Trades decision in September 1974. This dummy does not appear in the price equation which suggests that the model successfully predicts firms' price responses to the wage shock in that period.

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27 Detrended private final demand was also investigated as a measure of excess demand and found not to impact significantly on price inflation. This result is in contrast with that of de Brouwer and Ericsson (1995) where they find that detrended final demand impacts on inflation. However, their model does not include a wage equation and is over a shorter sample.

28 Layard, Nickell and Jackman (1991) conclude after surveying the mixed empirical findings on the impact of demand on prices that prices are relatively unresponsive to demand. See also the references cited in footnote 5.

29 In standard models, hysteresis is identified by a significant coefficient on changes in total unemployment.

3.3 Steady State Inflation

It is important that the price and wage system allows a range of possible inflation rates in the steady state. This property of the system can be achieved in a number of ways. Consider the following simplified version of our estimated price and wage system:

$$\Delta p_t = \Gamma_p + d_1 \Delta w_t + d_2 p_{t-1} \tag{9}$$

$$\Delta w_t = \Gamma_w + l_1 \Delta p_{t-1} \tag{10}$$

where Γ_p and Γ_w are the constants and the other exogenous variables from the price and wage equations respectively. Long-run linear homogeneity between prices and unit labour costs is imposed in equation (9) through the markup where $p = p - ulc$.

The steady state properties of the model depend on the short-run coefficients d_1 and l_1 on the price and wage inflation terms in the model. Using this simplified model we can distinguish between homogeneity in price and wage *levels* and homogeneity in price and wage *inflation rates*. The former is imposed in the model due to the long-run linear homogeneity condition. In this case, the markup is unaffected by a doubling of the level of prices and unit labour costs leaving steady state inflation unchanged and no real effects. Homogeneity in price and wage inflation rates, which we will refer to as short-run homogeneity, exists if $d_1 = 1$ and $l_1 = 1$ in the model. Consequently, if inflation is doubled in the steady state then the markup is unaffected and again there are no real effects.

The system displays distinctly different steady state properties depending on whether d_1 and/or l_1 are equal to unity. Three relevant combinations of these coefficients are considered in Table 2. When $d_1 = 1$ and $l_1 = 1$, short-run homogeneity is present along with the imposed long-run homogeneity and the system displays the properties of a standard macroeconomic model.[30]

The second combination corresponds to our unrestricted system estimated above where we find both $d_1 < 1$ and $l_1 < 1$. In this case, the system displays the

30 This follows in any standard model which incorporates a vertical long-run Phillips curve.

undesirable property of a unique rate of inflation in the steady state which conflicts with standard theory.[31] This undesirable property disappears in the third combination of the coefficients when $d_1 < 1$ and $l_1 = 1$. In the empirical analysis of the unrestricted system, the restriction that $d_1 = 1$ is comprehensively rejected in the price equation yet $l_1 = 1$ is accepted for the wage equation. The price and wage system was, therefore, re-estimated having imposed a coefficient of unity on lagged inflation in the wage equation. Estimation results of this restricted model are reported in columns 3 and 4 of Table 1. As may be expected there is little impact on the coefficients of the price and wage equations providing some indication of the ready acceptance of the restriction.

Table 2: Short & Long-Run Homogeneity and the Steady State

	(1) Standard macroeconomic model	**(2) Unrestricted model**	**(3) Restricted model**
Price equation	$d_1 = 1$	$d_1 < 1$	$d_1 < 1$
Wage equation	$l_1 = 1$	$l_1 < 1$	$l_1 = 1$
Long-run homogeneity	Yes	Yes	Yes
Short-run homogeneity	Yes	No	No
Steady state inflation	Non-unique	Unique	Non-unique
Relationship between steady state inflation and the markup	No relationship and the markup is unique	Unique markup and rate of inflation	Negative correlation

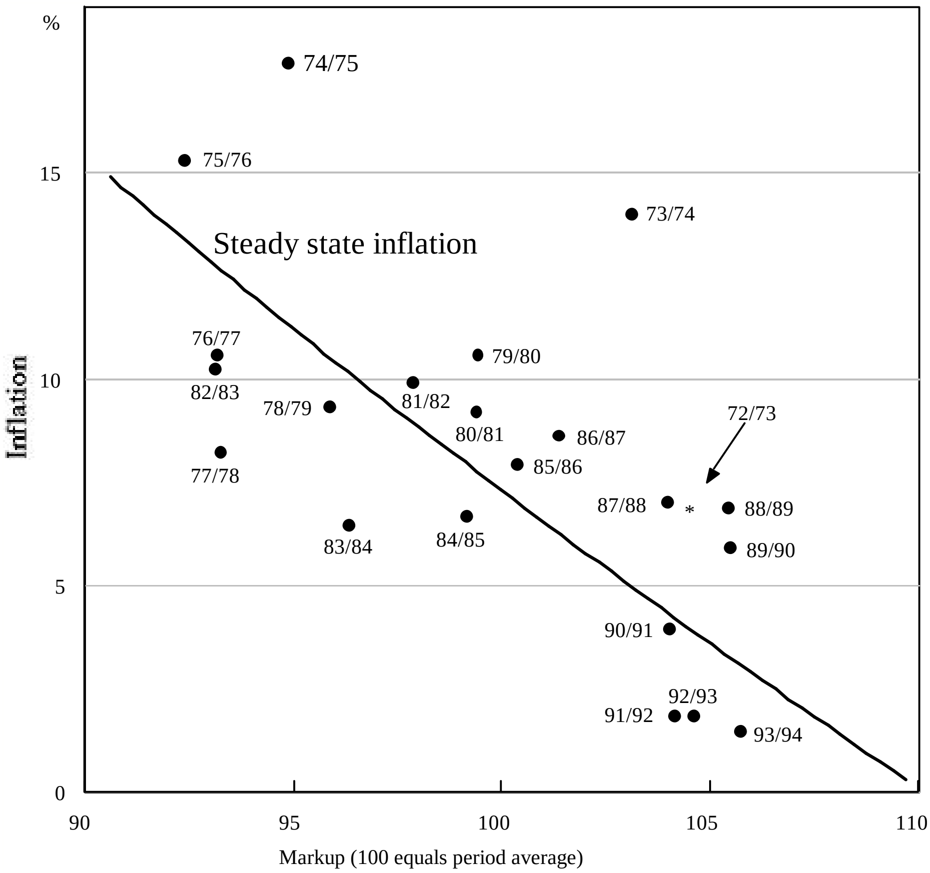
The restricted model now displays a range of possible inflation rates in the steady state. However, the model differs in an important way from the standard model in that the markup and inflation are negatively correlated in the steady state (see column 3 of Table 2). This result follows because $d_1 < 1$ in the price equation.

31 Because the unrestricted system has a unique inflation rate in the steady state, the markup is also unique.

The nature of long-run linear homogeneity is subtly changed in the restricted model. In the standard macroeconomic model, increases in unit labour costs are fully reflected in higher prices in the long run irrespective of the rate of steady state inflation. This is in contrast with the restricted model where increases in unit labour costs are fully reflected in higher prices *only if there is no change in steady state inflation*. As the markup and inflation are negatively correlated in the steady state, increases in unit labour costs which are associated with a shift in steady state inflation imply the markup has also changed and, therefore, the cost increase is not fully passed through into prices.

Inflation in the restricted model consistent with a given markup and with all the exogenous variables at their steady state values is illustrated as the solid line in Figure 6. Also shown as a scatter plot are the actual combinations of annual inflation and the markup. The negative correlation between inflation and the markup in the steady state is apparent in the estimated restricted model (the solid

Figure 6: Inflation and the Markup(a)



Note: (a) Inflation is measured as the sum of the quarterly inflation rates. Similarly, the markup is the average markup on a quarterly basis over each financial year.

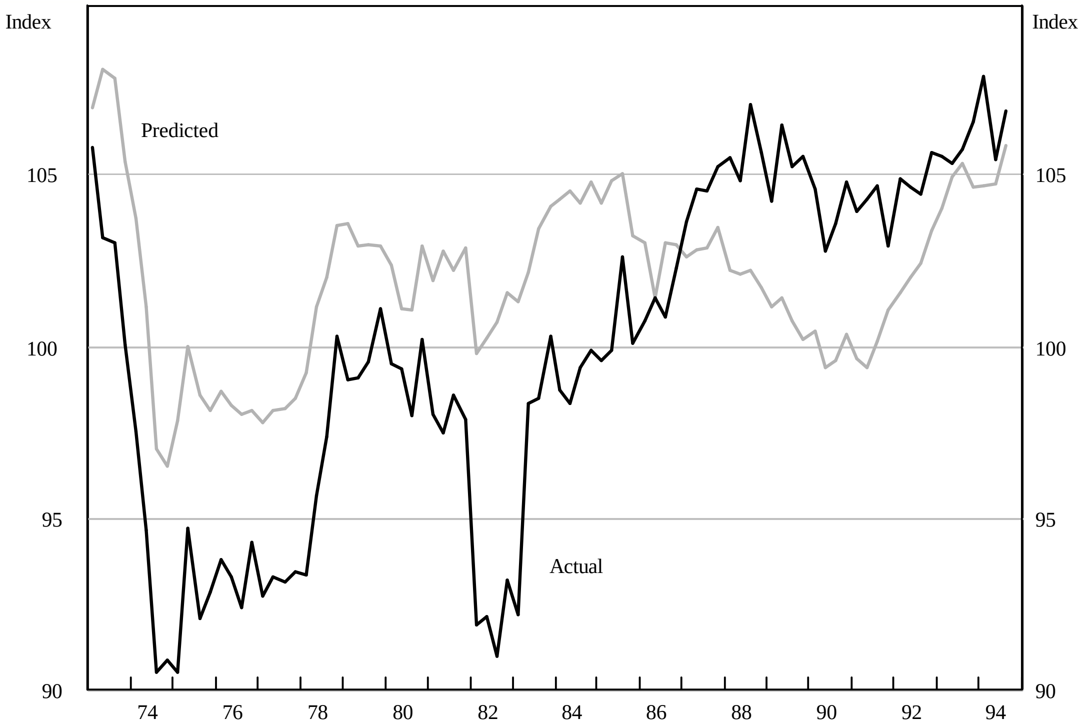
line) and in the data. This steady state relationship appears important. It is estimated that a 1 percentage point increase in annual steady state inflation is associated with a reduction in the markup by $1^1/_3$ percentage points.

The years 1973/74 and 1974/75 are two obvious outliers on Figure 6 and coincide with the wage shocks at the time of OPEC 1. By following the annual observations in chronological order in the figure we see the persistence of the shocks to the markup. Starting with the 1972/73 observation, the real wage shocks saw the markup fall and inflation rise dramatically. The markup slowly recovers and inflation slightly declines after 1975/76 until real wages again rise substantially relative to productivity in the early 1980s. The wage pause and Accord complete the process begun with OPEC 1 and the markup finally recovers to around its initial level in the late 1980s.

While the negative correlation between inflation and the markup conflicts with standard macroeconomic models, two explanations are offered in the literature. Bénabou (1992) explains the negative correlation through a reverse chain of causality, arguing that higher inflation increases search in customer markets which leads to greater competition and this results in a lower markup. Bénabou supports this view by showing that expected and unexpected inflation significantly reduce the markup using United States retail sector data. Alternatively, Russell (1994, 1995) explains the reduced markup when inflation increases as the cost that non-colluding price setting firms pay to avoid the repercussions of poor price coordination as they respond to changes in demand and costs. Russell demonstrates that the negative correlation in the steady state between inflation and the markup is also present in the data for the United States, the United Kingdom, Japan and Germany.

In Figure 6 the dispersion of the data points around the steady state inflation line is due to the lags in the data, the impact of the exogenous variables on inflation and shocks to the system. The exogenous variables also impact on the markup due to the different timing and response of wages and prices to these variables. As mentioned above, one of the difficulties encountered when estimating price and wage inflation is the sustained shifts in income shares over the sample. It is of interest, therefore, to see whether the system can accurately predict these shifts in income share. More importantly, as inflation and the markup are negatively correlated in the steady state then if the model fails to explain the observed range in the markup it also fails to explain the observed range in steady state inflation. To this end, Figure 7 shows the actual markup and the markup predicted by the restricted price and wage system using a dynamic forecast.[32] While the predicted markup appears to forecast movements in the markup fairly well, there are periods when there are discrete shifts in the level of the actual markup which are not captured by the model. This is made evident by the relatively low correlation between the predicted and actual *level* of the markup (0.57) compared with the correlation between the *changes* in these series (0.62). Particularly obvious is the range of the predicted markup is considerably less than that of the actual markup. It appears, therefore, that there are periods when some non-model influence impacts significantly on the level of the markup. However, the model does well at explaining movements in the markup given these unexplained shifts in the level of the markup.

Figure 7: The Predicted and Actual Markup



3.4 The Impact of Inside Unemployment, the Real Exchange Rate and Strikes on Inflation

For the estimated system, the exogenous variables impact on inflation directly and indirectly by causing the markup to vary. The lower three panels of Figure 8 show

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32 The dynamic forecast was calculated using the exogenous variables and the forecasted endogenous variables.

the estimated contributions to inflation of changes in inside unemployment, the real exchange rate and strikes for a given markup.[33] We see that changes in inside unemployment can explain up to $1^1/_2$ percentage points in annual inflation in short lived episodes over the sample. In contrast the impact of the real exchange rate on inflation is more persistent and powerful. For example, as a result of the depreciation in the real exchange rate in the mid 1980s, it is estimated that this led to inflation being around 3 percentage points higher than its steady state level in September 1987. The bottom panel shows the dramatic reduction the impact strikes have had on inflation since the onset of the wages pause and Accord.

4. CONCLUSIONS

This paper set out to estimate a price and wage system for Australia. The results suggest the Australian economy can be characterised as one where firms are trying to achieve their desired long run markup or income share while labour are primarily concerned with maintaining their real wage.

In estimating the system we addressed the problems of the substantial and persistent changes in income shares and the changing means in the inflation series. The first problem was overcome by starting the estimation period before the wage shocks in the early 1970s. With such a long run of data, it was necessary to construct a measure of labour market pressures that did not exhibit structural shifts during the sample. To achieve this the inside unemployment series was extended prior to its inception by producing a predicted value of inside

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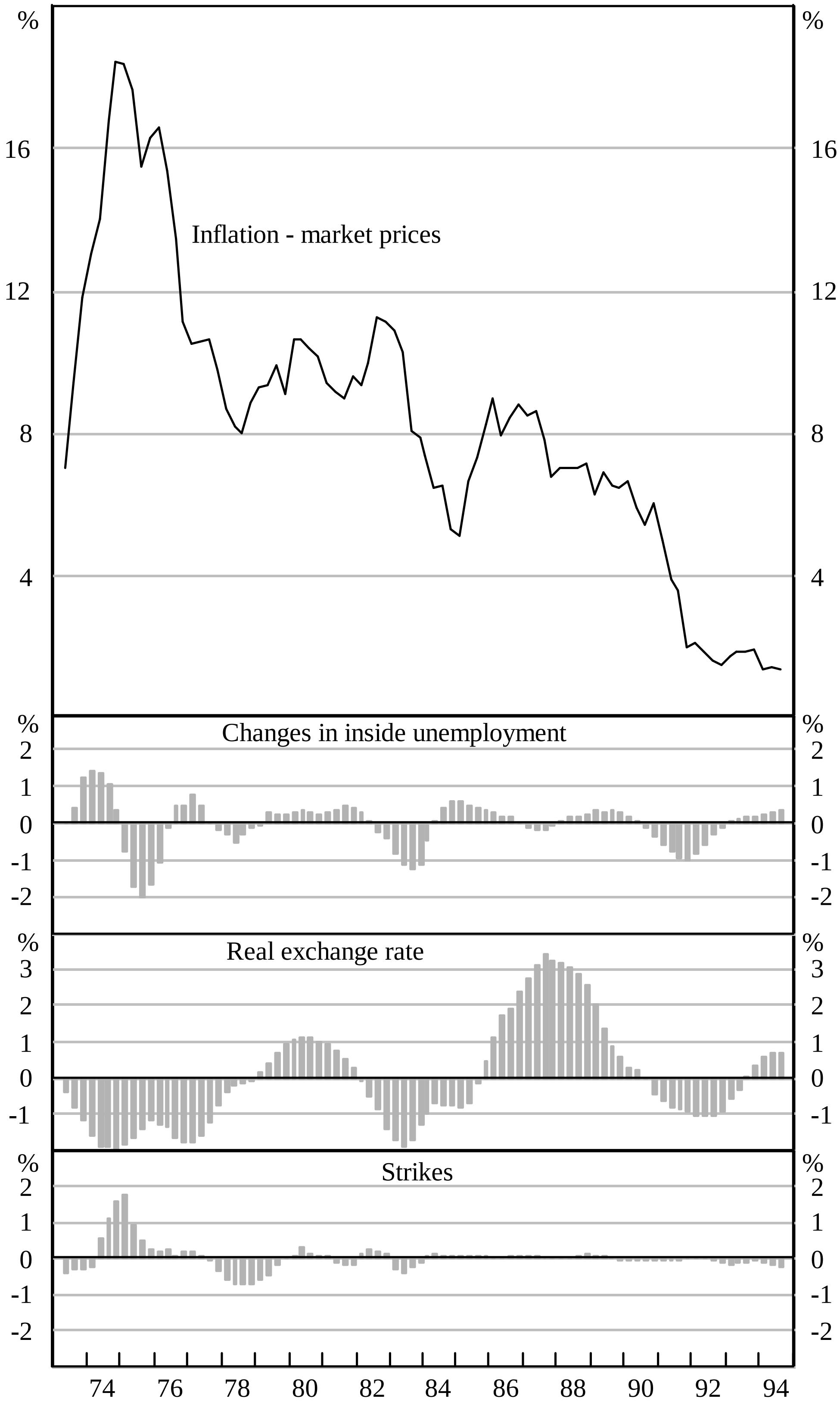
[33] The lower three panels of Figure 8 show the contributions to the *change* in inflation rather than the level of inflation. The unexplained component of the change in inflation is conceptually due to unexplained shocks to the markup.

Figure 8: Contribution of the Exogenous Variables to Inflation
(Four quarter ended)



unemployment based on the unemployment gap ratio. The second problem was addressed by imposing a restriction on the wage equation. This allowed steady state inflation in the estimated model to change over the sample. However, because a similar restriction did not hold in the price equation, we find inflation and the markup are negatively correlated in the steady state.

APPENDIX A: IMPERFECT COMPETITION MODEL OF INFLATION

This appendix solves a simple imperfect competition model of inflation of the Layard/Nickell tradition.

Price Equation

$$p - w = b_0 - b_1 U - b_2 \Delta U + b_3 z_p - b_4 \left(p - p^e\right) - b_5 f \qquad \text{(A1)}$$

Wage Equation

$$w - p = g_0 - g_1 U - g_2 \Delta U + g_3 z_w - g_4 \left(p - p^e\right) + g_5 f \qquad \text{(A2)}$$

Where p, w, U, p^e and f are the price level, average wage, unemployment rate, expected price level and productivity with lower case variables in logs. The shift variables for the wage and price equations are z_p and z_w respectively.

Eliminate the real wage from (A1) and (A2):

$$U = \frac{1}{g_1 + b_1}\begin{bmatrix} b_0 + g_0 - (b_2 + g_2)\Delta U + g_3 z_w + b_3 z_p \\ \\ -(b_4 + g_4)\left(p - p^e\right) - \left(b_5 - g_5\right) f \end{bmatrix} \qquad \text{(A3)}$$

Long-run unemployment rate or NAIRU when $\Delta U = 0$ and $p - p^e = 0$:

$$U^* = \frac{1}{g_1 + b_1}\left[b_0 + g_0 + g_3 z_w + b_3 z_p - \left(b_5 - g_5\right) f\right] \qquad \text{(A4)}$$

Deviations from NAIRU:

$$U - U^* = -\frac{(b_4 + g_4)\left(p - p^e\right)}{g_1 + b_1} - \frac{(b_2 + g_2)\Delta U}{g_1 + b_1} \qquad \text{(A5)}$$

Eliminate unemployment from (A1) and (A2):

$$w - p = \frac{1}{\gamma_1 + b_1}\left[\begin{array}{l} b_1\gamma_0 - b_0\gamma_1 + (b_2\gamma_1 - b_1\gamma_2)\Delta U + b_1\gamma_3 z_w \\ \\ - b_3\gamma_1 z_p + (b_4\gamma_1 - b_1\gamma_4)\left(p - p^e\right) + (b_5\gamma_1 + b_1\gamma_5)f \end{array}\right] \quad \text{(A6)}$$

Long-run real wage when $\Delta U = 0$ and $p - p^e = 0$:

$$(w - p)^* = \frac{b_1\gamma_0 - b_0\gamma_1 + b_1\gamma_3 z_w - b_3\gamma_1 z_p + (b_5\gamma_1 + b_1\gamma_5)f}{\gamma_1 + b_1} \qquad \text{(A7)}$$

Deviation from long-run real wage:

$$(w - p) - (w - p)^* = \frac{(b_4\gamma_1 - b_1\gamma_4)}{\gamma_1 + b_1}\left(p - p^e\right) + \frac{(b_2\gamma_1 - b_1\gamma_2)}{\gamma_1 + b_1}\Delta U \qquad \text{(A8)}$$

The Impact Of Shocks On Unemployment and Real Wage

Effect of wage shock on NAIRU and long-run real wage:

$\dfrac{\partial U^*}{\partial z_w} = \dfrac{\gamma_3}{\gamma_1 + b_1} > 0$ $\qquad$ $\dfrac{\partial (w - p)^*}{\partial z_w} = \dfrac{b_1\gamma_3}{\gamma_1 + b_1} > 0$ which is zero if firms price independently of demand and, therefore, $b_1 = 0$.

Effect of price shock on NAIRU and long-run real wage:

$$\frac{\partial U^*}{\partial z_p} = \frac{b_3}{\gamma_1 + b_1} > 0 \qquad \frac{\partial (w - p)^*}{\partial z_p} = -\frac{b_3\gamma_1}{\gamma_1 + b_1} < 0$$

Effect of productivity shock on the NAIRU and long-run real wage:

$$\frac{\partial U^*}{\partial f} = \frac{\gamma_5 - b_5}{\gamma_1 + b_1} \qquad \frac{\partial (w - p)^*}{\partial f} = \frac{b_1\gamma_5 + b_5\gamma_1}{\gamma_1 + b_1} > 0$$

APPENDIX B: INTEGRATION TESTS OF THE DATA

The following tables present tests of the time series characteristics of the data. Table B1 shows the standard augmented Dickey Fuller (Said and Dickey (1984)) (ADF) test where a unit root null hypothesis is tested against a stationary alternative. These result are compared with Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests in Table B2 for which the null hypothesis of stationarity is tested against the unit root alternative.

Using the augmented Dickey Fuller tests and a 5% level of significance, the level of market prices, prices at factor costs, import prices and petrol prices all accept the null hypothesis of non-stationarity. The first difference of these series reject the null hypothesis in favour of the stationary alternative. The level of the output gap, inside unemployment, and strike terms are all, as expected, found to be stationary. For each of these series, the results of the KPSS tests for a lag length of 8 accord with the above conclusions using a 5% level of significance (see notes for Table B2).

There are, however, four contentious results. While the ADF tests suggest wages and unit labour costs are stationary around a drift term, the null hypothesis of stationarity is rejected using the KPSS tests. Both these series are treated as non-stationary in the estimation. Of particular interest is the characterisation of the real exchange rate and labour's income share. In the paper both these series are characterised as stationary. However, the statistical tests produce conflicting results. In the ADF tests, both series do not reject the unit root hypothesis. The stationary null hypothesis in the KPSS tests is also not rejected at the 5% significance level. While the statistical results are ambiguous, the conclusion of stationarity follows from the graphical analysis and can be supported theoretically.

Table B1: Augmented Dickey – Fuller Tests

Variable	Φ_1	Φ_2	Φ_3	$\hat{t}$	$\hat{t}_m$	$\hat{t}_t$
prices [fc]	5.56#	3.71	5.31	0.05	-3.26*	-0.28
Δ *prices* [fc]	10.37**	8.50**	12.69**	-2.39*	-4.54**	-4.81**
prices	5.11	3.71	4.85	0.02	-3.13*	-0.73
Δ *prices*	2.27	12.09**	18.11**	-0.99	-2.12	-5.87**
wages	111.73**	74.45**	14.79**	1.16	-5.39**	-0.27
Δ *wages*	19.12**	19.88**	29.81**	-3.49**	-6.18**	-7.72**
unit labour costs	49.04**	32.79**	9.12**	0.98	-4.20**	-0.13
Δ *unit labour costs*	25.55**	23.46**	35.17**	-4.96**	-7.15**	-8.38**
import prices	22.14**	14.73**	3.56	3.20	-2.63#	-0.15
Δ *import prices*	24.60**	18.33**	27.49**	-5.65**	-7.01**	-7.41**
petrol prices	8.79**	5.84*	1.38	3.45	-1.63	-0.75
Δ *petrol prices*	60.49**	42.29**	63.43**	-9.46**	-11.00**	-11.26**
output gap	7.48**	5.37*	8.05*	-0.01	-3.87**	-3.97*
Δ *output gap*	51.36**	33.88**	50.79**	-10.19**	-10.13**	-10.08**
inside unemployment	7.54**	4.99*	7.48*	-0.81	-3.88**	-3.87*
Δ inside unemployment	21.90**	14.68**	21.92**	-6.66**	-6.60**	-6.61**
strikes	30.59**	20.42**	30.63**	-7.86**	-7.82**	-7.82**
Δ strikes	16.98**	11.37**	17.05**	-5.87**	-5.83**	-5.84**
rer	1.95	1.55	2.33	-0.05	-1.97	-2.15
Δ *rer*	42.95**	28.36**	42.54**	-9.32**	-9.27**	-9.22**
income share	2.04	4.38#	6.57#	-0.21	-2.02	-3.58*
Δ income share	15.48**	10.39**	15.43**	-5.60**	-5.56**	-5.55**

Notes: The likelihood ratio tests are:

$$\Phi_1 : (a, r) = (0,1) \; in Y_t = a + rY_{t-1} + e_t$$
$$\Phi_2 : (a, b, r) = (0,0,1) in Y_t = a + bt + rY_{t-1} + e_t$$
$$\Phi_3 : (a, b, r) = (a,0,1) in Y_t = a + bt + rY_{t-1} + e_t$$

The 't-tests' are $r = 1$ for $\hat{t} : in Y_t = rY_{t-1} + e_t$

$\hat{t}_m : in Y_t = a + rY_{t-1} + e_t$

$\hat{t}_t : in Y_t = a + bt + rY_{t-1} + e_t$

**, * and #, denotes significance at the 1%, 5% and 10% levels respectively. The critical values for the likelihood ratio tests are from Dickey and Fuller (1981) and the critical values for the 't-tests' are from Fuller (1976).

The shaded box indicates the form of the model used for inference in testing for non-stationarity.

The sample size for most cases in levels is 1971:Q1-1994:Q3 and in differences is 1971:Q2-1994:Q3. Exceptions to this are inside unemployment and strikes which end in 1994:Q2.

All variables are in logs except inside unemployment, strikes and labour's income share.

Strikes are adjusted for a break in mean in the first quarter of 1983.

Table B2: Kwiatkowski, Phillips, Schmidt and Shin Tests

	Constant			Constant and trend		
		Lag			Lag	
Variable	0	4	8	0	4	8
prices ^{fc}	9.33**	1.96**	1.13**	2.07**	0.45**	0.28**
Δ *prices* ^{fc}	3.67**	1.15**	0.74**	0.29**	0.13#	0.10
prices	9.33**	1.96**	1.13**	2.09**	0.46**	0.28**
Δ *prices*	4.22**	1.15**	0.73**	0.37**	0.13#	0.10
wages	9.16**	1.93**	1.13**	2.11**	0.46**	0.28**
Δ *wages*	2.46**	1.04**	0.71*	0.07	0.05	0.04
unit labour costs	9.07**	1.91**	1.11**	1.93**	0.43**	0.26**
Δ *unit labour costs*	1.64**	0.79**	0.60*	0.06	0.04	0.04
import prices	9.06**	1.90**	1.11**	1.88**	0.41**	0.25**
Δ *import prices*	0.83**	0.45#	0.40#	0.09	0.06	0.07
petrol prices	9.14**	1.91**	1.10**	1.96**	0.43**	0.26**
Δ *petrol prices*	0.33	0.40#	0.35#	0.07	0.10	0.11
output gap	1.45	0.38#	0.29	0.33**	0.09	0.07
Δ *output gap*	0.04	0.04	0.05	0.04	0.04	0.05
inside unemployment	0.25	0.07	0.06	0.24**	0.07	0.06
Δ inside unemployment	0.05	0.03	0.05	0.05	0.03	0.04
strikes	0.10	0.08	0.08	0.05	0.04	0.05
Δ strikes	0.01	0.04	0.06	0.01	0.03	0.05
rer	1.51**	0.35#	0.23	0.44**	0.11	0.07
Δ *rer*	0.07	0.06	0.05	0.07	0.06	0.05
income share	2.06**	0.51*	0.36#	0.61**	0.16*	0.12#
Δ income share	0.07	0.05	0.06	0.05	0.03	0.04

Notes: For this test the series, y_t, is expressed as $y_t = xt + r_t + e_t$, where $r_t = r_{t-1} + u_t$ and $u_t \sim iid(0, s_u^2)$. Then the null hypothesis of stationarity is the test that $s_u^2 = 0$. The critical values, with the inclusion of a constant at the 1%, 5%, and 10% levels of significance, are 0.739, 0.463 and 0.347 respectively. The critical values, with the inclusion of a constant and trend at the 1%, 5%, and 10% levels of significance, are 0.216, 0.146 and 0.119 respectively.

The lag length refers to the value of l chosen when calculating the estimate of the error variance, $s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s}$, used in the testing procedure. A lag length of 8 is chosen for inference following the approach of KPSS.

**, * and # denotes significance at the 1%, 5% and 10% levels respectively.

The sample size for most cases in levels is 1971:Q1-1994:03 and in differences is 1971:Q2-1994:Q3. Exceptions to this are inside unemployment and strikes which end in 1994:Q2.

All variables are in logs except inside unemployment, strikes and labour’s income share.

Strikes are adjusted for a break in mean in the first quarter of 1983.

REFERENCES

Bean, C.R. (1994), 'European Unemployment: A Survey', *Journal of Economic Literature*, 32(2), pp. 573-619.

Bénabou, R. (1992), 'Inflation and Markups: Theories and Evidence from the Retail Trade Sector', *European Economic Review*, 36(3), pp. 566-574.

Bils, M. (1987), 'The Cyclical Behavior of Marginal Cost and Price', *American Economic Review*, 77(5), pp. 838-855.

Bruno, M. and J.D. Sachs (1985), *Economics of Worldwide Stagflation*, Harvard University Press, Cambridge.

Carlin, W. and D. Soskice (1990), *Macroeconomics and the Wage Bargain: A Modern Approach to Employment, Inflation and the Exchange Rate,* Oxford University Press, Oxford.

Coulton, B. and R. Cromb (1994), 'The UK NAIRU', *Government Economic Service Working Paper* 124, HM Treasury Working Paper No. 66.

Coutts, K., W. Godley and W. Nordhaus (1978), *Industrial Pricing in the United Kingdom*, Cambridge University Press, London.

Cozier, B. (1991), 'Wage and Price Dynamics in Canada', Technical Report 56, Bank of Canada.

de Brouwer, G. and N.R. Ericsson (1995), 'Modelling Inflation in Australia', Reserve Bank of Australia Research Discussion Paper No. 9510.

DeJong, D.N., J.C. Nankervis, N.E. Savin and C.H. Whiteman (1992), 'Integrated Versus Trend Stationarity in Time Series', *Econometrica*, 60(2), pp. 423-433.

Dickey, D.A. and W.A. Fuller (1981), 'Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root', *Econometica*, 49, pp. 1057-1072.

Franz, W. and R.J. Gordon (1993), 'German and American Wage and Price Dynamics', *European Economic Review*, 37(4), pp. 719-762.

Fuller, W.A. (1976), *Introduction to Statistical Time Series*, Wiley, New York.

Grubb, D., R. Jackman and R. Layard (1983), 'Wage Rigidity and Unemployment in OECD Countries', *European Economic Review*, 21(1/2), pp. 11-39.

Gruen, D. and G. Shuetrim (1994), 'Internationalisation and the Macro Economy', in P. Lowe and J. Dwyer (eds), *International Integration of the Australian Economy*, Reserve Bank of Australia, Sydney, pp. 309-363.

Hall, R.L. and C.J. Hitch (1939), 'Price Theory and Business Behaviour', *Oxford Economic Papers*, 2 (Old Series), pp. 12-45.

Johansen, S. (1988), 'Statistical Analysis of Cointegration Vectors', *Journal of Economic Dynamics and Control*, 12, pp. 231-254.

Johansen, S. (1991), 'Estimation and Hypothesis Testing of Cointegration Vectors in Gausian Vector Autoregressive Models', *Econometrica*, 59(6), pp. 1551-1580.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt and Y. Shin (1992), 'Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root', *Journal of Econometrics*, 54(1-3), pp. 159-178.

Layard, R., S.J. Nickell and R. Jackman (1991), *Unemployment Macroeconomic Performance and the Labour Market*, Oxford University Press, Oxford.

Lewis, P.E.T. and G.A. MacDonald (1993), 'Testing for Equilibrium in the Australian Wage Equation', *Economic Record*, 69(206), pp. 295-304.

Manning, A. (1994), 'Wage Bargaining and the Phillips Curve: The Identification and Specification of Aggregate Wage Equations', *Economic Journal*, 103(416), pp. 98-118.

Mehra, Y.P. (1993), ‘Unit Labour Costs and the Price Level’, *Economic Quarterly,* Federal Reserve Bank of Richmond, 79(4), pp. 35-52.

Phillips, P.C.B. and B.E. Hansen (1990), ‘Statistical Inference in Instrumental Variables Regression with I(1) Processes’, *Review of Economic Studies*, 57(189), pp. 99-125.

Russell, B. (1994), ‘The Markup and the Inflationary Consequences of Nominal Demand Growth’, 23rd Conference of Economists, Surfers Paradise, Australia, September.

Russell, B. (1995), ‘The Inflationary Consequences of Private-Sector Profitability’, Reserve Bank of Australia, internal mimeo.

Said, S.E. and D.A. Dickey (1984), ‘Testing for Unit Roots in Autoregressive-Moving Average Series of Unknown Order’, *Biometrika*, 71(2), pp. 599-607.

Swan, T.W. (1963), ‘Longer-Run Problems of the Balance of Payments’, in H.W. Arndt and W.M. Corden (eds), *The Australian Economy*, Cheshire, Melbourne, pp. 384-395.

Sweezy, P. (1939), ‘Demand Under Conditions of Oligopoly’, *Journal of Political Economy*, 47, pp. 568-573.

Tobin, J. (1972), ‘Inflation and Unemployment’, *American Economic Review*, 62(1), pp 1-18.

Wilkinson, J. (1994), ‘Estimation of Potential Output using Trends in the Labour Force, the Capital Stock and Multifactor Productivity’, Reserve Bank of Australia, internal mimeo.