THE ELASTICITY OF DEMAND FOR LABOUR IN AUSTRALIA

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ABSTRACT

The elasticity of demand for labour at the aggregate level is an important parameter for macroeconomic analysis. In particular, policy issues concerning the impact of wage falls on employment and unemployment hinge on the size of this parameter. It is argued in this paper that previous work on the elasticity of demand for labour in Australia has been unsatisfactory in a number of ways. A new set of estimates is provided which are derived, using a better methodology than before.

THE ELASTICITY OF DEMAND FOR LABOUR

INTRODUCTION

The aggregate demand for labour is one of the most important relationships in macroeconomics. In particular, the impact of labour costs on demand for labour, employment and unemployment are of crucial importance. In Australia the response of labour demand to wage changes has received particular attention given the long history of centralised wage fixing and, more recently, the Prices and Incomes Accord. In this context control or influence of wages can be seen as a possible policy instrument affecting employment. An understanding of the nature of demand for labour is necessary to examine the effects of policies such as minimum wages, employment subsidies and incomes policy.

It will be argued that the aggregate demand functions and the derived elasticities of demand are little understood and have led to the wrong interpretation in much of the Australian literature. The aims of this paper are, first, to restate the theory of the demand for labour in order to clear up misunderstandings which permeate the Australian literature. The second aim is to critically assess the Australian literature on the demand for labour to date. The third aim is to provide new estimates of the relevant elasticities of demand for labour using the latest econometric methods.

The paper is structured as follows. The next section reviews the evidence on the aggregate demand for labour. This is followed by a statement of theory of the demand for labour. New estimates of the relevant elasticities are then provided. Finally, the last section provides a conclusion and discussion of the results.

BACKGROUND

Most studies implicitly adopt a neoclassical framework for the formulation of the demand for labour schedule, and hence the aggregate demand for labour is assumed to be negatively related to real wages and positively related to output. Assuming a constant elasticity of substitution production function, the ‘demand for labour’ has typically been expressed as a linear in logarithms function. The dependent variable is usually total employment or hours worked. The independent variables are either real wages, or some other measure such as real unit labour costs, and real gross domestic product. A time trend is also usually included as a proxy for Hicks-neutral technical progress. In practice, most studies take employment to be equal to the demand for labour. Thus, employment, measured in term of total employment or hours worked, is regressed on a number of variables including real wages, output and time. The relation is referred to as an ‘employment equation' and ‘demand for labour'.

Dynamics usually enter the empirical specifications by means of a partial adjustment mechanism through the inclusion of a lagged employment term on the right-hand side of the equation. Thus, the traditional ‘demand for labour’ function can be written as:

$$\ln L_t = \alpha_o + \alpha_1 \ln\left(\frac{w}{p}\right)_t + \alpha_2 \ln Q_t + \alpha_3 t + \alpha_4 \ln L_{t-1} + u_t \qquad (1)$$

where L is employment measured as numbers employed or hours worked;

w is the nominal wage rate, usually per week or per hour, depending on the employment measure adopted;

Q is output, which at the economy level is real gross domestic product;

t is a time trend, usually taken to proxy Hicks neutral technological progress.

The speed of adjustment of employment can be deduced from the size of the coefficient on the lagged employment term, a high value implying relatively slow adjustment. Most studies have found the coefficient on the lagged employment to be quite large, implying quite slow adjustment of employment to changes in variables such as wages, output and technological change.

The first studies of the employment relationship in Australia were conducted in the 1970s and were primarily concerned with assessing whether unemployment was classical, in the sense of being the result of wages that were too high, or Keynesian, in the sense of being the result of output levels that were too low. In general, the methodology adopted was to estimate a relationship between employment, wages and output. The conclusion from such studies (e.g., Higgins & Fitzgerald 1973, Clark 1976, Gregory & Duncan 1979, Sheehan, Derody & Rosendale 1979, Valentine 1980) was that the coefficient on real wages was either insignificant or relatively small in magnitude. Output was of far greater importance in explaining employment. If follows from this that an expansionary policy was preferred to wages policy in reducing unemployment. The fundamental flaw with this argument is that if unemployment is, indeed, Keynesian, then employment does not lie on the demand curve and the elasticity of demand with respect to wages and output is indeterminate. The demand curve is unidentifiable.[1]

Although in the minority, a few studies did find evidence of a real wage overhang, a term used to describe the excessive growth of real wages relative to productivity. Freebairn (1977), although not estimating any of his own parameters, concluded that the long-run elasticity of

employment with respect to output was about 0.7 and with respect to real wages was about -0.5. Johnston, Campbell and Simes (1978) tried several specifications using employment, unemployment and investment, respectively, as dependent variables, with the real wage overhang among the explanatory variables. The real wage overhang was insignificant in the employment equation although it was significant in the unemployment and investment equations.

The other early attempts to estimate the responsiveness of employment to real wages relied on simulations of the major macroeconomic models. Since they did not directly estimate the demand for labour they will not be discussed here.[2]

More recent studies have been undertaken by Lewis (1983), Lewis and Kirby (1988), Pissarides (1987), Russell and Tease (1991), Dungey and Pitchford (1998), Debelle and Vickery (1998) and Bernie and Downes (1999). Lewis and Kirby (1988) found that the Accord had brought about a shift in the supply curve for labour bringing about a 10 per cent fall in real wages and a rise in employment of 8 per cent implying an employment elasticity with respect to real wages of –0.8. Pissarides (1991) estimated a Layard and Nickell-type model of the Australian labour market and estimated an employment real wage elasticity of -0.8. Russell and Tease (1991) estimated a range of employment equations using a variety of real wage measures. They estimated an 'employment elasticity' of about -0.6 with respect to real wages and of 0.7 with respect to output. Technical progress was estimated to be labour saving in the order of 1 per cent per year. The results did not differ greatly if the number employed was replaced by total hours worked as the dependent variable. Dungey and Pitchford (1998), using more recent data estimate an elasticity with respect to real wages of

–0.4. Debelle and Vickery (1998), suggest an employment elasticity with respect to real wages of –0.7 for the period 1969 to 1997 and somewhat lower, -0.4 for the period from 1979. Bernie and Downes (1999) suggest that the differences are due to definitional and data problems. Their results from the TRYM model suggest an employment elasticity of about -0.6 with respect to real wages.

In summary, the results for Australia suggest an employment elasticity with respect to real wages of about -0.6 to -0.8, at the higher end of the scale of elasticities estimated for other countries (Hamermesh 1993).

The above studies can be criticised on several important points. First, most of the studies interpret the coefficient of real wages as an output constant elasticity of demand for labour with respect to real wages. This, as will be demonstrated below, is not the case. Second, the estimated equations are subject to a potential endogeneity problem with respect to real wages. Third, and this is hardly a criticism, they used regression techniques which have largely been superceded by new estimation methods. Finally, most studies have adopted a partial adjustment mechanism to represent the dynamics of their models. This has been shown to be unduly restrictive and inferior to more general representations (Hendry, Pagan and Sargan 1984). The increased availability of modern time series econometrics makes it apposite to re-examine these issues.

In this paper the theory of the aggregate demand for labour will be restated making clear the interpretations of the coefficients. The potential endogeneity problem will be specifically tested for and the demand model will be estimated using appropriate techniques based on

cointegration methodology incorporating general to specific dynamic procedures.

DERIVING THE DEMAND FOR LABOUR

The purpose of this section is to restate the derivation of the aggregate demand for labour in order that the underlying parameters cited in the literature can be clearly understood.

It is usual to assume that the economy can be represented by a constant elasticity of substitution (CES) production function.[3]

$$Q = [\alpha L^{\rho} + (1-\alpha) K^{\rho}]^{1/\rho} \tag{2}$$

Q is output

L is quantity of labour

K is quantity of capital

where α, ρ are parameters , α can be interpreted as the share parameter and ρ as the substitution parameter.

Taking the first partial derivative with respect to labour and equating the marginal product to the real wage yields:

$$\alpha \left(\frac{Q}{L}\right)^{(1-\rho)} = \frac{w}{p} \tag{3}$$

where $\frac{w}{p}$ is the real wage.

Taking natural logarithms of both sides yields:

$$\ln \alpha + (1-\rho) \ln Q - (1-\rho) \ln L = \ln \left(\frac{w}{p}\right) \tag{4}$$

Re-arranging (4) yields:

$$\ln L = A - \sigma \ln\left(\frac{w}{\rho}\right) + \ln Q \qquad (5)$$

Where A = $\frac{\ln\alpha}{(1-\rho)}$ and $\sigma = \frac{1}{(1-\rho)}$

σ in this equation is an estimate of the direct elasticity of substitution between capital and labour.

Adding a time trend to allow for Hicks-neutral technical progress, and an error term yields the following estimating equation:

$$\ln L_t = \alpha_o + \alpha_1 \ln\left(\frac{w}{p}\right)_t + \alpha_2 \ln Q_t + \alpha_3 t + u_t \qquad (6)$$

It is important to note that this is *not* a demand for labour curve but a *marginal productivity condition*. It is wrong to mistake this for a demand for labour curve and hence interpret the coefficients as elasticities of demand with respect to real wages and output. However, real wage elasticities can be easily derived from the parameters of the marginal productivity condition. σ, i.e. α_1 in (6), is the *elasticity of substitution* between labour and capital *not*, as stated in most of the literature, the output constant elasticity of demand for labour. This elasticity can, however, be easily derived as shown below.

For any demand function

$e = -\left[(1-s)\sigma\right]$ is the *output constant elasticity* of demand with respect to real wages and s is labour's share of national product.

$e' = -\left[(1-s)\sigma + s\eta\right]$ is the *elasticity* of demand for labour with respect to real wages, and η is the *scale effect* arising from output expanding as costs of production fall. η thus

represents the elasticity of demand for aggregate output, α_2 in equation (6).

The interpretation of the above is quite simple. The elasticity of demand for labour consists of two components. The first, $(1-s)\sigma$, arises from the *substitution* of labour for other inputs as real wages fall and is, therefore, correctly interpretable as the output constant elasticity of demand for labour with respect to wages, while the second, $s\eta$, arises from increased output due to a fall in costs of production.

Since equation (6) represents only the long run solution, the process by which the optimal quantity of labour adjusts to the long run solution needs to be incorporated into the estimated equation. As noted above this is usually done by the addition of a lagged dependent variable to the list of regressors in equation (6). However, apart from the criticism of this partial adjustment approach from a statistical viewpoint mentioned above, Hamermesh (1993) and Hamermesh and Pfann (1996) in an exhaustive review of the international evidence maintains that adjustment costs are not quadratic, which is a necessary assumption underlying the partial adjustment hypothesis. It is, thus, necessary to adopt a very general dynamic structure using the standard general to specific procedures.

ESTIMATION

It is now well known that it is inappropriate to estimate relations like equation (6) by ordinary least squares since this is open to the 'spurious regression' problem. In order to avoid these problems the parameters of equation (6) will be estimated using the Autoregressive Distributed Lag (ARDL) approach put forward by Pesaran and Shin (1995) and Pesaran, Shin and Smith (1996, 1999). This procedure can be applied to models irrespective of whether the regressors are I(0), I(1) or mutually cointegrated. Therefore, it avoids the usual pretesting

procedures associated with cointegration analysis, such as the techniques associated with Granger (1986)[4] and has the advantage that it is easily understood within the context of traditional ECM approaches. Since the ARDL method makes certain assumptions regarding the exogeneity of variables the model is also estimated using the more standard method associated with Johansen (1988). This provides both a useful check on the results and allows testing of the exogeneity assumptions directly.

The ARDL procedure of Pesaran, Shin and Smith (1996, 1999) consists of several steps. First, the existence of a long run relationship between the variables in the model is established. This is done through testing for the significance of the long run relationship in an error correction mechanism regression which can be regarded as a re-parameterisation of the VAR model.

The VAR(p) model can be written as

$$\mathbf{z}_t = \mathbf{b} + \mathbf{c}t + \sum_{i=1}^{p} \mathbf{\Phi}_i \mathbf{z}_{t-i} + \boldsymbol{\varepsilon}_t \tag{7}$$

(where **z** represents a vector of variables). Under the assumption that the individual elements of z are at most I(1) (ie do not have explosive roots) this be written as a simple Vector Error Correction Model

$$\Delta\mathbf{z}_t = \mathbf{b} + \mathbf{c}t + \Pi\mathbf{z}_{t-1} + \sum_{i=1}^{p-1} \mathbf{\Gamma}_i \Delta\mathbf{z}_{t-i} + \boldsymbol{\varepsilon}_t \tag{8}$$

where $\mathbf{\Pi} = -(\mathbf{I}_{k+1} - \sum_{i=1}^{p} \mathbf{\Phi}_i)$ and $\mathbf{\Gamma}_i = -\sum_{j=i+1}^{p} \mathbf{\Phi}_j$, $\mathrm{i} = 1,....\mathrm{p}-1$ are the (k+1)×(k+1) matrices of the long run multipliers and the short run dynamic coefficients. By making the assumption that there is only one long run relationship among the variables Pesaran et al (1996, 1999) focus

on (8) and partition $\mathbf{z}_t$ into a dependent variable y_t and a set of 'forcing' variables **x**. This is one of the key assumptions. Under such conditions the matrices **b, c Γ** and, most importantly, **Π,** the long run multiplier matrix, can also be partitioned conformably with the partitioning of **z**.

$$\mathbf{\Pi} = \begin{bmatrix} \pi_{11} & \boldsymbol{\pi}_{12} \\ \boldsymbol{\pi}_{21} & \mathbf{\Pi}_{22} \end{bmatrix} \qquad \mathbf{b} = \begin{bmatrix} b_1 \\ \mathbf{b_2} \end{bmatrix} \qquad \mathbf{c} = \begin{bmatrix} c_1 \\ \mathbf{c_2} \end{bmatrix} \quad \mathbf{\Gamma_i} = \begin{bmatrix} \gamma_{11,i} & \boldsymbol{\gamma}_{\mathbf{12,i}} \\ \boldsymbol{\gamma}_{\mathbf{21,i}} & \boldsymbol{\gamma}_{\mathbf{22,i}} \end{bmatrix}$$

The key assumption, that **x** is 'long run forcing' for y, then implies that the vector π_{21}=0. That is, that there is no feedback from the level of y on **Δx**. As a result the conditional model for Δy and **Δx** can be written as

$$\Delta y_t = b_1 + c_1 t + \pi_{11} y_{t-1} + \pi_{12}\mathbf{x}_{t-1} + \sum_{i=1}^{p-1}\gamma_{11,i}\Delta y_{t-i} + \sum_{i=0}^{p-1}\boldsymbol{\gamma}_{12,i}\mathbf{\Delta x}_{t-i} + \varepsilon_{1t} \tag{9}$$

$$\mathbf{\Delta x}_t = \mathbf{b_2} + \mathbf{c_2} t + \mathbf{\Pi}_{22}\mathbf{x}_{t-1} + \sum_{i=1}^{p-1}\gamma_{21,i}\Delta y_{t-i} + \sum_{i=1}^{p-1}\mathbf{\Gamma_{22,i}}\mathbf{\Delta x}_{t-i} + \boldsymbol{\varepsilon}_{2t} \tag{10}$$

Under standard assumptions about the error terms Pesaran et al (1996, 1999) re-write (10) as

$$\Delta y_t = a_0 + a_1 t + \phi y_{t-1} + \delta\mathbf{x}_{t-1} + \sum_{i=1}^{p-1}\upsilon_i\Delta y_{t-i} + \sum_{i=0}^{p-1}\varphi_i\mathbf{\Delta x}_{t-i} + \varpi_t \tag{11}$$

which they term an 'unrestricted error correction model'. Note that in (11) a long run relationship will exist among the levels variables if the two parameters ϕ and δ are both non zero in which case, the long run solution of (11) is:

$$y_t = -\frac{a_0}{\phi} - \frac{a_1}{\phi} - \frac{\delta}{\phi}x_t \tag{12}$$

Pesaran et al (1996, 1999) choose to test the hypothesis of no long run relationship between y and **x** by testing the joint hypothesis that $\phi = \boldsymbol{\delta} = 0$ in the context of equation (11). The test they develop is a bounds type test, with a lower bound calculated on the basis that the variables in **x** are I(0) and an upper bound on the basis that they are I(1). Pesaran et al (1999) provide critical values for this bounds test from an extensive set of stochastic simulations under differing assumptions regarding the appropriate inclusion of deterministic variables in the ECM. If the calculated test statistic (which is a standard F test for testing the null that the coefficients on the lagged levels terms are jointly equal to zero) lies above the upper bound the result is conclusive and implies that a long run relationship does exist between the variables. If the test statistic lies within the bounds no conclusion can be drawn without knowledge of the time series properties of the variables (hence standard methods of testing would have to be applied). If the test statistic lies below the lower bound no long run relationship exists.

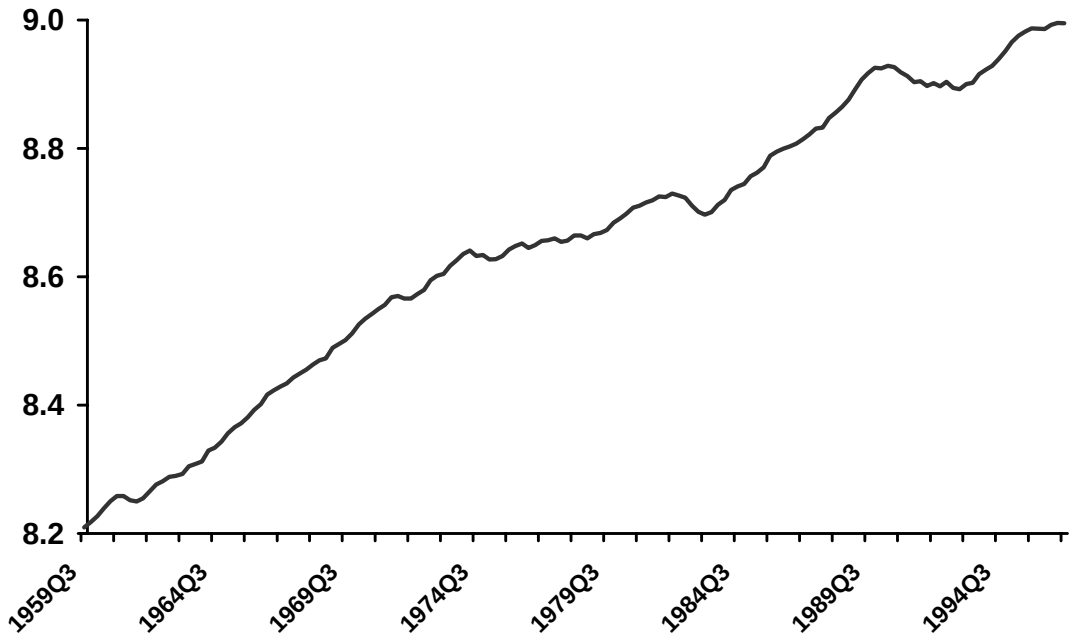
The above procedure was carried out for equation (6) using two measures of labour demand, namely, LEMP, the logarithm of employment of non-farm wage and salary earners and LHOURS, the logarithm of total hours worked identified by multiplying employment by average hours worked per week. Two measures of real wages are used, namely, LRWAGE, the logarithm of weekly wages of non farm employees and LHRWAGE, the logarithm of average hourly wage rates each deflated by the GDP deflator. LRGDP, is the logarithm of real gross domestic product. All data are from the Treasury's NIF10 database, and t is a time trend. The employment equation is estimated over the period 1959Q3 to 1998Q3 and the hours worked equation is estimated over the period 1966Q4 to 1998Q3. The difference in the sample sizes is due to the availability of hours worked data.

RESULTS

Figure 1 shows the movements of the dependent variable in the employment equation. Several points are of interest, the first being the slowing of employment growth after the oil shock and the subsequent wages explosion from the mid 1970s. The recovery in employment due to the fall in real wages under the Accord (see Lewis and Kirby 1988) during the 1980s is evident as is the 'recession we had to have' in 1989 which was quite long lasting.

FIGURE 1

Log of Employment



Equation (11) was estimated concentrating attention on the regression with LEMP as the dependent variable. In doing so it is assumed that the weak exogeneity (of RGDP and RWAGE) assumption is valid. Support for this assumption is provided below both via the estimation of the three possible inversions of (11) and later through estimating the long run relationship using Johansen estimation.

Two further aspects of the regression equation need specifying in practice. First, the lag order k in the regression. A maximum lag of 5 was chosen with information criteria and tests for residual autocorrelation used to guide the lag choice. As noted in Pesaran et al (1999) serially uncorrelated errors are important for the applicability of the bounds test. The second decision regards the inclusion of deterministic terms (constant and trend). Bounds test were carried out with an unrestricted constant and a restricted trend. As pointed out by Pesaran et al (1999) this may be the preferred form since, under the null of no cointegration, an unrestricted trend implies a quadratic trend in the dependant variable which seems implausible and, in this particular case, since the trend is a proxy for smooth technological progress, the test with a restricted trend also seems more appropriate.

TABLE 1

Tests of a long run relationship-employment

	Lag = 5	Lag = 4	Lag = 3	Lag = 2	Lag = 1
ΔLEMP					
F(4)	5.07	6.86*	6.44*	7.51*	10.77*
AR(1-5)	2.20	3.38	2.70	1.09	2.91
SB	-10.09	-10.13	-10.19	-10.28	-10.32
HQ	-10.32	-10.35	-10.38	-10.43	-10.44
FPE	2.67	2.74	2.74	2.65	2.69
ΔLRWAG					
F(4)	2.84	3.06	4.08	3.27	3.7
AR(1-5)	0.39	0.33	0.03	1.74	0.29
SB	-8.45	-8.52	-8.61	-8.65	-8.72
HQ	-8.71	-8.74	-8.8	-8.81	-8.84
FPE	13.81	13.72	13.25	13.48	13.36
ΔLRGDP					
F(4)	1.69	2.27	2.55	2.83	3.13
AR(1-5)	2.01	2.10	2.65	3.21	1.65
SB	-8.76	-8.85	-8.94	-9.01	-9.08
HQ	-9.02	-9.07	-9.13	-9.17	-9.2
FPE	10.09	9.84	9.53	9.41	9.32

Sample: 1961Q1 to 1998Q3

Notes:

F(4)	is the test for zero restrictions on the trend and lag terms (*denotes that the calculated test statistic lies above the upper bound using a 5 per cent significance level)
AR(1-5)	is the test for up to fifth order autocorrelation
SC	is the Schwarz Bayesian criterion
HQ	is the Hannan-Quinn criterion
FPE	is Final Prediction Error

As can be seen from Table 1 when ΔLEMP is the dependant variable a lag length of 2 seems most appropriate (on the basis of autocorrelation at other lags and the FPE criteria). The F test for the zero restriction on the trend and the lagged levels terms (F(4)) rejects the null of no long run relationship (the appropriate bounds are 5.17 and 6.15), indeed the test rejects for all lags below 5. As noted above the regression was also estimated in its alternative inversions, as in Pesaran et al (1996) as a test of the weak exogeneity assumption. The logic here is if real wages and real GDP are weakly exogenous the error correction terms should not be significant in these equations. As can be seen there are now no rejections of the null of no long run relationship and these results support the idea of a long run relationship where real wages and real GDP are weakly exogenous. The Johansen estimation results reported later provide further support for this.

Since the evidence suggests there is a long run relationship between the variables the relationship was estimated using the ARDL method suggested in Pesaran and Shin (1999) which allows for estimates of the asymptotic standard errors associated with the long run parameters. The unrestricted ECM can be re-written as ARDL(p,p,p) model. A lag length of 2 implies an ARDL(3,3,3) as appropriate for estimation. The regression coefficients for the full ARDL are not of great interest and for brevity are not repeated here. The long run relation and its associated standard error was:

LEMP	=	-0.0981	-	0.446 LRWAG	+	1.058 LRGDP	-	0.00307t
s.e.		(0.383)		(0.072)		(0.062)		(0.00037)
t stat.		(-0.26)		(-6.20)		(17.05)		(-8.31)

Finally the model can be reformulated as an ECM using these estimates of the long run parameters. The error correction term is significant and correctly signed, -0.19, with a t statistic of -5.16, thus suggesting a relatively slow adjustment to equilibrium (1-1.5 years given the quarterly data) .

As noted above the long run relationship using the more familiar Johansen method was also estimated. Not only does this provide a further test on the validity of the above results but also allows us to test the weak exogeneity assumption more directly.

Prior to implementing the Johansen procedure two things need to be established. First that the variables are all I(1) and, second, the appropriate lag length to be used. Standard unit root tests showed that all three variables do indeed appear to be I(1) with none of the variables able to reject a unit root in levels but all rejecting on first differencing.[5] In order to establish the appropriate lag length a VAR(8) was initially estimated and then the lag length was sequentially and symmetrically reduced. The choice of lag length was made on the basis of autocorrelation tests, Schwarz Bayesian, Hannan-Quinn and Akaike Information Criteria.[6]

Reduction below the VAR(4) specification were found to be unacceptable due to the presence of significant autocorrelation in the system. In fact the employment equation showed evidence of significant autocorrelation up to lag 7. The AIC selects VAR (7) while the other two information criteria select the VAR(2) specification. A sequence of F tests suggest reduction below VAR(6) is unacceptable.

As a result of the uncertainty regarding optimal lag length the estimation was carried out using a variety of lags ranging from 4 to 7. The results of the Johansen Trace and Maximal Eigenvalue tests are in Table 2 below and the estimated coefficients (of the long run relationship) are in Table 3.

TABLE 2

Johansen's test for cointegration

No. of lags in the VAR	Max. Eigenvalue Statistic	Adjusted Statistic	5% critical value	Trace test statistic	Adjusted statistic	5% critical value
4	29.88*	27.47*	25.5	51.81*	47.63*	42.4
5	29.89*	26.88*	25.5	52.41*	47.13*	42.4
6	24.86	21.85	25.5	49.75*	43.74*	42.4
7	24.24	20.82	25.5	52.78*	45.34*	42.4

Note: The constant was allowed to enter unrestricted and the trend restricted to the error correction. Estimation was over the period 1961Q3 to 1998Q3.

As can be seen from Table 2 there is robust evidence of a cointegrating vector between the variables with the null of no cointegration rejected by the trace statistic for all lag lengths.

TABLE 3

Estimated co-efficient on the long run relationship (normalised so that coefficient on LEMP = -1)

No. of lags in the VAR	LRWAG	LRGDP	t
4	-0.52	1.12	-0.003
5	-0.47	1.07	-0.003
6	-0.46	1.04	-0.003
7	-0.46	1.05	-0.003

From Table 3 the long run parameters are of consistent sign and orders of magnitude. Indeed at what seems the most appropriate lag order, lag 7, the long run relationship takes the form:

LEMP = -0.46 LRWAG + 1.05 LRGDP -0.003 trend

which is very close to the parameter estimates from the Pesaran et al estimation method above.

One advantage of the Johansen method is that the weak exogeneity assumption of real GDP and real wages can be more formally tested by imposing zero restrictions on the estimated α matrix. Thus assuming, based on the above results, that the rank of the long run matrix is one, the weighting coefficients of RWAG and RGDP are constrained to be zero, testing that the cointegrating relationship enters only the employment equation of the system. The results are in Table 4 and show that while the real wage and output variables cannot reject the zero restriction, implying that they are weakly exogenous, the employment variable can. This provides strong support for the notion that weak exogeneity can be assumed for real wages and GDP, and hence validates the results from the Pesaran et al testing procedure.

TABLE 4

Testing for weak exogeneity

No. of lags in the VAR	LRWAG $\chi^2(1)$	LRGDP $\chi^2(1)$	Joint test LRWAG and LRGDP: $\chi^2(2)$	LEMP $\chi^2(1)$
4	4.24	0.56	4.37	9.34**
5	1.90	1.14	2.11	12.49**
6	2.28	2.64	3.33	9.75**
7	0.83	0.83	1.03	8.51**

Note: ** denotes significant at 5 per cent.

There is strong support for the notion of a long run relationship between employment, real

wages and real GDP. The two methods of testing for such a relationship not only suggest that one exists but produce estimates of the long run parameters which are very similar, providing strong grounds for basing estimates of the elasticity of demand for labour on the numbers produced. The fact that both the ARDL and Johansen procedures indicate for the first time that the variables on the right hand side are weakly exogenous, validates the use of a single equation procedure in estimating the marginal productivity (employment) equation.

In summary, the results imply an elasticity of substitution between capital and labour of about -0.45 (not the wage elasticity). Given a labour share of GDP of about 0.6, this translates into an output constant elasticity of demand for labour with respect to real wages of smaller than –0.2 (0.45 x (1-0.6)). This is substantially lower than other estimates. Assuming an elasticity of demand for labour with respect to output of unity (the RGDP coefficient is not significantly different from unity) this implies an elasticity of demand for labour with respect to real wages of –(0.6 x 1 + 0.2), that is –0.8. Thus, the correctly interpreted and estimated elasticity is (somewhat fortuitously) close to the wrongly interpreted and estimated 'elasticity' of other studies.

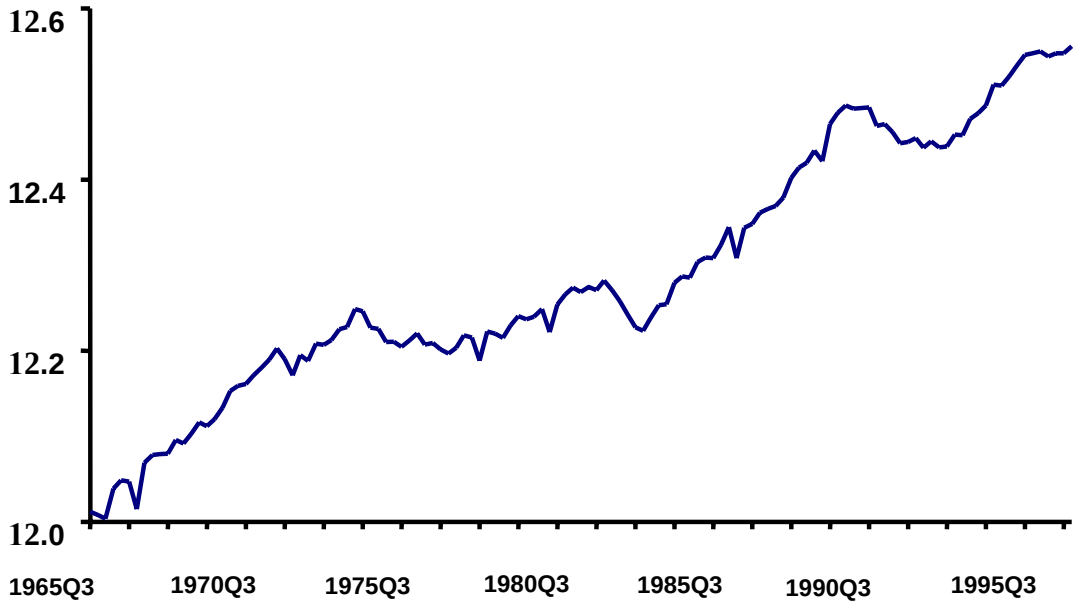
The coefficient of the trend term is the quarterly labour saving degree of technological change. A value of -0.003 on a quarterly basis implies technological change is labour saving of the order of 0.012 or 1.2 per cent per year.

Attention now focuses on hours worked. It could be argued that total employment is not the relevant demand for labour variable, although it is usually the focus of policy debate. Total hours worked are a more appropriate measure of the demand for labour. The discrepancy

between total hours and total employment has become greater since the 1970s with the growth in part-time work and increased hours by many in full-time employment (Norris and Wooden 1996).

Movement in the dependent variable in the hours equation is given in Figure 2. The general trends exhibited in employment are accentuated in hours worked. For instance, whereas employment *growth* fell during the post 1975 period the *level* of hours worked fell. Also, there appears, as expected, to be greater variation in hours than there is in employment. This occurs because it is much easier for employers to adjust hours worked than employment.

Figure 2
Log of Hours Worked



The previous procedures adopted to test and estimate the labour demand function for employment were then used to examine the relationship using the logarithms of total hours worked (LHOURS) as the dependent variable and the logarithm of real hourly wages (LRHWAG) as the relevant explantory variable. The tests for a long run relationship between the variables are given in Table 5.

TABLE 5

Tests of a long run relationship – hours

	Lag = 5	Lag = 4	Lag = 3	Lag = 2	Lag = 1
ΔLHOURS					
F(4)	3.21	4.18	6.56*	7.5*	11.64*
AR(1-5)	1.11	1.91	0.58	0.77	0.73
SC	-8.95	-9.05	-9.12	-9.21	-9.31*
HQ	-9.24	-9.3	-9.33	-9.38	-9.44*
FPE	7.96	7.72	7.65	7.48	7.26*
ΔLRHWAG					
F(4)	4.21	3.84	4.85	4.82	6.54*
AR(1-5)	0.43	0.62	0.57	1.32	0.51
SC	-8.43	-8.51	-8.6	-8.66	-8.75*
HQ	-8.72	-8.76	-8.81	-8.84	-8.88*
FPE	13.43	13.25	12.9	12.93	12.72*
ΔLRGDP					
F(4)	3.83	4.06	4.49	4.63	5.12
AR(1-5)	1.99	1.1	0.65	0.90	1.28
SC	-8.9	-8.99	-9.08	-9.16	-9.24*
HQ	-9.19	-9.24	-9.29	-9.33	-9.38*
FPE	8.37	8.17	8.01	7.86	7.74*

Sample 1967Q1 to 1998Q3

As can be seen for all three specifications a low order lag appears appropriate. The inversion with ΔLHOURS as dependent variable rejects the null that the trend and lagged level variables are zero at lags 3, 2 and 1 again supporting the existence of a long run relationship. There are no rejections for the ΔLRGDP inversion and only one for the ΔLRHWAG inversion. This again is generally supportive of the notion of a long run relationship between the variables. The result for the ΔLRHWAG specification, however, suggests some possible feedback from the error correction to the real wage equation.

Once again an ARDL(3,3,3) was used to estimate the long run parameters. The long run relation and its associated standard errors was:

LHOURS = - 0.5723 – 0.678LRHWAG + 1.339LGRDP - 0.00463t

s.e.	(1.083)	(0.061)	(0.109)	(0.00077)
t stat.	(-0.53)	(-11.14)	(12.21)	(-6.06)

The real wages coefficient for hours equation is somewhat larger than for employment as would be expected. The coefficient on real GDP, however, appears unacceptably large implying as it does significant decreasing returns to scale.

Once again it is possible to use the estimated long run relationship and re-estimate in the form of an ECM. The error correction term is significant and correctly signed with a coefficient of -0.28 and a t statistic of -4.78, thus suggesting a faster adjustment in hours worked than for the employment equation.

Finally the Johansen estimation is, once again supportive of the above results. There was some evidence of two cointegrating vectors between the three variables[7], the first corresponded closely to the to the results obtained for the employment equation and so the cointegration space was restricted to this vector and tests for the weak exogeneity of the other two variables were carried out on this basis. Once again weak exogeneity could not be rejected for the wage and GDP variables either individually or separately.

TABLE 6

Johansen's test for cointegration

No. of lags in the VAR = 4	Max. Eigenvalue Statistic	Adjusted Statistic	5% critical value	Trace test statistic	Adjusted statistic	5% critical value
H_0: 0 cv s	28.03*	25.34	25.5	56.43**	51.01**	42.4
H_0: ≤ 1 cv	18.31	16.54	19.0	28.4*	25.67*	25.3
H_0: ≤ 2 cv	10.12	9.131	12.3	10.1	9.131	12.3

NB the constant was allowed to enter unrestricted and the trend restricted to the error

correction. Estimation was over the period 1967Q3 to 1998Q3.

As can be seen the parameter estimates (shown below) of the long run relationship obtained from the Johansen estimation conformed reasonably closely (all are within two standard errors) to those obtained from the ARDL method:

Cointegrating Vector - Johansen Method:

LHOURS = -0.578LRHWAG + 1.285LRGDP -0.0045t

The χ^2 test for weak exogeneity of respectively LRHWAG, LRGDP and jointly are 1.53, 1.72 and 2.09 clearly supporting weak exogeneity.

Applying the procedure adopted above for using employment the relevant elasticities for hours can also be easily calculated. The elasticity of substitution between capital and labour is estimated to be about –0.6, the output constant elasticity of demand with respect to real wages is –0.3 and the total elasticity of demand for labour with respect to real wages is –0.9, slightly bigger than for total employment.

The coefficient of the trend term of -0.046 translates to labour saving technological change of about 1.8 per cent per year.

Finally the estimated parameters in both the employment and hours equations for the long run relationship were tested for their stability. This was done using tests described in Hansen (1992), namely SupF, MeanF and L_C test. In order to implement these tests a program written specifically by Hansen to carry out the tests was used.[8] The method also requires the use of the FM-OLS type estimators of cointegrating relationships suggested by Phillips and Hansen

(1990), which also provides a further check on the results above.

First, for the employment model the FM-OLS method yielded estimates of the parameters on LRWAG and LRGDP of -0.444 and 1.024 respectively, very close to those already obtained. The Lc, Mean F and SupF tests all failed to reject the null of stability suggesting that the long run relationship obtained is indeed stable. This leads to the conclusion that, for the employment equation, there is a robust and stable set of parameter estimates.

However, when the same tests were applied to the hours equation they revealed evidence of instability in the estimated regression with two out of the three tests rejecting the null of stability. The FM-OLS yielded parameter estimates of -0.614 on real wages and 1.12 on Real Output.

The instability of the hours equation could well be due to the observed behaviour of average hours worked during the estimation period (Dawkins 1996). The average hours worked fell during the mid to late 1970s but then plateaued and hours remained almost constant since. This is despite the large growth in part time work which would have been expected to reduce average hours worked. The increased number of part time workers has been accompanied by a growth in the number of people working long hours. For instance in the 1970s about 20 per cent of employed men and 5 per cent of employed women worked more than 49 hours per week while since the mid 1980s this had risen to 28 per cent and 9 per cent, respectively. The number working over 60 hours or more per week more than doubled for males to over 10 per cent in the 1990s (Dawkins 1996). Since most of these are Managers, Professionals and Tradespersons it is likely that many of these hours are unpaid for. It is also not known how

many of these reported hours are ‘productive’ and how many are simply attempts to impress employers. Whatever the speculation about the nature and causes of increased working hours, the implications are that the parameter on real GDP is likely to be biased. From a logical perspective it is hard to see why the coefficient would not be unity. The behaviour of hours and its implications for measurement of labour input and hourly labour costs is clearly an area for further research.

DISCUSSION AND CONCLUSION

The above results are very important from the point of view of knowledge of the demand for labour and for policy analysis. As already noted earlier there is regularly heated debate over the policy effectiveness of real wage restraint on employment in the Australian economy so a concise estimate of the relevant parameters is vital. The results from the employment equation, using both the ARDL and Johansen method, yielded an estimate of the parameter on the real wage term (LRWAG) of approximately –0.45. As noted earlier this is the estimate of σ, the elasticity of substitution between labour and capital – not as might be thought the output constant elasticity of demand for labour with respect to real wages. However as noted earlier the formulae for the constant output elasticity of demand with respect to real wages ($e = -\left[(1-s)\sigma\right]$) and the elasticity of demand for labour with respect to real wages ($e' = -\left[(1-s)\sigma + s\eta\right]$) can be used to estimate the elasticities of interest. η is the scale effect arising from output expanding as costs of production fall and for the CES case η is equal to one. s is labours share of GDP which during the sample period averaged approximately 60 per cent. Thus using these figures the output constant elasticity of demand for labour with respect to real wages is -0.2 and the total elasticity of demand for labour with respect to real wages is approximately -0.8.

Thus, had the parameter on real wages in the estimated equation been interpreted as the required output constant elasticity the estimated value for the employment equation would have been approximately -0.45, lower than previous work, but not substantially so. However, as the calculations above show, the correct elasticity is much lower, approximately -0.2. The truly substantial effect of wage cuts comes from their effect on employment via a reduction in costs and hence their effect on output. Assuming a unitary elasticity of demand for output the real wage elasticity is -0.8.

These results suggest that overall wage moderation would have a significant impact on employment growth. However, most of this comes from the effects of wage restraint on output rather than substitution. This is not to say that considerable labour/labour substitution does not exist (Lewis 1985) which implies that relative wage changes can significantly improve employment of particular groups such as youth or the long term unemployed.

With respect to future research findings there is a need for a different focus to that of the CES derived labour demand which has almost exclusively dominated the Australian literature. For instance, there is scope for a more flexible form of production function to be used. Also, there are potentially interesting results to be had by disaggregation of labour and capital (and possibly raw materials). In addition the important role of technical change in determining the demand for labour is well known (see Norris and Wooden, 1996) yet not incorporated into the analysis of labour demand. For instance, the growth in part-time and casual work, labour shedding in many sectors and the virtual elimination of full time work for teenagers are, in part, consequences of the impact of technological change on the demand for labour.

Adjustment of hours worked to changes in wages and output is much faster than employment. These results are consistent with evidence from overseas which shows that the speed of adjustment of hours worked in response to wages is greater than for levels of employment (Hamermesh 1993). This is consistent with labour hoarding during recessions and increasing hours of employment during recoveries. For hours worked the speed of adjustment is high with the gap between actual and optimal hours made up in less than one year.

Technical progress is found to be labour saving of about 1.2 per cent per year. From a policy perspective, this estimate and the approximate growth in the labour force of 2 per cent per year (Norris and Wooden, 1996), implies that output must increase by at over 3 per cent per year for the unemployment rate to be reduced.

This paper has presented new estimates of the elasticity of demand for labour at the aggregate level. Hopefully, the robustness of the results will allow policy makers to make more informed judgements regarding the efficacy of alternative policy prescriptions. Although of significance from a policy perspective it is likely that future work on the demand for labour would benefit from concentration on different issues, such as the extent of substitution of different types of labour, both between themselves and with capital, and the impacts of technological change.

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ENDNOTES

[1] Note, however, that Post-Keynesians deny the existence of a downwardly sloping aggregate demand curve)see Davidson, 1983). According to this view it is not demand which determines unemployment but the interaction of demand and supply.

[2] See Lewis and Seltzer (1996) for a review of these studies.

[3] Although a number of more flexible forms of the production function are possible this paper follows previous work using a CES framework. Also the use of within equation restriction is difficult with ARDL methodology.

[4] Note, however, that MacDonald (1997) has found real wages, employment and output to be all I(1) and that

[5] Unit root tests available on request. In brief we estimated A/DF tests with lags ranging from 0 to 5. In levels there were no rejections at the 5 per cent level. On first differencing the variables there were rejections at virtually all lag lengths.

[6] Again the results are lengthy and for brevity the full reduction sequence has been omitted. Full results are available from the authors.

[7] ADF tests indicate that LHOURS and LRHWAG are clearly I(1).

[8] The programme is available from Prof Hansen's home page at: http//www.ssc.wisc.edu/bhansen/