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Primary Factor Substitution and the Real Wage Explosions

by

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ABSTRACT

This paper reports estimates of the demand for labour across broad industry categories in the Australian economy obtained from time series data spanning 1962-63 through 1985-86. The focus is the empirical estimation of the elasticity of substitution between the primary factors of capital and labour. The model developed employs an error correction mechanism whereby disequilibrium in periods of change can be corrected in later periods.

Over the study period two major wages shocks occurred, the first in 1973-74 and the second in 1981-82. In the underlying model adopted here allowance is made for the effects of these two events on the elasticity of primary factor substitution and on the capital intensity of the technology which is of related interest. Allowance is also made for disequilibrium, at the height of the wages shocks, which is not adequately accounted for by error correction.

For certain of the industry groups studied, it was difficult to achieve convergence in maximum likelihood searches. For these groups modifications to the model were made and in some cases modifications were also made to the data.

Generally, the results show relatively high substitution elasticities (mostly between 0.6 and 1.0); whenever specification allowed, moreover, the substitution elasticities increased in the aftermath of the wages shocks. Exceptional cases are Agriculture (with a low estimated elasticity) and Manufacturing (with an apparently declining elasticity). Capital deepening is also indicated in most cases.

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THE REAL WAGE EXPLOSIONS

by

Maureen Rimmer*

1 *INTRODUCTION*

In this paper an attempt is made to estimate the demand for labour across broad industry groups in the Australian economy, from time series data spanning 1962-63 through 1985-86.[1] As in much applied work in this area, in these estimations a maintained hypothesis is that the production process is nested, so that it is meaningful to pose the minimization of primary factor costs in the production of value added as a sub-problem that must be solved by the representative firm. It is assumed that the production function is CES and takes the form:

$$Q_t = A_t \, [(1-b_t) \, K_t^{-\beta_t} + b_t \, L_t^{-\beta_t}]^{-1/\beta_t} \quad ; \qquad (1.1)$$

where Q_t is real value added, K_t is the flow of capital services, and L_t the flow of labour services (person-hours). The A_t variable for a given industry group is designed to capture two separate influences affecting output: sector-wide growth in factor productivity and industry-specific fluctuations about full capacity production. This technological variable is formulated as a function of constant secular growth combined with a business cycle component:

$$A_t = e^{(\psi t + \theta D_t + \delta)} \quad ; \qquad (1.2)$$

where ψ denotes the constant rate of secular growth across the particular industry group under study and θ is a constant multiplier of the dummy variable, D_t, which traces movements along the business cycle for the economy as a whole, and δ is a constant.

Unlike most formulations in the literature, the 'parameters' b and β above have been indexed by time to allow for the possibility that the wages

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* Without implicating them in any remaining errors, I wish to thank Alan A. Powell, Keith R. McLaren and Peter J. Wilcoxen for extensive helpful comments on an earlier draft of this paper.

1 This study may be seen as an update of Phipps' (1983) work, which used data from 1962-63 to 1976-77.

explosions of 1973-74 and 1981-82 may have affected the capital intensity of the technology and/or the ease of substitution between labour and capital.

The remainder of this paper is structured as follows. In Section 2 the model is developed and the basic form of the estimating equation established. The approach adopted here is from the cost side rather than the production side and includes error correction. Section 3 contains a description of the database. In Section 4 the basic model is estimated for the important industry group of Manufacturing. An allowance (in addition to that provided by error correction) is made for possible disequilibrium at the heights of the wages shocks and the model re-estimated for Manufacturing. The model developed in Section 4 is applied, in Section 5, to other broad industry groups for which data are available. Modifications to the model and/or data are made where appropriate. Because of estimation difficulties, simplifications to the model are made in some cases in order to obtain estimates of primary factor substitution elasticities. Section 6 contains concluding remarks.

2 *THE MODEL*

The production function (1.1) under cost minimization yields the following first order condition:

$$\frac{rK}{wL} = \frac{1-b}{b}\left(\frac{L}{K}\right)^{\beta} \quad ; \tag{2.1}$$

where time subscripts have been suppressed, and r and w, respectively, are the rental rate and the (hourly) wage rate.

Equation (2.1) is not the best starting point, however, for an equation explaining the share of labour in value added. An equation for labour's share which contains no other endogenous variable is more conveniently obtained from the cost side rather than the production side. The cost function dual to the production function described in (1.1) is given by:

$$C = C(w, r, Q) = \frac{Q}{A}\left\{\left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} + \left[\frac{r}{(1-b)^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}}\right\}^{\frac{1+\beta}{\beta}} . \tag{2.2}$$

Now Shephard's Lemma states that a firm's conditional factor demand for labour is the partial derivative of cost with respect to the wage rate, so that:

$$L(w, r, Q) = \frac{\partial C}{\partial w} \quad . \tag{2.3}$$

Denoting the price of value added by p, on multiplying throughout (2.3) by w/(pQ), (2.3) can be expressed in terms of the share of labour in value added as:

$$sh_L = \frac{wL}{pQ} = \frac{w}{p}\frac{\partial(C/Q)}{\partial w} \quad . \tag{2.4}$$

From (2.2) this yields:

$$sh_L = \frac{w}{p}\frac{\partial}{\partial w}\left[\frac{1}{A}\left\{\left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} + \left[\frac{r}{(1-b)^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}}\right\}^{\frac{1+\beta}{\beta}}\right]$$

$$= \frac{w}{pAb^{-1/\beta}}\left[\frac{w}{b^{-1/\beta}}\right]^{\frac{-1}{1+\beta}}\left\{\left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} + \left[\frac{r}{(1-b)^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}}\right\}^{\frac{1}{\beta}} \quad . \tag{2.5}$$

The term involving the rental rate r in this share of labour equation can be eliminated using the cost equation (2.2) which implies that:

$$\left[\frac{r}{(1-b)^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} = \left[\frac{CA}{Q}\right]^{\frac{\beta}{1+\beta}} - \left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}}$$

$$= [pA]^{\frac{\beta}{1+\beta}} - \left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} \quad ; \tag{2.6}$$

since under competitive conditions pure profits are zero and hence $pQ = C$. On substituting (2.6) into (2.5), the following expression for the share of labour in value added, involving only w, p, b, β, and A is obtained:

$$sh_L = b^{\frac{1}{1+\beta}}\left[\frac{w}{pA}\right]^{\frac{\beta}{1+\beta}} \quad . \tag{2.7}$$

An important feature of equation (2.7) is the apparent, though perhaps misleading, dependence of the share of labour in value added on the technological variable A. This occurs because of the elimination of the rental rate r and its replacement with p. At constant wage and rental rates the ratio of factor inputs used to produce a given level of output would not alter with a change in A, since such a change leaves the isoquant map unchanged. Hence, the share of labour in value added would not alter. However, the zero pure profit condition requires the value added price p to alter to offset any change in A, since otherwise pure profits would be generated. This can be seen algebraically in equation (2.6), since, with the terms involving r and w constant, pA must also be constant.

Table 1

Changes in Capital Intensity and Substitutability

Period	$d\beta$	db
1962/63 - 1973/74	0	0
1974/75 - 1978/79	c_1(const)	c_2(const)
1979/80 - 1981/82	0	0
1982/83 - 1985/86	c_3(const)	c_4(const)

It is assumed here that changes in both the capital intensity of the technology and the substitutability of labour for capital during the sample period 1962-63 to 1985-86, were brought about primarily by the wages explosions of 1973-74 and 1981-82. Clearly the impact of these two events on the capital intensity and input flexibility would not commence immediately; a one year delay in the onset of the effects is allowed here. Further, it is assumed that the full repercussions of the wage shocks on b and β take five years to unfold, with a constant rate of yearly change over the allowed period of adjustment to the new desired level. This hypothetical pattern of change in 'b' and 'β' is summarized in Table 1.

The basic estimating equation adopted here is derived from (2.7) using the Hendry methodology (see for example Hendry (1979, 1988)) of 'general to specific' in the dynamic model specification. Rather than adopting a first differenced model based on (2.7) in the face of nonstationarity in the data, a more general dynamic framework is adopted which combines the short-run advantages of a first differenced model with the long-run advantages of error correction.

In 'proportional change' format (2.7) yields:

$$d(\ln\,(sh_L)) \;=\; \frac{1}{(1+\beta)^2}\,\frac{d\beta}{dt}\,dt\left[\ln\,(\frac{w}{p}) - \ln A - \ln b\right] + \frac{\beta}{1+\beta}\left[d\ln\,(\frac{w}{p}) - d\ln A\right] + \frac{1}{1+\beta}\,\frac{d(\ln b)}{dt}\,dt \quad . \qquad (2.8)$$

Basically, equation (2.8) breaks down the proportional change in labour share by the source of that change: the proportional change in the real wage $d(\ln(\frac{w}{p}))$, the proportional change in the technological variable $d(\ln A)$, as well as the parametric changes $\frac{d(\ln b)}{dt}\,dt$ and $\frac{d\beta}{dt}dt$. The term $\frac{d(\ln b)}{dt}\,dt$ in equation (2.8) provides a measure of changes in the capital intensity of the technology, with lower b-values indicating higher capital intensity at any given factor price ratio. This follows from the role of 'b' in the production function, as described in equation (1.1). The final term, $\frac{d\beta}{dt}$ dt, provides a measure of the change in substitutability of labour for capital since the elasticity of substitution between labour and capital under the CES production function is given by $\sigma = 1/(1+\beta)$.

Equation (2.8) makes no allowance for disequilibrium in periods of rapid change (such as during wages shocks) and neither does it allow any such effects to be 'corrected' in later periods. An error correction term can be incorporated into (2.8) by making use of the 'levels' equation (2.7). The logarithmic transformation of (2.7) gives:

$$\ln(sh_L) = \frac{1}{1+\beta}\ln b + \frac{\beta}{1+\beta}\left[\ln(\frac{w}{p}) - \ln A\right] . \tag{2.9}$$

If disequilibrium occurs in period t-1 so that, from (2.9):

$$\ln(sh_L)^* \neq \frac{1}{1+\beta^*}\ \ln(b)^* + \frac{\beta^*}{1+\beta^*}\left[\ln(\frac{w}{p})^* - \ln A^*\right] \ ;$$

where * indicates year t-1, then the difference between the actual and the predicted value of $\ln(sh_L)$ in that year:

$$\ln(sh_L)^* - \frac{1}{1+\beta^*}\ \ln(b)^* - \frac{\beta^*}{1+\beta^*}\ \left[\ln(\frac{w}{p})^* - \ln A^*\right] , \tag{2.10}$$

can be used to form a correction term for year t in (2.8). This yields:

$$\begin{aligned} d(\ln(sh_L)) &= \frac{1}{(1+\beta)^2}\ \frac{d\beta}{dt}\ dt\ \left[\ln(\frac{w}{p}) - \ln A - \ln b\right] \\ &+ \frac{\beta}{1+\beta}\ \left[d\ln(\frac{w}{p}) - d\ln A\right] + \frac{1}{1+\beta}\ \frac{d(\ln b)}{dt}\ dt \\ &+ (\alpha - 1)\left[\ln(sh_L)^* - \frac{1}{1+\beta^*}\ln(b)^* - \frac{\beta^*}{1+\beta^*}\left(\ln(\frac{w}{p})^* - \ln A^*\right)\right] . \end{aligned} \tag{2.11}$$

When $\alpha = 0$ any excess in actual over predicted levels of $\ln(sh_L)$ in year t - 1 is fully corrected in year t, when $\alpha = 1$ no correction is made and when

$0 < \alpha < 1$ partial correction occurs. Values of α greater than unity (or less than -1) cannot be economically interpreted as they indicate explosive instability in the system and values of α less than zero indicate over compensation for disequilibrium. The partial adjustment restriction $0 \le \alpha \le 1$ will be maintained here.

This error correction term must be cointegrating to avoid the introduction of nonstationarity into the estimating equation (assuming the original data is autoregressive of order at most one). This is likely to be the case as the share of labour in value added is bounded, but it will be checked in estimation.

From equation (1.2) it follows that the term ln A in (2.11) is given by:

$$\ln A = \psi t + \theta D_t + \delta \quad , \tag{2.12}$$

which when substituted into equation (2.11) yields:

$$\begin{aligned} d(\ln(sh_L)) &= \frac{1}{(1+\beta)^2}\frac{d\beta}{dt}dt\left[\ln\left(\frac{w}{p}\right) - (\psi t + \theta D_t + \delta) - \ln b\right] \\ &\quad + \frac{\beta}{1+\beta}\left[d\left(\ln\left(\frac{w}{p}\right)\right) - (\psi dt + \theta dD_t)\right] + \frac{1}{1+\beta}\frac{d(\ln b)}{dt}dt \\ &\quad + (\alpha - 1)\left[\ln(sh_L)^* - \frac{1}{1+\beta^*}\ln(b)^* - \frac{\beta}{1+\beta}\left(\ln\left(\frac{w}{p}\right)^* - \psi(t-1) - \theta D_t^* - \delta\right)\right] . \end{aligned} \tag{2.13}$$

which is the initial estimating equation adopted here.

3 *THE DATA*

The data sets used in this study were selected in the most part from two ABS publications: Australian National Accounts: Gross Product by Industry at Current and Constant Prices (ABS Cat. No. 5211.0) and Australian National Accounts: National Income and Expenditure (ABS Cat. No. 5204.0). The information contained in these series enabled the analysis to be carried out for the broad industry classifications listed in Table 2.

The wage rate w was estimated as wages, salaries and supplements per unit of labour input, L. The wages, salaries and supplements were obtained from the ABS publication: *Australian National Accounts: National Income and Expenditure* (ABS, Cat. No. 5204.0). To make allowance for fluctuations in hours worked, the employment data, L, used here are labour hours rather than persons. This quantity of labour input is measured as the product of persons employed and average hours worked. The employed

Table 2

Broad Industry Groups Under Study

ASIC Division A (Agriculture, Forestry, Fishing and Hunting)
ASIC Division B (Mining)
ASIC Division C (Manufacturing)
ASIC Division D (Electricity, Gas and Water)
ASIC Division E (Construction)
ASIC Division F (Wholesale and Retail Trade)
ASIC Division GH (Transport, Storage and Communication)
ASIC Division L (Recreation, Personal and Other Services)

persons data are based on the ABS publication, *Australian National Accounts: Gross Product by Industry at Current and Constant Prices* (ABS, Cat. No. 5211.0), and were obtained from the ABS on request. The average hours worked data were obtained using the August figures on hours worked from two ABS sources: *The Labour Force Australia -- Historical Summary 1966 to 1984* (ABS, Cat. No. 6204.0) and the 1985 and 1986 editions of *The Labour Force Australia* (ABS, Cat. No. 6203.0). The August data were chosen since they are not affected from year to year by the inclusion or exclusion of public holidays. August figures for the years 1962 to 1965 were unavailable from this source and were assigned the value of the average hours worked in August over the five-year period, 1966 to 1970 inclusive. These figures for 1962 to 1986 were translated into fiscal year data for 1962-63 to 1985-86 by taking weighted averages of the August figure occurring within each fiscal year and the August figure in the fiscal year following (with respective weights of 2/3 and 1/3).

The price deflator p was calculated as the ratio of current prices gross value added to constant prices gross value added in each industry group, the data being obtained from ABS, Cat. No. 5211.0. The data were obtained primarily from the ABS on request but with some data from the 1974 edition of this publication. The principles and methods employed in linking the data follow Chung and Powell (1987).

The share of labour in value added for each industry group is the share of wages, salaries and supplements for the industry group in the contribution to GDP at factor cost. Such data can be obtained as the ratio of wages, salaries and supplements to value added from the ABS publication: *Australian National Accounts: National Income and Expenditure* (ABS, Cat. No. 5204.0). These data on wages, salaries and supplements were obtained from the 1986-87 publication of this series, supplemented by information obtained directly from the ABS for the earlier values of the series.

For Manufacturing, the industry group initially targeted, the published data for Labour share were adapted to make allowance for owner-operators (which are not included in the published data). The labour share inclusive of owner-operators for Manufacturing has been estimated by Dixon and McDonald (1988) for the period 1972-73 to 1985-86 and their estimates are used here. For the earlier part of the sample period not covered by the Dixon and McDonald data, estimates of the share of labour in value added, including owner-operators, were obtained by calculating the product of the share of labour without owner-operators, from the ABS published data cited above, with an estimated ratio of the share of labour with owner-operators to that without. This ratio was obtained by taking a backward projection, using the least squares line of best fit, of the ratio over the period 1972-73 to 1985-86 (over which both labour shares were available).

These Dixon and McDonald estimates are not available for all the industry groups of interest here and since for Manufacturing the estimation results were found to be unresponsive to the inclusion/exclusion of owner operators, the labour share data from the ABS publication were used without modification, for the remaining industry groups under study.

The dummy variable, D_t, which is used in constructing the technological variable A (as described in equation (1.2)) has been calculated using data on the ratio of actual to potential output in the non-farm economy, which has been accumulated by Peters and Petridis (1977) and (1988). The Peters and Petridis data for the period of this study, 1962-63 to 1985-86, was obtained from two source papers. The data for the subperiod 1962-63 to 1974-75 was obtained from the September 1977 issue of *The Economic Record*, with the more recent data covering 1975-76 to 1985-86 being extracted from a May 1988 discussion paper from the Department of Economics, the University of Western Australia.

The dummy D_t is concerned with movements in the ratio of actual to potential output rather than with the absolute values of this ratio. Using the June figures for actual to potential output from Peters and Petridis, which are reproduced in Table 2, D_t is assigned the value 0 if the magnitude of change in actual to potential output is less than 0.015, the value +1 for changes greater than 0.015 and -1 for changes less than -0.015. The D_t series and the change in this series, dD_t, are also recorded in Table 3.

Table 3

Business Cycle Dummy Variable D_t for

Changes in the Business Cycle

June quarter	Actual/Potential output	D_t	dD_t
1961	0.9443	–	–
1962	0.9577	0	–
1963	0.9494	0	0
1964	0.9706	1	1
1965	0.9992	1	0
1966	0.9678	-1	-2
1967	0.9816	0	1
1968	0.9838	0	0
1969	1.0003	1	1
1970	1.0173	1	0
1971	0.9701	-1	-2
1972	0.9563	0	1
1973	0.9853	1	1
1974	0.9590	-1	-2
1975	1.0180	1	2
1976	1.0068	0	-1
1977	0.9906	-1	-1
1978	0.9788	0	1
1979	0.9815	0	0
1980	0.9832	0	0
1981	0.9957	0	0
1982	0.9337	-1	-1
1983	0.9314	-1	0
1984	0.9526	1	2
1985	0.9568	0	-1
1986	0.9771	1	1

Source: Actual/Potential output data was obtained from Peters and Petridis (1977) and (1988).

4 THE EMPIRICAL RESULTS FOR MANUFACTURING

In Manufacturing with sh_L, w, p, D_t, b, and β as described above, a maximum likelihood estimation was performed on equation (2.13), under the constraints imposed on b and β, over the twenty-three year period 1963-64 to 1985-86.[2]

The estimating equation (2.13) can be represented as a matrix equation in which $\ln(\frac{w}{p})$ and $d(\ln(\frac{w}{p}))$ are vectors derived from w and p over the sample period, dD_t (= $D_t - D_{t-1}$) and D_t are the vectors described in Table 3 and $\frac{d(\ln b)}{dt}dt$, β, and $\frac{d\beta}{dt}dt$ are vectors determined by the imposed pattern of changes in b and β as described in Table 2.

Table 4 displays the estimated values of the parameters from the estimation of (2.13) for the industry division of Manufacturing.

The estimated movement in b over the sample period shows an approximately sixty per cent reduction in the first adjustment period and an approximately one hundred per cent reduction in the second adjustment period. The direction of movement indicates an increase in the capital intensity of the technology whenever flexibility allows.

Across the sample period, the elasticity of primary factor substitution σ fell strongly from an estimate .700 at the start of the sample period to .167 at the end. This result is surprising as it indicates a substantially decreased input factor flexibility in response to the wages shocks whereas the reverse was anticipated. The estimate of ψ displayed in Table 4 indicates a sectoral rate of Hicks-neutral technical change of approximately 2.1 per cent per annum. The positive estimates of θ (approx. 0.010) confirm a procyclical variation of productivity with the business cycle.

The estimated coefficient, α-1, of the error correction term is negative as expected, -.670, and satisfies $0 \leq \alpha \leq 1$ as required. This implies that in response to disequilibrium in a given period, partial adjustment occurs in the next period. The estimate of α-1 is significantly different from zero indicating that error correction does make a significant contribution to the analysis.

The σ estimates in Table 4 appear unsatisfactory because they show both an unexpected direction of movement across the sample period and a variation which is large in magnitude. Because of these difficulties in interpreting the results of Table 4, the possibility of model misspecification should be considered.

It may well be that the sharp changes in the share of labour in value added, induced by the wages shocks of the 'seventies and 'eighties, caused a disequilibrium in the levels to such an extent that the error correction term could not adequately model the adjustment process.

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2 The estimation package used was TSP version 4.1B on VAX/VMS version V5.1-1 .

Table 4

Parameter Estimates from Labour Share Equation (2.13) for Manufacturing†

b_0 *	.595
	(8.78)
b_1 **	.223
	(7.88)
b_2 ***	.000
	(.54)
σ_0 *	.700
	(7.75)
σ_1 **	.297
	(3.03)
σ_2 ***	.167
	(2.40)
ψ	.021
	(1.93)
θ	.010
	(1.34)
δ	2.163
	(9.11)
α	.330
	(1.34)
α-1	-.670
	(2.72)
Log Likelihood	73.49
R^2	.83
DW	1.82

Notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

To correct for this potential shortcoming an adjustment lag parameter is introduced into equation (2.13) for each of the transitions 1973-74 to 1974-75 and 1981-82 to 1982-83. The estimating équation thus obtained is given by:

$$d(\ln(sh_L)) = \frac{1}{(1+\beta)^2}\frac{d\beta}{dt}dt\left[\ln\left(\frac{w}{p}\right) - (\psi t + \theta D_t + \delta) - \ln b\right]$$

$$+ \frac{\beta}{1+\beta}\left[d\left(\ln\left(\frac{w}{p}\right)\right) - (\psi dt + \theta dD_t)\right] + \frac{1}{1+\beta}\frac{d(\ln b)}{dt}dt$$

$$+ (\alpha - 1)\left[\ln(sh_L)^* - \frac{1}{1+\beta^*}\ln(b)^* - \frac{\beta}{1+\beta}\left(\ln\left(\frac{w}{p}\right)^* - \psi(t-1) - \theta D_t^* - \delta\right)\right]$$

$$+ \lambda_1 \mu_{1t} + \lambda_2 \mu_{2t} \quad ; \qquad (4.1)$$

where μ_{1t} takes the value one when t = 1974-75 and zero elsewhere, and μ_{2t} is equal to one when t = 1982-83 with zeros elsewhere. The adjustment lag parameters λ_1 and λ_2 should then pick up the percentage point change in labour share at the height of the wages shocks that is due to disequilibrium and cannot be accounted for by error correction. It is anticipated that λ_1 and λ_2 should be positive with λ_1 numerically larger since the wages shock of the 'seventies was more severe than that of the 'eighties. Essentially, the adjustment lag parameters λ_1 and λ_2 pick up outliers in the data.

Table 5 contains the estimated values of the parameters from the estimation of equation (4.1) for Manufacturing. As predicted the adjustment lag parameters λ_1 and λ_2 are positive indicating that labour shares rose to values higher than could be adequately explained with the partial adjustment to disequilibrium model previously adopted. Also λ_1 is (slightly) higher than λ_2 as anticipated.

With the introduction of the two adjustment lag parameters the severity of the fall in the b and σ across the sample period is substantially diminished. The estimated value of b falls by approximately 40 per cent in each of the allowed adjustment periods (compared with 60 per cent and 100 per cent in Table 4) and the estimated primary factor substitutiton elasticity falls from .670 to .530 (compared with the fall from .700 to .167 obtained earlier).

The estimated rate of Hicks-neutral technical progress from Table 5 is 2.6 per cent per annum and the variation of productivity with the business cycle is procyclical. The estimated coefficient, α-1, of the error correction term is within the required range and is of similar magnitude to that obtained in the earlier estimation (reported in Table 4) without adjustment lag parameters.

Table 5

Parameter Estimates from Labour Share Equation (4.1) for Manufacturing†

b_0 *	.229
	(.41)
b_1 **	.139
	(.40)
b_2 ***	.088
	(.43)
σ_0 *	.670
	(4.68)
σ_1 **	.582
	(3.32)
σ_2 ***	.530
	(2.22)
ψ	.026
	(1.80)
θ	.023
	(1.63)
δ	.233
	(.05)
α	.284
	(1.08)
α-1	-.716
	(2.73)
λ_1	.037
	(2.02)
λ_2	.031
	(1.72)
Log Likelihood	75.86
R^2	.87
DW	1.98
DW_e #	.97
$Z_\alpha/\sqrt{2}$#	-7.51

notes:
t statistics in parentheses.
† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.
* = for the period of 1963-64 to 1973-74.
** = for the period 1979-80 to 1981-82.
*** = for the year 1985-86.
\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for DW_e > .386 and $Z_\alpha/\sqrt{2} < -4$.

The error correction term was tested for stationarity using its Durbin Watson statistic (See Engle and Granger (1987)). If the error correction term is nonstationary the Durbin Watson approaches zero. The Durbin Watson test given in Engle and Granger finds cointegration (rejects non-cointegration) if the Durbin Watson statistic of the error correction term is too large. To further test the null hypothesis of no cointegration a Phillips unit root test was applied to the error correction term. The test statistic used was the Z_α statistic from Phillips (1987) which is a transformation of the standardized estimator $T(\hat{\alpha} - 1)$ used for testing unit roots in $y_t = \alpha y_{t-1} + u_t$. The advantage with the Phillips test is that it gives consistent estimates under very general conditions. Evans and Savin (1981) have tabulated in detail the limiting cdf of $Z_\alpha/\sqrt{2}$ using numerical methods and so the values of the modified test statistic, $Z_\alpha/\sqrt{2}$, obtained here can be tested for significance against the Evans and Savin table.

The Durbin Watson statistic for the error correction term, DW_e, and the Phillips unit root test statistic, $Z_\alpha/\sqrt{2}$, for Manufacturing are included in Table 5. Both indicate cointegration of the error correction term.

In all, the estimation results under the inclusion of an adjustment lag parameters (see Table 5) appear to provide a better description than those without the adjustment lag parameter (see Table 4) and so the estimating equation in which the adjustment frictions are modelled, equation (4.1), is accepted as representing the final model.

In summary, the addition of adjustment lag parameters at the height of the wages shocks has considerable impact on the results. Without this addition the failure of Manufacturing to immediately reconfigure its factor demands implies a big fall in the elasticity of substitution (from 0.7 to 0.2, see Table 4). Even with the frictions modelled there is still an implied fall in the elasticity of substitution, but it is much smaller (from 0.7 to 0.5, see Table 5). The apparently lower substitution elasticity in the 'eighties was not expected and requires further research.[3]

With the inclusion of adjustment lags at the height of the wages shocks capital deepening continued to be indicated but to a lesser degree.

5 *THE EMPIRICAL RESULTS FOR OTHER BROAD INDUSTRY GROUPS*

In this section the estimating equation (4.1) adopted for Manufacturing in Section 4 is applied to the other broad industry groups for which data are available. These groups are described in Table 2. The empirical results are reported in Table 6.

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3 It is possible that extending the operation of the disequilibrium lags would lead to a smaller fall in the elasticity of substitution; alternatively, changes in composition of Manufacturing may account for the fall observed in this study. Further research on the latter may be warranted.

Table 6

Parameter Estimates from Labour Demand Equation (4.1)[†]

IND DIV.[(a)]	A Agric.	B Mining	D E. G. & W.	E Const.	F W. & R.	GH T. S. & C.	L R.P. & O.S.
b_0^{*}			.751			.639	.329
			(1.68)			(10.35)	(.95)
b_1^{**}			.662			.623	.466
			(2.26)			(35.54)	(1.06)
b_2^{***}			.448			.572	.523
			(3.58)			(12.27)	(1.12)
σ_0^{*}			.526			.734	.799
			(4.45)			(5.03)	(5.08)
σ_1^{**}			.639			1.085	.905
			(5.31)			(7.51)	(4.67)
σ_2^{***}			.934			1.167	.943
			(2.57)			(6.00)	(4.07)
ψ	Convergence	Convergence	.036	Convergence	Convergence	.016	-.029
			(5.17)			(.77)	(.72)
θ	not	not	.004	not	not	.042	.020
			(.41)			(1.07)	(.43)
δ	achieved	achieved	1.182	achieved	achieved	1.763	-.731
			(1.47)			(5.19)	(.17)
α			.339			.416	.267
			(2.00)			(3.02)	(.71)
α-1			-.661			-.584	-.733
			(3.90)			(4.25)	(1.5)
λ_1			.068			.063	.020
			(3.18)			(3.03)	(.96)
λ_2			.003			.067	.015
			(.14)			(3.95)	(.92)
Log Likelihood			77.03			73.53	67.55
R^2			.94			.91	.88
DW			2.75			1.70	1.75
$DW_e^{\#}$			1.14			1.18	1.83
$Z_\alpha/\sqrt{2}^{\#}$			-8.98			-9.77	-11.61

notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for $DW_e > .386$ and $Z_\alpha/\sqrt{2} < -4$.

(a) For description of industries see Table 2.

Convergence was not achieved for four of the broad industry groups under study: Agriculture; Mining; Construction; and Wholesale and Retail Trade. Convergence was achieved for the remaining three industry groups: Electricity, Gas and Water; Transport, Storage and Communication; and Recreation, Personal and Other services.

From Table 6 industry D (Electricity, Gas and Water), shows an increase in the elasticity of primary factor substitution across the sample period (increasing σ) and an increase in the capital intensity of the technology in response to the wages shocks. These results are in line with expectations since a positive wages shock should favour the adoption of a more capital intensive technology (if future positive wage shocks are feared) and cause producers to try to increase the flexibility of their technology in order to more adequately withstand possible future wage shocks.

The estimate of ψ for industry D in Table 6 indicates a sectoral rate of Hicks-neutral technical change of approximately 3.6 per cent per annum. This figure is higher than the rate of secular technical change (2.8 per cent) obtained by Dixon and McDonald (1988) for industry D during the period 1971-72 to 1986-87 but it is not significantly different from the Dixon and McDonald estimate. The positive estimate of θ indicates a procyclical variation of productivity with the business cycle.

The estimated coefficient, $(\alpha-1)$, of the error correction term is -.661 which lies within the appropriate range and is also significantly different from zero indicating that error correction does contribute to the model. The Durbin Watson and Phillips unit root tests support the cointegration of the error correction term.

The estimated adjustment lag parameters are positive as expected. The estimated value of the first adjustment lag parameter, $\psi_1 = 0.068$, was higher than expected. This figure indicates that at the height of the wages shock of the 'seventies (1974-75), a 6.8 per cent increase in the share of labour was due to disequilibrium factors not otherwise accounted for by the error correction term. While this figure is very high, the actual percentage increase in labour share in that year was also exceptionally high at 11.6 per cent. The results shown in Table 6 for industry D, Electricity, Gas and Water, thus can be adequately explained and no further empirical work will be done for this industry.

Industry GH (Transport, Storage and Communication) also shows (see in Table 6) increased capital intensity of the technology (decreased b) and both high and increasing primary factor substitution elasticity (increased σ). Hicks-neutral technical progress is estimated as 1.6 per cent per annum with productivity procyclical with the business cycle. The error correction term once again appears to make a contribution to the analysis (α-1 = -.584) and is cointegrated according to both the Durbin Watson and Phillips unit root tests. The adjustment lag parameters are of the predicted sign.

For industry L (Recreation, Personal and Other Services) the results appearing in Table 6 are similar to those for industry GH described above with the exception of the movements in b, the capital intensity of the technology indicator, and the estimate of Hicks-neutral technical change. The b estimates are increasing for industry L indicating an increase in the labour intensity of the technology. The estimate of Hicks-neutral technical change is negative (although not significantly so), ψ = -.029, unlike the estimates already obtained for industry D and GH in Table 6 and industry C, Manufacturing, in Table 5. However, negative technical change estimates for industry L have also been obtained by Dixon and McDonald (1988) for the period 1971-72 to 1986-87 and by Phipps (1983) for the period 1965-66 to 1976-77, with the Dixon and McDonald estimate being -1.2 per cent per annum and the Phipps estimate -.7 per cent per annum. As for industry GH, the estimated primary factor substitution elasticity in industry L is high and increasing. The coefficient of the error correction term is not significant. This term is, in this case, cointegrated under the Durbin Watson and Phillips unit root tests, at the 5 per cent level of significance. In all, the results reported in Table 6 for industry L are taken as final.

This completes the discussion of industries D, GH and L. The remaining industries in Table 6, those for which convergence was not achieved, are investigated further below.

For these industries, industries A, B, E, and F, a common modified estimating equation is developed with further modifications being made, where appropriate, to take into account the nature of individual industries. An initial simplification is made to the basic estimating equation by seeking a constant estimate of the elasticity of primary factor substitution, σ, over the study period, rather than allowing modelled changes in σ in response to the wages shocks. The estimating equation obtained by modifying equation (4.1) in this manner is given by:

$$\begin{aligned} d(\ln(sh_L)) &= \frac{\beta}{(1+\beta)}\left[d\left(\ln\left(\frac{w}{p}\right)\right) - (\psi dt + \theta dD_t)\right] \\ &\quad + \frac{1}{1+\beta}\frac{d(\ln b)}{dt}dt + \lambda_1\mu_{1t} + \lambda_2\mu_{2t} \\ &\quad + (\alpha-1)\left[\ln(sh_L)^* - \frac{1}{1+\beta^*}\ln(b)^* - \frac{\beta}{1+\beta}\left(\ln\left(\frac{w}{p}\right)^* - \psi(t-1) - \theta\overset{*}{D}_t - \delta\right)\right]; \end{aligned} \tag{5.1}$$

where β is now a scalar rather than a vector.

Unlike estimating equation (4.1), the parameters in estimating equation (5.1) cannot all be separately identified. Combining the terms from the right hand side of equation (5.1) that involve only parameters not tied to the data, the following expression is obtained:

$$\frac{1}{1+\beta}\frac{d(\ln b)}{dt}dt + \lambda_1\mu_{1t} + \lambda_2\mu_{2t} + (\alpha-1)\left[\frac{-1}{1+\beta}\ln(b)^* + \frac{\beta}{1+\beta}\delta\right]. \tag{5.2}$$

It should be noted that since $\frac{d(\ln b)}{dt}$ dt is invariant under multiplication of the vector b by a scalar and since δ and ln b are nowhere tied to data in (5.1), it follows from (5.2) that δ and b_0 (the initial value of b) cannot be separately identified. This can be readily seen by checking that the expression given in (5.2) is unaltered by multiplying each term in b by a positive scalar, c, and adding $\frac{\ln(c)}{\beta}$ to δ. The initial setting, b_0, of b has no influence on the estimated parameters of (5.1) with the exception of course of b and δ, and the setting as b_0 = 0.5 is adopted here. With b_0 set, all the remaining parameters can be separately identified.

The dummy business cycle indicator, D_t, is designed to detect productivity movements, other than those induced by Hicks-neutral technical change and movements in the capital intensity of the technology indicator. This may not be appropriate for industry A (Agriculture). A better indicator for Agriculture may be an index responsive to stochastic factors such as weather or pasture conditions since these factors play a major role in Agriculture.

Such an index has been developed by Flavel *et al.* (1987). It is designed to reflect the relationship between climatic conditions and pasture production[4] This index is a quarterly index over the period 1956 to 1985, finishing one year short of the study period adopted here. Another closely related index by Moir (1990) showed little change between the 1985 and the 1986 figures and so the Flavel index was extended to 1986 with figures unchanged in the final year from those in operation in 1985. The pasture indicator adopted here is obtained from this index by taking a simple average of the four quarterly index data for a given year, normalizing this index across the sample period and then taking first differences. The pasture index so obtained is reproduced in Table 7. When estimation of equation (5.1) for Agriculture was attempted, with this pasture index replacing the business cycle indicator, convergence failed to be achieved. The diagnostics accompanying the estimation attempts indicated a difficulty in obtaining an estimate of α which is associated with the error correction term. Now α must lie in the range $0 \leq \alpha \leq 1$ in order that the estimation of equation (5.1) for Agriculture be economically interpretable as a partial adjustment (without over correction) to disequilibrium model, and so the constraints $\alpha=0$ and $\alpha=1$, were imposed as these settings mark the boundaries of the acceptable range. Under both of these constraints convergence of equation (5.1) for Agriculture with the pasture index, was achieved. The estimation results are reported in Table 8.

For Agriculture a low estimate of primary factor substitution, was recorded under each constraint on α: $\sigma = .357$ when $\alpha = 0$ and $\sigma = .268$ when $\alpha = 1$. The capital intensity of the technology indicator moved in the

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4 The Flabel *et al.* (1987) index is weighted for the sheep industry and is used here as a proxy for Agriculture in general.

Table 7

Pasture Index for Australian Agriculture

Year	Index
1962-63	.10
1963-64	.87
1964-65	-.03
1965-66	.93
1966-67	-.03
1967-68	.91
1968-69	.11
1969-70	.87
1970-71	.22
1971-72	.69
1972-73	.33
1973-74	.99
1974-75	.41
1975-76	1.00
1976-77	-.10
1977-78	1.02
1978-79	-.04
1979-80	.85
1980-81	.04
1981-82	.78
1982-83	.00
1983-84	1.12
1984-85	-.26
1985-86	1.12

Based on quarterly Pasture Index from Flavel *et al.* (1987).

direction of increased capital intensity in both cases. Hicks-neutral technical change was estimated at 1.4 per cent per annum for $\alpha = 0$ (2.5 per cent per annum for $\alpha = 1$) and the variation of productivity with the pasture indicator was in each case anticyclical. This anticyclical result is in line with expectations since capital as the fixed factor must absorb the bulk of changes in exogenous conditions such as the weather, so that it is to be anticipated that labour share would rise as pasture condition deteriorates so that θ, the coefficient of the pasture indicator, should be negative. No estimate of δ is obtained under the constraint $\alpha = 1$ since in this case δ is eliminated from estimating equation (5.1). In Table 8 most of the estimated parameters are insignificantly different from zero (with full error correction (α=0) fairing better than no error correction (α=1)), and the poor

Table 8

Parameter Estimates from Labour Share Equation (5.1) for Agriculture with Pasture Index D_t†

	α(set) = 0	α(set) = 1 (no error correction)
b_0 * (set)	$\overline{.5}$	$\overline{.5}$
b_1 **	.316	.332
	(2.38)	(.40)
b_2 ***	.410	.184
	(1.93)	(.29)
σ	.357	.268
	(2.19)	(.89)
ψ	.014	.025
	(.74)	(.40)
θ	-.042	-.005
	(.15)	(.024)
δ	2.059	-
	(4.17)	
λ_1	.035	.054
	(.26)	(.23)
λ_2	.365	.341
	(3.16)	(1.85)
Log Likelihood	23.44	12.38
R^2	.83	.50
DW	2.21	2.61
DW_e #	1.97	-
$Z_\alpha/\sqrt{2}$ #	-15.26	-

notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for $DW_e > .386$ and $Z_\alpha/\sqrt{2} < -4$.

performance may well be due to the difficulty in obtaining reliable data in this industry. Cointegration of the error correction term was accepted under full error correction ($\alpha = 0$). The tests are not meaningful when $\alpha = 1$ as, in this case, no error correction occurs. The results in Table 8 under a pasture index are accepted as the final results for Agriculture.

For Mining, a constraint that the coefficient, θ, of the business cycle indicator be set to zero, was imposed. The reason for this is that Mining is an export industry responding primarily to the state of the world market rather than to a domestic business cycle. The estimation of (5.1) for Mining failed to produce a convergent outcome with the associated diagnostics indicating a difficulty in estimating ψ, the rate of Hicks-neutral technical change. Both Dixon and McDonald (1988) for the period 1972-73 to 1986-87, and Phipps (1983) for the period 1962-63 to 1976-77 obtained estimates of Hicks-neutral technical progress close to zero. The Phipps estimate, $\psi = 0.10$, was imposed and (5.1) estimated. The results of this estimation appear in Table 9. Also in Table 9 are alternative results with ψ constrained to the value of estimate obtained for Manufacturing, $\psi = .026$.

The results of the two estimations for Mining, reported in Table 9, are qualitatively the same and quantitatively very similar, showing high primary factor substitution elasticity (approximately 0.8), falling then rising capital intensity of the technology and negative (though insignificant) estimates of the adjustment lag parameters.

The Durbin Watson and Phillips unit root tests fail to reject non-cointegration at the 5 per cent level of significance. The Phillips test does however reject non-cointegration at the 1 per cent level. In any case the coefficient of the error correction term is insignificant at the 5 per cent level.

For Industry E (Construction) convergence of equation (5.1) was not achieved and the diagnostic information accompanying the attempted estimates indicated a problem in obtaining an estimate of ψ, the rate of Hicks-neutral technical change.

For Construction, the ABS does not provide a satisfactory measure of real output since its measure of value added is based (at least in part) on the same data as its measure of factor inputs. This implies that very little technical change should be detected in Construction. Phipps (1983) obtained an estimate of ψ close to zero ($\psi = .005$) for the period 1962-63 to 1976-77 and this constraint was imposed here.

Table 9

Parameter Estimates from Labour Demand Equation (5.1) for Mining with Imposed Secular Technical Change $\psi^{\dagger}$

	$\psi = 0.010$ (set)	$\psi = 0.026$ (set)
b_0 * (set)	$\overline{.5}$	$\overline{.5}$
b_1 **	.611	.622
	(2.64)	(2.66)
b_2 ***	.443	.460
	(2.63)	(2.68)
σ	.776	.786
	4.02)	(4.04)
δ	2.735	2.562
	(1.74)	(1.53)
α	.847	.841
	(7.58)	(7.18)
α-1	.153	-.159
	(1.37)	(1.36)
λ_1	-.038	-.040
	(.39)	(.40)
λ_2	-.015	-.012
	(.16)	(.13)
Log Likelihood	28.17	28.10
R^2	.31	.31
DW	1.72	1.73
DW_e #	.12	.14
$Z_\alpha/\sqrt{2}$ #	-2.24	-2.28

notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for $DW_e > .386$ and $Z_\alpha/\sqrt{2} < -4$.

The estimate of (5.1) for Construction under the constraint that ψ = . 005 is reported in Table 10.

Industry E (Construction) shows a technology approaching Cobb-Douglas, with elasticity of primary factor substitution close to unity (σ = .996, Table 10), suggesting that Construction is relatively flexible in its primary factor input mix. The estimated movements in b, the capital intensity of the technology indicator, are once again in the anticipated direction of increased capital intensity (falling b).

The adjustment lag parameters are positive as anticipated. The estimates of λ_1 (.026) and λ_2 (.004) indicates that a 2.6 (0.4) per cent increase in the share of labour immediately after the 'seventies ('eighties) wages shock was due to disequilibrium factors not accounted for by error correction.

The measure of θ for the Construction industry is high but procyclical as expected and not significantly different from zero. The coefficient, α-1, of the error correction term is significantly different from zero and cointegration of the error correction term is indicated. The results of Table 10 are taken as final for Construction.

For the industry group F (Wholesale and Retail Trade) the estimation of equation (5.1) failed to produce a convergent result. As for Mining and Construction the diagnostic information accompanying the unsuccessful attempts indicated difficulty in obtaining an estimate of ψ, the rate of Hicks-neutral technical progress. Dixon and McDonald (1988) have obtained an estimate of secular technical progress for this industry group close to zero over the period 1971-72 to 1986-87 and so the constraint that ψ = 0.0 was applied here. Under this constraint convergence of the estimating equation (5.1) was still not achieved with the diagnostic information indicating difficulty in estimating θ, the coefficient of the business cycle indicator. As most of the estimated values of θ for the other broad industry groups under study ranged between 0.00 and 0.02, two constraints θ = 0.00 and θ = 0.02 were applied and (5.1) estimated. The results of these estimations appear in Table 11.

The two estimation results reported in Table 11 are very similar with high primary factor substitution elasticity and falling then rising capital intensity of the technology. In both cases the coefficient of the error correction term is fairly low, cointegration of the error correction term is accepted and the adjustment lag parameters are positive.

This completes the estimations for the broad industry groups under study here and a summary of the elasticity of primary factor substitution results and the capital intensity of the technology results are reproduced in Table12.

Table 10

Parameter Estimates from Labour Demand Equation (5.1) for Construction with Imposed Secular Change†

	ψ = .005 (set)
b_0^{*} (set)	$\overline{.5}$
b_1^{**}	.438
	(51.35)
b_2^{***}	.420
	(42.72)
σ_0	.996
	(11.79)
θ	1.505
	(.05)
δ	-57.817
	(.04)
α	.300
	(1.17)
α-1	.700
	(2.72)
λ_1	.026
	(1.13)
λ_2	.004
	(.19)
Log Likelihood	65.12
R^2	.50
DW	1.82
DW_e #	1.45
$Z_\alpha/\sqrt{2}$ #	-11.85

notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for DW_e > .386 and $Z_\alpha/\sqrt{2} < -4$.

Table 11

Parameter Estimates from Labour Demand Equation (5.1) for Wholesale and Retail Trade with Imposed Secular Technical Trade and Coefficient of Business Cycle Indicator†

	$\psi = 0,\ \theta = .02$ (set)	$\psi = 0,\ \theta = 0.0$ (set)
b_0 * (set)	$\overline{.5}$	$\overline{.5}$
b_1 **	.521	.526
	(28.29)	(29.99)
b_2 ***	.492	.493
	(22.54)	(23.10)
σ	.876	.950
	(9.68)	(7.81)
δ	1.569	-.387
	(1.62)	(.05)
α	.684	.671
	(4.21)	(4.14)
$\alpha-1$	.316	.329
	(1.94)	(2.03)
λ_1	.028	.025
	(1.45)	(1.20)
λ_2	.055	.057
	(2.74)	(2.77)
Log Likelihood	63.71	66.55
R^2	.61	.57
DW	1.92	1.94
DW_e #	.61	.61
$Z_\alpha/\sqrt{2}$ #	-5.51	-5.72

notes: t statistics in parentheses.

† $\sigma = \frac{1}{1+\beta}$ is reported rather than β.

* = for the period of 1963-64 to 1973-74.

** = for the period 1979-80 to 1981-82.

*** = for the year 1985-86.

\# The critical value for the test for non-cointegration is .386 for DW_e and -4 for $Z_\alpha/\sqrt{2}$ at the 5 per cent level of significance. The tests find cointegration for $DW_e > .386$ and $Z_\alpha/\sqrt{2} < -4$.

Table 12

Elasticity Estimates from Tables 5, 6, 8, 9, 10 and 11

	Industry Group	Primary Factor Elasticity of Substitution σ	Capital Intensity of the Technology Indicator
A	Agriculture (Forestry, Fishing and Hunting)	.357 , .268	$.\bar{5}$ → .32 → .41 .5 → .33 → .48
B	Mining	.776 , .786	$.\bar{5}$ → .61 → .44 .5 → .62 → .46
C	Manufacturing	.67 → .58 → .53	.23 → .14 → .09
D	Electricity, Gas and Water	.53 → .64 → .93	.75 → .66 → .45
E	Construction	.996	$.\bar{5}$ → .44 → .42
F	Wholesale and Retail Trade	.876 , .950	$.\bar{5}$ → .52 → .49 .5 → .53 → .49
GH	Transport, Storage and Communication	.73 → 1.09 → 1.17	.64 → .62 → .57
L	Recreation, Personal and Other Services	.80 → .90 → .94	.33 → .47 → .52

note: For the estimating equations involving only a point estimate of primary factor substitution elasticity, the initial value of the capital intensity of the technology is set at .5 (indicated by $.\bar{5}$). See the discussion following Equation (5.2) for details.

6. *CONCLUSION*

For the broad industry groups under investigation here, the results of this study mainly show relatively high short-run elasticities of primary factor substitution which increase across the sample period whenever flexibility allows. The only exceptions are Agriculture with low point estimates of substitution elasticity (.3 or .4) and Manufacturing with decreasing values (σ = .7 in 1963-64; declining to .5 in 1985-86).

Construction and Wholesale and Retail Trade showed point estimate of primary factor substitution of around unity while Mining exhibited elasticity estimates of around .8. Electricity, Gas and Water; Transport, Storage and Communication; and Recreation, Personal and Other Services all showed increasing substitution elasticity estimates across the sample period; .5 to .9 for Electricity, Gas and Water, .7 to 1.2 for Transport, Storage and Communication and .8 to .9 for Recreation, Personal and Other Services. The implication is that firms in these three industries became on average more able to reconfigure their capital/labour ratio in response to factor price shocks and hence more able to contain costs in the face of such shocks. The reverse is true for Manufacturing. Rather than increasing their ability to withstand cost shocks over the study period, Australian Manufacturing firms seem to have become on average more vulnerable to such shocks.

One possible explanation of this surprising result could be compositional change in Manufacturing favouring industries with low substitution elasticity at the expense of industries with higher elasticity. Future research may be warranted on the impact of compositional changes on the ease of substitution of primary factor inputs in Manufacturing as a whole. Another contributing factor may be the nature of technological change in this industry. It may well be that the observed deepening of the capital intensity of the technology (see Table 5) is associated with a more rigid production framework with firms sacrificing flexibility for efficiency. That is to say, the newer (presumably lower cost) technologies which became available during the study period may just 'happen', for reasons unrelated to Australia's wages shocks, to involve higher capital intensity *and* lower substitution elasticity. After all, Australia is a very small part of the world market for manufacturing technology.

Like Manufacturing, the majority of the industry groups under study showed increased capital intensity of the technology. The exceptions here are Mining and Wholesale and Retail Trade with falling then rising capital intensity of the technology but little overall change; and Recreation, Personal and Other Services with falling capital intensity of the technology whenever the specification of the model allowed.

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