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PRIMARY FACTOR SUBSTITUTION IN MANUFACTURING AND THE REAL WAGE EXPLOSIONS

by

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Preliminary Working Paper No. OP-69 Melbourne November 1989

ISSN 1031 9034 *ISBN 0 642 10009 8*

The Impact Project is a cooperative venture between the Australian Federal Government and the University of Melbourne, La Trobe University, and the Australian National University. By researching the structure of the Australian economy the Project is building a policy information system to assist others to carry out independent analysis. The Project is convened by the Industries Assistance Commission on behalf of the participating Commonwealth agencies (the Australian Bureau of Agricultural and Resource Economics, the Industries Assistance Commission, the Bureau of Industry Economics, the Department of Employment, Education and Training, the Bureau of Immigration Research and the Department of the Arts, Sport, the Environment, Tourism and Territories). The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Commonwealth Government.

ABSTRACT

In this paper an attempt is made to estimate the demand for labour in Australian manufacturing from time series data spanning 1962-63 through 1985-86. Over this study period two major wage shocks occurred; the first in 1973-74 and the second in 1981-82. The effects of these two events on the elasticity of primary factor substitution in manufacturing are estimated here. Surprisingly a substantial fall in the substitution elasticity was recorded across the sample period. Of related interest are the movements in the capital intensity of the technology over the study period; contrary to expectations, these movements seem to indicate a strong fall in the capital intensity of the technology.

When allowance is made for possible disequilibrium at the height of the wages shocks, however, the latter result is overturned. With these frictions modelled there is still an implied fall in the elasticity of substitution but it is much smaller and, contrary to the earlier results, the expected deepening of the capital in the aftermath of the wages shocks was confirmed.

The results show increased rigidity in the primary factor input mix in Manufacturing over the sample period, with the implication that, on average, firms became less able to reconfigure their capital/labour ratio in response to factor price shocks, and hence less able to contain costs in the face of such shocks.

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the 'eighties was not expected and requires further research.[1]

The inclusion of adjustment lags at the height of the wages shocks did, however, cause the behaviour of the capital intensity indicator, b, to move in the manner originally anticipated; that is, a deepening in the capital intensity of the technology ensued in the aftermath of the shocks (compare Tables 4 and 15). These changes in the technology, nevertheless, remained insignificantly different from zero.

1 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.

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1979-80 - 1981-82 b	.0686	.0608
1985-86 b	.0650	.0488
1963-64 - 1973-74 σ	.7873 (6.17)	.7380 (5.79)
1979-80 - 1981-82 σ	.7596 (3.52)	.4857 (1.61)
1985-86 σ	.4702 (2.38)	.4436 (1.33)

are significantly different (at the 5 per cent level) from the earlier results of Table 12. On prior grounds, however, the point estimate of the neutral component of technological change obtained in Table 12 is preferred.

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 about 0.7 or 0.8 to about 0.4 or 0.5; see Table 15). The apparently lower substitution elasticity in

Table 14

Parameter Estimates from Labour Share Equation (5.1)

	Optimal Likelihood Solution	Solution from Table 12
1963-64 - 1973-74b (set)	.07	.07
1974-75 - 1978-79db	-.0003 (.14)	-.0018 (.17)
1979-80 - 1981-82b	.0686 (6.56)	.0608 (1.11)
1982-83 - 1985-86db	-.0009 1.46	-.0030 1.46
1985-86 b	.0650 (3.90)	.0448 (.56)
1963-64 - 1973-74β	.2701 (1.31)	.3549 (1.52)
1974-75 - 1978-79dβ	.0093 (.15)	.1408 (.59)
1979-80 - 1981-82β	.3165 (.85)	1.0591 (.83)
1982-83 - 1985-86dβ	.2025 (1.06)	.0488 (.09)
1985-86 β	1.1266 (1.26)	1.2544 (.74)
ψ	.0063 (.21)	.0233 (1.46)
θ	.0223 (1.35)	.0170 (1.31)
δ	5.8341 (6.52)	4.7718 (2.65)
λ_1	.0488 (2.55)	.0459 (1.71)
λ_2	.0686 (2.59)	.0497 (2.76)
D.W.	1.92	1.85
Log.Like.	71.39	70.28

PRIMARY FACTOR SUBSTITUTION IN MANUFACTURING AND THE REAL WAGE EXPLOSIONS

by

Maureen Rimmer*

1 INTRODUCTION

In this paper an attempt is made to estimate the demand for labour in Australian manufacturing 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 is designed to capture two separate influences affecting output: sector-wide growth in factor productivity and (Manufacturing) 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:

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

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

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

where ψ denotes the constant rate of secular growth across Manufacturing 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 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. Section 3 contains a description of the database, and in Section 4 the initial empirical results are presented. The final section, Section 5 contains a re-estimation of the estimating equation to allow for possible disequilibrium at the height of the wages shocks.

2 THE MODEL

The production function (1.1) under cost minimization yields:

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

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

The estimates presented in this study were obtained as a result of an extensive search for the optimal value of the likelihood function. This search was made difficult by an abundance of local maxima. After completion of this study a further search revealed a solution with a higher log likelihood than that presented in Table 12, and which is believed to be the solution with the global maximum of the log likelihood function. Since these results are essentially the same for all starting b-values, differing only in their estimates of δ and b, but not in the percentage change in b during the allowed adjustment periods, only one result is presented, that for a starting b-value of 0.07. This result is shown in Table 14 together with the corresponding result from Table 12 for comparison. The corresponding estimates of the elasticity of substitution are compared in Table 15, which also includes the estimated capital intensity indicator b.

The description of the estimating equation offered by these two results is essentially the same (the residual plots are almost identical). Both show rising capital intensity and falling elasticity of factor substitution but the estimates of the rate of Hicks-neutral technical progress are strikingly at variance, being 2.33 per cent in the earlier estimation and 0.63 per cent in the final estimation. As already noted the estimated rate of change of the Dixon and McDonald technological variable was close to 2 per cent and this puts serious doubt on the reading of 0.63 per cent. However, the asymptotic t-static on this estimate is very low and when this 0.63 per cent was tested for its difference from the 2.33 per cent obtained earlier, there was found to be no significant difference at the five per cent level. In fact none of the final parameter estimates

Table 13

Estimates of Elasticity of Substitution (σ) and Capital Intensity (b) from the Labour Share Equation (5.1)

1963-64 - 1973-74 b (set)	.01	.02	.05	.07	.2	.5	.6	.7
1979-80 - 1981-82 b	.0087	.0174	.0434	.0608	.1737	.4343	.5212	.6080
1985-86 b	.0070	.0139	.0348	.0488	.1394	.3483	.4181	.4876
1963-64 - 1973-74 σ	.7380 (5.79)	.7380 (5.79)	.7380 (5.79)	.7380 (5.79)	.7380 (5.79)	.7380 (5.79)	.7380 (5.79)	.7383 (5.79)
1979-80 - 1981-82 σ	.4854 (1.62)	.4856 (1.61	.4856 (1.61)	.4856 (1.61)	.4856 (1.61)	.4856 (1.61)	.4856 (1.61)	.4856 (1.61)
1985-86 σ	.4431 (1.33)	.4435 (1.32)	.4435 (1.32)	.4435 (1.32)	.4435 (1.32)	.4435 (1.32)	.4435 (1.32)	.4435 (1.32)

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:

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

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:

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

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:

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

From (2.2) this yields:

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

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

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:

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

$$= [pA]^{\frac{\beta}{1+\beta}} - \left[\frac{w}{b^{-1/\beta}}\right]^{\frac{\beta}{1+\beta}} \qquad (2.6)$$

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:

$$sh_L = b^{\frac{1}{1+\beta}} \left[\frac{w}{pA}\right]^{\frac{\beta}{1+\beta}} \qquad (2.7)$$

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 12 continued

ψ	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)	.0233 (1.46)
θ	.0170 (1.31)	.0170 (1.31)	.0171 (1.31)	.0170 (1.31)	.0170 (1.31)	.0170 (1.31)	.0170 (1.31)	.0170 (1.31)
δ	6.7155 (3.70)	6.0238 (3.31)	5.1083 (2.83)	4.7718 (2.65)	3.7220 (2.06)	2.8055 (1.56)	2.6235 (1.46)	2.4690 (1.37)
λ_1	.0459 (1.71)	.0459 (1.71)	.0459 (1.72)	.0459 (1.72)	.0459 (1.72)	.0459 (1.72)	.0459 (1.72)	.0467 (1.72)
λ_2	.0497 (2.75)	.0497 (2.74)	.0497 (2.76)	.0497 (2.76)	.0497 (2.76)	.0497 (2.76)	.0497 (2.76)	.0497 (2.76)
D.W.	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Log.Like.	70.28	70.28	70.28	70.28	70.28	70.28	70.28	70.28

Table 12

Parameter Estimates from Labour Share Equation (5.1)
(Conditional on Initial Setting of b)

1963-64 - 1973-74 b(set)	.01	.02	.05	.07	.2	.5	.6	.7
1974-75 - 1978-79db	-.0003 (.17)	-.0005 (.17)	-.0013 (.17)	-.0018 (.17)	-.0053 (.17)	-.0131 (.17)	-.0158 (.17)	-.0184 (.17)
1979-80 - 1981-82b	.0087 (1.11)	.0174 (1.11)	.0434 (1.11)	.0608 (1.11)	.1737 (1.11)	.4343 (1.11)	.5212 (1.11)	.6080 (1.11)
1982-83 - 1985-86db	-.0004 (.36)	-.0009 (.36)	-.0021 (.36)	-.0030 (.36)	-.0086 (.36)	-.0215 (.36)	-.0258 (.36)	-.0301 (.36)
1985-86 b	.0070 (.56)	.0139 (.55)	.0348 (.56)	.0488 (.56)	.1394 (.56)	.3483 (.56)	.4181 (.56)	.4876 (.56)
1963-64 - 1973-74β	.3550 (1.52)	.3547 (1.52)	.3549 (1.52)	.3549 (1.52)	.3549 (1.52)	.3550 (1.52)	.3549 (1.52)	.3550 (1.52)
1974-75 - 1978-79dβ	.1410 (.59)	.1407 (.59)	.1408 (.59)	.1408 (.59)	.1408 (.58)	.1409 (.58)	.1408 (.58)	.1409 (.58)
1979-80 - 1981-82β	1.0601 (.83)	1.0581 (.83)	1.0591 (.83)	1.0591 (.83)	1.0591 (.83)	1.0593 (.83)	1.0588 (.83)	1.0593 (.83)
1982-83 - 1985-86dβ	.0491 (.09)	.0497 (.09)	.0488 (.09)	.0488 (.09)	.0488 (.09)	.0488 (.09)	.0489 (.09)	.0488 (.09)
1985-86 β	1.2566 (.74)	1.2570 (.74)	1.2544 (.74)	1.2544 (.74)	1.2544 (.74)	1.2546 (.74)	1.2542 (.74)	1.2546 (.74)

The basic estimating equation adopted here is derived from (2.7) by transforming it into 'proportional change' format. This yields:

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

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 $\sigma = 1/(1+\beta)$.

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.

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)

From equation (1.2) it follows that the term ln A in (2.8) is given by:

$$\ln A = \psi t + \theta D_t + \delta \quad , \qquad (2.9)$$

which when substituted into equation (2.8) yields:

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

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

$$+ \frac{1}{1+\beta} \frac{d(\ln b)}{dt} dt \quad , \qquad (2.10)$$

which is the estimating equation adopted here.

(see Table 4), this tendency evaporates with the inclusion of these adjustment lag parameters. No significant movement in capital intensity now occurs in either allowed adjustment period. In every case the estimated movement in the capital intensity indicator during the adjustment periods was slightly negative in keeping with a small rise in capital intensity.

The estimates of the elasticity of substitution σ that follow from the β estimates in Table 12 are given in Table 13. These indicate a much smaller, though still substantial, variation over time than was obtained without the adjustment lag parameters. The estimated σ values vary from around 0.74 at the start of the sample period, to 0.49 at the end of the first adjustment period and to around 0.44 at the end of the sample period.

Dixon and McDonald (1988) estimated a technological variable A_t in a CES production function, of the form given in (1.1), for which the β value was set rather than estimated. In addition, the Dixon and McDonald study used capital stock data whereas no such data were used here. For the appropriate β setting[1], the average yearly percentage change in their A_t series could be compared with the estimate of Hicks-neutral technical change obtained here. Over the maximum period of overlap between the samples, 1970-71 to 1985-86, the average percentage change in the Dixon and McDonald A_t series was 1.90 per cent compared with 2.33 per cent for the rate Hicks-neutral technical change in this study (see Table 12).

1 Dixon and McDonald estimated their A_t series for three different β settings, β = -0.5, β close to zero, and β = 1.0; corresponding to elasticities of substitution of 2.0, 1.0 and 0.5. The elasticity estimates obtained in this study are closer to 0.5 than to the other two assigned values and so the A_t series for β = 1.0 is chosen here.

percentage change in labour share due to disequilibrium at the height of the wages shocks. It is anticipated that λ_1 and λ_2 should be positive with λ_1 larger numerically since the wages shock of the 'seventies was more severe than that of the 'eighties.

Table 12 contains the estimated values of the parameters ψ, θ, δ, λ_1, λ_2, b and β associated with the initial b-values over which the estimation of equation (5.1) was conducted. As predicted the adjustment lag parameters λ_1 and λ_2 are positive indicating that labour shares rose to values higher than would be consistent with equilibrium. The estimation of λ_1 at approximately .046 (λ_2 at approximately .050) indicates that, at the height of the wage shocks in the 'seventies ('eighties), 4.6 (5.0) percentage points of the increased share of labour in value added was a disequilibrium phenomenon - that is, while the price of labour had risen exogenously, the quantity demanded had not immediately adjusted, thus leaving labour's share temporarily higher than our cost minimizing theory would indicate.

The variation in productivity with the business cycle is once again procyclical with a stronger positive estimate of θ (0.0170 approx.) and the sectoral rate of Hicks-neutral technical change is estimated, by ψ, at a lower value of 2.33 per cent per annum.

The introduction of two adjustment lag parameters had a marked effect on the estimated movements in the capital intensity indicator b. Whereas, prior to the employment of adjustment lag parameters, a very strong increase (against expectations) in the labour intensity of the technology was attributed to the wages shocks

3 THE DATA

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 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:

Table 2

Business Cycle and 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).

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 persons data are based on the ABS publication, *Australian*

that equation, as a change in the capital intensity of the technology indicator b, since all other parameters are either estimated over the entire sample period (or tied to parameters which are so estimated) or tied to yearly data. It may well be, then, that sharp changes in the share of labour in value added, induced by the wages shocks of the 'seventies and 'eighties, gave rise to artificially high readings for $\frac{d \ln b}{dt} dt$ on application of estimating equation (2.10). Essentially, this means that if the equilibrium assumption which underlines equation (2.7) failed to hold at the height of the wages shocks 1973-74 to 1974-75 and 1981-82 to 1982-83, then the major effect of this model failure would be overestimated b-values.

To correct for this potential shortcoming an adjustment lag parameter is introduced into equation (2.10) for each of the transitions 1973-74 to 1974-75 and 1981-82 to 1982-83. The estimating equation thus obtained is given by:

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

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

$$+ \frac{1}{1+\beta} \frac{d(\ln b)}{dt} dt + \lambda_1 \mu_{1t} + \lambda_2 \mu_{2t} \quad ; \qquad (5.1)$$

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

Once again in this second adjustment period, the share of the labour intensive subindustries (Textiles, Clothing and footwear; and Transport equipment) fell (see Table 11) while the estimated labour intensity of the technology rose.

In summary, the b and σ estimates reported in Tables 3 and 4 are not able to be satisfactorily interpreted because of the direction of movement, in the case of the b-estimates, and the size of the variation, in the case of the σ-estimates. This issue is pursued below.

Table 11

Share of Textiles; Clothing and footwear; and Transport equipment in the Value Added for Manufacturing, 1982-83 through 1985-86

Period	Year	Shares
Second Adjustment Period	1982-83	.175
	1983-84	.168
	1984-85	.170
	1985-86[a]	.168

(a) Because no survey into Manufacturing was conducted during 1985-86, the share data was unavailable from the source for that year. The share reported here was estimated as the average of the shares for 1984-85 and 1986-87.
Source: ABS, Cat. No. 8202.0, 1982-83 to 1984-85 and 1986-87.

5 RE-ESTIMATION WITH AN ADJUSTMENT LAG

With regard to the difficulties in interpreting the b and σ results of Section 4, the possibility of model misspecification should be considered. Returning to the estimating equation (2.10), it is clear that any sharp change in the shares of labour in value added data would be most readily absorbed, in the the right hand side of

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 Manufacturing; 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 is the share of wages, salaries and supplements in the contribution of Manufacturing 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. However, these figures do not include the services of owner-operators. The labour share inclusive of owner-operators 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).

4 THE EMPIRICAL RESULTS

With sh_L, w, p, D_t, b, and β as described above, a maximum likelihood estimation was performed on equation (2.10), under the constraints imposed on b and β, over the twenty-three year period 1963-64 to 1985-86.[1]

The estimating equation (2.10) 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

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

Table 9

Effective Rates of Assistance in Textiles; Clothing and footwear; Transport equipment; and Manufacturing as a Whole 1982-83 through 1985-86

ASIC Code	Description	1982-83	1983-84	1984-85	1985-86
23	Textiles	68	68	74	71
24	Clothing and footwear	192	227	>250	<146
32	Transport equipment	61	63	66	60
	Manufacturing	21	21	22	20

Source: Industries Assistance Commission, Annual Report 1986-87.

Table 10

Average Yearly Percentage Change in Effective Rate of Assistance (based on Table 9)*

ASIC Code	Description	Adjustment Period 1982-83 to 1985-86
23	Textiles	1.6
24	Clothing and footwear	-4.4
32	Transport equipment	-0.3
	Manufacturing	0.0

* This average is over comparisons of pairs of successive years of percentage changes in effective rates of assistance.

Initially, production occurs at A with value added Q° and technological environment T_0, and the rental to wage ratio given by the slope of the tangent to $Q^{\circ}(T_0)$ at A. The immediate effect of a positive wage shock at constant value added, would be to shift production to a point like B which has lower labour intensity, and to C if value added fell to Q^1. The increased protection for the labour intensive industries in Manufacturing can be viewed as a labour using technical change shifting the isoquant $Q^1(T_0)$ to $Q^1(T_1)$ with production shifting from C to D, lifting the labour intensity of technology indicator b. The combined effect on observed labour intensity is unclear, since the movements from A to B and from B to D are in opposite directions. Consequently, a decrease in labour intensity is quite compatible, in the presence of a wages shock and increased protection for labour intensive industries, with an increase in the labour intensity of the technology.

So far we have focused only on the first adjustment period in discussing the observed movement in the capital intensity indicator b. During the second adjustment period the estimated labour intensity of the technology increased but to a slightly lesser degree than in the first adjustment period. However, this occurred without the presence of increased protection to the labour intensive subindustries of Textiles; Clothing and footwear; and Transport equipment. The effective rates of assistance to these industries over the second adjustment period are shown in Table 9 and their average values are shown in Table 10. The increase in protection for Textiles shown in Table 10 does not compensate for the decline for Clothing and footwear, and for Transport equipment, since the Textiles subindustry is small compared to those other two subindustries.

described in Table 2 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 1.

Combining the terms from the right hand side of equation (2.10) that involve parameters not tied to data, the following expression is obtained:

$$\frac{1}{(1+\beta)^2}\frac{d\beta}{dt}dt\ [-\delta - \ln b] + \frac{1}{(1+\beta)}\frac{d(\ln b)}{dt} \quad . \qquad (4.1)$$

It should be noted that since $\frac{d(\ln b)}{dt}$ dt is invariant under multiplication of b by a scalar and since δ and ln b are nowhere tied to data in (2.10), it follows from (4.1) that δ and b_0 cannot separately be identified. This can be readily seen by checking that the expression given in (4.1) is unaltered by multiplying each term in b by a positive scalar, c, and subtracting ln (c) from δ. For this reason a number of values between 0 and 1 were assigned to the initial value of b for estimation purposes. The initial setting of b should have no influence on the estimated parameters from equation (2.10), with the exceptions, of course, of b and δ.

Table 3 displays the estimated values of the parameters ψ, θ and β associated with the set of initial b-values over which the estimations were conducted and confirms the inability of the initial b setting to substantially affect the estimates of the remaining parameters. The estimates of ψ and θ agreed to four significant digits while the precision for β was slightly less, computed values agreeing to four significant digits in the initial subperiod 1963-64 to 1973-74 and ranging from 3.6232 to 3.6250 at the end of the sample period. The direction of movement in β, whenever flexibility

Table 3

Parameter Estimates from Labour Share Equation (2.10)
(Conditional in Initial Setting of (b))

1963-64 - 1973-74	b (set)	.01	.02	.05	.07	.2	.5	.6	.7
1974-75 - 1978-79	db	.0023 (1.97)	.0045 (1.97)	.0113 (1.97)	.0158 (1.97)	.0452 (1.97)	.1129 (1.97)	.1355 (1.97)	.1580 (1.97)
1979-80 - 1981-82	b	.0213 (3.72)	.0426 (3.72)	.1064 (3.72)	.1490 (3.72)	.4258 (3.72)	1.0645 (3.72)	1.2773 (3.72)	1.4902 (3.72)
1982-83 - 1985-86	db	.0032 (1.42)	.0064 (1.42)	.0160 (1.42)	.0224 (1.42)	.0640 (1.42)	.1601 (1.42)	.1921 (1.42)	.2241 (1.42)
1985-86	b	.0341 (2.42)	.0682 (2.42)	.1705 (2.42)	.2386 (2.42)	.6819 (2.42)	1.7050 (2.42)	2.0457 (2.42)	2.3866 (2.42)
1963-64 - 1973-74	β	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)	.3625 (1.26)
1974-75 - 1978-79	dβ	.4051 (.74)	.4051 (.74)	.4051 (.74)	.4050 (.74)	.4051 (.74)	.4052 (.74)	.4050 (.74)	.4050 (.74)
1979-80 - 1981-82	β	2.3878 (.86)	2.3880 (.86)	2.3879 (.86)	2.3875 (.86)	2.3879 (.86)	2.3885 (.86)	2.3877 (.86)	1.3877 (.86)
1982-83 - 1985-86	dβ	.3090 (.80)	.3090 (.80)	.3090 (.80)	.3089 (.80)	.3090 (.80)	.3091 (.80)	.3090 (.80)	.3090 (.80)
1985-86	β	3.6237 (.86)	3.6241 (.86)	3.6238 (.86)	3.6232 (.86)	3.6238 (.86)	3.6250 (.86)	3.6236 (.86)	3.6235 (.86)

Figure 1

Combined Effects of a Wages Shock and Labour-using Technical Change

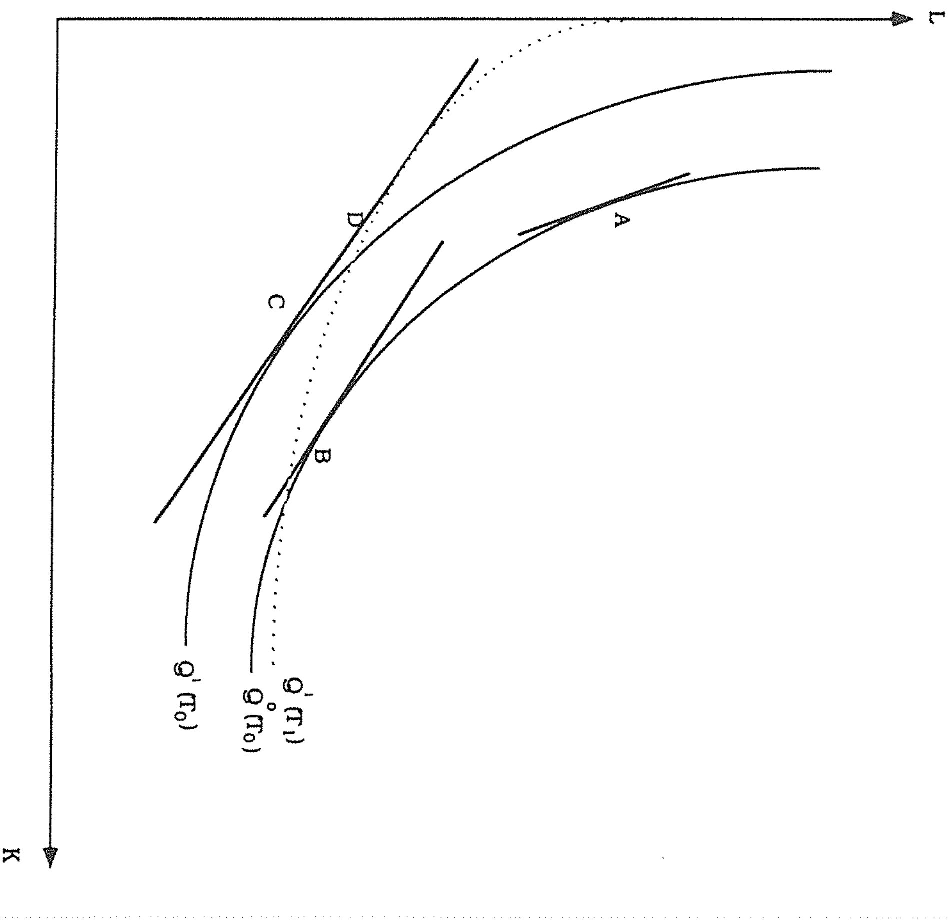

Table 8

Share of Textiles; Clothing and footwear; and Transport equipment in the Value Added for Manufacturing, 1974-75 through 1978-79

Period	Year	Shares
First Adjustment Period	1974-75	.178
	1975-76	.188
	1976-77	.187
	1977-78	.177
	1978-79	.175

Source: ABS, Cat. No. 8202.0, 1974-75 to 1978-79.

relative to Manufacturing as a whole. However, the 'all else equal' premise on which the argument depends was violated by the wages shocks prior to the two allowed adjustment periods.

It is important here to make the distinction between changes in observed labour intensity and changes in the labour intensity of the technology. Movements in observed labour intensity incorprate not only the effects of alterations to the technological environment but also the direct effects of changes in relative factor prices. On the other hand, the labour intensity of the technology reflects the shape of the isoquant map for the industry. Compositional changes within the industry are tantamount to a change in the isoquant map.

The anticipated combined effects of a wages shock and a labour-using change in the technology together with a fall in value added (which occurred in Manufacturing during the first adjustment period 1974-75 to 1978-79) can be illustrated using Figure 1.

Table 3 continued

ψ	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)	.0315 (2.39)
θ	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)	.0112 (1.33)
δ	7.3036 (7.68)	6.6105 (6.95)	5.6942 (5.99)	5.3578 (5.63)	4.3079 (4.53)	3.3916 (3.57)	3.2093 (3.37)	3.0552 (3.21)
D.W.	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
Log.Like.	64.44	64.44	64.44	64.44	64.44	64.44	64.44	64.44

allowed, was identical across initial b-settings with the ratio of the rate of change of β in the first adjustment period to that rate for the second adjustment period being 1.31 in all cases.

The estimate of ψ displayed in Table 3 indicates a sectoral rate of Hicks-neutral technical change of approximately 3.15 per cent per annum. The positive estimates of θ (approx. 0.0112) confirm a procyclical variation of productivity with the business cycle.

The estimated movements in b over the sample period show a one hundred per cent rise in the first adjustment period 1974-75 to 1978-79, and a fifty per cent rise over the second adjustment period, 1982-83 to 1985-86. This direction of movement implies a fall in the capital intensity of the technology whenever flexibility allowed.

A summary of the estimates of the elasticity of substitution between labour and capital, σ, that follow from the β-estimates via the formula $\sigma = 1/(1+\beta)$, are shown in Table 4, which also reproduces the estimated b-values from Table 3.

The substitution elasticity σ fell substantially across the sample period with a particularly large fall from around 0.73 to 0.30 during the first allowed adjustment period 1974-75 to 1978-79, and a further fall to approximately 0.22 by the end of the sample period.

The b and σ results shown in Table 4 are surprising as they indicate an increased labour intensity of the technology and a

Table 6

Effective Rates of Assistance in Textiles; Clothing and footwear; Transport equipment; and Manufacturing as a Whole, 1974-75 through 1978-79

ASIC Code	Description	1974-75	1975-76	1976-77	1977-78	1978-79[a]
23	Textiles	39	50	51	57	58
24	Clothing and footwear	87	99	141	149	149
32	Transport equipment	45	59	54	61	65
	Manufacturing	27	28	27	26	27

(a) Effective rates of assistance for 1978-79 were not available in the source document. They were estimated as the projected assistance for that year times the ratio of the actual to predicted assistance in the previous year.

Source: Industries Assistance Commission, Annual Report 1980-81.

Table 7

Average Yearly Percentage Change in Effective Rate of Assistance (based on Table 6)*

ASIC Code	Description	Adjustment Period 1974-75 to 1978-79
23	Textiles	11.0
24	Clothing and footwear	15.5
32	Transport equipment	10.6
	Manufacturing	0.0

* This average is over comparisons of pairs of successive years of percentage changes in effective rates of assistance.

During the first adjustment period there were rises in the effective rates of protection for these three subcategories of Manufacturing (Textiles; Clothing and footwear; and Transport equipment). Table 6 shows the effective rates of assistance to these three broad groups of heavily protected Manufacturing industries, and to Manufacturing as a whole during the first adjustment period. The corresponding average percentage changes in effective assistance over this adjustment period are given in Table 7, which shows that, while effective protection in Manufacturing as a whole did not change, the level of assistance to Textiles; Clothing and footwear; and Transport equipment rose substantially.

The shift in protection, favouring these labour-intensive industries should, all else equal, alter the composition of Manufacturing in favour of these industries, and tend to increase the labour intensity in Manufacturing. The rise in protection for these particular industries could then be expected to lead to compositional change which would show up, in our single industry paradigm, as a shift in the technological environment of production favouring the use of labour, and thus leading to the observed increase in b.

Evidence of the alteration in the composition of Manufacturing could be sought to corroborate this proposition and to explain the estimated increase in the labour intensity of the technology (as indicated by the rise in b). In fact though, as shown in Table 8, the share of Textiles; Clothing and footwear; and Transport equipment actually *fell* over the first adjustment period at the same time as these industries received increased assistance

decreased input factor flexibility in response to the wages shocks, whereas the reverse was anticipated.

Table 4

Estimates of Elasticity of Substitution σ and Capital Intensity b from the Labour Share Equation (2.10)

1963-64 - 1973-74	b (set)	.01	.02	.05	.07	.2	.5	.6	.7
1979-80 - 1981-82	b	.0213	.0426	.1062	.1490	.4258	1.0645	1.2731	1.4902
1985-86	b	.0341	.0682	.1705	.2386	.6819	1.7050	2.0457	2.3866
1963-64 - 1973-74	σ	.7339 (4.73)	.7339 (4.473)	.7339 (4.73)	.7339 (4.73)	.7339 (4.73)	.7339 (4.73)	.7339 (4.73)	.7339 (4.73)
1979-80 - 1981-82	σ	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)	.2952 (1.22)
1985-86	σ	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)	.2163 (1.10)

With regard to the seemingly perverse response of b and σ to the wages shocks, it could be anticipated that, all else equal, a positive wages shock would favour the adoption of a more capital intensive technology (decreasing b), and (due to the fear of possible further wage shocks), cause producers to seek to increase the flexibility of their technology (increasing σ), since the risk of such shocks makes it important for firms to be able to reconfigure their capital/labour ratio. However, these predicted movements were not observed, and the estimated movements in b and σ over the first adjustment period are explored in more detail below.

The process of varying the size of a firm's labour force is not cost-free; real costs are involved in hiring and firing. Moreover, these costs may be affected by the perceived nature of the desired alteration to labour force size; be it temporary or permanent. Because of the cost of rebuilding a skilled workforce when business picks up again, producers may well be unwilling to make substantial changes to their labour force in response to a wages shock which they expect to be short lived.

In the absence of large wages shocks during the 'sixties producers at first may have viewed the wages shock of the early 'seventies as a temporary shift in their cost structure and adopted a cautious approach to alterations in factor inputs, being reluctant to shed labour at the rate appropriate to the earlier σ-value since this would entail historically large reductions in the labour force. Under this scenario a fall in the measured value of σ might be observed in the adjustment period following the wages shock of the early 'seventies. Table 4 shows such a fall in the adjustment period 1974-75 to 1978-79. However, the severity of the fall is surprising, as is the further fall after the wages shock of the early 'eighties. It appears to indicate that labour hoarding persisted into the eighties despite a history of high labour costs.

The capital intensity indicator b provides a means of detecting technical progress which is labour using or capital using. The estimated rise in b over the two adjustment periods, 1974-75 to 1978-79 and 1982-83 to 1985-86, indicates a rise in the labour intensity of the production technology at the same time as the wages shocks.

This apparent choice of a technology favouring labour in the face of wage cost rises would seem illogical unless some other countervailing force, promoting the use of labour, was prevalent at the time. A possible explanation of the estimated rise in the labour intensity of the technology during the first adjustment period 1974-75 to 1978-79 might be sought in terms of compositional effects.

During the sample period the three most heavily protected two-digit ASIC subcategories of Manufacturing were Textiles; Clothing and footwear; and Transport equipment; in each of these industries the amount of labour hours employed per unit of value added exceeded the corresponding figure for Manufacturing as a whole as (see Table 5).

Table 5

Labour per unit of Real Value Added in Textiles; Clothing and footwear; Transport equipment; and Manufacturing as a Whole

Period	Year	Labour per Unit of Real Value Added			
		Textiles	Clothing and footwear	Transport equipment	Manufacturing as a whole
First Adjustment Period	1974-75	80.1	78.3	69.3	66.2
	1975-76	73.3	96.6	67.6	63.9
	1976-77	68.8	96.4	66.0	60.9
	1977-78	68.4	93.8	66.8	60.2
	1978-79	62.3	89.0	66.6	57.7
Second Adjustment Period	1982-83	57.8	75.3	55.8	51.8
	1983-84	54.7	72.0	55.7	49.4
	1984-85	51.2	71.9	52.4	46.8
	1985-86[a]	-	-	-	-

(a) Real Value Added data unavailable for 1985-86.

Source: The real value added data were obtained from ABS, Cat. No. 8211.0 1984-85. An estimate of labour hours was obtained as the product of average hours worked and employed persons in each subindustry (from ABS, Cat. No. 8211.0) As average hours worked data were not available at the two digit subindustry level, this was approximated by average hours worked for manufacturing as a whole (from ABS, Cat. Nos. 6203.0 and 6204.0).