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OCCUPATIONAL WAGE RELATIVITIES AND LABOUR-LABOUR SUBSTITUTION IN THE AUSTRALIAN ECONOMY : APPLICATIONS OF THE ORANI MODEL

by

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The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Australian government

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The scale factor, λ, was selected to ensure that, <u>on average</u>, the cross elasticities of substitution between the nine occupations equalled the CES value of 0.35. That is

$$\sum_{\substack{i,j\\ i\neq j}} S_i^* S_j^* \sigma_{ij} \Bigg/ \sum_{\substack{i,j\\ i\neq j}} S_i^* S_j^* = \sigma = 0.35 \qquad \text{(A15)}$$

where the shares, S_i^* , come from the ORANI data base.

Making the substitutions (A4) and (A14) in (A15) ,

$$\sigma = \frac{\lambda}{\sum_{\substack{i,j\\ i\neq j}} S_i^* S_j^*} \sum_{\substack{i,j\\ i\neq j}} \left[S_i^* S_j^* b_i b_j \Big/ \sum_k S_k^* b_k \right]$$

which produced the result, $\lambda = 1.31$. The scaling of the b_i values by this multiplier provides the estimates of CRESH substitution parameters given in column (iv) of Table A1. These figures in turn generate the partial substitution elasticities given in Table 3.1 of the text.

TABLE A1. GENERATION OF CRESH SUBSTITUTION PARAMETERS

OCCUPATION	(i) Share in 1968/9 Wage Bill[1] (S_i^*)	(ii) Close-Substitute Occupations	(iii) Sum of Wage bill Shares of Close Substitute Occupations (b_i)	(iv) Estimated Substitution Parameter (σ_i)
1. Professional White Collar	.074	2	.188	.246
2. Skilled White Collar	.188	1,3,4,8	.469	.614
3. Semi - and Un-Skilled White Collar	.216	2,5,6	.282	.369
4. Skilled Blue Collar - Metal & Electrical	.118	2,6	.191	.250
5. Skilled Blue Collar - Building	.046	3,7	.467	.611
6. Skilled Blue Collar - Other	.023	3,4	.334	.437
7. Semi - and Un-Skilled Blue Collar	.251	5,8	.107	.140
8. Rural Workers	.061	2,7	.439	.575
9. Armed Services	.025	3	.216	.283

1. As provided in the ORANI data base.

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1. INTRODUCTION

The theoretical structure of ORANI[1] allows producers to substitute between nine occupational categories in determining their aggregate demands for labour. The aggregation functions which relate usage of labour of different occupations to aggregate labour input are assumed to be of the CRESH form.[2] It is assumed that producers are cost minimizers, so that labour demand functions can be derived in which each industry's demand for labour of a given occupation is a function of its aggregate demand for labour and the relative wage rate of the nine occupations.[3]

To date almost all published ORANI applications have assumed fixed occupational wage relativities, thus bypassing the labour - labour substitution facility in the model.[4] One reason for

* We gratefully acknowledge the comments of Alan Powell and the computing assistance provided by Russell Rimmer.

1. ORANI is a multisectoral model of the Australian economy which has been developed as part of the Australian Government's, inter-agency IMPACT project. The model is fully described in Dixon, Parmenter, Sutton and Vincent (1981), hereafter referred to as "DPSV".
2. DPSV, section 11.
3. DPSV, subsection 12.1.
4. Exceptions are Dixon, Parmenter and Sutton (1977 and 1978) in which wage relativities were allowed to change and the elasticity of substitution between labour categories is set to the provisional value of 1.

the frequent adoption of the fixed-wage-relativity assumption has been that the values in the ORANI data files[1] for the required labour - labour substitution parameters were not regarded as very reliable. This, plus the incomplete status of current work on relative-wage-induced, supply-side changes in the occupational mix, has limited the range of labour-market issues which would be elucidated by ORANI simulations.

In this paper we report recent progress on the implementation of labour - labour substitution in ORANI. In section 2 we outline briefly the details of the theory of labour demand in the model. In section 3 we review the empirical evidence on the required labour - labour substitution parameters, including some new estimates recently generated within the IMPACT Project. The sensitivity of ORANI results to the values of the labour - labour substitution parameters is investigated in section 4, and in section 5 we report the results of an experiment which projects, using our best estimates of the parameters, the effects of the changes in occupational wage relativities which accompanied the wage explosion of the early 1970's. Brief concluding remarks are contained in section 6.

1. DPSV, subsection 29(c).

CRESH Substitution Elasticites

Since non-linearity in the variables was not easily handled with the available data base and estimation package, some simple ad hoc procedure was needed to generate values of CRESH substitution elasticities. The motivation for this was not to attach any great weight to the particular values estimated, but to examine the sensitivity of ORANI simulation results when substitution elasticities were allowed to vary between different occupational pairs. In this spirit, the only restriction or control imposed on the CRESH values was that the cross elasticities should average, in some sense, the 0.35 CES value.

The essence of the method was to assume that the general degree of substitutability of an occupation (as measured by the substitution parameter, σ_i) is proportional to the (cost) size of other occupations which are its close substitutes. The first step in the procedure is presented in column (i) of Table A1 which shows the wage bill shares of each occupation at 1968/69. Column (ii) identifies occupations which are judged to be relatively close substitutes. This identification is rough and ready, but is based on data at least to the extent that there have been non-zero net movements between the identified occupations in the IMPACT labour mobility data.[1] Column (iii) shows the sum of the wage bill shares for the occupations identified in column (ii).

The relative sizes of the sums in column (iii) determine the the relative sizes of the substitution parameters; i.e.,

$$\sigma_i = \lambda b_i , \qquad \text{(A14)}$$

where

b_i = sum of the cost shares of close-substitute occupations.

1. Lynne S. Williams (1981), 'The Demographic Characteristics of People who Change their Occupations: A Preliminary Examination of the Data', Australian Bulletin of Labour, v.7 (3), pp.139-173.

Substituting (A10a) and (A10b) in (A10) and using (A8),

$$\text{var}\,(\dot{L}_{it}) = (26.69)^2 \left\{ \left(N_{it}^{68/69}\right)^{-1.2} + \left(N_{it}^{73/74}\right)^{-1.2} \right\} . \quad \text{(A11)}$$

However the required left hand variable (see equation (A4)[1]) involves a share weighted sum of changes in all occupational demands. Thus

$$V_{it} = \text{var}\left(\dot{L}_{it} - \sum_{j=1}^{n} S_{jt}\,\dot{L}_{jt}\right) = \text{var}\left(\dot{L}_{it}\right) + \text{var}\left(\sum_{j=1}^{n} S_{jt}\,\dot{L}_{jt}\right)$$

$$- 2\,\text{cov}\left(\dot{L}_{it}, \sum_{j=1}^{n} S_{jt}\,\dot{L}_{ji}\right) . \quad \text{(A12)}$$

Under certain assumptions concerning the covariances,[2] this reduces to

$$V_{it} = \text{var}\left(\dot{L}_{it}\right) + \sum_{j=1}^{n} S_{jt}^{2}\left[\text{var}\left(\dot{L}_{it}\right)\right] - 2\,S_{it}\left[\text{var}\left(\dot{L}_{it}\right)\right]$$

$$= \left(1 - 2S_{it}\right)\text{var}\left[\left(\dot{L}_{it}\right)\right] + S_{it}^{2}\left[\text{var}\left(\dot{L}_{it}\right)\right] . \quad \text{(A13)}$$

The calculated variances can then be used to form transformed variables as suggested in equations (A6a & b).

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1. An alternative, which is simpler, would have been to transfer the share weighted sum variable to the right hand side and to ignore measurement error in it. But in order to take account of as much measurement error as possible, the above procedure was preferred.
2. The covariances between $\dot{L}_{it}$ and $\dot{L}_{ht}$ vanish because, under repeated sampling (viz., under replication of surveys) there is no reason why an outcome which involved (say) a positive value of $\left(\dot{L}_{it} - E(\dot{L}_{it})\right)$ - - i.e., a positive measurement error due to sampling variation in the case of occupation i - - should involve an outcome $\left(\dot{L}_{ht} - E(\dot{L}_{ht})\right)$ of any particular sign in the case of occupation h. The measurement errors due to sampling variation are essentially independent.

2. LABOUR DEMAND IN ORANI

The relationship between inputs and the activity level for each industry in ORANI is described in detail in DPSV, subsection 11.1. These technological assumptions are summarized in Figure 2.1. The figure indicates that the production functions, which exhibit constant returns to scale, are of a three-level, nested form. At the first level, effective inputs of each of G classes of produced inputs,[1] effective inputs of primary factors and inputs of "other costs"[2] are required in fixed proportions.[3] At level 2, effective units of produced input i are defined as CES[4] combinations of domestic supplies and imports of the i^{th} commodity classification, and effective units of primary factors are defined as CRESH[5] combinations of capital, agricultural land and effective inputs of labour. Finally, at level 3 (enclosed by the broken line in Figure 2.1) effective inputs of labour are defined as CRESH combinations of labour of M different occupational groups.[6]

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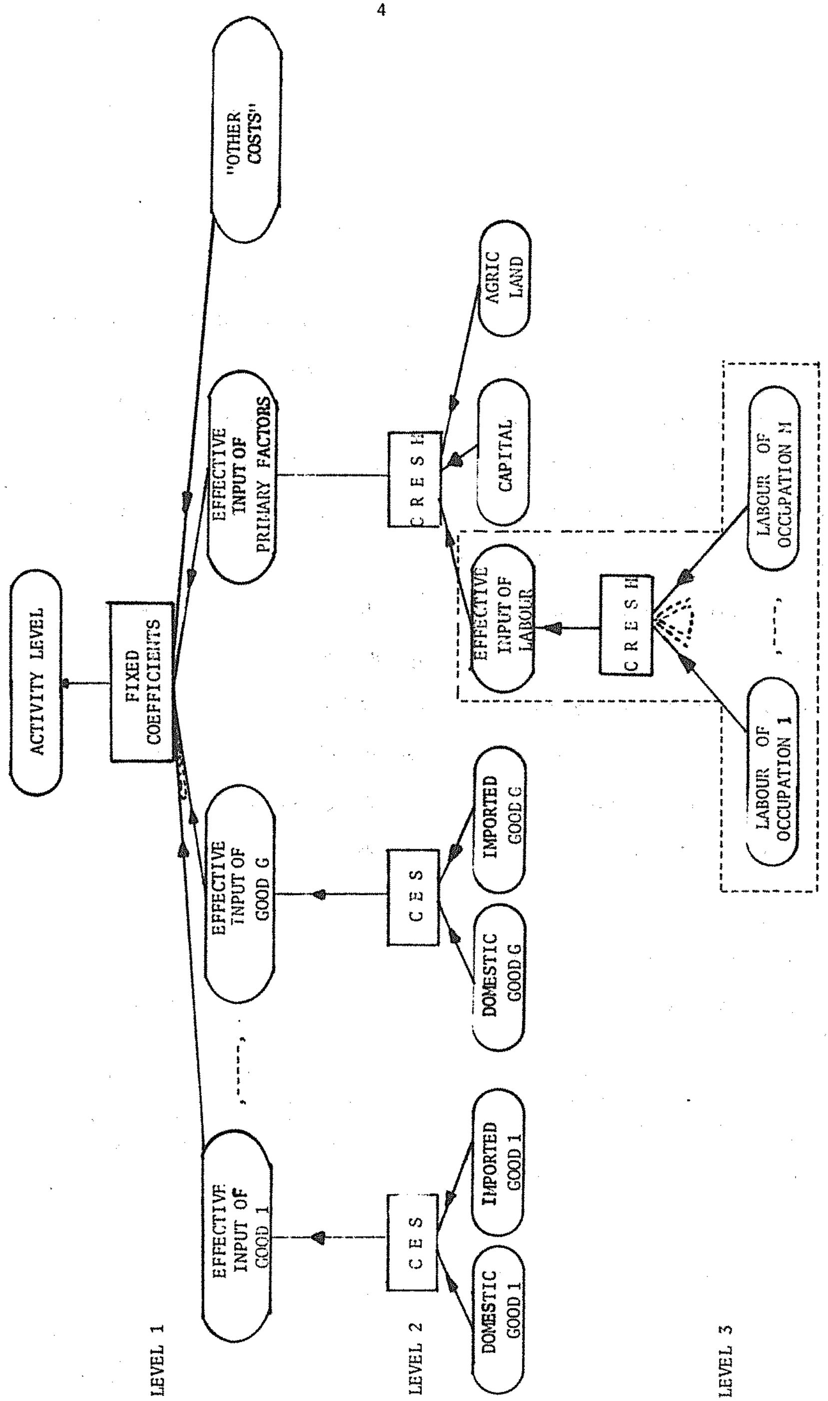
1. In the current version of ORANI, G = 115.
2. "Other costs" include production taxes and the costs of working capital.
3. Whilst no substitution is allowed between input categories at level 1, the input-output coefficients are treated as exogenous variables rather than parameters in ORANI. Technological change can then be imposed on the model by exogenous changes in these variables.
4. See Arrow et al. (1961).
5. CRESH (Constant Ratios of Elasticities of Substitution, Homothetic) is a generalization of CES in which the Allen-Uzawa partial elasticities of substitution between pairs of inputs can differ but are constrained to exhibit constant ratios, i.e., the ratio of the elasticity between inputs i and j to the elasticity between i and k must be equal to the ratio of the elasticities between ℓ and j, and ℓ and k. See Hanoch (1975) and DPSV, subsection 11.1.
6. Currently in ORANI, M = 9.



to a derivation[1] of the variances V_{it} .

According to Ryland and Parham (1978b),[2] the percentage standard errors on variables in the levels can be written

$$\frac{S.E.\ (L_{it})}{L_{it}} = 26.69 \quad N_{it}^{-0.6} , \qquad (A8)$$

where

$$S.E.\ (L_{it}) = \text{standard error of estimate for variable } L_{it} ,$$

and

N_{it} = estimate of the size of population in occupation i at observation t.

Since

$$\dot{L}_{it} = \log\ L_{it}^{73/74} - \log\ L_{it}^{68/69} \qquad (A9)$$

(where the superscripts indicate the relevant time periods), and since at a lag of 5 years it is most unlikely that survey sampling errors are serially correlated,

$$var\ (\dot{L}_{it}) = var\left(\log\ L_{it}^{73/74}\right) + var\left(\log\ L_{it}^{68/69}\right) . \qquad (A10)$$

Further,

$$var\left(\log\ Lit^{73/4}\right) \doteq var\left(L_{it}^{73/4}\right) \Big/ \left[\left(L_{it}^{73/4}\right)^2\right] ; \qquad (A10a)$$

and

$$var\left(\log\ L_{it}^{68/69}\right) \doteq var\left(L_{it}^{68/9}\right) \Big/ \left[\left(L_{it}^{68/9}\right)^2\right] . \qquad (A10b)$$

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1. We are grateful to Alan Powell for providing this derivation.
2. Ibid.,p.9.

from Parham and Ryland (1978b)[1]. Consequently, it is possible to institute a transformation to correct for heteroscedasticity. (Details of the calculation of the appropriate transformation weights are provided below). The estimation procedure for the CES case becomes

(1) calculate V_{it}, the variances in the left hand variables (see below) ;

(ii) form the homoscedastic transformed variables

$$\dot{L}^*_{it} = \left[\dot{L}_{it} - \sum_{j=1}^{n} S_{jt}\,\dot{L}_{jt}\right] \Big/ \sqrt{V_{it}} \quad ; \qquad \text{(A6a)}$$

$$\dot{W}^*_{it} = \left[\dot{W}_{it} - \sum_{j=1}^{n} S_{jt}\,\dot{W}_{jt}\right] \Big/ \sqrt{V_{it}} \quad . \qquad \text{(A6b)}$$

(iii) estimate σ from the stacked single-equation regression

$$\begin{bmatrix} \dot{L}^*_{it} \\ \vdots \\ \dot{L}^*_{nt} \end{bmatrix} = \sigma \begin{bmatrix} \dot{W}^*_{it} \\ \vdots \\ \dot{W}^*_{nt} \end{bmatrix} + \begin{bmatrix} U^*_{it} \\ \vdots \\ U^*_{nt} \end{bmatrix} \quad ; \qquad \text{(A7)}$$

where

$$U^*_{it} = U_{it} \Big/ \sqrt{V_{it}} \; .$$

Underlying this procedure is the assumption that the variances of equation disturbances (like U_{it} in (A1)) are negligible by comparison with the measurement errors (due to survey sampling variation) in $(\dot{L}_{1t},\ldots,\dot{L}_{nt})$. The result of this procedure was an estimate of σ = 0.35 (t value = 1.60). The remainder of this subsection is devoted

1. G.J. Ryland and D.J. Parham (1978b), 'ABS Labour Force Survey and Income Distribution Survey Data: Preliminary Analysis', IMPACT Preliminary Working Paper No. IP-05, Industries Assistance Commission, Melbourne (May).

Note how the technological assumptions illustrated in Figure 2.1 restrict the range of substitution between inputs available to producers in ORANI. No substitution is available between produced inputs of different commodity classifications (steel and plastics, for example), or between produced inputs, primary factors and "other costs". Imports and domestic supplies of produced inputs of the same commodity classification are assumed to be sustitutes, but not perfect substitutes. Similar assumptions are made with respect to alternative supplies of primary factors; labour, capital and land are imperfect substitutes in forming an industry's effective input of primary factors, and different occupations are imperfect substitutes in forming effective inputs of labour. It is substitution at this last level, i.e., substitution between occupations, which is the main focus of this paper.

Producers in ORANI are assumed to be price takers and to minimize the costs of producing any given output level. By solving the cost-minimization problem with the technological assumptions described in Figure 2.1 as constraints, we can derive the producers' input-demand equations. Given the nested production function, primary-factor demand equations for industry j take the form[1]

$$X^{(1)}_{(g+1)j} = f_j\left\{Z_j,\ A^{(1)}_{(g+1)j}\right\}, \qquad (2.1)$$

$$X^{(1)}_{(g+1,.)j} = f_j\left\{X^{(1)}_{(g+1)j},\ P^{(1)}_{(g+1,.)j},\ A^{(1)}_{(g+1,.)j}\right\}, \qquad (2.2)$$

and

$$X^{(1)}_{(g+1,1,.)j} = f_j\left\{X^{(1)}_{(g+1,1)j},\ P^{(1)}_{(g+1,1,.)},\ A^{(1)}_{(g+1,1,.)j}\right\}, \qquad (2.3)$$

1. See DPSV, subsection 12.1.

where, following the notation used in DPSV, $X^{(1)}_{(g+1)j}$ is the effective input of primary factors to industry j; $\tilde{Z}_j$ is j's activity level; $X^{(1)}_{(g+1,.)j}$ is the vector of (effective) inputs of labour, capital and agricultural land to j with $X^{(1)}_{(g+1,1)j}$ denoting the effective input of labour; $P^{(1)}_{(g+1,.)j}$ is the corresponding factor-price vector[1]; $X^{(1)}_{(g+1,1,.)j}$ is the m x 1 vector of occupation-specific inputs of labour to industry j; $P^{(1)}_{(g+1,1,.)}$ is the vector of occupation-specific wage rates; and $A^{(1)}_{(g+1)j}$, $A^{(1)}_{(g+1,.)}$ and $A^{(1)}_{(g+1,1,.)j}$ are all exogenous technological coefficients. The absence of prices from equation (2.1), the inclusion of effective factor prices only in equation (2.2) and the inclusion of occupation-specific wage rates only in (2.3) reflect the range of factor-substitution possibilities which were described in the previous paragraph.

Equation (2.5) gives the precise form for the typical occupation-specific labour demand equation in ORANI:

$$x^{(1)}_{(g+1,1,m)j} = x^{(1)}_{(g+1,1)j} - \sigma^{(1)}_{(g+1,1,m)j}\left(p^{(1)}_{(g+1,1,m)j} - \sum_{\ell=1}^{M} p^{(1)}_{(g+1,1,\ell)j}\, S^{*}_{(g+1,1,\ell)j}\right) - \sigma^{(1)}_{(g+1,1,m)j}\left(a^{(1)}_{(g+1,1,m)j} - \sum_{\ell=1}^{M} a^{(1)}_{(g+1,1,\ell)j}\, S^{*}_{(g+1,1,\ell)j}\right). \quad (2.5)$$

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1. Note that the price of an effective unit of labour to industry j is defined as an index of occupation-specific wage rates. In percentage changes

$$p^{(1)}_{(g+1,1)j} = \sum_{m=1}^{M} p^{(1)}_{(g+1,1,m)}\, S^{(1)}_{(g+1,1,m)j}\ , \quad (2.4)$$

where the $\left\{S^{(1)}_{(g+1,1,m)j}\right\}$ are the shares of the occupations in the total costs of labour in industry j.

It is at these values of occupational shares that the σ_i are to be mapped to the σ_{ij}. However, unlike typical time series data, in the industry cross-section case there is considerable variation in the values of industry-specific wage-bill shares around the central values $\{\bar{S}_i,\ldots,\bar{S}_n\}$. As a consequence there are significant errors involved in the approximation to the theoretical model (A1) obtained when (A4) is substituted into (A3). Among other things, these errors mean that the system (A3) and (A4) can be estimated as if of full rank n without computational failure and that the alternative of estimating a system with (n-1) stochastic equations would provide results sensitive to the selection of equation for deletion. Since both of these consequences are results of approximation errors only and run contrary to what the theory would require in their absence, we have serious reservations about estimates produced by this method.

CES Estimation of the Elasticity of Substitution

For a CES system, the problem of non-linearity in the variables can be avoided easily at the estimation stage. The CRESH system collapses to the CES case when all σ_i's are set equal in (A4). With some re-arrangement, the system can be written

$$\left(\dot{L}_{it} - \sum_{j=1}^{n} S_{jt}\,\dot{L}_{jt}\right) = -\sigma\left(\dot{W}_{it} - \sum_{j=1}^{n} S_{jt}\,\dot{W}_{jt}\right) + U_{it} \quad (i=1,\ldots,n), \quad (A5)$$

where variables contained in brackets can be formed as data transformations.

It was noted in section 3 that there are measurement errors attached to each variable. A formula for the standard errors of estimate of variables extracted from Labour Force Surveys is available

σ_{ij} = elasticity of substitution between occupation i and occupation j ;

U_{it} = error term in equation i .

One method of estimating this system whilst preserving linearity in the variables (a requirement of the adopted estimation package) is to perform the share weightings as a data construction. This gives

$$\dot{L}_{it} = \sum_{j=1}^{n} \sigma_{ij} \left[S_{jt} \dot{W}_{jt}\right] + \sum_{j=1}^{n} \left[S_{jt} \dot{L}_{jt}\right] + U_{it} \qquad (i = 1,\dots,n), \qquad (A3)$$

where the brackets group variables formed as a data construction.

By multiplying each side by S_{it} and summing over i, and remembering that homogeneity of the demand functions implies that $\sum_{i=1}^{n} S_{it}\,\sigma_{ij} \equiv 0$, it can be seen that the covariance matrix of the above system is of rank $(n - 1)$. However, the CRESH restrictions on the CRESH substitutions parameters $\{\sigma_1,\dots,\sigma_n\}$ must be imposed at central values (or at some other selected constant values) in order to preserve linearity in the variables for estimation. That is

$$\sigma_{ij} = \frac{\sigma_i \sigma_j}{\sum_{k=1}^{n} \bar{S}_k\, a_k} - \delta_{ij} \frac{\sigma_i}{\bar{S}_i} \qquad (\delta_{ij} = 0,\ i \neq j,\ \ \delta_{ij} = 1,\ i = j), \qquad (A4)$$

where

$\bar{S}_k$ = the constant value of the share of occupation k in the total wage bill aggregated across all industries (viz., across all observations).

Lower case symbols denote percentage changes in the variables defined by the corresponding upper cases (the X's, P's and A's). The $\sigma^{(1)}_{(g+1,1,m)j}$ are substitution parameters from the CRESH labour aggregation function.[1] The $S^{*}_{(g+1,1,\ell)j}$ are modified cost shares required by CRESH as weights.[2]

i.e.,

$$S^{*}_{(g+1,1,m)j} = \frac{\sigma^{(1)}_{(g+1,1,m)j}\, S^{(1)}_{(g+1,1,m)j}}{\sum_{\ell=1}^{M} \sigma^{(1)}_{(g+1,1,\ell)j}\, S^{(1)}_{(g+1,1,\ell)j}}\ , \qquad (2.6)$$

where the $S^{(1)}_{(g+1,1,\ell)j}$ are defined as for equation (2.4) (see p.6, footnote 1).

According to equation (2.5), industry j's demand for labour of occupation m varies proportionately to j's demand for labour in general (defined by (2.2)) if occupational wage relativities do not change and if technology is fixed. If, on the other hand, the wage of occupation m falls relative to a j-specific index of the average wage, or if occupation-m-augmenting technological change occurs, (i.e., if $a^{(1)}_{(g+1,1,m)j}$ is negative), then industry j will increase the share of that occupation in its labour force, i.e., it will substitute between occupation m and other occupations. The strength of the substitution effects depends on the shares of the occupations in the industry's wage-bill, and on the parameters $\sigma^{(1)}_{(g+1,1,\ell)j}$. In the next section we review the empirical evidence on the substitution parameters.

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1. Note that the imposition of the CRESH form reduces the required number of labour - labour substitution parameters from M^2 to M (cf. p.3, fn.5).
2. See DPSV, subsection 12.1.

3. EMPIRICAL EVIDENCE ON LABOUR - LABOUR SUBSTITUTION

The extent to which different types of labour can substitute for each other is conventionally measured in terms of Allen-Uzawa partial elasticities of substitution.[1] Studies which attempt to estimate values of these elasticities have burgeoned in recent years, due to a heightened policy interest in the area, coupled with greater empirical capability in terms of technique and data. However, despite the closer empirical examination, a firm consensus on appropriate values of substitution elasticities fails to emerge.[2]

A number of reasons can be offered to explain the inconclusiveness of the available evidence. Studies differ

(i) in the criteria used to disaggregate the labour force; such as, occupation (production and non-production workers (e.g., Berndt and Christensen (1974)), educational attainment (e.g., Tinbergen (1975)), age (e.g. Welch & Cunningham (1978)) and sex (Freeman (1979));

(ii) in the separability assumptions adopted in the specification of the production technology. Following Griliches (1969) one major stream of concern has been the different impact that capital may have on different types of labour. The

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1. The relationship between these and the substitution parameters in ORANI is described in the Appendix.

2. Tinbergen (1975) attempted to interpret differences in the literature between estimated values of substitution elasticities. Hammermesh and Grant (1979) provide an extensive review of the U.S. literature and find no general agreement except for the direction of substitution relationships between capital and skill groups, and between broadly defined age groups.

APPENDIX : ESTIMATION OF CES AND CRESH SUBSTITUTION ELASTICITIES

This appendix covers three issues: (i) the approximation errors in the Ryland and Parham procedure, (ii) an estimation of the CES elasticity which incorporates a correction for heteroscedasticity in measurement errors due to survey sampling variation and (iii) generation of CRESH elasticities.

Approximation Errors

The first order conditions, linearized in terms of proportional changes, for a cost minimization problem subject to a CRESH aggregation function, can be written

$$\dot{L}_{it} = \sum_{j=1}^{n} S_{jt}\,\sigma_{ij}\,\dot{W}_{jt} + \dot{L}_t + U_{it} \qquad (i = 1,\ldots, n); \qquad \text{(A1)}$$

and

$$\dot{L}_t = \sum_{j=1}^{n} S_{jt}\,\dot{L}_{jt} \,, \qquad \text{(A2)}$$

where

$\dot{L}_{it}$ = proportional change in demand for occupation i at observation (viz., by industry) t ;

S_{jt} = share of occupation i in total wage bill at observation (viz., by industry) t ;

$\dot{W}_{jt}$ = proportional change in wages paid to occupation i at observation (viz., by industry) t ;

$\dot{L}_t$ = proportional change in an aggregate index of labour demand at observation (viz., by industry) t ;

Williams, L.S. (1980), 'Adjustment to Labour Supply Data for BP-16', IMPACT Research Memorandum No. BA-83, Industries Assistance Commission, Melbourne.

____________ (1981), 'Occupational Mobility in Australia : A Quantitative Approach', Unpublished Ph.D. Thesis, Monash University, Melbourne.

capital-skill complementarity hypothesis has been tested by such researchers as Berndt & Christensen (1974). More recently, interest has grown in the differential impact that rising energy prices may have on different types of labour (e.g., Berndt and White (1978)). On the other hand, many studies focus exclusively on substitution within the workforce in isolation from the effects of other factors of production.

(iii) in the choice of framework (e.g., production function versus cost function) within which estimation is carried out;

(iv) according to whether or not they attempt to identify unequivocally labour demand functions by including explicit consideration of labour supply (see Tinbergen (1975));

(v) in the substitution possibilities allowed for by the econometric specification. Earlier studies typically employed a CES specification whereas more recent and more ambitious studies are based on translog (e.g., Berndt and Christensen (1974)) or CRESH (e.g., Weiss (1977)) functions, which allow richer sets of substitution possibilities;

(vi) in the behavioural assumptions adopted, especially as reflected in the choice of exogenous variables;

(vi) in the nature and quality of data used to test substitution hypotheses. Whereas some studies employ time series data, others rely on industrial or regional cross-sections.[1]

Ryland and Parham (1978) provide some Australian evidence on substitution between five occupational groups.[2] Their approach is well suited to the ORANI framework, since the occupational groups are based on the IMPACT classification; in common with ORANI, occupational demands are assumed separable with respect to other factors of production; and, also as in ORANI, substitution possibilities are assumed to conform to a CRESH specification (of which CES can be considered a special case). The Ryland and Parham estimates are based on an industry cross section of changes in labour demands over the period 1968/69 to 1973/74.

We have two major reservations about the Ryland and Parham results. First, the data base is not of high quality. The wage change information (measured in terms of annual earned income) was taken from

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1. For coverage of the implications that this (and other points above) may have for estimated values of substitution elasticities, see Hammermesh and Grant (1979).

2. These groups are Professional, Skilled White Collar, Semi - and Un-skilled White Collar, Skilled Blue Collar and Semi - and Un-skilled Blue Collar.

REFERENCES

Arrow, K. J., H.B. Chenery, B.S. Minhas and R.M. Solow (1961), 'Capital-Labour Substitution and Economic Efficiency', Rev. of Economics and Stats v. 45 (Aug), pp. 225-250.

Berndt, E. and L. Christensen (1974), 'Testing for the Existence of a Consistent Aggregate Index of Labour Inputs', Am. Ec. Rev., v.64 (June), pp.391-404.

Craigie, R. (1980), 'The Construction of a Time Series for Weekly Wages by IMPACT Occupation 1965/66 to 1976/77', IMPACT Research Memorandum No.BA61, Industries Assistance Commission, Melbourne.

Dixon, P.B., B.R. Parmenter and J. Sutton (1977), 'Industry Implications of International Trade Policy : Experiments with the ORANI Model', Paper presented to 48th ANZAAS Congress; IMPACT Working Paper No.G-06, Industries Assistance Commission, Melbourne.

__________ (1978), 'Some Causes of Structural Maladjustment in the Australian Economy', Economic Papers, No.59 (Jan), pp. 10-26.

Dixon, P.B., B.R. Parmenter, J. Sutton and D.P. Vincent (1981), ORANI : A Multisectoral Model of the Australian Economy, North-Holland (forthcoming).

Freeman, R.B. (1979), 'The Effect of Demographic Factors on Age-Earnings Profiles', J. Human Resources, v. 14 (Summer), pp. 289-318.

Griliches, Zvi. (1969), 'Capital - Skill Complementarity', Review of Economics and Statistics, v.51 (Nov), pp. 465-68.

Hammermesh, D. and J. Grant (1979), 'Econometric Studies of Labor-Labor Substitution and their Implications for Policy' J. Human Resources, v. 14 (4), pp. 518-542.

Hanoch, G. (1975), 'Production and Demand Models with Direct and Indirect Implicit Additivity', Econometrica, v. 3 (May), pp. 395-419.

Powell, A.A. (1980), 'Aspects of the Design of BACHUROO, An Economic - Demographic Model of Labour Supply', IMPACT Preliminary Working Paper No.BP-24, IMPACT Research Centre, Melbourne (Nov).

Ryland, G.J. and D.J. Parham (1978), 'Estimation of Occupational Demands in Australian Industry', IMPACT Preliminary Working Paper No.OP-21, Industries Assistance Commission, Melbourne.

Tinbergen, Jan (1975), 'Substitution of Academically Trained by Other Manpower', Weltwirtschaftliches Archive, Band 111, pp. 466-475.

Weiss, Randall D. (1977), 'Elasticities of Substitution Among Capital and Occupations in U.S. Manufacturing', J. Am. Stat.Assoc., v. 72 (Dec), pp. 764-771.

Welch, F. and J. Cunningham (1978), 'Effects of Minimum Wages on the Level and Age Composition of Youth Employment' Rev. Ec. and Stats., v. 60 (Feb), pp. 140-145.

labour demand) and wages as income (relevant to labour supply). With such a facility included, ORANI could be used to solve for full-employment wage rates by occupation or for occupationally disaggregated unemployment levels.

the ABS Income Distribution Surveys of 1968/9 and 1973/74, and labour demand data (measured in terms of hours worked) were extracted from various ABS Labour Force Surveys.[1] Since these surveys were not designed to provide reliable disaggregated data by industry and occupation, measurement errors on variables are high. Second, the statistical package employed by Ryland and Parham in the estimation phase[2] could not properly accommodate non-linearities in the variables. The use of cross-sectional data (with high variations of cost shares around central values) means that central value approximations involve potentially high errors.

In order partly to circumvent these problems, the Ryland and Parham data were reworked, correcting for heteroscedasticity due to sampling variation in estimated growth rates of occupational shares in the workforces of various industries. This re-estimation was in a CES framework, within which non-linearity in the variables could be avoided. The resultant estimate of the elasticity of substitution between the 5 occupational groups was 0.35.[3] The statistical fit was sufficiently poor to discourage an attempt to rework the CRESH results. Such a reworking would, in any event, have required either acceptance of the errors of approximation referred to above, or alternatively, the use of a full non-linear package allowing non-linearity in variables (as well as in parameters). In its place, an ad hoc procedure was used

1. See Ryland and Parham (1978), section 4.
2. More details are provided in the Appendix.
3. For details see Appendix.

to form notional values of CRESH parameters characterizing substitution possibilities among the required nine ORANI occupations. The main requirement imposed on these estimates was that they be consistent with an average cross substitution elasticity of 0.35.[1] These CRESH elasticities are presented in Table 3.1. (These are based on the CRESH substitution parameters given in Appendix Table A1).

Two points should be mentioned before proceeding with the ORANI simulations. First, the timing of the response of labour demand to relative wage changes in the results is not clear. The data reflect one five-year transition period but, within this period, neither the time path of relative wage changes nor the speed of adjustment in labour demands is known.[2] Second, the data base is far too weak to support estimation of industry-specific substitution elasticities. Necessarily, therefore, the estimated values adopted for use in the ORANI simulations are economy-wide.[3]

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1. For details of the estimation procedure, see the Appendix. An alternative, which was tried, was to augment the Ryland and Parham results in ad hoc fashion. CRESH results in this paper are restricted to the first set of parameter estimates (those described) in the Appendix).

2. Some allowance for the timing issue is made in the ORANI simulations that follow by adopting alternative assumptions for the adjustment path.

3. Indeed, it is the replication over industries of observed changes in the input-mix and in relative wages during 1968-69 to 1973-74 that provided the degrees of freedom needed to estimate the substitution parameter $\sigma = 0.35$.

6. CONCLUDING REMARKS : DIRECTIONS FOR FUTURE RESEARCH

In this paper we have reported results of some simulations designed to show how labour demand and the industry structure in ORANI adjust to an exogenous change in wage relativities, assuming slack labour markets; and how real wage rates and the industry structure adjust to a tariff change, assuming no changes in occupational employment. Two mechanisms are available in the model to facilitate the adjustment of the labour market to these shocks. The first is changes in the industrial composition, and the second is substitution within industries between different occupational categories. In most previous ORANI simulations the second of these mechanisms has been bypassed by assuming fixed wage relativities. Recent re-estimation of the required substitution parameters (see section 3) has allowed us to accommodate this aspect of labour demand with more confidence. In fact, the experiments reported in section 4 indicate that, provided that at least a moderate degree of labour-labour substitution is allowed, results for most ORANI variables are not very sensitive to the values of the substitution parametes, nor to the details of the functional specification of substitution possibilities.

The next step in the line of research aimed at extending the application of ORANI to detailed labour market issues is to append an explicit modelling of flexibility in the occupational pattern of labour supply. Drawing on empirical work undertaken as part of the BACHUROO project, we plan to experiment with labour supply functions explaining the level and occupational mix of labour supply as a function of the average level of real wages and the vector of occupational wage relativities. Some additional accounting equations may also be necessary to permit the distinction between wages as costs (relevant to on activity in some major internationally trading industries. Each of the industries in the last 10 places of the ranking has a workforce which concentrates heavily on occupations 7 or 8. In our data the relative wages of both of these occupations increases (see Table 5.1). Seven of these industries (i.e., 14, 25, 11, 13, 6, 63 and 30) are heavily dependent (directly or indirectly) on export sales. Two (i.e., 39 and 79) face strong import competition. Because they are constrained in raising their selling prices by international competition, all nine contract their output (and employment levels) in response to the increases in their labour costs. Industry 111 (Personal Services) sells entirely to the domestic market (mainly to household consumption) and faces no import competition. Its place among the main losers in the simulation is explained by an adverse substitution effect in household consumption. The industry is very labour intensive and occupation 7 has a very high share (0.66)[1] in its wage bill. Hence the change in wage rates causes a strong rise in the costs of Personal Services. Other important consumption goods which compete with Personal Services for the household dollar (e.g., the outputs of those industries appearing at the top of Table 5.3) experience falls in costs. The net result is a significant reallocation of (fixed) aggregate household spending.[2]

1. This occupation accounts for only 25 per cent of the economy-wide wage bill.

2. Some care should be exercised in relying on ORANI results which depend on substitution effects in consumption. The domestic consumption parameters (see DPSV, subsection 29(e)) are one of the weaker parts of the ORANI data base.

TABLE 3.1 : IMPLIED CRESH ELASTICITIES OF SUBSTITUTION BETWEEN OCCUPATIONS IN ORANI SIMULATIONS

	PROF	SWC	USWC	SBC-ME	SBC-B	SBC-O	USBC	RUR	AS
PROF	-3.16	.42	.25	.17	.42	.30	.10	.40	.19
SWC		-2.21	.63	.43	1.05	.75	.24	.99	.49
USWC			-1.33	.26	.63	.45	.14	.59	.29
SBC-ME				-1.94	.43	.31	.10	.40	.20
SBC-B					-12.24	.75	.24	.98	.48
SBC-O						-18.47	.17	.70	.35
USBC							-.50	.23	.11
RUR								-8.50	.45
AS									-11.10

Occupation key :
PROF = Professional White Collar
SWC = Skilled White Collar
USWC = Semi- and Un-skilled White Collar
SBC-ME = Skilled Blue Collar, Metal & Electrical
SBC-B = Skilled Blue Collar, Building
SBC-O = Skilled Blue Collar, Other
USBC = Semi- and Unskilled Blue Collar
RUR = Rural Workers
AS = Armed Services

4. THE SENSITIVITY OF ORANI RESULTS TO LABOUR-LABOUR SUBSTITUTION ASSUMPTIONS: THE CASE OF A 25 PER CENT TARIFF INCREASE

DPSV (chapter 7) contains ORANI projections of the short-run effects on the Australian economy of a 25 per cent across-the-board tariff increase with a fixed real wage rate and a slack labour market assumed for each occupation. The projections for some summary variables and for labour demands are reproduced in column (1) of Table 4.1. The rest of the table contains projections of the effects of the same tariff change in simulations in which, instead of slack labour markets, we have assumed occupation specific employment constraints and have solved for the effects on occupational wage rates. Apart from what is assumed about the labour market, all the projections in Table 4.1 were generated using the same set of underlying assumptions, namely, those described in detail in DPSV, section 44. In each of columns (2) - (8) of the table we have made a different assumption about what labour - labour substitution possibilities are open to producers. As noted in section 3, there is, with currently available data, no possibility of identifying industry-specific labour - labour substitution parameters. The same assumptions have therefore been applied to all industries in generating Table 4.1. The assumptions are as follows:

Column (2) : no labour - labour substitution allowed (a Leontief assumption), i.e., all of the $\sigma^{(1)}_{(g+1,1,m)j}$ in equation (2.5) set equal to zero. For this experiment employment constraints were set for only the first eight occupations. It is not possible in ORANI to set the employment of "armed services" labour exogenously unless labour - labour substitution is allowed. The reason is that this occupation is employed only by the defence industry,

TABLE 5.3 (Cont'd)

Rank	ORANI Industry Number	Description	Percentage Change in Output	Rank	ORANI Industry Number	Description	Percentage Change in Output
65	20	Fruit & Veg Products	-0.17	89	44	Pulp, Paper	-0.32
66	59	Cement	-0.17	90	80	Rubber Products	-0.33
67	15	Crude Oil	-0.17	91	57	Glass	-0.34
68	56	Oil & Coal Products	-0.17	92	70	Locomotives	-0.34
69	77	Construction Equipt	-0.17	93	4	Northern Beef	-0.34
70	21	Marge, Oils & Fats	-0.19	94	85	Gas	-0.35
71	43	Furniture, Mattresses	-0.19	95	64	Other Basic Metals	-0.35
72	45	Fibreboard	-0.20	96	9	Services to Agriculture	-0.36
73	28	Alcoholic Drinks N.E.C.	-0.22	97	40	Sawmill Products	-0.39
74	16	Non-Metallic Minerals N.E.C.	-0.22	98	31	Man-Made Fibres, Yarn	-0.40
75	55	Chemical Prods N.E.C.	-0.22	99	36	Textile Products N.E.C.	-0.41
76	54	Cosmetics, Toiletry	-0.23	100	3	High Rainfall Zone	-0.46
77	46	Paper Products N.E.C.	-0.23	101	94	Railway Transport	-0.50
78	7	Other Farming Import Comp	-0.23	102	10	Forestry	-0.51
79	76	Agricultural Mach.	-0.25	103	79	Leather Products	-0.54
80	1	Pastoral Zone	-0.26	104	30	Prepared Fibres	-0.55
81	58	Clay Products	-0.26	105	63	Basic Iron & Steel	-0.60
82	81	Plastic Products	-0.27	106	6	Other Farming Export	-0.63
83	24	Confectionery	-0.28	107	13	Other Metallic Minerals	-0.65
84	41	Plywood, Veneers	-0.28	108	11	Fishing	-0.67
85	2	Wheat/Sheep Zone	-0.30	109	39	Footwear	-0.75
86	93	Road Transport	-0.30	110	111	Personal Services	-0.82
87	18	Meat Products	-0.30	111	25	Food Products N.E.C.	-1.18
88	49	Chemical Fertilisers	-0.32	112	14	Coal	-2.34

TABLE 5.3 RANKING OF INDUSTRY-OUTPUT RESPONSES TO THE CHANGE IN WAGE RELATIVITIES LISTED IN TABLE 5.1.

Rank	ORANI Industry Number	Description	Percentage Change in Output
1	106	Health	0.68
2	107	Education, Libraries	0.42
3	108	Welfare Services	0.37
4	109	Entertainment	0.19
5	47	Newspaper & Books	0.19
6	52	Pharmaceuticals	0.12
7	23	Bread, Cakes	0.04
8	71	Aircraft Building	0.04
9	102	Other Business Serv	0.04
10	91	Motor Vehicle Repair	0.01
11	87	Residential Building	0.0
12	103	Ownership of Dwellings	0.0
13	105	Defence	0.0
14	104	Public Admin	-0.00
15	42	Joinery & Wood Prods	-0.01
16	96	Air Transport	-0.01
17	82	Signs, Writing Equipt	-0.02
18	32	Cotton, Silk, Flax	-0.02
19	110	Restaurants, Hotels	-0.02
20	48	Commercial Printing	-0.02
21	72	Scientific Equipt	-0.03
22	37	Knitting Mills	-0.03
23	19	Milk Products	-0.04
24	90	Retail Trade	-0.05
25	86	Water, Sewerage	-0.05
26	101	Investment, Real Est	-0.06
27	27	Beer & Malt	-0.06
28	84	Electricity	-0.06
29	73	Electronic Equipt	-0.06
30	22	Flour & Cereal Prods	-0.07
31	99	Finance & Life Ins	-0.07
32	112	Business Expenses	-0.07
33	60	Ready-Mixed Concrete	-0.08
34	69	Ship & Boat Building	-0.08
35	88	Building N.E.C.	-0.08
36	12	Iron	-0.08
37	68	Motor Vehicles, Parts	-0.09
38	51	Paints, Varnishes	-0.09
39	78	Other Machinery	-0.09
40	33	Wool & Worsted Yarns	-0.09
41	92	Other Repairs	-0.09
42	29	Tobacco	-0.10
43	50	Industrial Chemicals	-0.10
44	66	Sheet Metal Prods	-0.10
45	8	Poultry	-0.10
46	62	Non-Metal Min Prods	-0.11
47	98	Banking	-0.11
48	35	Textile Floor Covers	-0.11
49	65	Structural Metal	-0.11
50	61	Concrete Products	-0.11
51	53	Soap & Detergents	-0.12
52	17	Services to Mining	-0.12
53	83	Other Manufacturing	-0.12
54	5	Milk Cattle	-0.13
55	74	Household Appliances	-0.13
56	89	Wholesale Trade	-0.14
57	75	Electrical Machinery	-0.14
58	26	Soft Drinks, Cordials	-0.14
59	38	Clothing	-0.14
60	95	Water Transport	-0.16
61	97	Communication	-0.16
62	34	Textile Finishing	-0.16
63	67	Metal Products N.E.C.	-0.17
64	100	Other Insurance	-0.17

TABLE 4.1. MACRO AND EMPLOYMENT RESULTS FOR 25 PER CENT ACROSS-THE-BOARD TARIFF INCREASE WITH VARIOUS LABOUR-MARKET ASSUMPTIONS

VARIABLE \ LAB MKT. ASSN.	(1) Slack Labour Markets	(2) FIXED EMPLOYMENT BY OCCUPATION	(3)	(4)	(5)	(6)	(7)	(8)
		LEONTIEF	CES Elasticity of Substitution = 0.14	CES Elasticity of Substitution = 0.35	COBB-DOUGLAS	CES Elasticity of Substitution = 100	CRESH 2/5ths of Substitution Parameters from Sec. 3	CRESH Substitution Parameters from Section 3
Aggregate Employment	-0.21							
Employment by Occupation								
1. Professional	-0.13							
2. Skilled White Collar	-0.06							
3. Semi and Un-skilled White Collar	-0.09							
4. Skilled Blue Collar, Metal & Electrical	-0.00							
5. Skilled Blue Collar, Building	0.11							
6. Skilled Blue Collar, Other	0.02							
7. Semi and Un-skilled Blue Collar	-0.12							
8. Rural Workers	-2.09							
9. Armed Services	0.00	0.00						
Real Wage Rates by Occupation								
1. Professional		-10.0	-0.53	-0.11	0.01	-0.18	-0.67	-0.23
2. Skilled White Collar		7.56	0.30	0.25	0.15	-0.18	0.32	0.19
3. Semi and Un-skilled White Collar		-1.60	0.28	0.25	0.16	-0.18	0.31	0.20
4. Skilled Blue Collar, Metal & Electrical		4.22	1.37	0.84	0.44	-0.18	1.70	1.00
5. Skilled Blue Collar, Building		21.03	1.32	0.72	0.34	-0.18	1.08	0.54
6. Skilled Blue Collar, Other		20.26	1.93	0.86	0.31	-0.18	1.69	0.67
7. Semi and Un-skilled Blue Collar		-5.73	0.06	0.21	0.17	-0.18	-0.14	0.14
8. Rural Workers		-7.12	-5.58	-4.98	-3.77	-0.28	-5.34	-4.57
9. Armed Services		0.0[(a)]	0.25	0.21	0.11	-0.18	0.22	0.11
Aggregate Exports	-2.52	-1.85	-2.01	-2.03	-2.05	-2.11	-2.02	-2.04
Aggregate Imports	-1.53	-1.36	-1.54	-1.58	-1.65	-1.86	-1.55	-1.61
Balance of Trade ($m)	-31.7	-13.5	-12.1	-11.1	-9.0	-3.0	-11.7	-10.4
Consumer Price Index	2.20	2.51	2.14	2.10	2.01	1.73	2.12	2.06
Investment Price Index	2.76	3.88	2.72	2.63	2.50	2.17	2.71	2.60

(a) A slack labour market and a fixed real wage rate were assumed for this occupation in this simulation (see p.14 of the text).

the output of which is entirely exogenous. The price of defence output (defined as the sum of its costs) does not appear elsewhere in the model. With no labour - labour substitution, there is nothing in the model to determine the wage rate for "armed services" (if it is endogenous) since the price of defence can take any value.

Column (3) : CES labour - labour substitution[1] with the elasticity of substitution between all pairs of occupations equal to 0.14. This value is two fifths of the CES estimate described in section 3. That estimate was made on the basis of data points 5 years apart. As explained in section 3, no information is available to indicate how the adjustment should be apportioned over the 5 year period. Here we are assuming that two fifths of the adjustment occurs in the ORANI short run (1-2 years).

Column (4) : CES labour - labour substitution with the elasticity of substitution equal to 0.35, i.e., the CES estimate from section 3. The assumption here is that all the 5-year adjustment takes place within the ORANI short-run (cf. the discussion of column (3)).

Column (5) : Cobb-Douglas labour - labour substitution, i.e., unitary elasticity of substitution between each pair of occupations. This was the assumption made in Dixon, Parmenter and Sutton (1977, 1978).

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1. CES is a special case of CRESH. If we set $\sigma^{(1)}_{(g+1,1,m)j} = \sigma^{(1)}_{(g+1,1)j}$ for all m, equation (2.5) reduces to the labour demand function derivable from cost minimisation subject to a CES labour aggregation function. Note that the $S^{*}_{(g+1,1,m)j}$ reduce to ordinary cost shares (cf. equation (2.6)).

(via labour - labour substitution) and the economy as a whole (via industry-composition changes) are able to change the compositions of their workforces to take advantage of the changes in wage relativities.

The industry results from the simulation are presented in Table 5.3. It contains percentage changes in industry-output levels, ranked in descending order. Surprisingly few industries experience output gains. All the gainers enjoy falls in their wage costs on account of the change in wage relativities. The shares of occupations whose wages fall (i.e., 1, 2 or 6) are relatively high in the workforce compositions of these industries whilst the shares of the occupations whose wages rise (i.e., 3, 7 or 8) are relatively low. Of the top six industries three (i.e., industries 109, 47 and 52) are import competing industries, and all sell significant shares of their outputs to domestic consumption. The reductions in their selling prices allowed by the falls in their wage costs generate favourable substitution effects. The first 14 industries in the ranking of Table 5.3 (i.e., those industries with non-negative output changes) account for high shares of the total employment of those occupations whose wages fall in Table 5.1. The relevant shares are occupation 1, 0.75; occupation 2, 0.35; and occupation 6, 0.20. The result is that for most other industries the change in relativities constitutes an increase in average wage costs. Hence, the preponderance of negative output changes in Table 5.3.

Examination of the main losers in the simulation, i.e., those industries which appear towards the bottom of the ranking in Table 5.3, supports our earlier contention that most of the unemployment generated by the change in wage relativities is accounted for by a squeeze

We computed our economy-wide average wage increase (on the basis of which the changes in occupational relativities were calculated) using occupational weights in the aggregate domestic wage bill. If we were to compute a GDP price deflator it would, therefore, show no movement. The domestice consumption bundle is apparently relatively intensive in the use of occupations experiencing relative wage falls, whilst investment has a slight bias towards occupations with rising relative wages.

The most interesting result in Table 5.2 is the fall in aggregate employment generated by the wage changes despite the fact that they represent no change in the average real wage rate. The explanation is that relative wage increases are experienced by occupations 3, 5 and 7 which are all employed heavily in sectors of the economy which are subject to international competition, particularly the export sectors. The selling prices of these sectors are constrained by world - market prices with the result that increases in their domestic costs cause significant falls in their outputs. This effect is also evident in Table 5.2 in the fall in aggregate exports, the slight rise in imports and the consequent deterioration in the balance of trade. On the other hand, those occupations which experience relative wage declines (i.e., occupations 1, 2, 5 and 6) are all heavily concentrated in sectors of the economy which produce non-traded goods for domestic markets. The outputs of these sectors are largely determined by the level of aggregate domestic absorption (fixed in this simulation) and are comparatively insensitive to domestic costs. The occupation-specific employment results follow the expected pattern. Relative wage increases generate falls in labour demand for the relevant occupations (3, 7 and 8), whilst demand increases for those occupations (1, 2, 5 and 6) whose relative wages fall. Both individual industries

Column (6) : CES labour - labour substitution with an elasticity of substitution of 100. This implies that labour is almost homogeneous from the employers' viewpoint.

Column (7) : CRESH labour - labour substitution with values for the substitution parameters $\left\{\sigma^{(1)}_{(g+1,1,m)j}\right\}$ equal to two fifths of those listed in Table A1.

Column (8) : CRESH labour - labour substitution using the values from Table A1 for the substitution parameters.

The results in column (1) of Table 4.1 indicate that, in ORANI, an increase in tariffs causes a fall in total employment if real wages remain constant. The reason is that the tariff increase leads to an increase in the domestic price level relative to world prices and erodes the competitive position on world markets of lightly protected trading sectors, especially exporters. The effects of the contraction in exports outweigh the expansion of import-competing activities. The main symptom of this in the occupation-specific employment results is the contraction of the demand for rural workers. The employment effects in the other occupations are small. Using our occupational classification, which for most occupations is not very industry-specific, the only clear indicator of employment expansion in the import-competing sector is the increase in employment in occupation 5 (Skilled Blue Collar, Building). This expansion is generated by the reallocation of the economy's aggregate investment budget (assumed fixed) towards the import-competing sector where capital formation is relatively intensive in the use of construction.

The wage results in columns (2) - (8) of Table 4.1 are different projections of the changes in wage rates required for the demand for labour of each occupation to remain constant following the tariff increase. These would be the wage changes necessary to offset the employment effects of the tariff increase only if no adjustment took place on the supply side.[1]

For the simulation reported in column (2) of Table 4.1., only one mechanism is available in ORANI to preserve the original level and occupational pattern of labour demand in the face of the tariff increase. Individual industries are not permitted to change the compositions of their workforces via labour - labour substitution so that aggregate employment by occupation can change only as a consequence of changes in the industrial composition of the economy. The wage results in column (2) are thus the changes in wage rates necessary to induce a change in the industry structure which will preserve the original level of labour demand following the tariff increase. In general, the wage changes must be such as to stimulate activity in sectors which are heavy users of those occupations for which (under fixed wage rates) the tariff increase reduced demand, and to reduce activity in those sectors which use intensively occupations for which employment was increased by the tariff increase in column (1) of Table 4.1.

As noted above, by far the largest employment effect in column (1) of Table 4.1 is the reduction in the demand for rural workers (occupation 8). In column (2) this fall in demand is reflected by a reduction in the real wage rate earned by the rural occupation (7.12 per cent). What is surprising in column (2) is that the fall in the rural

1. The estimation of inter-occupational transformation elasticities in the BACHUROO model (Powell, 1980) is not yet complete (see, however, Williams (1980)).

TABLE 5.2 : MACRO AND EMPLOYMENT EFFECTS OF THE CHANGES IN WAGE RELATIVITIES LISTED IN TABLE 5.1

Variable	Percentage change
Aggregate Employment	-0.51
Employment by occupation	
1. Professional	1.32
2. Skilled White Collar	2.43
3. Semi- and Un-Skilled White Collar	-1.08
4. Skilled Blue Collar, Metal & Electrical	-0.03
5. Skilled Blue Collar, Building	0.55
6. Skilled Blue Collar, Other	2.70
7. Semi- and Un-Skilled Blue Collar	-2.09
8. Rural Workers	-0.96
9. Armed Services	0.04
Aggregate Exports (Foreign Currency)	-0.67
Aggregate Imports (Foreign Currency)	0.03
Balance of Trade ($ 1968/9 million)	-26.3[a]
Consumer price index	-0.12
Investment price index	0.07

(a) Measured as a change, not a percentage change.

To get some insight into how these changes in relativities would have affected the structure of the economy we imposed the percentage changes listed in Table 5.1 as exogenous changes in real occupational wage rates in ORANI. In the absence of the necessary data, no allowance was made for any differential changes in occupation-specific labour productivity which may have occurred. The standard neo-classical short-run configuration of ORANI was used for the simulation, that is, industry-specific capital stocks were held fixed, the level and broad composition of real domestic absorption were exogenous, the balance of trade was endogenous, the labour market for each occupation was assumed slack, and the exchange rate was the numeraire. (See DPSV, sections 23 and 44 for an extended discussion of these assumptions.) In view of the difficulty of obtaining reliable estimates of occupation-specific substitution parameters (see section 3), and in view of the results of our sensitivity analysis (see section 4), we have reported, in this section, only results derived under the assumption that labour - labour substitution is of the CES type. A value of 0.35 was used for the elasticity of substitution between occupations, that is, the value reported in section 3. In fact in the simulation reported here only the results for employment by occupation are sensitive to the value of the labour - labour substitution parameters or to the form of substitution assumed.[1]

Results from the simulation for some macro variables and for employment by occupation are reported in Table 5.2. Note first the results for the two price indexes: a small fall in the index of consumer prices and a small rise in the investment goods price index..

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1. This depends on properties of the Johansen solution method. Minor variations in other variables would be evident if Euler-style solutions were computed (see DPSV, chapter 5).

wage is not larger relative to the wage changes for some other occupations. Occupation 1 (Professionals), for example, experienced a demand reduction of only 0.13 per cent in column (1), but suffers a 10 per cent real wage reduction in column (2). Similarly, occupations 5 (Skilled Blue Collar, Building) and 6 (Skilled Blue Collar, Other) have only small employment increases in column (1) (0.11 per cent and 0.02 per cent, respectively) yet enjoy wage increases of about 20 per cent in column (2). The reason is that activity (and therefore employment[1]) in the rural industries is much more sensitive to cost changes than is activity in those industries which account for most of the employment of occupations 1, 5, or 6. In column (1) of Table 4.2 we have listed the shares in the total usage of occupations 1,5,6 and 8 of the five main users of each of the occupations. As can be seen from column (2) of the same table, it is changes in employment in these main using industries which account for the bulk of the differences in the occupational employment results between simulations (1) and (2) in Table 4.1.[2] The main users of rural workers are all either export industries or industries which sell large shares of their outputs to export industries.[3] Export

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1. In short-run ORANI experiments in which industry-specific capital and land stocks are fixed, output (z_j) and employment (ℓ_j) in industry j are related by the equation

$$z_j = S_{Lj} \ell_j ,$$

where S_{Lj} is the share of labour in j's aggregate primary-factor costs.

2. For example, in simulation (2) from Table 4.1 the employment of rural workers is 2.09 per cent higher than in simulation (1). Column (2) of Table 4.2 shows that 0.83 of this 2.09 per cent is accounted for by the difference (as between the two experiments) in the employment of rural workers in the Wheat/Sheep Zone (industry 3). The five main users of rural workers (i.e., industries 2,3,5,6 and 9) together account for 1.66 of the 2.09.

3. A more detailed analysis of the sales patterns of the ORANI industries is in DPSV subsection 45.2, especially Table 45.4.

TABLE 4.2 : SHARES IN THE TOTAL EMPLOYMENT OF OCCUPATIONS 1,5,6 AND 8 ACCOUNTED FOR BY THEIR FIVE MAIN USERS AND THEIR CONTRIBUTIONS TO THE CHANGE IN EMPLOYMENT BETWEEN SIMULATIONS (1) AND (2)

	M A I N		U S E R S	
Occupation	ORANI Code	Description	Share in base-period employment	Contribution to change in employment between simulations 1 and 2
	107	Educ., Libraries	0.25	0.03
	106	Health	0.13	0.03
1 Professional	102	Other Bus. Services	0.10	0.02
	104	Public Admin.	0.10	0.01
	108	Welfare Services	0.05	-0.01
			0.63	0.08
	88	Building N.E.C.	0.46	-0.05
	87	Residential Build.	0.20	0.00
5 SBC, Building	42	Joinery and Wood Prod.	0.05	-0.02
	43	Furniture, Mattresses	0.04	-0.04
	89	Wholesale Trade	0.03	0.01
			0.78	-0.10
	18	Meat Products	0.16	0.80
	90	Retail Trade	0.15	-0.02
	23	Bread, Cakes	0.11	-0.19
6 SBC, Other	48	Commercial Printing	0.09	-0.17
	110	Restaurants, Hotels	0.09	-0.48
			0.60	-0.06
	2	Wheat/Sheep Zone	0.23	0.83
	3	High Rainfall Zone	0.14	0.40
8 Rural Workers	9	Services to Ag.	0.14	0.16
	5	Milk Cattle	0.10	0.16
	6	Other Farm Export.	0.08	0.11
			.69	1.66

TABLE 5.1 : PERCENTAGE CHANGES IN REAL AVERAGE EARNED ANNUAL INCOMES BY OCCUPATIONS RELATIVE TO THE AVERAGE CHANGE ACROSS ALL OCCUPATIONS 1968/9 - 1973/4

Occupation group	Percentage change in relative income
1. Professional	-5.30
2. Skilled White Collar	-7.74
3. Semi- and Un-Skilled White Collar	2,69
4. Skilled Blue Collar, Metal and Electrical	-0.26
5. Skilled Blue Collar, Building	-1.73
6. Skilled Blue Collar, Other	-8.68
7. Semi- and Un-Skilled Blue Collar	5.89
8. Rural Workers	1.62
9. Armed Services	0.0[(a)]

(a) No data were available for this occupation. Its wage rate was assumed to move at the average rate.

5. THE EFFECTS OF CHANGES IN OCCUPATIONAL WAGE RELATIVITIES ON THE AUSTRALIAN ECONOMY 1968/9 - 1973/4

The ORANI model has previously been used (see Dixon, Parmenter and Sutton, 1978) to provide some quantitative analysis of the effects on the economy of the wage explosion which took place during the early 1970's. The analysis focused mainly on the effects of the increase in the average level of real wages, but included some projections of the likely effects of the accompanying compression in male-female wage differentials. An aspect of the wage changes not considered was the marked change in occupational wage relativities. In this section we extend the previous analysis to include the occupational-relativities dimension, using the evidence on labour - labour substitution parameters which was discussed in section 3.

Our data on occupational wage relativities are given in Table 5.1. Information on hourly wage rates (the appropriate unit for ORANI) was not directly available. As a proxy we have used data on average annual earned incomes derived from Williams (1980) and Craigie (1980). We have assumed that changes in the income relativities represent changes in wage rate relativities; that is, we have not adjusted for differential (across occupations) changes in hours worked. The percentage change in the average real income per year for each occupation group was calculated for the period 1968/9 - 1973/4. These changes were then deviated from the average across occupations. This latter was computed using occupational shares in the economy-wide wage bill from the ORANI input-output data base. As can be seen from the table, the data suggest that during the relevant period wage relativities moved against the skilled occupations (with the exception of occupation 4, Skilled Blue Collar, Metal and Electrical) and in favour of the semi- and un-skilled groups (3, 7 and 8).

demand elasticities are assumed, in general, to be quite high in ORANI with the consequence that export industries are readily able to expand their output levels in response to falls in their costs. On the other hand, industries producing non-traded commodities are heavily represented among the main users of occupations 1, 5 and 6, especially 1 and 5. Real aggregate domestic absorption is fixed in all our simulations, and it is much more difficult to induce changes in activity by cost changes for industries which sell only to domestic users and face little or no import competition. A significant share (0.16) of the employment of occupation 6 is in the export industry 18 (Meat Products). Ceteris paribus, increases in wages for occupation 6 would have a marked contractionary effect on output in this industry. The problem is that the other wage changes that are occurring (especially the fall in wages for occupation 7) tend to stimulate exports of meat products with the result that the net contribution of the industry to eliminating the increase in demand for occupation 6 is negative. Hence a very large increase in wages is required for the occupation in order to reduce demand for it by its other users.

The changes in wage rates which were discussed in the previous paragraph are also reflected in the results for the aggregate trade and price index variables in column (2) of Table 4.1. As is implied by the earlier discussion, the fall in wage rates (especially of rural workers) mitigates the adverse effect of the tariff increase on aggregate exports. On average, costs in the import competing sector are increased by the wage changes, hence imports do not decline as much, following the tariff increase, as was the case in the fixed-wage experiment (column (1) of Table 4.1). The net effect is an improvement in the balance of trade relative to simulation (1). Rises in the wage rates of occupations important in producing commodities for domestic markets are evident in the results for the two price indices, which both rise more in column (2) of the table than in column (1). The effect of the big rise in the wage rate of occupation 5 is especially evident in the investment-goods price index.

In the simulations reported in columns (3) - (8) of Table 4.1 substitution between occupations within individual industries is allowed to occur. This adds a second mechanism (additional to industry-composition effects) through which wage changes can offset the employment effects of the tariff increase. In terms of equation (2.5), we are setting the $\sigma^{(1)}_{(g+1,1,m)j}$ to non-zero values, thus permitting the substitution term in the equation (the second term on the RHS) to play a role in determining occupational employment levels. In columns (3) - (6), CES labour - labour substitution possibilities were specified with values of the elasticity of substitution between occupations varying from 0.14 to 100 (see pp.16,17). As soon as we allow substitution at moderate rates (columns (3) - (5)) the extent of the wage changes necessary to eliminate the employment effects of the tariff increase shown in column (1) of the table rapidly diminishes and approaches what one would intuitively expect on the basis of column (1), i.e., a significant fall in rural wages but very little change in the wage rates of the other occupations. The effects on the aggregate variables are also intuitively plausible in all cases. The fall in average wage levels (necessary to eliminate the fall in aggregate employment from column (1)) results in smaller rises in the domestic price levels in columns (3) - (5) than in column (1), and the tariff increase has less contractionary effects on exports and more expansionary effects on import - competing industries. Differences among columns (3) - (5) are relatively minor. In

particular, the question of what proportion of the adjustment implied by the CES values derived from section 3 we assume to occur within the ORANI short run does not appear very crucial (cf. columns (3) and (4)). Column (6) of the table represents the case in which the elasticity of substitution between occupations is so high that labour is almost homogeneous from the employers' point of view. In this case occupational wage rates tend to change by the same percentage, i.e., the small negative change necessary to eliminate the small reduction in aggregate employment from column (1).

Finally, in columns (7) and (8) of Table 4.1 we have allowed CRESH labour - labour substitution using the CRESH parameters described in section 3. As explained in section 3, these represent the same average amount of substitution between occupations as is allowed by the CES parameters described in that subsection (i.e., those used for columns (3) and (4) of Table 4.1). Column (7) corresponds to column (3) of the table in the sense that both allow within the ORANI short run only two fifths of the adjustment underlying the substitution parameters described in section 3. Similarly, column (8) corresponds to column (4) - both assume that all the adjustment occurs within the ORANI short run. Comparing the results in these pairs of columns suggests that accounting for the variation between pairwise substitution elasticities which is allowed for under CRESH is not a very important aspect of labour - labour substitution in ORANI. This is reassuring given the difficulty, described in section 3, of measuring labour - labour substitution parameters with existing Australian data.