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OCCUPATIONAL MOBILITY IN AUSTRALIA:

A QUANTITATIVE APPROACH

by

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(Monash University)

Working Paper No. BP-13 Melbourne December 1980

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1. INTRODUCTION AND OUTLINE

Labour markets in developed economies are traditionally of the disequilibrium variety. The distribution of the workforce demanding jobs in specific occupations in a given region rarely, if ever, exactly matches the supply of same. The essential feature that differentiates the labour market from other types of markets is that prices (in this case the overall real wage and the structure of relative wage rates) do not easily adjust so as to cause the market to clear. Institutional frictions damp the movements of wages in either direction (but especially downwards), seriously attenuating the tendency for a labour market to move towards equilibrium in the short to medium term.

Empirical evidence for Australia suggests that occupational mobility accounts for a large part of the annual redistribution of the workforce: available survey data reveal that while immigrants and entrants from the education sector respectively add of the order of one per cent and three per cent to the workforce annually, approximately four to five per cent of employed people change their occupations within the same time period.

The aim of this paper is to formulate and estimate a model to explain occupational mobility in Australia. Both the demand and the supply sides of the labour market are affected by and affect this process. Any attempt

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* This paper is drawn from part of the work reported in the author's Ph.D. thesis (Williams 1980(c)). Without implicating him in any of the remaining errors, I would like to thank Alan Powell for his extensive assistance and supervision of the project.

to capture the factors determining observed occupation changes, therefore, must be from a structural point of view.

In order to focus attention on this process, as opposed to the operation of the labour market as a whole, many of the inputs to the model are treated as exogenous. These include entrants to the labour force from the education and immigration sectors.

The main hypotheses advanced in the development of the theoretical model are

(i) that occupational mobility varies with excess demand (or supply) in the aggregate labour market;

(ii) that segmentation occurs within individual markets for specific occupations; and

(iii) that net labour mobility between occupations is responsive to changes in relative occupational wage rates after adjustment for differential risks of unemployment.

Currently the only information available on annual movements between occupations is from two surveys by the Australian Bureau of Statistics (ABS) which yield data for the twelve month periods prior to November 1972 and December 1975. Analysis consequently must rely largely on cross-sectional evidence.

This paper comprises six sections. The basic mobility equation is formally derived in section two, where the appropriate weighting parameters for the demand and supply functions are presented as an aggregate not only over all regions, but over all occupations. Section three contains the derivation of the functions for occupation specific demand for transferees. In section four, the corresponding supply functions are developed. Estimates for the parameters of the supply of transferees functions are presented in section 5. The "complete" model is drawn together in section six, which concludes with a brief statement of the author's perspectives for future

2. DERIVATION OF THE BASIC MOBILITY EQUATION

Let mobility from occupation i to occupation j be defined by a nested function of the form

$$QM_{ij} = F[DM_{ij}, SM_{ij}], \quad (i \neq j), \tag{1}$$

where QM_{ij} = net observed movement from occupation i to occupation j ;

DM_{ij} = a function representing net demand by employers for labour of occupation of type j from source occupation i ;

SM_{ij} = a function representing the net supply of labour[1] to occupation j from occupation i .

Suppose equation (1) takes the specific functional form

$$QM_{ij} = \mu DM_{ij} + \gamma SM_{ij}, \; 0 \leqslant (\mu, \gamma) \leqslant 1, \quad (i \neq j) \tag{2}$$

where μ = a (common) weighting factor incorporating (i) the relative importance of aggregate labour demand (as opposed to supply) in the determination of observed labour flows; and (ii) an average of the degree to which the demand for and the supply of occupation changers are matched in the various sub-markets (i.e., an allowance for the existence of frictional mis-matching);

γ = the corresponding (common) weighting factor on the supply side.

Equation (2) is defined as the basic mobility equation and is derived in the following manner. Consider the individual regions, each of which is assumed to contain every occupation. Each occupation in each region is in either excess demand[2] or excess supply. Further, for each occupation

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[1] A full definition of this supply function is contained in section four.

[2] For analytic convenience, demand equal to supply is allocated to the excess demand regime.

it is possible to calculate an aggregate over all regions, thus determining whether the occupation is in a situation of excess aggregate demand or excess aggregate supply.

Let the intra-region[1] specific reduced form mobility equation for movement from occupation i to occupation j be

$$(3) \qquad qm_{ij}^{k} = \min_{\{dm,\ sm\}} (dm_{ij}^{k},\ sm_{ij}^{k}),$$

where qm_{ij}^{k} = the net observed movement from occupation i to occupation j that occurs in region k;

dm_{ij}^{k} = the net demand for occupation j type labour from occupation i that exists in region k;

sm_{ij}^{k} = the net supply of labour to occupation j from occupation i in region k.

That is, for region[2] k,

$$(4) \qquad qm_{ij}^{k} = \sigma_{ij} dm_{ij}^{k} + (1 - \sigma_{ij}) sm_{ij}^{k},$$

where $\sigma_{ij} = \begin{cases} 0 & \text{if } dm_{ij}^{k} > sm_{ij}^{k}\ ; \\ 1 & \text{if } dm_{ij}^{k} \leqslant sm_{ij}^{k}\ . \end{cases}$

Aggregating equation (3) over all regions yields

$$(5) \qquad QM_{ij} = \sum_{k} \min_{\{dm,\ sm\}} (dm_{ij}^{k},\ sm_{ij}^{k}) ,$$

$$= \sum_{k \varepsilon K^{*}} dm_{ij}^{k} + \sum_{k \varepsilon K^{**}} sm_{ij}^{k} ,$$

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1 The following treatment implicitly assumes that no inter-regional mobility occurs. If inter-regional mobility were recognized for explicitly, derivation of equation (2) would involve aggregation of the flows between as well as within regions, but its final estimating form would remain unchanged.

2 Note that in this paradigm it is assumed that mismatching does not exist at the intra-regional level (i.e., within regions).

where K^* are regions of excess demand or equilibrium and K^{**} are regions of excess supply, so that the set of regions $\{K^* \cup K^{**}\}$ is exhaustive.

Equation (5) can be rewritten as

$$QM_{ij} = \frac{\sum_{k \epsilon K^*} dm_{ij}^k}{\sum_k dm_{ij}^k} \cdot \sum_k dm_{ij}^k + \frac{\sum_{k \epsilon K^{**}} sm_{ij}^k}{\sum_k sm_{ij}^k} \cdot \sum_k sm_{ij}^k ,$$

$$= \mu_{ij} DM_{ij} + \gamma_{ij} SM_{ij} , \tag{6}$$

where $QM_{ij} = \sum_k qm_{ij}^k$, $DM_{ij} = \sum_k dm_{ij}^k$, $SM_{ij} = \sum_k sm_{ij}^k$ and are as previously defined,

and μ_{ij} is the share of the aggregate demand for occupation i to j changers that exists in demand determined regions, with $\mu_{ij} \leqslant 1$; and γ_{ij} is the share of the aggregate supply of occupation i to j changers that exists in supply determined regions, with $\gamma_{ij} \leqslant 1$ also.

Equation (6) utilizes different weighting factors for movement between different pairs of occupations. However, because of data limitations it is highly unlikely that sufficient information will exist to provide individual estimates of all the μ_{ij} and γ_{ij} parameters. Instead, common values for μ and γ are imposed over the whole labour market, thus yielding the functional form as specified in equation (2), viz.,

$$QM_{ij} = \mu DM_{ij} + \gamma SM_{ij}, \; 0 \leqslant (\mu, \gamma) \leqslant 1. \tag{2}$$

The equality $\mu + \gamma = 1$ only occurs if:

(i) every occupation in every region is simultaneously in excess supply, whence $QM_{ij} = DM_{ij}$ (i.e., $\mu = 1$, $\gamma = 0$); or

(ii) every occupation in every region is simultaneously in excess demand, whence $QM_{ij} = SM_{ij}$ (i.e., $\mu = 0$, $\gamma = 1$); or

(iii) every sub-market is simultaneously in equilibrium with $dm_{ij}^{k} = sm_{ij}^{k}$ for each k, whence there is no leeway for mismatching and $QM_{ij} = DM_{ij} = SM_{ij}$.

Generally, however $\mu + \gamma \neq 1$. That is, even if the net demand for and the net supply of occupation changers are equal in the aggregate, the mismatching of sub-market specific demands and supplies may prevent the attainment of "equilibrium".[1] The parameters μ and γ, therefore, incorporate *both* the extent of aggregate excess demand/supply, *and* the degree of mismatching between the sub-market specific demands and supplies.

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[1] "Equilibrium" here has a Pareto optimal interpretation, in that - by moving - some people may obtain employment with no consequent unemployment of others.

3. DEVELOPMENT OF THE SOURCE AND DESTINATION SPECIFIC DEMAND FOR TRANSFEREES

The theory relating to the determination of demand for specific i to j transferees is developed in terms of the behaviour of the representative firm. This firm is a convenient fiction which avoids aggregation problems involved in summing over all individual firms. The difference between an individual firm and the representative one is that, whereas each individual agent is sufficiently small to be unaffected by supply constraints which apply to the market as a whole the representative firm is bound by them. In effect, then, the representative firm is just a proportionately scaled down version of the economy as a whole, and aggregation over all such (identical) firms yields the appropriately constrained behaviour of this economy.

The demand for labour of a given type is defined as a derived demand, which for the purposes of this analysis is assumed to be determined at a previous level of the firm's decision making in its production process. This enables attention to be confined to the 'allocation' of this demand to the various sources supplying labour of this particular type.

Total labour supply can be broken into two main components: those people employed in a particular occupation who wish to remain there, and those workers who wish to enter a particular occupation. The major sources of additional labour supply are people who want to change their occupations, and entrants to the labour force from the education and immigration sectors.[1] It is possible that the firm may

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[1] An implicit assumption of this approach is that the participation rate is exogenous and fixed over the estimation period.

have some preference ordering as regards these alternative sources. For example, employers may feel it is easier for new graduates to assimilate into their firm than for occupation changers to adjust. Alternatively, they may feel that older workers may have more general experience which could increase their worth to the firm relative to younger graduates. No consistent information exists on these preferences. Further, in the Australian labour market the nature of the institutional framework is such that the Commonwealth Conciliation and Arbitration Commission determines a series of award wages for specific tasks. Firms are obliged to pay these wages, irrespective of the source of the labour, i.e., there are no source-specific wage differentials for a particular job. Thus, although it might be attractive to set up a model in which firms operate so as to minimize the cost of obtaining their additional labour requirements, the absence of wage differentials between alternative sources of labour supply (in Australia) means that any such model would yield no information on the quantities demanded from alternative sources.

It is therefore assumed that the allocation of a firm's total demand for labour of a particular type among alternative sources is determined according to the relative numbers offering from each of these sources. This implies that the elasticities of substitution in the firm's production function between workers of the same occupation hired from different sources are infinite. In other words, there exist no specific advantages or disadvantages to the different groups competing in the labour market -- for example, native born are not favoured over immigrants, nor new workforce entrants over occupation changers.

It is further assumed that first preference in employment is given to those workers already in a particular occupation who wish to remain there. This quantity is equal to the previous period stock corrected for deaths, retirements and resignations. The assumption imposed, therefore, is that the demand for stayers is equal to the supply of stayers (which in turn is equal to the number who actually remain in occupation j).

Denote the representative firm's demand for labour of occupation j as $D(LT)_j$. Suppose this demand is determined outside this model. This quantity can be disaggregated thus:[1]

(7) $$D(LT)_j = D(LN)_j + G^D(\sum_{i \neq j} DM_{ij}, DE_j, DI_j),$$

where $D(LN)_j$ = the demand for labour currently employed in occupation j (i.e., the previous period stock corrected for resignations, deaths and retirements); for convenience, call this quantity "inside" demand;

$\sum_{i \neq j} DM_{ij}$ = the demand for occupation j type labour from all other occupations, i.e., DM_{ij} = the demand for occupation j type labour from source occupation i ;

DE_j = the demand for occupation j type labour from the education sector;

DI_j = the demand for occupation j type labour from the immigration sector;

$G^D(\cdot)$ = a function combining the demands for the alternative sources of labour supply, i.e., "outside" demand.

Rearranging equation (7) yields

(8) $$D(LX)_j = D(LT)_j - D(LN)_j = G^D(\sum_{i \neq j} DM_{ij}, DE_j, DI_j) ,$$

where $D(LX)_j$ = the demand for an additional unit of labour of occupation j type, i.e, "outside" demand.

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[1] Imagine there is a t (current time period) subscript on all variables.

Imposing the assumption that the quantities demanded from each source of labour are determined according to the relative supplies available from each of these sources, $G^D(\cdot)$ can be expressed as

(9) $$G^D\left(\sum_{i\neq j} DM_{ij}, DE_j, DI_j\right) = \sum_{i\neq j} DM_{ij} + DE_j + DI_j$$

and

(10) $$DM_{ij} = \alpha_{ij} D(LX)_j, \quad DE_j = \beta_j D(LX)_j, \quad DI_j = \gamma_j (DLX)_j,$$

(10.1) $$\alpha_{ij} = \frac{SM_{ij}}{S_j}, \quad \beta_j = \frac{SE_j}{S_j}, \quad \gamma_j = \frac{SI_j}{S_j},$$

where

(10.2) $$S_j = \sum_{i\neq j} SM_{ij} + SE_j + SI_j = SM_{.j} + SE_j + SI_j,$$

and

(10.3) $$\sum_{i\neq j} \alpha_{ij} + \beta_j + \gamma_j = 1 \quad \text{and} \quad \sum_{i\neq j} \alpha_{ij} = \alpha_{.j},$$

where α_{ij} = the proportion of "outside" demand for labour of occupation j type from source occupation i ;

$\alpha_{.j}$ = the proportion of "outside" demand for labour of occupation j type from all other occupations ;

β_j = the proportion of "outside" demand for entrants from the education system ;

γ_j = the proportion of "outside" demand for immigrants ;

SM_{ij} = the supply of labour to occupation j from occupation i ;

$\sum_{i\neq j} SM_{ij} = SM_{.j}$ = the supply of labour to occupation j from all other occupations ;

SE_j = the supply of labour from the education system to occupation j ;

SI_j = the supply of labour from the immigration system to occupation j .

Combining (10) and (10.1) yields

$$(11) \qquad DM_{ij} = \left[\frac{SM_{ij}}{\sum_{i \neq j} SM_{ij} + SE_j + SI_j} \right] D(LX)_j \ , \ (i \neq j) \ .$$

Equation (11) represents the demand by all firms for labour of occupation j type from source occupation i . Equations (7) to (11) allocate a certain additional demand[1] for labour of occupation j type to be satisfied from alternative sources. In turn, the proportions demanded from each source are determined by the relative number of workers in each source willing and able to supply jobs of occupation j type. Thus the proportions are supply or worker determined, while the total number of opportunities are demand determined.

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[1] It is assumed that total "outside" demand $D(LX)_j > 0$, and the case for $D(LX)_j < 0$ is not considered, though the same analysis is applicable but in reverse. If $D(LX)_j = 0$, then no net movement occurs into this occupation.

4. DEVELOPMENT OF THE SOURCE AND DESTINATION SPECIFIC SUPPLY OF TRANSFEREES

4.1 Derivation of the Simple Estimating Form

The supply schedule for workers who wish to shift from occupation i to occupation j is determined at the second stage of a two level process. At the first stage, aggregate supply to each particular occupation $\{S(LT)_j\}$ is determined. This quantity is then broken down into its component parts: the stock of labour already in that occupation wishing to remain -- "inside" supply $\{S(LN)_j\}$; supply from all other occupations $\{\sum_{i \neq j} SM_{ij}\}$, and supply from the education $\{SE_j\}$ and immigration $\{SI_j\}$ sectors -- collectively denoted as "outside" supply.

In order to focus attention on the development of the supply of occupation changers schedule it is assumed that total occupation specific supplies are predetermined.[1]

The identity operating over aggregate supplies to each occupation is of the form[2]

$$\overline{S(LT)_j} = S(LN)_j + S(LX)_j \,, \tag{12}$$

where $S(LN)_j$ = the number of effective manhours worked by employees who are currently employed in occupation j and who desire to remain there (i.e., "inside" supply);

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[1] Two alternative theoretical developments of the structural form appropriate to the occupation specific total supply functions are contained in Williams (1978) and Craigie, Parham and Ryland (1979). In the analysis presented in this paper the $\{S(LT)_j\}$ series appropriate to each of the two estimation years is assumed predetermined but such that each ensures the internal consistency of the data base. See Williams (1980(a)) for full details.

[2] A bar over a variable denotes it is either predetermined or exogenous.

$S(LX)_j$ = the additional supply of effective manhours of occupation j supplied by changers and entrants from the education and immigration sectors (i.e., "outside" supply).

Assuming that $S(LN)_j$ is also predetermined (at $\overline{S(LN)}_j$), then so too is the aggregate additional supply magnitude of effective manhours to occupation j for a particular time period. This can be represented by

(13) $$S(LX)_j = \overline{S(LT)}_j - \overline{S(LN)}_j .$$

Further, "outside" supply can be expressed in terms of its component parts thus

(14) $$\overline{S(LX)}_j = \sum_{i \neq j} SM_{ij} + SE_j + SI_j = SM_{.j} + SE_j + SI_j .$$

It is hypothesized that observed movements in $S(LX)_j$ in a given year other than those resulting from inter-occupational transfers are predetermined. The planned occupation mix of entrants from the education system in any one year is largely determined by decisions taken over many previous years, and can only effect a minor variation in $S(LX)_j$ in the short run (i.e., one year). In this model it is assumed that SE_j is known and predetermined at $\overline{SE}_j$.

Similarly, the occupational composition of the migrant intake is treated as predetermined (at $\overline{SI}_j$), justifiable on the grounds that there generally exists a significant time delay between the decision to immigrate and entry into the Australian workforce. This is tantamount to postulating that occupation changing makes up the residue of optimal total labour supply $S(LT)_j$ to each occupation j once supplies have been offered by all other sources.

Exogeneity of two of the sources of "outside" labour supply reduces equation (14) to

$$\overline{S(LX)}_j = SM_{\cdot j} + \overline{SE}_j + \overline{SI}_j \;. \tag{15}$$

Rearranging (15) and substituting from (13) gives

$$\begin{aligned} SM_{\cdot j} &= \overline{S(LX)}_j = \overline{SE}_j - \overline{SI}_j \;, \\ &= \overline{S(LT)}_j - \overline{S(LN)}_j - \overline{SE}_j - \overline{SI}_j \;. \end{aligned} \tag{16}$$

The concern now is to break the $SM_{\cdot j}$ variable into its source occupation specific components, i.e., to determine SM_{ij} for all j, $i \neq j$.

First, however, it is necessary to clarify the interpretation of the supplies of movers variable, the $\{SM_{ij}\}$. In the accounting framework set out above, the $\{SM_{ij}\}$ represent the stocks of people who would want to move under given conditions (and whose occupational skills are such that they would be able to do so if the labour market were in overall equilibrium with matched supply and demand in all sub-markets as well as at the aggregate level). However, the variation among occupational certainty equivalent wage rates[1] (CEW's) at a given point in time has nothing to do with the explanation of the $\{SM_{ij}\}$. Specifically, the latter movements do not drive the occupational wage divergencies to zero, nor is the restoration of equilibrium conceived of in this way. Rather the paradigm is one of *exogenous* relativities which cannot be affected by the $\{SM_{ij}\}$ (in the short run). The role of the

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[1] The certainty equivalent remuneration or wage rate (CEW) existing in occupation j, R_j, is defined as

$$R_j = (W_j - Y_j)(1 - U_j) \;,$$

where W_j = the after tax wage pertaining in occupation j;
Y_j = the privately-borne training costs of entry into j;
U_j = the unemployment rate in occupation j, so that $(1 - U_j)$ represents the probability of obtaining employment in occupation j.

$\{SM_{ij}\}$, then, is to restore stock equilibrium in the occupational composition of the workforce following an *exogenous change* in certainty equivalent wage relativities (CEWR's). Movements $\{SM_{ij}\}$, therefore, must not be interpreted as a response to a *given* set of occupational CEWR's at a *given* point in time, but rather as the response to a *change* in relativities between two points in time.

In order to derive the estimating equations for the $\{SM_{ij}\}$, several assumptions are required. Let[1] $Q(LT)_{j(-1)}$ be the stock of workers in occupation j at the beginning of year t, excluding those who enter the workforce at this point in time or subsequently during the course of year t.

Assumption 1

The $Q(LT)_{j(-1)}$ are all in equilibrium with the CEWR's that prevailed at the beginning of year t for all years t in the sample.

Assumption 2

The changes $\{\Delta R_j\}$ in occupational certainty equivalent wage levels R_j between the beginning and end of year t are exogenous.

Assumption 3

The stocks $Q(LT)_{j(-1)}$ in occupation j at the beginning of t all represent people in their first preference (given their occupational skills).[2] Thus, $Q(LT)_{j(-1)}$ is both an observed market quantity and a measure of supply.

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[1] Recall that there is a t (current time period) subscript on all variables unless otherwise specified.

[2] It is highly unlikely that this assumption held after 1975, when the labour market became increasingly more slack.

Assumption 4

The transformation frontier on which the $Q(LT)_j$ lie at any point of time t is strictly CET (one *only* transformation elasticity exists for all pairs of occupations). Although this is a highly restrictive assumption, it is unlikely that the available data base could support any more complex a formulation.

Now, suppose that the inputs to facilitate occupational transfer in year t are $\{N_{1t}, \ldots, N_{Kt}\}$. At a given set of CEWR's, let the elasticity[1] of the stock of people in occupation j with respect to the k^{th} input be ε_{jk} $(j=1, \ldots, n;\ k=1, \ldots, K)$. Let the elasticities of the $\{Q(LT)_j\}$ with respect to the i^{th} CEW R_i be η_{ji}. For any *given* set of $\{N_{1t}, \ldots, N_{Kt}\}$ the cross-wage supply elasticities are given by

(17) $$\eta_{ji} = \tau_{ji} S_i, \quad (j \neq i),$$

where τ_{ji} is the tranformation elasticity between j and i, and S_i is the share of occupation i in the certainty equivalent wage bill.[2]

Assumption 4 allows the subscripts on the τ in equation (17) to be omitted, yielding

(18) $$\eta_{ji} = \tau S_i, \text{ for all } j, \quad (j \neq i).$$

All cross-wage elasticities are now proportional to the share in the CE wage bill of the occupation whose wage changes.

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[1] One year adjustment allowed.

[2] See Powell (1974), p. 13, for the analogous result on the demand side. In transformation problems the τ_{ji} typically have negative signs.

Homogeneity of degree zero in wage levels implies

(19) $$\sum_i \eta_{ji} = 0 \quad \text{for all } j ,$$

so that

(20) $$\eta_{jj} = -\sum_{i \neq j} \eta_{ji}$$

which, from (18), is

(21) $$\eta_{jj} = -\tau \sum_{i \neq j} S_i$$

$$= -\tau(1 - S_j) .$$

Assumption 5

The supplies of occupation changers generated from workforce stayers may be approximated by a function of $\{R_1, \ldots, R_n ; N_1, \ldots, N_K\}$ which is linear in logarithmic differentials.

The rates of change of the occupational distribution of the workforce can now be expressed as

(22) $$d \log Q(LT)_{j(-1)} = \sum_i \eta_{ji} \, d \log R_i + \sum_k \varepsilon_{jk} \, d \log N_k ,$$

where the first and second terms on the right hand side represent respectively movements *around* and movements *of* the transformation frontier.

Using (18), (21) and (22),

(23) $$d \log Q(LT)_{j(-1)} = -\tau[d \log R_j - \sum_i S_i \, d \log R_i] + \sum_k \varepsilon_{jk} \, d \log N_k .$$

Substituting

(24) $$d \log Q(LT)_{j(-1)} = \frac{\sum_{\ell=1}^{n} SM_{\ell j}}{Q(LT)_{j(-1)}} , \quad \ell \neq j ,$$

it is then possible (data permitting) to estimate the parameters τ and $\{\varepsilon_{jk}\}$.

To explain the composition of $SM_{\cdot j}$ it is necessary to partition (23) into terms corresponding to source occupations. Consider equation (23) in two parts:

(i) The relative wage (or transformation) effects can be represented by

$$\text{tfn. part of } \frac{\sum_{\ell=1}^{n} SM_{\ell j}}{Q(LT)_{j(-1)}} = -\tau[(1-S_j)\ d \log R_j - \sum_{i \neq j} S_i\ d \log R_i] ,$$

$$= -\tau \sum_{i \neq j} S_i [d \log R_j - d \log R_i] ;$$

(ii) The shift part of (23) (namely, the term in the $\{N_k\}$).

The latter raises problems: specifically, what are the variables which change the position of the transformation frontier, and what data are available to measure them?

Faced with a similar problem in agricultural supply analysis, Powell and Gruen (1968) dealt with the issue thus: the location and shape of the frontier were parameterized on the lagged value of the exogenous variables (which were levels). Analogous procedures were used by Vincent, Dixon and Powell (1980). In the current situation, data limitations again prove highly restrictive -- time series on private and social inputs of type k for facilitating the transfer of workers in occupation i to occupation j (i,j=1, ..., n) (viz., changing the shape, not the elasticity of the CET function) simply are not available.[1]

A procedure which, when applied to (23), is analogous to Powell and Gruen's use of lagged output, and which is directly comparable to the approach adopted by Vincent, Dixon and Powell (1980), is to replace

[1] In fact, such inputs may not be fully specific, suggesting a CRETH/CRESH framework (See Vincent *et al.* (1980)). Data on all relevant inputs, however, would still be needed.

$\sum_k \varepsilon_{jk}$ d log N_k in equation (23) by $\phi_j \rho_{jt}$, a variable which, in the levels, corresponds to a linear trend. Here ρ_{jt} is the trend growth rate, at t, of $Q(LT)_j$. This corresponds to the hypothesis that, at a given set of CEWR's, the positions of each $Q(LT)_j$ on the transformation surface grow (or decline) at an exogenous trend rate.

Equation (23) can now be represented as

$$(26) \qquad d \log \dot{Q}(LT)_{j(-1)} = -\tau \sum_{i \neq j} S_i [d \log R_j - d \log R_i] + \phi_j \rho_{jt}$$

whence (by (24) and rearrangement)

$$(27) \qquad \frac{\sum_{\ell=1}^{n} SM_{\ell j}}{Q(LT)_{j(-1)}} = \phi_j \rho_{jt} - \tau \sum_{i \neq j} S_i [d \log R_j - d \log R_i] .$$

The specific occupation i to j flow of job changers over any one time period in response to a change in wage relativities, then, is given by

$$(28) \qquad \frac{SM_{ij}}{Q(LT)_{j(-1)}} = \phi_{ij} \rho_{jt} - \tau S_i [d \log R_j - d \log R_i]$$

(in which $\sum_i \phi_{ij} \equiv \phi_j$).

which is the natural disaggregation of equation (27).

Equation (28) involves $[\frac{1}{2}n(n-1) + 1]$ parameters[1] (i.e., the ϕ_{ij} and τ), which is probably sufficiently parsimonious as to allow estimation from the limited supply of data available. Equation (28) thus yields the supply of suitably qualified transferees from occupation i to occupation j as a result of changes in wage relativities between two points in time.

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[1] In this study, the Australian labour market has been disaggregated into nine occupations (i.e., n=9) so that the number of parameters to be estimated is 37.

Estimation of equation (27) on the other hand, demands much less of the data in that information is only required on the marginal totals of the supply of movers matrices, with the number of parameters to be determined being [n+1] , (i.e., the ϕ_j and τ).

4.2 The Role of Specification Error

Recall that SM_{ij} is a net variable so that, using the skew symmetry property that $SM_{ij} = -SM_{ji}$, a second equation for SM_{ij} is

$$(29) \qquad \frac{SM_{ij}}{Q(LT)_{j(-1)}} = -\phi_{ji}\,\rho_{jt} - \tau\, S_j (d \log R_j - d \log R_i) \; ,$$

again, an equation in $[\frac{1}{2}n(n-1) + 1]$ parameters, with τ being common to both equations (28) and (29).

It was originally conjectured that the realized values of either the upper or lower triangle of the SM_{ij} net mobility matrix contained all of the information available for the estimation of τ , the CET parameter. However, individual empirical implementation of equations (28) and (29) show τ to be dependent on which choice is made. An analogous result occurs in the CES production function literature, where alternative estimates for σ , the elasticity of substitution between labour and capital, result from using the labour as opposed to the capital first order condition.[1]

In ongoing work by Powell and Williams (1980) it is hypothesized that specification error may be responsible for the non-uniqueness of

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[1] See Caddy (1979) for a summary of empirical work in this area.

the direct estimates of the τ parameter. The approach adopted, therefore, is to develop an estimator which allows for, and then annihilates the possibility of such error. Preliminary empirical estimation suggests that the solution is dependent on the peculiar constraints of the data supply faced in the present study.

The results reported in the next section are confined to those relevant to the simple estimating forms proposed in section 4.1.

5. EMPIRICAL RESULTS

5.1 Estimation Framework

The proposed theoretical model is summarised by equation (2), which says that observed mobility from occupation i to occupation j is a (predetermined) weighted function of both the demand for and supply of job changers functions. These functions are in turn derived from the behaviour and technology assumed appropriate to the relevant agents.

$$(2) \qquad QM_{ij} = \bar{\mu}DM_{ij} + \bar{\gamma}SM_{ij} \quad , \quad 0 \leqslant (\mu,\gamma) \leqslant 1 \; , \qquad (i \neq j)$$

Combining equations (8), (11) and (15) yields

$$(30) \qquad DM_{ij} = \frac{SM_{ij}}{\sum\limits_{i \neq j} SM_{ij} + \overline{SE}_j + \overline{SI}_j} \quad (\overline{D(LT)_j} - \overline{D(LN)_j}) \; .$$

Similarly, equation (28) represents a reduced form expression for SM_{ij} .

$$(28) \qquad SM_{ij} = Q(LT)_{j(-1)} [\phi_{ij} \; \rho_{jt} - \tau \; S_i (d \log R_j - d \log R_i)] \; .$$

The model can therefore be reduced to a very simple recursive system comprising three equations: a demand equation, a supply equation, and a "clearing" equation to determine the quantity of job changers who actually move between occupations in a given time period.

5.2 Data Availability

The data base necessary to estimate this system is not readily available. Problems exist both with respect to the lack of information on the exogenous or predetermined variables (those denoted with a bar) and with respect to ensuring consistency between the unobserved variables and the labour market overall. The derivation of the parameters $\bar{\mu}$ and

$\bar{\gamma}$, and a consistent data base for the unobserved SM_{ij} (and hence DM_{ij}) variables from the limited available information involved fairly complex procedures. Full details of the solution methods adopted are contained in Williams (1980(a)).

The IMPACT Project general equilibrium model ORANI[1] was used to generate the data for occupation specific labour demands $(D(LT)_j)$. This procedure involved simulating the Australian economy over the period 1972 to 1975 in an attempt to assess the effects of known changes in exogenous variables on demands for alternative types of labour.

Data on the supply of entrants from the immigration and education sectors (SI_j and SE_j) was derived by amalgamating information from a variety of sources and by imposing assumptions on factors such as cohort attrition rates, pass rates and the like.

Extensive details on all data construction can be found in Williams (1980(c)).

5.3 The Parameters of the Transformation Frontier

In this paper, attention is focused on estimating the parameters of the supply of movers equation. These can be divided into those affecting the position of the frontier (the $\{\phi_{ij}, \phi_{ji}\}$), and that determining its shape (the transformation elasticity, τ). The major concern is to derive the best estimate of τ, the CET parameter. To this end, empirical work reported focuses on equation (27), the reduced form specification for total net movement into each occupation j from all other occupations. This equation utilises all the information contained in the net mobility

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[1] See Dixon *et al.* (1977).

matrix, but avoids the need to disaggregate into the (less reliable) source-destination components.

In the case of the nine IMPACT occupations, equation (27) represents a supply system in 10 parameters: the single CET, τ, and the nine destination specific shift parameters ϕ_j. In order to enable simultaneous estimation of these, it is necessary to pool all information on the mobility supply rates contained in the two cross-sections of data. This provides 18 observations to determine 10 parameters.

Applying ordinary least squares (OLS) to equation (27) yields a value of -1.1779 for the CET, $\hat{\tau}$, with a corresponding t-statistic of 3.1674. This coefficient is significant at the one per cent level, and has the expected negative sign. It suggests that changes in wage relativities play an important role in determining the net supply of occupation changes.

The value of the $\hat{\phi}_j$ parameters are contained in Table 1, with only 3 of the 9 being significant at the one per cent level. However, as there are no *a priori* expectations as to either the magnitudes of the signs of these shift variables, it is difficult to interpret these results. The coefficient of determination (corrected for degrees of freedom) for the equation overall is $\bar{R}^2 = 0.8355$.

TABLE 1: ESTIMATED SHIFT PARAMETERS, ϕ_j, OF THE TRANSFORMATION FRONTIER

Occupation	ϕ_j [(a)]
Professional	0.9682 (4.5791)
Lecturers and Teachers	-0.1838 (-1.1775)
Skilled White Collar	-0.2266 (-0.8224)
Semi and Unskilled White Collar	-0.0303 (-0.1148)
Skilled Blue Collar : Metal & Electrical	-0.1329 (-0.5655)
: Building	-0.1657 (-0.4925)
: Other	2.0666 (2.6085)
Semi and Unskilled Blue Collar	0.3685 (1.0518)
Rural	218.6575 (4.3361)

(a) t-statistics in parentheses

These results suggest that the proposed theoretical model performs relatively well when compared both to the naive reduced form approach adopted by Naphtali, McIntosh and Williams (1978), and to the two-stage approach developed in Williams (1980(b)). Unlike these two previous studies, there is a strong structural basis underlying the final reduced form equation, with the empirical results yielding a well-determined estimate for the CET, of the expected *a priori* sign and feasible order of magnitude.

In order to complete the framework outlined in section 5.1, equation (28), an equation involving the 36 source-destination specific shift parameters $\{\phi_{ij}\}$ is estimated by pooling the *lower* triangle elements of the two net mobility matrices. Thus each (i, j) pair appears once, and only once yet (as outlined in section 4) the resulting estimates of the parameters are not invariant to the choice of pairings. This yields a value of -1.3411 for $\hat{\tau}$, with a corresponding t-statistics of 3.6365. Again this coefficient is significant at the one per cent level and has the expected negative sign. The values of the ϕ_{ij} parameters are contained in Table 2, with only 7 of the 36 being significant at the five per cent level (four of which also exceed the one per cent critical value). The coefficient of determination (corrected for degrees of freedom) for the equation overall is $\bar{R}^2 = 0.3643$.[1]

5.4 Estimates of Own- and Cross-Wage Elasticities

Following the development outlined in section 4, the interoccupation mobility supply response as a result of a change in any destination occupation certainty equivalent wage, R_j, is specified as

$$(18) \qquad \eta_{ij} = \tau S_j, \quad (i \neq j),$$

where τ is the common CET and S_j is the share of occupation j in the certainty equivalent wage bill.

The own-wage elasticity of occupation j, η_{jj}, as a result of an increase in its certainty equivalent wage, R_j, all other wages remaining unchanged can be derived from equation (27). From this equation, if $d \log R_j = 1$ and $d \log R_i = 0$ for all $i \neq j$, then

$$d \log Q(LT)_j = -\tau \sum_{i \neq j} S_i = -\tau(1-S_j),$$

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1 Use of equation (29) rather than (28) led to unsatisfactory results which in turn prompted ongoing work on the possible influence of specification error. The estimate of τ obtained from equation (28), however, is acceptably close to that obtained from the use of equation (27). This equation uses aggregate data of much higher reliability than the disaggregated data used in (28) and (29).

TABLE 2 : ESTIMATED SHIFT PARAMETERS $\hat{\phi}_{ij}$ OF THE TRANSFORMATION FRONTIER

Source Occupation	Destination Occupation: Professional White Collar	Lecturers and Teachers	Skilled White Collar	Semi- and Unskilled White Collar	Skilled Blue Collar - M & E	Skilled Blue Collar - Building	Skilled Blue Collar - Other	Semi- and Unskilled Blue Collar	Rural
PWC									
L & T	0.0217 (0.2448)								
SWC	0.2960 (3.0178)	-0.0648 (-0.5706)							
S & USWC	0.2730 (2.9942)	-0.0323 (-0.2816)	0.0304 (0.5428)						
SBC: M & E	0.1111 (1.2301)	-0.0160 (-0.1392)	-0.0440 (-0.7433)	0.0413 (0.8770)					
: Build	0.0537 (0.6076)	-0.0001 (-0.0001)	0.0007 (0.1303)	0.0310 (0.6394)	-0.0005 (-0.1169)				
: Other	0.0108 (0.1223)	-0.0217 (-0.1912)	-0.0009 (-0.1813)	-0.0407 (-0.8241)	-0.0328 (-0.7492)	-0.0983 (-0.4878)			
S & USBC	0.1966 (2.1295)	-0.0914 (-0.7540)	-0.1137 (-1.3299)	0.0370 (0.6479)	-0.1305 (-2.8712)	-0.1893 (-0.9131)	0.8487 (1.7755)		
Rural	0.0894 (1.0019)	-0.0148 (-0.1306)	-0.0200 (-0.3983)	0.0510 (1.0249)	0.0782 (1.7354)	0.2558 (1.2648)	-0.0709 (-0.1532)	0.2666 (7.1071)	

(t-values in parentheses)

whence $\eta_{jj} = -\tau(1-S_j)$.

Utilising the estimated value of -1.1779 for $\hat{\tau}$, Table 3 contains the own- and cross-wage elasticities corresponding to the occupation whose C.E. wage changes.

The maintained CET assumption implies that the cross-wage elasticity is invariant to the source of occupation changers, being determined only by the share in the C.E. wage bill of the occupation whose wage changes. Thus any increase in a C.E. wage will generate a larger response (i.e., movement <u>from</u> other occupations) into those occupations with a larger share of the total C.E. wage bill.

TABLE 3: COMPONENT OF ELASTICITY OF SUPPLY DUE TO WITHIN WORKFORCE MOBILITY WITH RESPECT TO CERTAINTY EQUIVALENT WAGES

Destination Occupation whose C.E. Wage Rate Changes, j	Component of Elasticity (a) η_{ij}	Own Wage Elasticity η_{jj}	S_j (b)
Professional White Collar	-0.0860	1.0919	0.0730
Lecturers and Teachers	-0.0342	1.1437	0.0290
Skilled White Collar	-0.1918	0.9861	0.1628
Semi and Unskilled White Collar	-0.1796	0.9983	0.1525
Skilled Blue Collar : Metal & Electrical	-0.1825	0.9954	0.1549
: Building	-0.0777	1.1002	0.0660
: Other	-0.0284	1.1492	0.0241
Semi and Unskilled Blue Collar	-0.3269	0.8510	0.2775
Rural	-0.0709	1.1070	0.0602
SUM	-1.1779	9.4231	1.0000

(a) The figure shown is the estimated per cent change in the stock of workers in the destination occupation as a result of interoccupational transfers consequent to a one per cent rise in the ratio of the certainty equivalent wage in the destination occupation to the certainty equivalent wage in the source occupation. The value is independent of the source occupation i .

(b) S_j is the share of occupation j in the total C.E. wage bill.

6. CONCLUSIONS

Given the exogenous changes in occupation specific wage relativities between two points in time, equation (28) can be used to estimate the supply of movers between particular source and destination occupations over this period, i.e., the $\{SM_{ij}\}$. In turn, provided that information exists on occupation specific labour demands for the period under consideration (the $\{D(LT)_j\}$), the $\{DM_{ij}\}$ can be solved from equation (30).

Now, given values for μ and γ (parameters representing respectively the importance of excess demand and excess supply pressures) which ensure the internal consistency of the data base, equation (2) -- the basic mobility equation -- can be solved for the net *actual* movement between particular source and destination occupations over a given time period in response to a change in occupation specific wage relativities.

However, in order to determine the exact values of μ and γ , information on the occupation specific supply of workers $\{S(LT)_j\}$, as well as the occupation specific demands $\{D(LT)_j\}$ are required. Work proposed in Craigie, Parham and Ryland (1979) will provide estimates for $\{S(LT)_j\}$.

The variables representing supplies from the education and immigration sub-sectors, the $\{SE_j\}$ and $\{SE_j\}$ are also treated as exogenous in this study, but again future developments may enable this assumption to be relaxed.

The estimated model performs relatively well on the major statistical criteria when compared to previous reduced form studies. The empirical evidence, albeit based on an extremely limited data base, suggests that the model is well specified and may -- with the emergence of a superior body of data -- be extended to provide estimates of transformation elasticities which vary between pairs of source and destination occupations.

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