IMPACT OF DEMOGRAPHIC CHANGE ON INDUSTRY STRUCTURE IN AUSTRALIA

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BACHUROO - AN ECONOMIC-DEMOGRAPHIC MODULE FOR AUSTRALIA

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Working Paper No. B-02 Melbourne April 1976

Also presented at the 47th ANZAAS Congress, Hobart, May, 1976

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ACKNOWLEDGEMENTS

IMPACT is essentially a team effort, both between the participating agencies (now including the Australian Bureau of Statistics, the Department of Employment and Industrial Relations, the Department of Industry and Commerce and the Industries Assistance Commission) and members of the project team and consultants to the project. In particular, the authors would like to thank Gerry Rodgers and other members of the World Employment Program of the International Labour Office, Allen C. Kelley of the Center for Demographic Studies of Duke University and Richard Blandy of the Institute of Labour Studies of Flinders University for their valuable comments on the model; Alan Powell for his original conception and subsequent interpretation of IMPACT; Vern Caddy for his help in deriving certain equation forms; and members of the BACHUROO team, Brenda Jackson, John Leaper, Vince Manion, Jan Naphtali and Ron Silberberg, for their contributions to the individual sub-modules.

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1. INTRODUCTION

The purpose of this paper is to describe the structure of an economic-demographic module of Australia called BACHUROO.* The BACHUROO module is one of the three modules being developed within the framework of the IMPACT[1] model, which is designed to study the implications for Australian industry and trade of changing demographic characteristics and changing patterns of demand and supply. The IMPACT project has been designed to estimate annual levels of sectoral demand, local production, imports, population, labour supply and demand and household income with a forecast horizon of 7 to 10 years, and give "snapshots" of the economy 15, 20 and 25 years hence. It is particularly important as a tool to answer policy questions related to international trade, immigration, education and manpower.

The IMPACT model consists of three modules :

MACRO covering the main macro-economic aggregates in the economy;

ORANI covering the sectoral composition of final demand, output, imports, exports, investment and demand for labour; and

BACHUROO covering the demographic composition of the population, skill composition of the workforce, participation rates, labour mobility and personal distribution of income.

This paper outlines the structure of the BACHUROO module.

The basic concepts of the module are similar to those used in

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1. Alan A. Powell and Tony Lawson, "Impact : An Economic-Demographic Model of Australian Industry Structure - Preliminary Outline," Impact of Demographic Change on Industry Structure in Australia, Preliminary Working Paper I-01, Industries Assistance Commission, Melbourne, September 1975.

* A preliminary outline of the BACHUROO module was given by Ashok Tulpulé "Cutline of An Australian Economic-Demographic Module - BACHUROO" Impact of Demographic Change in Industry Structure in Australia, Working Paper B-01, Industries Assistance Commission, Melbourne, February 1976.

the BACHUE models developed by the International Labour Office.[1] The I.L.O. models have been used to study developing economies and concentrate on growth and development phenomena. A number of modifications have been made, and new concepts introduced to the BACHUE models, in order to allow for the more complex nature of the Australian economy. In particular, BACHUROO emphasises the occupational structure and rigidities of the labour force. It models people by qualifications at a detailed vocational level and the labour force by occupation and industry. Tertiary training is modelled in detail as is household formation, structure and income.

The BACHUROO module has been divided into a set of sub-modules which reflect aspects of population, education, labour force participation and structure, household and personal income distribution. The following sections of this paper deal first with the overall module structure, then with each of the sub-modules in turn, and finally with some suggested improvements and extensions and a summary. For convenience, equations and variable listings have been placed in appendices after the main text.

2. MODULE STRUCTURE

The overall structure of the BACHUROO module is shown in figure 1. The module has been divided into a number of sub-modules, each of which uses output from other sub-modules and provides either final or intermediate output. These sub-modules are based on an accounting system of stocks and flows, with the flows being modelled in behavioral

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1. R. Wery, G.B. Rodgers, M.D. Hopkins, "BACHUE-2 : Version 1, A Population and Employment Model for the Philippines," Working Paper No. 5, World Employment Programme, International Labour Office, Geneva, July 1974.

equations. Thus, for the base year, the characteristics of the Australian population, labour force etc., are given as input data and values for each subsequent year are estimated by adding the entrants to each category and subtracting the leavers. The values of many of the variables used in the behavioral relationships are estimated within the IMPACT model but others are determined exogenously. The exogenous variables in the module structure have been carefully selected to enable the examination of the possible economic and demographic consequences of alternative policies.

The structure of the module ensures that the sum total of various components is equal to the aggregate. (Eg. The sum of employment by occupation equals the sum of employment by industry.) Some of the forecasts made by the BACHUROO module depend on forecasts of variables from the MACRO or ORANI modules, although usually such independent variables in BACHUROO equations are in a lagged form. Some of the interactions are shown in figure 1 and are discussed in later sections.

3. POPULATION

The population sub-module provides forecasts of population by sex and age using mainly standard demographic techniques. To the population at the start of any year are added births by sex, and immigrants by sex and age. Deaths and emigrants by sex and age are subtracted. Within the 50 age groups used (single ages to 24, 5 year groups to 54, single ages to 69, and one group of 70 years and over) people are matured by one year using a corrected quadratic interpolation procedure for the grouped years.

Estimations of the flows into and out of the population provide both the behavioral and policy areas of interest in this sub-module.

Birth rates by mother's age will be taken in the first instance from a recent comprehensive study of demographic trends in Australia.[1] These are long-term trend rates and a project is in hand to impose some of the "new home economics"[2] ideas over them to assess fluctuations around the trend. A model involving unemployment rates, education levels and income as explanatory variables has been constructed along similar lines to some USA models[3] and is undergoing testing. Incorporation of previous issue is planned to account for completed family size and allow reconciliation with the trend rates.

Death rates by sex and age have been assumed constant initially and have been extracted from standard life tables. Provision has been made in the model for changes to the death rates for the very young and old groups at a later stage of development. This may become important in long-term runs as some improvement in pediatric and geriatric care may be anticipated.

Immigration is a policy variable of major interest to both the population and labour force sub-modules. The initial strategy being adopted is to estimate exogenously the target programme and then calculate from past trends the composition of the intake by sex and age (and occupation for the labour force sub-module). Exogenous estimates of the target programme for runs where the immigration policy is not the focus of attention are being derived in scenario analyses by members of the Department of Immigration and Ethnic Affairs in the first instance, but a project is in hand to model the immigration target in terms of government response to unemployment and related conditions in Australia and in its migrant source countries.

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1. Australian Government, National Population Enquiry (W.D. Borrie, Chairman), Population and Australia - A Demographic Analysis and Projection, Australian Government Publishing Service, Canberra 1975.

2. Richard A. Easterlin, "Towards a Socioeconomic Theory of Fertility : A Survey of Recent Research on Economic Factors in American Fertility", Fertility and Family Planning: A World View. ed. S.S. Behrman, L. Corsa, Jr. and Ronald Freeman, Ann Arbor, University of Michigan Press, 1969.

3. A.L. Redwood and M.M. Kleiner, "A Population Projection Methodology for Regional Planning" Regional Science Perspectives, Vol. 5 (May 1975), pp. 87-107.

Emigration has been estimated endogenously as sex and age specific functions of local conditions, travel costs and immigrant intakes for previous periods.

Both immigration and emigration have been considered in three separate categories of permanent, long-term and short-term movements. The official immigration targets relate to permanent arrivals, with less direct control being exercised over the other categories of arrivals and almost no restrictions on departures. Policy analyses which focus on labour force structure and adjustment require consideration in this detail whereas simple population or total labour force projections using a set of possible immigration scenarios may be quite adequately based on the net inflow of permanent and long-term settlers and ignore the short-term movements.

4. EDUCATION

The emphasis in BACHUROO is ultimately on employment and income and the education sub-module reflects this by grouping together formal courses and qualifications to reflect their consequences in the labour market. The groupings are closely related to the occupational groupings (see section 6) although due account has been taken of those courses with no direct occupational relationship. Appendix 1 shows the classifications

For any year, the two stocks of importance to the education sub-module - population by sex, age and qualification and full and part-time students by sex, age and course - are calculated from the previous year's estimates using demographic changes (deaths, maturation, immigration and emigration) and new entries, completions and wastage from courses.

The study of education statistics in Australia is somewhat complicated due to the diversity and independence of the systems in the 6 States and the Territories. Following completion of compulsory education from ages 5 to 15, an individual may quit education, continue at school to the Higher School Certificate (HSC) or equivalent level, enter an apprenticeship or, following

the HSC, proceed to a tertiary institution for diploma or degree studies. Persons continuing straight through are known in the sub-module and in many of the education systems as N-type or "normal" students. People may reenter the system at later stages, when they are known as E-type or "exceptional" students.

The decision by an individual to enter or continue voluntary education will depend on the private costs (such as fees, transport and income foregone) and benefits (such as possibly enhanced prospects of finding a job, a better job, more pay, higher social status) of doing so. The decision is also likely to be influenced by social factors such as parental education levels. Such factors determine the demand for places in each course.

The supply of places in educational institutions to meet the demand will depend mainly on the stock of existing facilities, and on the cost of providing each additional place. Only partial adjustment of supply to meet either increases or decreases in demand in any one year can be expected because of long lead times for construction, recrutiment, course expansion and related factors.

The actual number of students placed on any one course will also be affected by factors such as the numbers of unplaced students applying for related courses.

It is proposed to use factors such as those above to formulate separate models for N and E-type and full and part-time students entering each of the course categories.

It should also be noted that participation in education is closely related to participation in the labour force and, for women, fertility. This suggests a simultaneous model for these three decisions, and such a model is undergoing preliminary testing.

Reconciliation of numbers in courses to total participation by sex and age in education will be achieved proportionally.

5. LABOUR FORCE SIZE

The size of the labour force depends on the size of the working age population and on labour force participation rates.

In most age groups, participation rates, and especially those for women, have been rising steadily. In recent years, participation rates for females, as well as males, have actually fallen in the younger age groups, with an increasing proportion of the population over 15 remaining in or reentering formal education and most school leavers entering the workforce at various ages between 15 and 24, depending on the length of the course undertaken. To capture the areas of maximum interest, the participation rates by sex have been estimated for single age cohorts between 15 and 24; 5 or 10 year age cohorts for ages 25 to 54; and, for ages between 55 and 65, again by single year cohorts to take into account possible changes in the age of retirement.

Both cross sectional analysis using the 1966 and 1971 Census data and time series analysis using data from the quarterly Labour Force Surveys have been used. Variables considered to be of major importance in explaining variations in age specific male participation rates include :

(a) The proportion of the male population of the age group undertaking full-time education or other training. This variable will be most relevant to the 15 to 24 age group and may be very near zero for most others. It will be influenced by other variables in the model as indicated in the education sub-module.

(b) The proportion of the male population of a given age who will permanently retire from the workforce before year t. This will be of importance only for the older ages and may be set exogenously in the first instance. For runs endogenising retirement rates, inflation rates can be expected to have a significant influence through the erosion of the value of superannuation and related investments for retirement.

(c) The male unemployment rate in the previous year or years. This variable allows for the much observed "discouraged worker

effect of unemployment".[1] The higher the rate of recent unemployment the greater the numbers of males of all ages (with the extent of the effect varying between ages) who are discouraged from entering or remaining in the labour force (which, of course, partially distorts official unemployment figures as measures of real unemployment). Other measures of the severity of unemployment may be considered in attempting to specify the discouraged worker effect (e.g. ratio of unemployed to vacancies).

(d) The proportion of married males in the age group. It is expected that the higher the proportion the higher will be the participation rate.

(e) The proportions of males with particular qualifications in the age group. The aim of this variable is to cater for different participation patterns for persons with skilled versus unskilled and white versus blue collar training. This variable may have a positive influence on participation rates.

(f) The porportion of immigrants in the age group. This should cater for the different participation rate patterns of migrants seeking to establish themselves in a new country. This variable is also likely to have a positive influence on participation rates.

(g) Average earnings. The net effect of the income variable is expected to be positive in relation to labour force participation rates.

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1. For Australia : J.B. Bowdler and C. Higgins, "Short Term Variation in Labour Force Participation," Paper presented to the Second Conference of Economists, Sydney, 1971.

R.G. Gregory and P.J. Sheehan, "The Cyclical Behaviour of the Australian Labour Market," Paper presented to the Third Conference of Economists, Adelaide, 1973.

For U.S.A. : S.O. Schweitzer and R.E. Smith, "The Persistence of the Discouraged Worker Effect," Industrial and Labour Relations Review, Vol. 27, No. 2 (January 1974) pp. 249-260, reprinted by the Urban Institute, Washington D.C., 1974.

Although linear forms will be used in the first instance, nonlinear forms (eg. the reciprocal of the unemployment rate) may ultimately prove to be more appropriate.

These variables have been included in the initial analysis and their retention in the module will depend on their importance in explaining variations in labour force participation rates.

The rationale for the above approach to male workforce participation is that for most ages (25 to 54) participation rates have been and are expected to remain high (around 95% or more) and fairly constant, with only marginal discouraged worker effects. For the 15 to 24 and the 55 and over age groups, participation in full-time education and changes in retirement rates respectively, have been the causes of secular changes in participation with cyclical discouraged worker effects of greater significance than for males aged 25 to 54.

Participation rates for married and other females will be estimated separately. The growth in labour force participation of married women has been particularly rapid in recent years in relation to that for other women, although the labour force participation rate of married women is still lower than that for the not married group.

In expressing labour force participation rates as functions of several explanatory variables, it should be noted that the participation rates observed in time series data are a result of interactions between demand for and supply of labour. In a general explanatory model of the labour market it is difficult to separate the demand and supply effects. However, equations involving both supply and demand variables can be interpreted as a reduced form equation which can be estimated appropriately by least squares regressions provided only that the list of variables on the right hand side is exhaustive of predetermined factors affecting supply and demand, and does not include any variables properly regarded as being co-determined with supply and demand.

For married females, the participation rates for each age group will be estimated in terms of the following variables :

(a) The proportion of the married female population in the age group undertaking full-time education. As has been noted previously education and fertility may be modelled simultaneously with labour force participation rather than in this form.

(b) The male unemployment rate, since female unemployment statistics have too many deficiencies to be used as a proxy for economic or general labour force conditions. This variable will reflect two conflicting tendencies - one, the discouraged worker effect noted earlier, and the other an additional worker effect as the unemployment (or decreasing overtime) of a family's main breadwinner will tend to encourage other family members to enter the workforce. Which of these effects dominates may vary between age groups and will be determined by empirical analysis.

(c) The proportion of employment in the tertiary or service sector which allows for the relatively higher employment of female workers, per unit of output, in the tertiary sector. The proportion of employment in the tertiary or service sector may also capture the differential rate of increase of population in urban as opposed to rural areas as most of the relatively fast growth of the tertiary sector has been accompanied by slower growth in the primary sector and increasing urbanisation. Under the hypothesis that urban females are likely to have higher participation rates than rural females, this tertiary sector variable

is likely to model the two effects of female opportunities and urbanisation. Fortunately both are likely to have the same sign.

(d) The proportion of women in the age group with children under five. Women with children of pre-school age are far less likely to be in the workforce whan are other women.[1,2,3] The numbers and ages of women in this category will be available for the base year and will be estimated in future years by the population sub-module. The negative influence of children on workforce participation of their mothers is decreasing over time so that it will be necessary to allow for changing coefficients or to include a trend term to reflect changing attitudes to and provisions for women with young children working.

(e) The proportion of the married female population who will retire permanently. This will be related to other variables in the model (eg economic growth, unemployment) and to the retirement of the women's husbands, but will be most important for the older age groups.

(f) The time variable is included at this stage to take account of the secular increase in participation that is taking place. It would purport to represent the changing social attitudes towards women working that cannot be explained in terms of economic or demographic factors. Although inclusion of this variable may be satisfactory for short to medium-term forecasts, it will create problems for work on long-term projections, in which case appropriate variables will have to be found by analysing socio-economic factors affecting participation of

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1. W. Bowen and A. Finegan, The Economics of Labour Force Participation, Princeton University Press, Princeton 1969, pp. 198-204.

2. G.C. Cain, Married Women in the Labour Force, University of Chicago Press, Chicago, 1966.

3. J.A. Sweet. Women in the Labour Force, Seminar Press, New York 1973.

females in the labour force in the long run, perhaps by international comparisons.

The same variables will be used to explain participation rates of other (ie non-married) females, but the variable relating to children will be excluded. For both married and other women, additional dependent variables representing the proportion of immigrants, qualifications, etc. will be considered and their importance as explanatory variables will be tested. Most of the explanatory variables will be estimated endogenously within the BACHUROO module. Tertiary Sector employment will be obtained from interaction of the BACHUROO and ORANI modules.

6. LABOUR FORCE BY OCCUPATION

Estimates of population (section 4) and of participation rates (section 5) together give control totals for the labour force.

Independent estimates for each occupation are obtained by taking into account the sex and age structure of the workforce in each occupation in the base year and accounting for changes in the stock of labour due to new entries (net immigration and transfer from education to workforce), deaths, retirements and transfers from one occupation to another. Heuristic procedures will be used to reconcile the sum of the occupation specific labour supplies with the control totals provided by the labour force size sub-module, which is thought to provide more accurate assessments of the short-term movements into and out of the labour force, and the long-term changes in attitudes.

The crux of any description of the labour force is the occupational code and its grouping together into a classification to be used in a model. The standard groupings used in Australia by the Australian Bureau of Statistics (ABS) follow international standards and

are based primarily on the nature of the work being done with skill level as the second major factor. However in Australia there are major institutional rigidities which limit occupational upgrading and mobility without extensive formal retraining. Rigidities are also apparent in the award wage structure used by the Arbitration and Conciliation procedures for wage negotiation.

To reflect these rigidities, and through them to account for such factors as occupational mobility, retraining, wage relativities, productivity and consumption patterns, a regrouping mainly on the basis of skill has been made for Censuses, Labour Force Surveys and other data. At the aggregate level there are 10 groups of white and blue collar occupations classified as professional, skilled, semi-skilled and unskilled. At the detailed level, there are 39 groups which separate, for example, metal and electrical trades. A listing of the IMPACT occupation groups is shown in Appendix 1.

One of the main aims of the regrouping is to define and minimise the problems associated with modelling occupational mobility. An individual's ability to do a wide range of jobs has the effect of making nonsense of supply and demand forecasts for individual occupations when supply may adjust to demand by almost instantaneous occupational mobility. By re-defining the occupational groups primarily by formally attained skill level, it is hoped that most mobility between groups will proceed via the education system. Most other mobility should occur within the groups and only a very small mobility component between groups will be possible. It is also expected that the distribution of incomes within each IMPACT occupation group will be in a much more narrow band than if the ABS occupation groups were used.

The labour force in each occupation in the base year is classified by age and sex. For each year it is matured by one year using quadratic interpolation for the groups and adjustment is made for deaths, retirements, transfers, immigration and education.

The number of deaths is estimated by applying the same age/sex specific death rates to all occupations. (Results of counts in Australia[1] show that death rates for males differ for different occupations. Similar data on females are unavailable. The information on male death rates by occupation is not being used initially because preliminary analysis of these data indicate that, out of the total variation in death rates, the proportion explained by the age factor is far more important than that attributable to occupations. Inclusion of different age specific death rates by occupations may be considered later.)

Retirements are considered to be mainly a function of age, with most retirements occurring between ages 55 and 65. Persons retiring from the labour force at such ages are considered to be permenently retired in that they do not seek reentry. At all other age groups, the retirees and reentrants will be captured by the age and sex specific participation rate estimates in the first instance. Retirement rates have been included specifically at the older ages only to allow the module to simulate the effects of changes in the statuory retirement ages.

Immigrants and emigrants by age and sex have been modelled in the population sub-module. The additional factor of occupation of immigrants is also to be endogenous, and functions have been specified mainly in terms of previous years' programs to capture the family reunion component, and unemployment in Australia to capture the preference in the program for skilled versus unskilled workers.

Persons moving out of the labour force into formal education (known here and in some State education systems as E-type students) are modelled in the education sub-module, as are reentrants on completion of courses. Corresponding accounting entries are made in the labour force categories.

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1. Commonwealth Bureau of Census and Statistics, Deaths 1972, Reference No. 4.8, CBCS, Canberra, November 1973.

New entrants to the labour force from the education system are allocated to occupations on the basis of qualifications obtained and models of initial destinations. Studies of initial destinations[1] are available for some specific areas, but others will be inferred initially from employment patterns among those young enough to have been new or recent graduates.

For transfers between occupations other than via formal education, the 'mobility' between occupations is estimated from the probability that a worker from one occupational category transfers to another occupation, which is postulated to be a function of the difference in wage rates (or earnings*) in the two occupations and the costs of transfer. The cost of transfer will be quantified in money terms and called 'generalized costs of interchange'. The term 'generalized' is used to indicate that there may be some occupational interchanges that do not involve money costs or time costs (training), but the changes are nevertheless considered highly undesirable by the potential candidate for occupational change. In such cases the generalized costs would be set so high that the probability of transfer will be near zero. An exponential form is proposed for the probability function.

7. EMPLOYMENT AND WAGES

Having estimated the labour force by occupation (summed over sex and age) labour supply will be assumed fixed for any one year. The demand for labour by occupation (summed over industries) is estimated in the ORANI module where factor demands are related to industry activity levels.

The number of workers employed, the average hours worked and the

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1. Graduate Careers Council of Australia First Destinations of 1973 Graduates, and later editions.

* It may be more desirable to use 'expected earnings' as the relevant factor because the wage rate and the probability of obtaining a job are likely to influence jointly the decision to change occupation.

remuneration[1] by occupation, and hence the total wage bill, for each industry are known for the base year. Demand for labour of each type in each industry in subsequent years can be derived from the estimated share of the national product going to labour of each type at base year wage rates. If the resulting demand for labour is too high, then hours worked and wages would have to rise until demand and supply were in equilibrium. If the demand is too low, then hours worked and wages would fall. Since in practice this latter process for wages is unrealistic and there are constraints on the former, there may be a gap between supply and demand which could be used to give an estimate of unemployment or excess demand for labour, as the case may be. It may be possible to calculate the unresponsiveness of wages to excess supply of and demand for labour since these are major factors determining long-run union negotiating power. The IMPACT occupation groups are better suited to this task because each contains fewer unions and there is relatively little overlap of more than one group by any one union. In the first instance a simple partial adjustment process will be used to model the timing of changes in both hours worked and wages in the elimination of excess supply/demand in the labour market.

The estimate of unemployment so obtained is "structural" in that is omits the "hard core" and "frictional" (between jobs) unemployed. These would have to be estimated separately, the latter through a labour turnover model, to be comparable to official statistics and reconcilable with the figures generated in MACRO. Experience has shown that unemployment estimates are extremely difficult and, since the main value of the module in this area is to give policy consequences, the structural component will suffice in the first instance to show the direction and order of magnitude effect of policies for structural change.

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1. The term 'wage rate' used here does not mean 'award wage'; it is synonymous with average earnings per head.

8. MAPPING OF INCOME DISTRIBUTION FROM FUNCTIONAL SECTORS TO HOUSEHOLDS

The method used to estimate household wage income in BACHUROO is similar to the one used in BACHUE-2[1] with one major difference. In BACHUE-2 the labour force participation or activity rates of non-heads in the households and their average wages are related to the industry in which the head of the household works. The main justification for relating the industry of the head and non-head in the household is the less developed structure of the Philippines economy described by BACHUE-2, in which the working members of the household are commonly in the one industry. It has been suggested that "In principle the employment status of the head would be a superior explanatory variable, but the behavioral base of the sectoral variable was preferable".[2] However, the association between the industry (sector) of the head and non-heads in a household observed in the Philippines is less likely in Australia. Instead, there may be a stronger correlation between the occupational category or level of qualifications of the head and non-heads. Some sociological surveys from developed countries show such links between the occupations of husbands and wives.[3,4] In view of this rather limited evidence, some further analysis is desirable, but at this stage it was felt that heads and other members of households should be linked but by their occupations rather than the industries in which they work.

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1. R. Wery, G.B. Rodgers, M.D. Hopkins, "BACHUE-2" op. cit.

2. M.D. Hopkins, G.B. Rodgers and R. Wery, Population and Employment Working Paper 20, "A Structural Overview of BACHUE : Philippines," ILO, Geneva, May 1975, p. 17.

3. Lois Bryson and Faith Thompson, An Australian Newtown. Life and Leadership in a Working-Class Suburb, Harmondsworth, 1972.

4. A. Alain Gerard, 'The Time Budget of Married Women in Urban Centres,' in Employment of Women, Regional Trade Union Seminar, O.E.C.D., Paris, 1970.

To make estimates of household earned income, it is first necessary to estimate the average earned income of the head, the spouse and other non-heads. This is done for households classified by sex and occupation of the head. The procedure adopted requires estimates of relativities between males and females in each occupational category. Initial relativities will be estimated from the base period data and those for future years will be estimated exogenously.

Most workers come from households with male heads. About 8% of the total households in 1971 were single person households with female heads and there is also a small proportion with female heads and other persons present. The procedure for estimating average household earned income is described below.

$$y_i = w_i + f_i \sum_j w_j \alpha_{ij} + m_i \sum_j w_j \gamma_{ij} \qquad \text{(i)}$$

or in matrix notation

$$y = w + \hat{f}\alpha w + \hat{m}\gamma w$$

$$= [I + \hat{f}\alpha + \hat{m}\gamma] w \qquad \text{(ii)}$$

where

y_i = mean household earned income where the household head is in occupational category i.
(i = 1, 2 .... 26; the first 13 i's represent males in the 13 occupational categories and the second 13 i's represent females in those categories). (The 3 additional categories are for Unemployed, Students and Not in Labour Force.)

w_i = mean earned income per worker in category i
(i = 1... 26).

α_{ij} = proportion of spouses in category j when the head is in category i ; $\sum_j \alpha_{ij} = 1$ (all i) .

Thus in matrix form $[\alpha] = \begin{bmatrix} 0 & \vdots & \alpha_{12} \\ \cdots & \vdots & \cdots \\ \alpha_{21} & \vdots & 0 \end{bmatrix}$

γ_{ij} = proportion of non-heads in category j when the head is in category i ; $\sum_j \gamma_{ij} = 1$ (all i) .

f_i = mean number of spouses per household when the head is in category i ($f_i \leq 1$).

m_i = mean number of non-spouse non-heads over 15 years of age when the head is in category i .

$\alpha_{ij} f_i$ = mean number of spouses per household working in category j when the head is in category i .

$\gamma_{ij} m_i$ = mean number of non-heads (excluding spouses) per household working in category j when the head is in category i .

$$\hat{f} = \begin{bmatrix} f_1 & & \underline{0} \\ & \ddots & \\ \underline{0} & & f_{26} \end{bmatrix}$$

$$\hat{m} = \begin{bmatrix} m_1 & & \underline{0} \\ & \ddots & \\ \underline{0} & & m_{26} \end{bmatrix}$$

It may be difficult to obtain data on γ_{ij} classified by the sex of non-heads. The total will be split by assuming that the proportions of male and female non-heads overall applies in all occupational categories.

Let H_i be the number of households where the head is in category i, and N_i the number of workers in category i. Further among these non-heads (over the age of 15) whose household head works in occupational category i, let the proportion who work in category j be B_{ij}. It follows that :

$$N_i = H_i + \sum_j H_j B_{ji} n_j \qquad \text{(iii)*}$$

or in matrix form

$$N^1 = H^1 [I + \hat{n}B] \qquad \text{(iv)*}$$

which gives

$$H^1 = N^1 [I + \hat{n}B]^{-1} \qquad \text{(v)}$$

where

$$B_{ij} = \frac{\alpha_{ij} f_i + \gamma_{ij} m_i}{f_i + m_i} \qquad (\sum_j B_{ij} = 1, \text{ all } i),$$

$$n_i = f_i + m_i$$

and

$$\hat{n} = \begin{bmatrix} n_1 & & \underline{0} \\ & \ddots & \\ \underline{0} & & n_{26} \end{bmatrix}$$

(Note : $n_i + 1$ = average number of adults per household in households whose head is in category i .)

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* See Appendix for derivation of these results.

Estimates of mean household income are obtained by (ii) , and of the number of households by (v) . These estimates will then be checked in order to ensure that the sum total of all household earned income is the same as the total estimated earned income in the ORANI module. This completes the occupational income distribution of households. In each occupational category there will be a distribution of actual incomes around the mean. This will be estimated after adding together earned and unearned incomes, by relating the base year distribution within each category to the demographic characteristics of the households such as the age of the head and the size of the household.

Values of B_{ij} in the base period are known. In each subsequent period, B_{ij}'s will be adjusted by an iterative procedure that ensures that the row and column totals are correct. It is not yet clear how the values of B_{ij} will change over time and it would be desirable to study the sociological factors that may change marriage rates between men and women in different occupations and also study the trends in children's occupations in relation to the household heads' occupation - a study not unrelated to the education sub-module.

The unearned income of households is defined as income from government transfer payments and from investments. Income from these two sources are treated separately : the former include pensions, unemployment benefits, child endowments, and educational scholarships; the latter include property rent, interest and dividends.

In the low income groups, a large proportion of household heads tend to be pensioners who derive much of their total income from government transfers. Households whose head is not a pensioner may contain pensioners and these households may therefore derive part of their household income from this source. Other government transfer income includes child endowment allowances and scholarships which do not depend on the level of earned income of the household but on the number of children, their ages and education. In the past some scholarship support has depended on family income. However, in most households this is likely to be a relatively less important source of transfer payment and therefore initially, total transfer payments in the model are not related to the household income.

For the base year it will be possible to obtain an estimate of average government transfer payments for households whose head is in occupation* i (i = 1,....,26) as a function of demographic characteristics of the average household given the various rates of payment. Thus

$$g_{i,t} = f(C_{1,i,t}, C_{2,i,t}, PM_{i,t}, PF_{i,t}, \{R_{j,t};\ j=1,\ 2..4\}) \qquad \text{(vi)}$$

where

g_{it} = average Government transfer payments in year t to households whose head is in occupation i ;

$C_{1,i,t}$ = average number of children below 15 in that type of household;

$C_{2,i,t}$ = average number of children aged over 15 in that type of household;

$PM_{i,t}$ = average number of males over the age of 65 in that type of household;

$PF_{i,t}$ = average number of females over the age of 65 in that type of household;

$R_{j,t}$ = rate of Government transfer payment of type j . (j = 1,2,3.....)

---

* We are not suggesting that government transfer payments are occupation specific. They are estimated for households whose head is in occupation i so that the total (earned and unearned) income can be estimated

The above function (13) need not include $R_{j,t}$ as a separate variable. Instead the coefficient of the other variables could be expressed as a product of the rate $R_{j,t}$ and a factor that depends on characteristics of the persons in the households. Both approaches will be investigated.

The above relationship will be fitted to the base data and the consistency between total government transfer payments and the total of payments to households in all occupational classes will be checked. Having estimated a relationship for the base year it will be possible to make forecasts based on changes in demographic characteristics and in rates of payment.

Investment income of households depends on the level of asset endowment and the rates of return. The rate of return on investment may vary according to occupation of the head of the household. Professional workers, for example, may be in a position to receive a better rate of return due to their knowledge of investment opportunities. On the other hand, if they have a high level of earned income as well as asset endowment, they may invest in such a way as to defer income from investment and this may reduce the immediate rate of return in favour of either capital gains or a high rate of return to be realized at some later date. As information on these variables (assets/rates of return) is not readily available, the rate of return will be assumed the same for all occupational groups. Data on average income from investment for household classified by head's occupation can be obtained from survey data. Average rate of return (r_t) will be estimated from information on interest rates, dividends, property rents, etc. outside the model. Once the value of the base year rate of return is estimated by using the information on income from assets in the base year, then a value of assett endowment can be estimated from the following relation.

$$K_{it} = a_{it} / r_t$$

where

$a_{i,t}$ = average income from investment in year t by households where head is in occupation i ;

r_t = average rate of return in year t ;

$K_{i,t}$ = average assets or capital endowment in year t of households whose head is in occupation i .

$K_{i,t}$ can be estimated for the base year, given $a_{i,t}$ and r_t . For future years $K_{i,t}$ will have to be adjusted taking into account the amount of saving (or dis-saving) during year t (estimated as total income less consumption and taxes). Thus for year $t + 1$:

$$K_{i,t+1} = K_{i,t} + S_{i,t} \qquad \text{(vii)}$$

where

$S_{i,t}$ = average savings in year t by households whose head is in occupation i

$K_{i,t}$ = as in (14) above.

The determinants of $S_{i,t}$ are to be estimated econometrically from the household data.

The average household income from all sources for households for year $t + 1$ can now be estimated as a sum of head and non-head earned income, government transfer payments and income from investments. The estimates for each future year will be reconciled with the aggregates being estimated in other parts of the IMPACT model.

The above procedure estimates the average household income and its components for households whose heads are in the different occupational categories. The distribution of income within each group

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* Propensity to save is not expected to be occupation specific but is expected to depend on the income. However, the average earned income depends on the occupation of the head. Work on estimating relationships between consumption and socio-economic-demographic variables is in progress (Ref: Ross Williams, "Estimation of Household Responses Using Cross-section Data: A Systems Interpretation of Podder's Result, Impact of Demographic Change on Industry Structure in Australia, Preliminary Working Paper No. SP-02, Melbourne, March 1976.) and similar work will be undertaken to estimate propensity to save for different types of households.

for the base year will be obtained from survey data. For the base year earned income of males and females within each occupational category will be related to the age of the earner. It is expected that in some categories the earned income will rise with age while in others the variation may be small. The relationships between earned income and age will be assumed stable initially. Research into sociological and educational factors and the influence of policy on distribution of income will be conducted to improve this initial assumption.

Government transfer payments will be related to demographic factors and rates of payment applicable in various situations. The investment income may be related to the asset endowment of households in various income groups irrespective of the occupational category of the head. A recent study by Atkinston and Harrison[1] in the U.K. indicates that investment income increases monotonically with wealth (or asset endowment) but at a decreasing rate. A relationship of the following form may be used :

$$a_i = b_o K_i^{b_1} \quad (o<b_o, b_1<1) \qquad \text{(viii)}$$

where a_i is investment income and K_i is the asset endowment. When such a relationship is estimated, it will be possible to obtain estimates of investment income based on estimates of asset endowment (section 8.4) and decreasing rates of return.

Work on this topic is at an early stage and it may be necessary to modify these procedures to fit Australian data.

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1. A.B. Atkinston and A.J. Harrison, "Wealth Distribution and Investment Income in Britain" Review of Income and Wealth, Vol. 20, No. 2 (1974), p. 13[illegible].

9. HOUSEHOLD FORMATION

Future household formation in BACHUROO is based on a stock of households in the base year modified by maturation, deaths, births, separation and new formations in a manner very similar to the population sub-module. The household classification is shown in appendix 1.

The formation of new households may be modelled in stages as follows:

(i) Age and sex specific marriage rates will be modelled separately as functions of economic conditions and variables to account for attitudinal changes.

(ii) Since only heterosexual marriages are sanctioned in Australia and are of interest to this model, total male and female marriages will be reconciled by pro rata adjustments made to each age group.

(iii) Non-married households will be estimated separately and added to the married ones.

(iv) The household structure[1] of the immigration program will be estimated from the size of the program and the change in its size to separate out the family reunion component, which has different demographic characteristics to the worker component.

Subsequent changes to the distribution of household types will be calculated as follows:

(v) Divorces and separations by age of female will be estimated. The female's age is more important than the male's because the female usually keeps any children to form a new household.

(vi) Death rates will be used to predict changes in the structure as well as the disappearance of households.

(vii) Emigration of entire households or of members of households will be estimated similarly to the method used for immigration household structure.

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1. See Appendix 1.

(viii) Changes due to children being born are most important and will be calculated from the fertility estimates in the population sub-module.

10. FURTHER EXTENSIONS

The estimates of household income distribution and demographic characteristics of households obtained above will be used to project household consumption patterns on the basis of econometric estimates of demand behavior. This work lies at the interface of the ORANI and BACHUROO modules. It may be done outside the framework of BACHUROO as estimates of consumption are not planned to have feedback effects on variables in BACHUROO.

The labour supply and employment in the current framework is in terms of numbers of persons by age, sex and occupation. It may be desirable to consider estimating employment in terms of total hours worked, allowing for increased labour input through overtime. This extension may be included once the module in its present form is developed to produce the desired output. At that stage it will be necessary to drop the assumption of fixed labour supply in one year in terms of number of workers because the supply in terms of hours worked could change according to the wage and or overtime rates offered. The econometric estimation of the supply of labour and overtime would form a natural component of the estimation of demand behavior.[1]

1. See, e.g., Roger R. Betancourt, "The estimation of price elasticities from cross-section data under additive preferences" International Economic Review, Vol. 12, No. 2, June 1971 pp. 283-292, who specifies a system of demand equations incorporating the demand for leisure.

11. DATA, INPUTS FROM OTHER MODULES AND OUTPUTS

Most of the data used in this module was collected in the 1971 Census of the Australian Population. Other data come from various population and labour force surveys. The published data however, are not classified in the same way as that specified in the module. A number of special tabulations will be required. The 1972 Labour Mobility Survey provided information on movement of people between occupations but the survey did not include questions on whether there was any training required or whether the new job was a better paid job. Some data on these aspects will become available from the February 1976 population survey. The BACHUROO module requires the following estimates and forecasts from the ORANI and MACRO modules :

1. Demand for labour by industry and occupation
2. Total wage bill by industry and occupation
3. Total unemployment
4. Rates of return on assets
5. Government expenditure on education, pensions, child endowments, scholarships etc., rates of payment and also rates of unemployment benefits
6. Output of service industries as a percentage of total output.

In addition, exogenous estimates of annual immigration are required.

The BACHUROO module will provide the following outputs for use in the other modules :

1. Size of the Australian population by age and sex
2. Annual levels of immigration and emigration
3. Number of students by type of education
4. Labour force by sex and occupation
5. Number of households by type
6. Household income distribution

12. SUMMARY

This paper gives a brief description of the BACHUROO module. Starting with basic demographic information, and by interacting with the MACRO and ORANI modules, the BACHUROO module traces participation rates, labour supply, employment, wages and household income through time. The module formulation to be adopted in the initial runs is described above. It will be modified in the light of results obtained from the initial runs, data availability and comments on this paper.

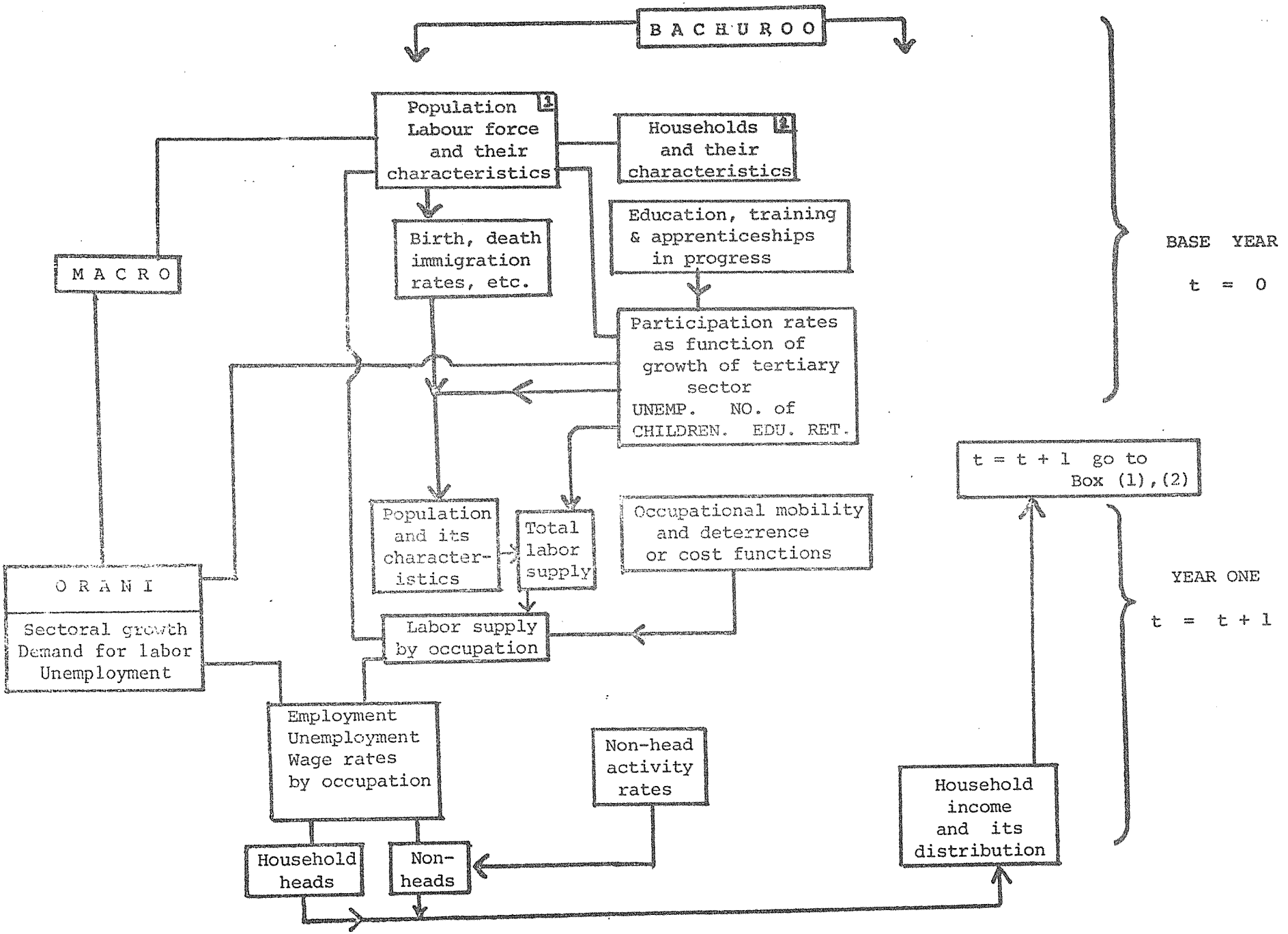

Figure 1 : BACHUROO MODULE and its links with MACRO and ORANI MODULES

Appendix 1 : Occupation, Qualification and Household Classifications used in IMPACT

SUMMARY OF OCCUPATIONS

MAJOR GROUPS

1 Professional White Collar
2 Skilled White Collar
3 Semi and Unskilled White Collar
4 Skilled Blue Collar, Metal and Electrical
5 Skilled Blue Collar, Building
6 Skilled Blue Collar, Other
7 Semi and Unskilled Blue Collar
8 Rural Workers
9 Armed Services
10 Other (nec)

MINOR GROUPS

A PROFESSIONAL WHITE COLLAR

1 Scientists
2 Engineers
3 Medical
4 Societal
5 Tertiary Teachers
6 Secondary Teachers

B SKILLED WHITE COLLAR

7 Technical Teachers
8 Primary Teachers
9 Para-medical
10 Technicians

C SEMI AND UNSKILLED WHITE COLLAR

14 Clerical
15 Sales
16 Semi-skilled medical
17 Audio Visual

D SKILLED BLUE COLLAR, METAL AND ELECTRICAL

18 Metal Trades
19 Electrical trades
20 Instrument trades

E SKILLED BLUE COLLAR, BUILDING

21 Wood trades
22 Brick, Stone and Glass trades
23 Painters

F SKILLED BLUE COLLAR, OTHER

24 Food trades
25 Textile trades
26 Printing trades

G SEMI AND UNSKILLED BLUE COLLAR

27 Semi Skilled metal and electrical
28 Building
29 Miners
30 Drivers
31 Protective Services
32 Production
33 Services
34 Labourers

H RURAL WORKERS

35 Farmers
36 Farm workers

I ARMED SERVICES

37 Officers
38 Other Ranks

J OTHER

39 Other (nec)

SUMMARY OF QUALIFICATIONS AND COURSES

MAJOR GROUPS

1 Higher Degree
2 First Degree
3 Diploma
4 Trade Certificates
5 Higher School Certificate
6 School Certificate
7 Not classified
8 No qualification

MINOR GROUPS

A HIGHER DEGREE
- 1 Higher Degree

B FIRST DEGREE
- 2 Science
- 3 Engineering
- 4 Medical
- 5 Societal
- 6 Teaching
- 7 Non-vocational and other

C DIPLOMAS AND OTHER NON DEGREE TERTIARY
- 8 Teaching
- 9 Para-medical
- 10 Technician
- 11 Creative
- 12 Business
- 13 Other and non-vocational

D TRADE LEVEL
- 14 Metal
- 15 Electrical
- 16 Building, wood
- 17 Building, other
- 18 Food
- 19 Textiles
- 20 Printing
- 21 Other (nec)

E HIGHER SCHOOL CERTIFICATE
- 22 Higher School Certificate

F SCHOOL CERTIFICATE
- 23 School Certificate

G NOT CLASSIFIED
- 24 Not classified

H NO QUALIFICATION
- 25 No qualification

SUMMARY OF HOUSEHOLD COMPOSITION

1 Male head only

2 Female head only

3 Male head with 1 or more children

4 Female head with 1 child

5 Female head with 2 children

6 Female head with 3 children

7 Female head with 4 or more children

8 Male, Female with 1 child

9 Male, Female with 2 children

10 Male, Female with 3 children

11 Male, Female with 4 or more children

12 Male, Female with 1 person over 15 and 1 child

13 Male, Female with 1 person over 15 and 2 children

14 Male, Female with 1 person over 15 and 3 or more children

15 Male, Female with 2 or more persons over 15 and 1 child

16 Male, Female with 2 or more persons over 15 and 2 or more children

17 Others

Appendix 2 : Equations for the Population Sub-Module

The basic accounting equation is :

$$POP(ISEX, IAGE) = M(POP_{t-1}(ISEX, IAGE)) + IMIG(ISEX, IAGE) - EMIG(ISEX, IAGE) - DEATHS(ISEX, IAGE)$$

To POP(ISEX), 1) are added BIRTHS(ISEX)

M is the maturation function, which is simply

$$POP(ISEX, IAGE) = POP_{t-1}(ISEX, IAGE-1)$$

for the single age cohorts, but involves quadratic interpolation for the age groups to determine the numbers in the oldest single year cohorts to be moved to the next oldest groups.

Deaths

The equation for deaths is given simply by :

$$DEATHS(ISEX, IAGE) = POP_{t-1}(ISEX, IAGE) * DRATE(ISEX, IAGE)$$

where the age and sex specific death rate is given by :

$$DRATE(ISEX, IAGE) = DRATE_{t-1}(ISEX, IAGE) * (1-DDRATE(ISEX, IAGE))$$

This allows for changes in the death rates over time. It is unlikely that DDRATE (ISEX, IAGE) will differ significantly from zero, except for the very young and the very old, where conceivably it could be modelled along lines used for developing countries in terms of affluence and its distribution. Initially it will be zero and the death rates derived from standard tables.

Births

The equation for births is given by :

$$BIRTHS(ISEX) = POP_{t-1}(IFEM, IAGE) * BRATE(IAGE)$$

The females' age specific birth rate is given by :

BRATE (IAGE) = CRATE (IAGE) * AVBTH

where CRATE = confinement rate

AVBTH = average number of births per confinement

The confinement rate is the first important behaviorable variable. Initially it will be specified exogenously. Endogenisation will be made along the lines :

CRATE (IAGE) = f (INCOME, MALES, UNEMPL, FEMED)

where INCOME = personal disposable income

MALES = excess of males in the population

UNEMPL = unemployment rate

FEMED = female education levels

The income variable reflects both the financial constraints on family size and preference for children compared to other consumer goods.

There was a very significant shortage of females over the period 1949-1966 which was caused by high migrant worker intakes and has only recently reversed as the longer-life expectancy of women has begun to dominate. Balance between the sexes is most important at the prime marriage ages and will be derived from the population estimates for ages 15 to 45.

Unemployment is expected to influence fertility in two directions. When high, people are less secure in their jobs and may defer having children. Alternatively, some women unable to find work for long periods may elect to have children now so that they may resume work when the prospects improve. The first effect is expected to dominate.

Female education levels are indicative of attitudinal changes towards a career by women in preference to the traditional housewife role. Several variables have been used, with the most promising to date being the fraction of women university students.

An obvious improvement would be to incorporate age specific labour force and education levels in the equation on the grounds that these are the important alternatives a woman may consider. The equation, which would require simultaneous estimation would then become :

CRATE (IAGE) = f (PDI, MALES, UNEMPL, FEMED, EDPT (FEM, IAGE), LFPT (FEM, IAGE))

Finally, the incorporation of completed family size may be derived using :

CRATE (IAGE, IBTHS) = confinement rate for women of age IAGE with IBTHS children already.

Similar functions would be estimated with a tendency to zero for large numbers of children and constrained to converge to the long-term trend.

Migration

The migration flows comprise permanent, long-term and short-term movements of the form :

IMIG (ISEX, IAGE) = PARIV (ISEX, IAGE)
+ LTARIV (ISEX, IAGE)
+ STARIV (ISEX, IAGE)

EMIG (ISEX, IAGE) = PDEPT (ISEX, IAGE)
+ LTDEPT (ISEX, IAGE)
+ STDEPT (ISEX, IAGE)

The permanent arrivals, particularly, are determined by the immigration target. Long-term arrivals are similarly constrained, while visas for short-term visits are relatively unregulated. No regulation takes place on the departures. Behavioral equations for these flows are estimated from functions of the form :

$$PARIV = f (TIMIG, IMIG_{t-1})$$

with the age and sex composition determined subsequently in the form :

$$\frac{\text{PARIV (ISEX, IAGE)}}{\text{PARIV}} = f\ (\text{TIMIG},\ \text{IMIG}_{t-1})$$

where TIMIG is the target for the program

$$\text{LTARIV} = f\ (\text{TIMIG},\ \text{IMIG}_{t-1},\ \text{UNEMPL})$$

$$\text{PDEPT} = f\ (\text{PARIV}_{t-2},\ \text{FARES})$$

$$\text{LTDEPT} = f\ (\text{LTARIV}_{t-1},\ \text{POP})$$

Since over 25% of the short-term arrivals leave in under 1 month it may be more reasonable to model net short-term movements as :

$$\text{STARIV} - \text{STDEPT} = f\ (\text{INCOME},\ \text{FARES})$$

Age and sex composition determined as functions of the size of the current and previous years' movements. Attitudinal variables to careers for females, or even female participation rates in education and the labour force (lagged to avoid the simultaneity problem) are also likely to be appropriate for the departure estimates.

Appendix 3 : Equations for the Education Sub-Module

In any course, i, the demand for places may be estimated by an equation of the form :

$$N_i^* = f\ (P_i,\ CS_i,\ IA_i,\ U,\ U_i,\ W,\ WM_i,\ SS_i,\ FA_i)$$

where N_i^* = number of places demanded on course i

P_i = persons in prime age group for course i

CS_i = cost to the student of doing course i

IA_i = availability of course i in institutions

U = total unemployment

U_i = unemployment in occupations related to course i

W_i = mean or median wage rate for occupations related to course i

WM_i = comparative wage rate for the decile of persons in occupations related to course i

SS_i = social status of course i

FA_i = family or related influence on students in course i

= fraction of the older generation having qualifications from course i

Then, since adjustment to demand in any one year will be partial,

$$N_i - N_i^{t-1} = \gamma_i\ (N_i^* - N_i^{t-1})$$

where $\gamma_i = \gamma_i\ (CG_i,\ P_i)$

where CG_i = cost to government of providing course i

P_i = population in prime age group doing course i, as anticipated by planners

In the model, this will become an equation of the form :

$$EDENT\ (ICORS) = f\ (EDENT_{t-1}\ (ICORS),\ CS\ (ICORS),....)$$

Subsequent equations to disaggregate the new entrants by age and sex may be of the form :

$$\frac{\text{EDENT (ISEX, IAGE, ICORS)}}{\text{EDENT (ICORS)}} = f\,(\text{UNEMPL (ICORS)}, \text{WAGE (ICORS)}, \ldots)$$

where UNEMPL (ICORS) and WAGE (ICORS) are mean unemployment and wages for the group of occupations associated with ICORS.

Then, the accounting procedures would be incorporated in the equation

$$\begin{aligned}\text{STUD (ISEX , IAGE, ICORS)} = {} & M\,(\text{STUD}_{t-1}\ \text{(ISEX , IAGE, ICORS)}) \\ & + \text{EDENT (ISEX, IAGE, ICORS)} \\ & - \text{WASTE (ISEX, IAGE, ICROS)} \\ & - \text{GRADS (ISEX, IAGE, ICORS)}\end{aligned}$$

Wastage, graduations and students remaining can be specified simply in terms of annual average success rates for the course in the form :

$$\text{GRADS} = \text{EDENT}_{t-n} * \text{SUCRT}^{n}$$

where n = duration of the course

$$\text{WASTE} = \text{STUD} * (1 - \text{SUCRT})$$

More complex equations involving rates of repeating for failed years and success rates which differ from year to year have been derived, but are unlikely to be supported by adequate data for a global education model.

Appendix 4 : Equations for the Labour Force Size Sub-Module

The size of the labour force by age and sex will be given by :

LABSUP (ISEX, IAGE) = POP (ISEX, IAGE) * LFPRT (ISEX, IAGE)

The behavioral relations for the participation rates will be of the form :

For males

LFPRT (IMALE, IAGE) = f (STUD (IMALE, IAGE), RETRT (IMALE, IAGE), $UNEMPL_{lag}$, PMARRY (IMALE, IAGE)

For females

LFPRT (IFEM, IAGE) = f(STUD (IFEM, IAGE), RETRT (IFEM, IAGE), $UNEMPL_{lag}$, $LABDEM_{t-1}$ (ITERT), FCHLU (IAGE), FEMED)

(This will probably be estimated separately for married females.)

where STUD (ISEX, IAGE) = students

RETRT (ISEX, IAGE) = retirement rate

$UNEMPL_{lag}$ = total unemployment rate

PMARRY (ISEX, IAGE) = proportion married

$LABDEM_{t-1}$ (ITERT) = labour demand in the tertiary sector in the previous year

FCHLU (IAGE) = fraction of women with children under 5 years old

FEMED = female education variable

Estimates for these quantities will be derived as follows :

STUD (ISEX, IAGE) will be estimated in the education sub-module

RETRT (ISEX, IAGE) may be set exogenously or estimated in terms of affluence and, for older age groups, inflation rates.

UNEMPL will be estimated from previous solutions of the ORANI and BACHUROO modules

PMARRY (ISEX, IAGE) will be estimated in the household formation sub-module

LABDEM (INDUST) is estimated in ORANI for each industry

FCHLU (IAGE) is estimated in the population sub-module

FEMED is derived from the education sub-module.

Appendix 5 : Equations for the Labour Force by Occupation Sub-Module

The basic accounting equation is :

$$
\begin{aligned}
\text{LABSUP (ISEX, IAGE, IOCC)} = {} & \text{M (LABSUP}_{t-1}\text{(ISEX, IAGE, IOCC))} \\
& + \text{IMIG (ISEX, IAGE, IOCC)} \\
& - \text{EMIG (ISEX, IAGE, IOCC)} \\
& - \text{DEATHS (ISEX, IAGE, IOCC)} \\
& - \text{RETIRE (ISEX, IAGE, IOCC)} \\
& + \text{NEWENT (ISEX, IAGE, IOCC)} \\
& - \text{EDENT (ISEX, IAGE, IOCC)} \\
& + \text{MOVERS (ISEX, IAGE, IOCC)}
\end{aligned}
$$

where M is the maturation function

DEATHS and RETIRE are obtained by applying the death and retirement rates to the previous year's supply of labour

IMIG and EMIG are obtained from endogenised breakdowns of permanent, long-term and short-term movements of the form :

$$\frac{\text{PARIV (ISEX, IAGE, IOCC)}}{\text{PARIV (ISEX, IAGE)}} = \text{f (UNEMPL (IOCC), TIMIG)}$$

It is anticipated that this will be a fairly weak function of unemployment and the target immigration program with the skill mix of the intake remaining fairly constant. Only in very recent times of high unemployment has the emphasis shifted so far away from semi and unskilled labour, and this should be captured by one or both of these variables.

New entries and entrants to the education system will be calculated in the education sub-module.

Probably the most important and interesting component of this equation is the number of movers from one occupation to another. It is likely that this will be estimated as follows :

1. Movers from occupation 1 to occupation 2 will be estimated separately for each sex as :

   MOVERS (IOCC1, IOCC2) = f (WAGE (IOCC1), WAGE (IOCC2)
   UNEMPL (IOCC1), UNEMPL (IOCC2), GCOST (IOCC1, IOCC2)
   LABSUP (IOCC1))

2. Net movers will be calculated by summation
3. The age distribution will then be imposed on the total.

Appendix 6 : Derivation of Household Income Mapping Equations

This appendix describes the derivation of equations (iii) and (iv) in section 8.

Let P_{ij} = number of adult non-heads (including spouse) in category j when head is in category i ;

$\sum_j P_{ij}$ = number of adult non-heads in all categories when head is in category i ;

$\sum_i P_{ij}$ = number of adult non-heads in category j ; irrespective of the category head is in

N_a = total workers in category a ;

H_a = total number of households with head in category a .

We can now write

$$B_{ij} = \frac{P_{ij}}{\sum_j P_{ij}} \quad \text{or} \quad P_{ij} = B_{ij} \sum_\ell P_{i\ell} \; ;$$

$$n_i = \frac{\sum_j P_{ij}}{H_i} \quad \text{or} \quad \sum_j P_{ij} = n_i H_i \; ;$$

and therefore

$$B_{ij} n_i = \frac{P_{ij}}{\sum_\ell P_{i\ell}} \frac{\sum_\ell P_{i\ell}}{H_i} = \frac{P_{ij}}{H_i} \; .$$

Now total workers in category a = Total heads in a + Total non-heads in a .

i.e.

$$N_a = H_a + \sum_i P_{ia}$$

$$= H_a + \sum_i (B_{ia} \sum_\ell P_{i\ell})$$

$$= H_a + \sum_i (B_{ia} n_i H_i) \; . \qquad \text{(iiia)}$$

In order to get (iiia) in a form which is directly comparable with (iii) above, it is only necessary to make a change in the subscripts used. If we change the subscript on the summation sign to j and replace the subscript a with i, then we get

$$N_i = H_i + \sum_j H_j B_{ji} n_j \qquad \text{(cf. (iii)above}$$

It can also be shown that the matrix form of the equation (see (iv)) is consistent with (iii).

We have

$$\hat{n}B = \begin{bmatrix} n_1 & & \underline{0} \\ & \ddots & \\ \underline{0} & & n_k \end{bmatrix} \begin{bmatrix} B_{11} & B_{12} \cdots\cdots\cdots & B_{1k} \\ \vdots & \vdots & \\ B_{k1} & B_{k2} \cdots\cdots\cdots & B_{kk} \end{bmatrix}$$

$$= \begin{bmatrix} n_1B_{11}, & n_1B_{12}, & \cdots & , n_1B_{1k} \\ \vdots & \vdots & & \vdots \\ n_kB_{k1}, & n_kB_{k2}, & \cdots & , n_kB_{kk} \end{bmatrix}$$

and therefore

$$I + \hat{n}B = \begin{bmatrix} 1 + n_1B_{11} & n_1B_{12}, & \cdots & , n_1B_{1k} \\ \vdots & \vdots & & \\ n_kB_{k1} & n_kB_{k2}, & \cdots & , 1 + n_kB_{kk} \end{bmatrix}$$

Now, it has been asserted that

$$N' = H'[I + \hat{n}B]$$

i.e.

$$[N_1\ N_2 \ldots\ N_k] = [H_1\ H_2\ \ldots\ H_k]\ [I + \hat{n}B] \quad .$$

Carrying out the matrix multiplication and then equating the elements on the LHS with those on the RHS gives :

$$\begin{aligned} N_1 &= H_1 + H_1 n_1 B_{11} + H_2 n_2 B_{21} + \ldots\ldots H_k n_k B_{k1} \\ &\vdots \qquad\quad \vdots \qquad\quad \vdots \qquad\qquad \vdots \\ N_k &= H_k + H_1 n_1 B_{1k} + H_2 n_2 B_{2k} + \ldots\ldots H_k n_k B_{kk} \end{aligned}$$

or

$$\begin{aligned} N_1 &= H_1 + \sum_j H_j n_j B_{j1} \\ &\vdots \\ N_k &= H_k + \sum_j H_j n_j B_{jk} \quad . \end{aligned}$$

The general equation in the above system is

$$N_i = H_i + \sum_j H_j n_j B_{ji} \quad .$$

This can be seen to be identical with (iii) above.