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IMPACT is an economic and demographic research project conducted by Commonwealth Government agencies in association with the Faculty of Economics and Commerce at The University of Melbourne, the Faculty of Economics and Commerce and the Departments of Economics in the Research Schools at the Australian National University and the School of Economics at La Trobe University.

Paper presented at the XXth General Conference of the International Union for the Scientific Study of Population, Florence, Italy
5 - 12 June 1985

PROGRESS REPORT ON AN ECONOMIC-DEMOGRAPHIC MODEL FOR AUSTRALIA

by

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General Paper No. G-60 Melbourne March 1985

The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Commonwealth or Victorian Governments

ISBN 0 642 52610 9

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SUMMARY

The IMPACT Project, Melbourne, Australia, as part of its research towards the construction of a computable medium-term model of the Australian economy, has developed a large highly disaggregated economic-demographic computer model for use in the analysis, and projection, of Australian population, labour force and households. Utilizing ideas from the "new home economics" the model attempts to account econometrically for economic aspects of the determination of demographic behaviour. The eventual aim is to use this model as a basis for highly disaggregated projections of labour supply and of household consumption behaviour, for later integration with the macroeconomic and industry structure models also developed at the IMPACT Project.

This paper describes the main features of the IMPACT population model: its databases, the use of model schedules for data condensation and to provide links with econometric models, the means by which male and female marital flows are made consistent, its novel and only partly successful approach to the projection of fertility, and the two econometric models used to project broad demographic indicators of fertility, marriage, divorce labour force participation and household formation. Selected simulations of the model under scenarios of low and high economic growth are then summarized, highlighting the detail that can be derived from a model of this complexity.

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INTRODUCTION

The relatively limited use of econometric models to explain and project population change, particularly at a disaggregated level, can be attributed to the following factors:

(i) while economic variables can have an immense cumulative impact on demography, the latter tends to change slowly over time (particularly in those countries which have completed demographic transition). Thus the more important phenomena from the policy analyst's viewpoint may not be demographic;

(ii) there is no theory which captures the interrelationships between economy and demography definitively. As a result, economic-demographic models so far have had limited success (e.g., the substantial literature regarding regional migration has provided neither comprehensive explanation nor accurate projections of regional migration);

(iii) the data required to implement such models are often

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* This paper documents work done while the author was on the staff of the IMPACT Project, University of Melbourne, Australia. It reflects the joint effort of many members of that Project, in particular Dr. Dennis Sams and Professor Alan A. Powell, upon whose comments and writings the author has drawn heavily. The views expressed in this paper, of course, do not necessarily represent those of the above people, of the participating agencies of the IMPACT Project, of the Victorian or Australian Governments, nor of the author's current employer.

lacking, especially data on social factors impacting on demographic change; and

(iv) despite significant advances in computer technology, the manageability of models with high degrees of detail is a significant limitation, especially in lowly-resourced agencies involved in population forecasting.

At the IMPACT Project a population projection model has been constructed which addresses the above concerns (see Sams and Williams, 1983a, for a non-technical overview). This model, developed within a major project to construct a computable medium-term model of the Australian economy (Powell, 1977, and 1983), therefore is well integrated with economic behavioural sub-models relevant to demography. Very simply, to use the population model, one needs:

(i) a database of past demographic and economic variables; and

(ii) scenarios of expected growth in certain exogenous demographic and economic variables.

These are used in conjunction with:

(iii) econometric models inter-relating demographic, social and economic variables, which are used to project broad demographic indicators of fertility, marriage, divorce, labour force participation and household formation;

(iv) sets of model schedules, which are used to convert the broad demographic indicators into estimates of disaggregated demographic flows; and

(v) a cohort component demographic model;

to produce simulations of changes in Australia's population (by sex, single years of age and four marital states), demographic flows (such as first marriage, remarriage and divorce, by sex and age; and births by parity or age), labour force (by sex, age

ages this responsiveness is increased by incomes which grow more rapidly (in response to increased female wages) and by rises in labour force participation.

When the projections of household headship rates and population structure are combined to produce projections of household numbers, the sensitivity of household formation to economic conditions is obvious. Between the low and high scenarios, there is a difference of about 10% in the number of households by the year 2001, and the average number of new households per year can vary (in the same year between the two scenarios) by about 30%. While the majority of all households and the majority of projected new household formation have male heads, women are projected to become increasingly important, especially under the higher growth scenario. This projection is consistent with past trends, as is the projected reduction in the dominance of traditional married male and widowed female headed households, due to the above average population and headship rate growth for non-traditional groups, particularly under the higher growth scenario. However, the dominance of the traditional headship groups remains unchallenged, with married male heads still providing around 50% of the increase in households in each year. Because of the ageing (noted earlier) of the population, new housing requirements are projected to shift away from the needs of young persons to those of older persons; this shift is, however, mitigated to some extent under higher economic growth.

CONCLUDING REMARKS

The projections of population, labour force and households produced with the IMPACT population model are in general intuitively sound and enable some quantification of the impact of economic growth upon demographic variables. However, the model requires further work to improve the specification of the econometric relationships and to link up with the rest of the IMPACT medium term model via the projection of labour supply by occupation and hours offered, and of household demands. Funding for such further research is, however, uncertain in the current climate of Government expenditure restraint and excess labour supply.

projections, predominantly as a result of assumed increases in education participation, although this is offset under the higher growth scenario by increases in real wages and demand for female labour. Prime-aged unmarried females experience increases in participation rates principally due to rising female wages (this effect of course being stronger under the higher growth scenario), while for older females, both married and unmarried, this positive effect is mitigated by rising social security payments. As a result, the total labour force participation rate for unmarried females rises from 14.9% in 1980 to (17.4, 15.4)% in 2000 under the (low, high) growth scenarios. This compares with the total married female rate which varies from 22.4% in 1980 to (20.5, 27.4)% in 2000 under the (low, high) scenarios. The higher married female participation rates are accompanied by higher growth in the population of married women, so the share of married females in the labour force rises (compared to a fall in the lower growth projection).

Household Formation

The IMPACT population model projects a positive relationship between economic growth and future household formation[4]. The changes, discussed earlier, in population and labour force structure under a scenario of high economic growth act to reinforce this positive relationship. However, even under the economic stagnation represented by the low growth scenario, household headship rates in the next 20 years decline only marginally - a decline which is in contrast to the strong growth which occurred in the past 20 years. Under higher economic growth, substantial increases in headship rates are projected for all demographic groups, predominantly as a result of rising incomes, increased labour force participation and improved labour market conditions. Responsiveness to economic conditions is highest amongst less traditional groups. For women in the prime

4. Details of the projections reported here are given in Sams and Williams (1982). The underlying scenarios differ slightly from those discussed earlier, so precise figures have not been given.

group and nuptiality) and households (by sex, age group and marital status of head); see Figure 1.

Useful features of this model are that

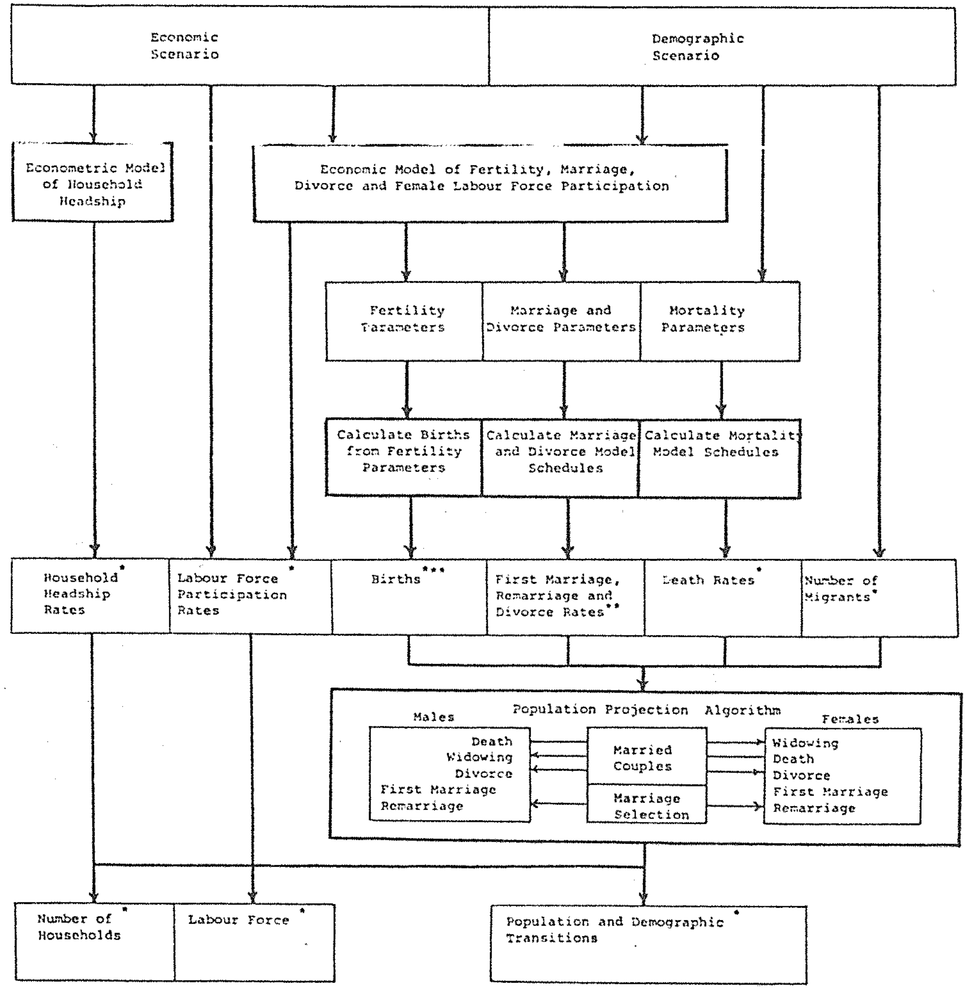
(i) it allows policy-related simulations (e.g., what would happen to future fertility, marriage, divorce, labour force participation and household formation if all pensions were increased to 25 per cent of average weekly earnings?);

(ii) it maintains a level of disaggregation not normally available from policy-analytic population models. This is achieved by using a powerful data condensation technique, in which the age profiles of marriage, divorce, deaths and fertility are represented by model schedules (Williams, 1981). Econometric or trend projections of a few interpretable variables (i.e., mean, variance and area under the curve) can be used, with the model schedules, to provide projections of the full age profiles of the demographic transitions. Projections are then made with a conventional cohort-component model, which ensures consistency between demographic stocks and flows; and

(iii) it has been constructed with a view to wide availability throughout Australian government and research centres. (The facility is maintained by the Bureau of Labour Market Research.) Flexibility has therefore been emphasized, and users are provided with substantial documentation and a suite of easily accessible computer programs.

This paper briefly examines the main features of this model, signalling those aspects which presented the greatest difficulties in development and which require further work. Sample simulations of the model are reported, highlighting the detail that can be derived from a model of this complexity.

FIGURE 1. SCHEMATIC REPRESENTATION OF THE POPULATION PROJECTION FACILITY



* Disaggregated by Age, Sex and Marital Status

** Disaggregated by Age and Sex

*** Disaggregated by Sex.

Labour Force

The model indicates a positive relationship between labour force participation rates and economic growth, particularly for married women. Thus, despite the negative relationship between economic growth and population growth (via fertility), the projected labour force is larger under a higher growth scenario: the ratio of labour force to population rises from 46.2% in 1980 to (47.3, 51.4)% in 2000 in the (low, high) projection. As noted earlier, labour force participation rates for males are set exogenously, and they do not vary between the chosen scenarios. In the projections reported here, participation rates are assumed (because of rising education participation) to decline for young males, assumed to remain approximately constant for prime-aged males, and assumed (because of improved possibilities for, and social acceptance of, early retirement) to decline for older males. Consequently, the size of the male labour force varies little between the projections (resulting in a fall in the male share of the labour force), and the total male labour force participation rate falls from 78.2% in 1980 to 76.1% in 2000.

For women, the econometric model is used to determine labour force participation rates. As discussed earlier, high economic growth has the effect of increasing demand for child services and limiting growth in fertility. Both factors act to increase the labour force participation of married women; they bear and raise less children and they are drawn into the workforce to earn sufficient income to support high levels of child quality. Labour market variables (i.e., female wages, unemployment rates and demand for female labour) encourage married women to join the labour force, particularly under the higher growth scenario. Thus, the separate effects of fertility and labour market variables are complementary when economic growth is high and countervailing when growth is low, resulting in a rise in labour force participation rates for married women of childbearing age under the high growth scenario, and approximately constant rates under the low growth scenario.

For young unmarried women, participation rates decline in both two counteracting influences result in a fall in the dependency ratio from 53.8% in 1980 to (51.4, 50.8)% in the (low, high) projections in 2001.

Marital Status

The presence of higher economic growth tends to promote increased movement between marital states. Marriage becomes more popular, due to the positive effects on first marriage and remarriage rates of growth in incomes and demand for child services outweighing the negative effects of increasing female wage rates and rising female educational attainment. Remarriages of divorcees are also increased by the relatively higher number of divorcees in the high growth economy. This high relative popularity of divorce is due to the positive influence of growth in real income, in female wage rates and in social security payments, and of decline in the numbers of children per married woman (resulting from the fertility trends discussed above). The proportion married is also relatively higher in the high growth economy, resulting in even higher numbers "at risk" of divorce. The resulting marital status distribution of the adult population in 2001 reflects the differential impact of the economic growth scenarios chosen:

	Males			Females		
	1980	2001		1980	2001	
		Low	High		Low	High
Never married	31.4	32.7	29.6	23.0	24.7	21.3
Married	62.2	57.6	60.1	61.6	56.2	58.6
Divorced	3.8	7.0	7.8	4.4	8.8	9.8
Widowed	2.6	2.7	2.5	11.0	10.4	10.3

These variations in marital status distribution have implications for labour force and household formation behaviour, as discussed below.

FEATURES OF THE IMPACT POPULATION MODEL

Data

Probably the single most important factor retarding the development of economic-demographic models of population change is lack of data, particularly at disaggregated and/or regional levels and over long time periods. Australia is fortunate in this regard in having available a demographic databank providing actual and constructed information on fertility, death, international migration and marital status transitions sufficient to <u>consistently</u> track the annual growth in the Australian population, disaggregated by sex, single years of age and four marital states, from 1921 to 1976, and currently being updated to 1981 (Brown and Hall, 1978 and 1980). It has also been possible to collect and/or construct data (not always of high quality) on relevant economic and social variables over a similar time period.

This augmented databank provides an excellent basis for economic-demographic modelling of long term national population change; the high level of disaggregation allowed by it within the population model provides flexibility in use, richness of detail and the scope to identify and project population groups with relatively homogeneous behaviour. Construction of the database, however, required substantial computational and other resources, possibly placing such an endeavour beyond the capability of a single agency. The IMPACT models have been built with a view to wide application and usage; it is only in this way that their cost can be recouped.

Whilst the IMPACT population model is a national model, it has also been possible to apply the model to specific regions (but not in multi-regional mode) by using limited regional databases and assuming similarity in parameter estimates at the national and regional levels (Williams, Sams and Martin, 1982). To date, however, projections of regional migration have been made exogenously in such applications.

Model Schedules

Since it would be impractical to model the determinants of each age-specific rate of marital status change or fertility, data condensation techniques were necessary for manageability and to facilitate links with the econometric models. In the IMPACT population model, death rates, the parity distribution of family size, and the age profiles of first marriage, divorcee remarriage, widow remarriage, and divorce, have all been represented by model schedules. The parameters of these schedules are projected, either from econometric models (marriage, remarriage, divorce and family size), or from trend analysis (deaths). The population model requires only projections of these parameters of the model schedules (rather than all age specific rates) to produce full projections of transitions by age. (The user may, however, override the econometric models, preferring to use "standard" age profiles, with or without uniform or age-specific scaling.)

In selecting the model schedules, emphasis has been placed upon ease of interpretability of the parameters, the success of these parameters in characterising important features of behaviour, and the goodness of fit of the schedules. For each of first marriage, divorcee remarriage, widow remarriage, and divorce rates and the distribution of family size, a gamma (or modified gamma) distribution with four parameters was used, while for death rates a modification of the formula suggested by Heligman and Pollard (1979) with up to nine parameters was adopted. These schedules were fitted, using a least squares method minimizing error in the numbers rather than rates of occurrence[1], to

1. The fitting of the schedules for each demographic transition in each year was determined by iterating on the parameters, following a search technique available from IMSL (International Mathematics and Statistical Library). Rogers and Planck (1983) have devised a general fitting program which can be used by other modellers. Unfortunately this program does not allow the user to minimize errors in numbers rather than rates of occurrence. The former is preferable in the common situation where the tails of the age profile relate to very few events.

Fertility

The two economic/demographic scenarios underlying the projections reported here assume the same continued high level of international migration and the same declining mortality rates[3]. Differences in the projected total populations are therefore predominantly the result of differences in fertility: high rates of economic growth are shown to have a dampening effect on Australia's fertility. While nuptial confinements increase under both scenarios, the rate of increase is lower when economic growth is higher (despite the slower fall in the number of married women in a high growth economy; see later). When economic growth is high, the first nuptial confinement rate grows slowly, due to the positive effects of increased numbers of first marriages, increased real income and declining infant mortality being mitigated by the negative effects of rising female wage rates and rising income support for the aged. Similarly, in the higher growth scenario, for higher order confinements, the negative influences of rising female wage rates and social security payments predominate over the positive influences of increasing income and decreasing infant mortality. As a consequence, the birth rate per married woman of childbearing age (which was 118.7 in 1980) is, by 2000, 127.0 under the low growth scenario and only 113.2 under the high growth scenario. Reflecting these figures and the population structures discussed earlier, the proportion of children in the population falls from over 25% in 1980 to (21.8, 21.5)% in the (low, high) projections in 2001. At the same time, the proportion aged 65 or more increases from 9.6% in 1980 to (12.15, 12.20)% in 2001. These

3. The two economic scenarios can be best characterized as follows: in the (low, high) growth scenario, real Gross Domestic Product per head grows at (0.0, 2.0)% per year, while the unemployment rate declines to (6.0, 2.0)% by 1990 and remains at that level. Annual international migration is set at 0.6% of the population and therefore grows from 87,500 in 1980 to 115,500 in 2000. Mortality rates are assumed to decline by 1.5% per year throughout the projection period. Further details of the assumptions made and the resultant projections are provided in Sams and Williams (1982).

Immigration and Ethnic Affairs, 1984b). It was then necessary to illustrate the value of economic-demographic linkages within population projection models via sensitivity studies comparing demographic outcomes under a number of economic scenarios (Sams and Williams, 1982, Williams and Sams, 1982). The importance of this education process should not be underestimated.

To assess the impact of different rates of economic growth on Australia's population, labour force and household formation, 20 year projections were made based on low, medium and high economic growth scenarios. Such projections will be largely determined by the structure of the population in the base year; the population already born will age by 20 years and those born during the projection period will have hardly reached adulthood by the end of the projection period. However, significant swings in fertility, marriage, divorce, labour force and household formation behaviour, with consequent effects on population, can occur. Also, in Australia as in most developed countries, significant ageing of the population will occur. For Australia two important factors exist:

(i) while continuing improvements in life expectancy will probably occur, past fertility patterns will reduce the ageing of the population: the low fertility during the Depression of the 1930's will result in a smaller group moving into the retirement ages over the next 20 years, and high fertility during the "Baby Boom" of the 1950's and 1960's has resulted in a population bulge (and its echoes) which will increase the numbers of people in the childbearing and working ages over the next 20 years; and

(ii) international migration has been, and continues to be, an important determinant of Australia's population growth, adding about as much to the population in each year as natural increase. Continued high levels of international migration will reduce the ageing of the population and increase the numbers of working age.

historical data from 1921 to 1976 for first marriage, remarriage and divorce (Williams, 1981); and from 1950 to 1976 for deaths (Brooks, Sams and Williams, 1980); see later for a discussion of the treatment of fertility/family size.

Given the substantial variation in behaviour over the long sample periods under study, the model schedules provide a robust approximation to the historical data. However, accuracy of fit was sacrificed in the pursuit of ease of interpretability of parameters. Rogers (1982) has fitted a double exponential function to Australian first marriage, remarriage and divorce data with what he considers to be superior results, at the cost of introducing a further parameter. The choice of a functional form for the model schedules requires some balancing of these demands for accuracy versus interpretability.

The Two-sex Problem

The value of the marital status disaggregation in population projections has been stated elsewhere (Keilman, 1982). In the context of demo-economic modelling, such disaggregation is of particular value in the determination of non-demographic variables, such as labour supply, household formation and consumption demands. Projections by marital status do, however, substantially increase the data requirements and complexity of the model and introduce the "two-sex problem"; i.e., the marital behaviour of men and women are complementary and the model must ensure projections are consistent. Keilman (1982) provides an excellent summary of approaches to the two-sex problem and a categorization of the requirements for its appropriate solution.

As discussed above, the IMPACT population model econometrically projects parameters of first marriage, divorcee remarriage, widow remarriage and divorce for men and women, which are then used to calculate age specific rates of marriage and divorce. However, these initial projections of marriage and divorce have been determined separately for men and women (although using similar forms of econometric equations and model schedules). Thus, there is no guarantee that there will be consistent numbers of marriages and divorces for men and women. To ensure such consistency, the model utilizes two-sex marriage and divorce models (Sams, 1981). In terms of Keilman's categorization, these models fulfill the availability, monotony, homogeneity and symmetry requirements, and in cases of excess demand fulfill the competition and substitution requirements.

For marriages (abstracting from the previous marital status of both partners), we require estimates of the probability that a woman (man) of a given age will marry a man (woman) of any age - the marriage selection distribution. The marriage rates derived from the model schedules (based as they are on gamma distributions) are equivalent to the marginal distributions of a bivariate gamma distribution. The bivariate gamma, which can provide the individual cells of the marriage selection distribution, can be fully specified from a knowledge of the parameters of the two marginal distributions and a correlation coefficient, which can be estimated. However, while data are available, this correlation coefficient has not yet been estimated, and the population model relies upon historical data to provide a stationary marriage selection distribution - an unnecessary limitation.

The marriage selection distribution is used with the initial estimates of numbers of marriages of women and men (as calculated from the model schedules and stocks of women and men) to determine two separate estimates of marrying couples by age of bride and groom. These separate estimates are reconciled using a linear programming technique in which, if there are no supply constraints, the final numbers of marrying couples in each year are given by the arithmetic mean of the number of couples as determined by the 'male' and 'female' estimates. Any excess demand for spouses of a given sex, age or previous marital status is eliminated by distributing the excess proportionately across ages and marital states.

their average expected permanent income, in real housing cost terms (Williams and Sams, 1981).

The major component of growth in Australian household formation has been population. However, there is still a significant contribution from changing headship rates and the size of that contribution increases with the level of economic growth. This model has been successful in explaining this substantial residual growth, particularly amongst non-traditional groups, in Australian household headship rates. In conjunction with the projections of population and labour force (upon which there are no feedbacks from household formation), the household projections are able to capture the impact upon household formation of changes in both demographic and economic variables. Of course, a major limitation of this approach is the decreasing relevance of the concept of the household "head" and the lack of linkage between the demographic status of the head and the composition of the whole household. Other authors, such as Ermisch and Overton (1984), have attempted to avoid these limitations in their models of household formation, but the necessary databases are not available for Australia.

SELECTED SIMULATION RESULTS

Conventional demographic projections are widely available in Australia in the publications of Government agencies (e.g., Australian Bureau of Statistics, 1982, Department of Immigration and Ethnic Affairs, 1984a). It has therefore been necessary to convince sceptical demographers of the value of a new and relatively complicated population projection facility. The first step in this process was to reproduce the projections made by more conventional means, highlighting the extra information available (i.e., the marital status dimension, the consistent labour force and household projections, and the ability to input international migration by eligibility category), and the public accessibility of the IMPACT population model (i.e., the user being able to input his or her own assumptions regarding changes in demographic variables rather than relying on those chosen by Government agencies (Sams and Williams, 1983b, Department of and the number of dependent children. Finally, six equations for labour force participation of women (i.e., married and unmarried women in three broad age groups) were estimated as dependent on variables such as female wages, demand for female labour, alternative income (Government pensions for the unmarried and spouse's income for the married) and, for married women, demand for child services. Male labour force participation was not modelled, but supplied exogenously, reflecting the relative insensitivity in the past of male labour force behaviour to changes in economic conditions.

Given its ambitious brief and its simple log-linear structure with limited simultaneity between endogenous variables and a high degree of serial correlation, the econometric model performed reasonably successfully: the coefficients on variables generally accorded with a priori expectations and the model tracked reasonably well the substantial changes in the demographic variables over the 55 year estimation period. However, probably as a result of the deficiencies noted above, the equations for the mean and variance of implied completed family size tracked poorly, particularly during Australia's baby boom over the 1950's and 1960's. The marriage and divorce equations generally performed well, with the exception of the mean and variance in age at divorce, although recent significant changes in marriage and divorce behaviour were captured less well. The modelling of labour force participation is incomplete - male rates are not modelled at all and female rates are modelled at a very aggregate level. The model would greatly benefit from specification within a more rigorous microeconomic framework, and concentration on more recent behaviour, enabling use of more reliable data series.

In modelling household formation, it is proposed that household headship rates for a demographic group depend upon the ability of members of that group to afford to form and maintain a separate household (with supply constraints being transmitted via the cost of housing). Using data from 1961 to 1976 and functional forms which constrain household headship rates to lie in sensible ranges and to follow smooth profiles acros ages, these rates were estimated for 64 age/sex/marital status groups as a function of

For divorce, a similar procedure and feasibility constraints are enforced, except that it is not the marriage selection, but married couples, distribution which is of relevance. Given that the model calculates marrying, divorcing and widowing couples by the age of both partners (see later), it is able to continually update the stock of married couples to project divorces and widowings of men and women consistently. As Keilman notes, "foreign" marital flows can lead to inconsistencies in the projected numbers of married men and women. This problem arises for Australia mainly because of separate immigration of spouses in different time periods. Thus, the model maintains a balancing matrix of migrant married couples.

The final marital flow is widowings, which are endogenised by multiplying the doubly age-specific stock of couples by the probability that one's spouse dies within the relevant time period (i.e., the relevant sex/age/marital status specific death rate). This more direct approach seems preferable to that proposed by Keilman, except on the grounds of the more substantial data requirement.

Fertility

A distinction is maintained between nuptial and ex-nuptial fertility (made possible by the availability of marital status-specific information within the model), and emphasis is placed on capturing the sequential decision-making process undertaken by a family. (However, the user is given the option of projecting fertility using "standard" age profiles of nuptial and ex-nuptial confinement rates, with or without uniform or age-specific scaling.) While ex-nuptial births are supplied exogenously as a proportion of nuptial births, the decision by married couples to have a first nuptial confinement is modelled separately from the decisions to progress from a first to a second nuptial confinement, etc. The latter decisions are determined from a distribution of implied completed family size (based on the indefinite maintenance of parity progression ratios in the year in question). This distribution is approximated by a (gamma) model schedule, the two parameters of which are modelled by, and projected using, the econometric model. Parity progression ratios can be calculated from the projected distribution of implied completed family size, and used to project confinements by parity. Adjustments are then made for stillbirths, multiple births and the ratio of the sexes at birth.

While this approach captures elements of the sequential decision-making process, its success has been limited. The model keeps no track of the age at which women have their children or their ages at the time of previous confinements; nor is the actual size distribution of families tracked. The model's performance could be improved by the projection of parity progression ratios not just for all married women as a group, but separately for each cohort of women of childbearing age in any given year. This would allow the behaviour of cohorts to be conditioned by their previous histories as well as current economic conditions. This would, however, require longitudinal fertility survey data, which are not available for Australia. Alternatively, currently available time series data could be used to construct stocks of women by age and parity, providing the basis for an historical data series of age and parity-specific nuptial (and age-specific ex-nuptial) confinement rates. These data could then be fitted with model schedules (as for marriage and divorce), whose time-dependent parameters could be econometrically modelled. This would improve the model's ability to capture both the demographic and economic influences on fertility.

The Econometric Models

The econometric model driving the IMPACT population model is based loosely on the 'new home economics'[2], which extends consumer theory by incorporating non-pecuniary aspects of consumption, such as the utility derived from children and the role of time constraints. Families are viewed as maximizing (subject to income and time constraints), their utility from the

2. Household formation is modelled and projected using a separate econometric model discussed later.

consumption of "household commodities", such as children (or "child services" - the product of the number of children and their quality or resource intensity), home-cooked meals, etc., which are produced within the household by combining market goods and services and the time of family members (which has a shadow price - the market wage rate). In this process, fertility decisions are influenced by family income and the relative prices of the number and quality of children (a major determinant of which is the shadow price of the mother's time - her wage rate). Simultaneously, participation in the labour force will be determined by the choice between time spent in work, leisure and, for married women, child-bearing and rearing. Availability of alternative income, female wages, demand for female labour and demand for child services are all relevant to this decision. The marriage decision is inter-related, being partly a derived demand for children and reflecting gains from specialization between a man and woman in the production of household commodities. For divorce the reverse of the factors affecting marriage apply.

The potential theoretical elegance and rigour of this framework is not captured in the econometric model, but is used only to suggest pertinent variables. Thirty-four log linear equations relating economic/social variables to fertility, marriage, divorce and female labour force behaviour over 1921/22 to 1975/76 were estimated (Brooks, Sams and Williams, 1982). Four fertility equations (i.e., first nuptial confinement rate, mean and variance of implied completed family size, and a child quality proxy) were estimated as dependent (with a lag) upon variables such as real income, female wages, Government pensions, infant mortality, contraceptive usage and, for first confinements, number of first marriages. Eighteen first marriage and remarriage equations (i.e., propensity, mean and variance in age for first marriage, divorcee remarriage and widow remarriage for men and women) were estimated as dependent on variables such as child services, real income, relative male/female wages, female educational attainment and contraceptive usage. Six divorce equations (i.e., propensity, mean and variance in age for divorce of men and women) were estimated as dependent on variables such as real income, relative male/female wages, Government pensions