IMPACT PROJECT

A Commonwealth Government inter-agency project in co-operation with the University of Melbourne, to facilitate the analysis of the impact of economic demographic and social changes on the structure of the Australian economy

FERTILITY, FAMILY FORMATION AND FEMALE LABOUR FORCE PARTICIPATION IN AUSTRALIA, 1922-1974

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1. INTRODUCTION

In recent years there has been a renewed interest by economists in demography, particularly fertility. The 'micro-economic' approach to fertility assumes that fertility behaviour has a strong component of economic rationality. The so-called new home economics has performed the important task of providing a clear-cut conceptual framework within which not only fertility but other inter-related family decisions can be analysed. It assumes that individuals and families use their limited resources to maximise utility from both non-traded home-produced commodities and market goods and services in the light of their preferences. Children appear as an argument in the family utility function together with other commodities.

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In this paper we have attempted to employ some of the theoretical insights to be gained from the new home economics in order to develop an empirically testable model of family formation which is designed to operate in conjunction with a general equilibrium model[1] so that detailed projections of fertility, female work force participation, first marriage, divorce and remarriage can be made. We do not claim that this, or indeed any other model, can completely capture the way in which a vast array of inter-related social and economic factors impinge upon family formation behaviour. Notwithstanding this, we are of the opinion that the incorporation within a simultaneous decision-making framework of some of the more important economic and social influences on family formation behaviour constitutes a worthwhile step towards improving the quality and usefulness of demographic projections. The approach described in this paper differs significantly from the standard methods of making demographic projections in Australia which conventionally have avoided any explicit attempt to incorporate the influence of economic and social factors within a systematic framework.[2] The standard approach often involves the use of time trends to project demographic variables. Such techniques inevitably must fail when sudden changes in the economic and social environment occur. In addition they can offer little insight into the problem of identifying the relative importance of various factors impinging on family behaviour.

The model presented in this paper has four major features :

(a) A distinction is made between the demand for child services and children *per se* which has important

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1. See Alan A. Powell, *The IMPACT Project : An Overview, March, 1977, First Progress Report of the IMPACT Project, Vol. 1* (Canberra : Australian Government Publishing Service, 1977).

2. See for example, National Population Inquiry (W. D. Borrie, Chairman), *Population and Australia : A Demographic Analysis and Projection* (Canberra : Australian Government Publishing Service, 1975), Vols. 1 and 2, pp. xxxiv + 760.

implications not only for fertility but also for other family formation and work force decisions;

(b) the growth of the family is treated as a sequential decision making process;

(c) we attempt to explain not only the probability of making a decision to change marital status (i.e., first marriage, divorce or remarriage) but the stage in an individual's life when this decision might be expected to occur; and

(d) the econometric and demographic framework adopted reflects the simultaneous nature of inter-related decision making in the context of family behaviour.

These points are briefly expanded upon below.

The household production model as developed by proponents of the new home economics views a physical number of children as an inappropriate measure of the volume of child services desired by parents. Parents demand and produce a given 'full' stock of children which is a function of both the number of children and the resource intensity of these children. Expenditure on children is treated as a 'quality' dimension which is subject to the choice of parents. If child services are a 'normal' good then demand will increase when family income increases or the price of the child service falls. But whether this increase takes the form of an increase in desired family size or an increase in quality per unit depends on the magnitude of the relative price and income elasticities of demand, the elasticity of substitution between quantity and quality, and the relative weights of quantity and quality in the production of the full stock of children.

Not only does this distinction between number and child services influence fertility decisions but it can also be expected to influence other family decisions. For example, conventional treatments of female labour force participation indicate a negative relationship between fertility and activity rates of married women. We argue that, as the demand for quality intensive children increases, there is a strong economic inducement for married women to participate in the work force in order that the family can provide the additional capital which increased child quality requires. Furthermore, we believe that marriage and demand for child services cannot be viewed as two independent processes. Specifically, we test the hypothesis that marriage behaviour is influenced by the demand for child services.

The second feature of the model is the treatment of the growth of the family as a sequential decision making process. Each increment to the family is treated as one in a series of decisions relating to family size. Estimates of total births in any time period are calculated by applying endogenously determined incremental probabilities to the 'stock' of families classified by size, at the commencement of the period.

The third feature of the model is that we attempt to explain not only the probability of making a decision to change marital status but the stage in an individual's life when such an event may occur. For any age group the ratio of females making a change in marital status decision (for example, first marriage, divorce, remarriage) to the stock of at risk females (for example, never married, married, divorced and widowed) is endogenously determined. The method employed to do this is to derive for each type of change in marital status ratio three parameters which can be used to describe the functional relationships between change in marital status ratio and female age. These three parameters, which are indicators of average age of females at the time of marital status change, variance of female ages at this time, and propensity of females to undergo marital status change, are modelled explicitly.

This feature of the model considerably increases its usefulness since it enables very detailed projections of marital status ratios to be produced. Thus, for instance, it is possible to derive from the model separate estimates of the first marriage to single female ratio by age of female for individual ages 15 through to 60 for any given year.

Finally, the model to be estimated comprises 19 structural equations, pertaining to fertility, first marriage, divorce, remarriage and female labour force participation. Since the spheres of family behaviour are inter-related, ordinary least squares estimates of the parameters of the model would be statistically inconsistent and biased as a result of the fact that many of the current endogenous variables appear as explanators in the structural equations for other endogenous variables. Accordingly, simultaneous equations techniques are used; specifically, full information maximum likelihood estimates are computed, thus ensuring statistical consistency.

2. THE NEW HOME ECONOMICS

Before proceeding to outline the particular form of the model which we have employed, it may be useful to review briefly the nature and direction of recent work in the new home economics. Whilst it provides a framework for analysing the joint nature of decisions regarding family formation, fertility, education and labour force participation, much of the empirically oriented theoretical work has concentrated on a systematic analysis of fertility behaviour. The new home economics has extended the concepts of human capital and the value of human time to a household production model.[1] In this model, the household is treated as a firm producing utility, purchasing inputs (market goods and services) and allocating its scarce time resources within a maximizing framework. In contradistinction to neoclassical economic theory, the new home economics assumes that the household does not derive utility directly from purchased commodities, but instead these factors must be first transformed into basic items of consumption called 'household commodities.' In the model children are viewed as home-produced durable assets which yield satisfaction or psychic income to parents. The flow of child services is the multiplicative result of the number of children and the 'quality' or resource intensity of children.[2] Since

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1. The seminal articles are those of Gary S. Becker, "A Theory of the Allocation of Time," Economic Journal, Vol. 75, September 1965, and Kelvin J. Lancaster, "A New Approach to Consumer Theory," Journal of Political Economy, Vol. 75, April 1966.

2. This definition of the full stock of child services as the product of quality and quantity indexes results in (a) unit elasticity of substitution between quantity and quality, and (b) homogeneity of second degree of the production function for the full stock of child services. Neither of these assumptions is essential to the theory. See for example, Dennis N. De Tray, "Child Quality and the Demand for Children," Journal of Political Economy, Vol. 81, No. 2, Pt. II, March/April, 1973, p. S72.

household commodities, including child services, are not purchased or traded in the market place, they have no explicit market price. However, since each commodity is produced with varying proportions of the household's scarce resources, each has a shadow price that will reflect the time intensity of the production processes and the value of opportunity cost of time.

The model begins with a lifetime family utility function which has as separate arguments the total number of children born N, quality per child Q, and a composite commodity S, which represents all other household production-consumption activities.[1] The family utility function is written as

(2.1) $$U = U(N, Q, S) \quad ,$$

where

N = lifetime number of children ;

Q = quality per child ; and

S = real consumption level of parents .

The level of utility the family may achieve is limited by its capacity to produce child services and the composite commodity. Under the assumptions that there is no joint production of child quality and that parents choose an equal level of child quality for each child born, the production function for the quality per child is written as the linearly homogeneous function

(2.2) $$Q = f(t_C/N, X_C/N) \quad ,$$

1. The exposition below borrows heavily from Robert J. Willis, "A New Approach to the Economic Theory of Fertility," Journal of Political Economy, Vol. 81, No. 2, Pt. II, March/April, 1973.

where t_C and X_C are respectively, the vectors of the total amount of time and goods devoted to all children during the parents' lifetime, so that t_C/N and X_C/N are the amounts of time and goods devoted to each child. Multiplying (2.2) by N, we may write

$$(2.3) \qquad C = NQ = f(t_C, X_C) \quad ,$$

where C is the total amount of child quality, or 'child services.'

The aggregate commodity S is assumed to be produced according to the linearly homogeneous household production function :

$$(2.4) \qquad S = g(t_S, X_S) \quad ,$$

where t_S and X_S are, respectively, vectors of time and goods devoted to S production. It is assumed that inputs to S do not jointly produce child quality.

In arriving at the desired lifetime levels of C and S , the family maximizes equation (2.1) subject not only to the technological constraint (equations (2.2) - (2.4)) but also to its lifetime supplies of time and goods. The resource constraints are :

$$(2.5) \qquad t_{iN} + t_{i,Q} + t_{i,S} = T_i \quad ;$$

and

$$(2.6) \qquad t_{m,L} W_m + t_{f,L} W_f + V = (X_N . P_N + X_Q . P_Q + X_S . P_S) \quad ,$$

where

i = m, f (male, female) ;

X_j = market goods and services used in the j^{th} production process (j = N, Q, S) ;

P_j = the exogenous per unit price of X_j ;

V = the exogenous level of non-labour income ;

$t_{m,L}$ = total time input of the husband in the labour market ;

$t_{f,L}$ = total time input of the wife in the labour market ;

T_i = the exogenous total time available for inputs by individual i (i = m, f) ;

W_m = the exogenously given male lifetime wage rate (per unit time) ;

W_f = the exogenously given female lifetime wage rate (per unit time) .

Since time can be exchanged for goods at the market wage rate, the time and budget constraints can be combined into a 'full wealth' or lifetime resource constraint ,

(2.7)
$$I_y = T_m.W_m + T_f.W_f + V ,$$
$$= \pi_C.NQ + \pi_S.S = \pi_C C + \pi_S S ,$$

where I_y is the household's lifetime full wealth and π_C and π_S are the shadow prices of C and S . In order to measure real rather than nominal full wealth, S could be chosen as the numéraire commodity and π_S , its shadow price, set equal to unity. The demand functions for N, Q, and S are derived by maximizing the utility function (equation

2.1) subject to the full wealth constraint (equation 2.7), where I_y, π_C, and π_S are treated as parameters. Maximizing the Lagrangian expression,

$$U(N, Q, S) - \lambda(I_y - \pi_C NQ - \pi_S S) , \tag{2.8}$$

where λ is a Lagrange multiplier $(\lambda > 0)$, the following first-order conditions for a maximum are obtained[1] :

$$U_N - \lambda\pi_C Q = 0 ;$$

$$U_Q - \lambda\pi_C N = 0 ;$$

$$U_S - \lambda\pi_S = 0 ;$$

$$\pi_C NQ - \pi_S S + I_y = 0 .$$

This yields the marginal equalities

$$\frac{U_N}{\pi_C Q} = \frac{U_Q}{\pi_C N} = \frac{U_S}{\pi_S} = \lambda , \tag{2.9}$$

where $\pi_C Q = P_N$ is the marginal cost of an additional child of given quality, $\pi_C N = P_Q$ is the marginal cost of raising the quality per child given the number of children, $\pi_S = 1$ is the marginal cost of the parents' standard of living, and λ is the marginal utility of money income.

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1. The convention adopted is that $\frac{\partial U}{\partial N}$ is written as U_N ; and so on.

Equation (2.9) tells us that when the family's utility is a maximum, it consumes N, Q and S in such a combination that the marginal utilities of the number of children, quality per child, and parents' standard of living are proportionate to their prices. A dollar spent on N for example, will add as much to the family's utility as a dollar spent on Q or S. Thus parents must not only equate the utility they receive from the flow of child services against the satisfactions derived from the aggregate household commodity, but they must also decide whether to increase family size or to raise the quality of a given number of children.[1] The micro-economic theory of fertility is concerned with analysing the effects of the differences in the price of time of parents that enter directly and indirectly into the production of child services. In order to generate testable hypotheses it is usually assumed that the bearing and rearing of children is intensive in the use of female's time, whereas the male specialises in market production. Most empirical studies have found a negative relationship between the female opportunity wage rate and family size.[2] The rising value of female time leads families to substitute a smaller number of high quality children for a larger number of low quality children, and therefore helps to explain the decline in family size over time. In cross-sectional studies this negative substitution effect is offset by an income effect associated with a positive correlation between male earnings and family size.[3] While the model

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1. Ibid., p. S26.

2. Dennis N. De Tray, op. cit., p. S87 ; also Kenneth Maurer, Rosalinda Ratajczak and T. Paul Schultz, Marriage, Fertility and Labour Force Participation of Thai Women : An Econometric Study. R-829-AID/RF. Santa Monica, California : RAND Corporation, April 1973; also Julie Da Vanzo, The Determinants of Family Formation in Chile, 1960 : An Econometric Study of Female Labour Force Participation, Marriage and Fertility Decisions. R-830-AID, Santa Monica, California : RAND Corporation, August 1972 ; also Marc Fulop, "A Dynamic Disequilibrium Model of Population Growth for the United States," unpublished Ph.D. thesis, Department of Economics, New York University, 1975.

3. De Tray, op. cit..

represents a prediction on child services it cannot predict a priori the outcome of an income change on the demand for child numbers or expenditure for a given number of children unless assumptions are made about the structure of family tastes.[1]

The new home economics approach to fertility is mainly a theory about the demand for children. The biological factors which shift the 'supply curve' of children, while of concern to demographers, have received little attention from economists. Supply considerations, such as contraception and infant mortality, are brought into the micro-analysis of fertility to the extent that they alter the relative prices of number and quality of children. However, it is fairly obvious that if children are in excess demand then fertility is dominated by supply considerations.[2]

Because the conventional household production model is of the one-period, static-state variety, it is assumed that decisions about ultimate family size are made at one point in the life cycle (usually at the time of marriage), on the basis of lifetime resource and wealth constraints. The importance of children in determining marriage behaviour is recognised in recent extensions of the new home economics,[3] but the theoretical and operational significance of this interpretation has not been handled explicitly.

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1. See Willis, op. cit., pp. S27-28.
2. Yoram Ben-Porath, "Notes on the Micro-Economics of Fertility," International Social Science Journal, Vol. XXVI, No. 2, 1974.
3. Gary S. Becker, "A Theory of Marriage : Part I," Journal of Political Economy, Vol. 82, Part II, March/April, 1974, pp. S11-S33.

The model fails to analyse the way families adjust their fertility to disequilibrium situations. For example, a failure on the part of the family to attain its target standard of living may have important implications for its fertility behaviour and labour force participation. Furthermore, reproduction occurs sequentially which makes it essential that the framework of constrained choice be widened to analyse the incremental nature of the family formation process.

The predeliction of the new home economics toward the consumer durable aspects of children has led to a comparative neglect of the necessity to explain the investment in children as a producer or capital good. This has resulted in an oversimplification of the analysis of the allocation of the household's resources to the bearing and rearing of children. For example, in the standard micro-theory of fertility, expenditures on children's education serve to increase psychic income to parents by augmenting child quality. But if children are viewed in part as producer durables, then the decision to invest in child schooling will be influenced by a complex set of factors, including the sex of children as well as their parents' evaluations of the returns from education as viewed in an inter-temporal decision-making context.[1]

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1. Allen C. Kelley, review article in Journal of Economic Literature, Vol. XIV, No. 2, June, 1976, p. 520.

3. A MODEL OF FERTILITY, FAMILY FORMATION AND FEMALE WORKFORCE PARTICIPATION

The approach which we now outline freely uses concepts drawn from the new home economics as sketched above. The work is exploratory, and at this stage we have not followed in detail the procedure of mapping from constrained utility maximization into behavioural equations. We have, however, introduced dynamic ideas lacking in the prototype of Section 2, and as well have modified the theory to take into account that it will be applied to aggregate data. In particular, we introduce below equations to explain, at any given point of time, the variance among individuals of key endogenous variables. This procedure is of considerable importance in the subsequent derivation of a framework within which to project through time the distributions over individuals of demographic characteristics.

3.1 Fertility

In common with some of the more recent economic studies,[1,2] the growth of the family is treated as a sequential decision making process. The method, which is described below, is based on the hypothesis that families make decisions about their intended completed family size and that these decisions can be subject to revision over time. We specify four basic equations :

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1 J. J. Heckman and R. J. Willis, in N. E. Terleckyi (ed.), Household Production and Consumption (New York : Columbia University Press), forthcoming.

2 R. T. Michael and R. J. Willis, in N. E. Terleckyi (ed.), op. cit..

$$(3.1) \qquad N_t = f_1 \left\{ (Wf)_{t-1},\ Y_{t-1},\ I_{t-1},\ (O)_{t-1},\ Z^*_{t-1},\ R_{t-1} \right\}$$

$$(3.2) \qquad Q_t = f_2 \left\{ (Wf)_{t-1},\ Y_{t-1},\ I_{t-1},\ (O)_{t-1} \right\}$$

$$(3.3) \qquad (Nv)_t = f_3 \left\{ (Wf)_{t-1},\ Y_{t-1},\ Q_{t-1},\ (O)_{t-1},\ Z^*_{t-1},\ R_{t-1} \right\}$$

$$(3.4) \qquad \Gamma^*_t = f_4 \left\{ (Wf)^*_{t-1},\ Y^*_{t-1},\ R^*_{t-1},\ I^*_{t-1},\ (wMf)^*_t,\ (O)^*_{t-1},\ Z^*_{t-1},\ A^*_t \right\}$$

where each f_j is a linear function including a constant and where unstarred symbols stand for the logarithms of the corresponding variables. The symbol N^*_t represents the implied lifetime number of children demanded by a family who have their first child in year t ; Q^*_t is an index of quality per child; $(Nv)^*_t$ is the variance associated with implied completed family size by families having their first child in year t ; Γ^*_t is the number of first nuptial confinements occurring in t ; $(Wf)^*_t$ is the real hourly female wage in t ; Y^*_t is real per capita income in t ; R^*_t is the real value of the old age pension in year t ; $(O)^*_t$ is the level of oral contraceptive usage in t ; I^*_t is the infant mortality rate in t ; Z^*_t is a dummy variable for World War II; $(wMf)^*_t$ is a weighted series of number of first marriages in the year t and in previous years ; and A^*_t is a dummy variable for postponed first births.

In the current notation, the level of child services is written C^*_t , and, as a matter of definition, $C^*_t \equiv N^*_t Q^*_t$. As noted above, adoption of this (Cobb-Douglas) functional form as a definition of child services implies that the elasticity of substitution between child numbers and quality is set a priori to unity.

Equations (3.1) and (3.2) respectively are the demand functions for the number and quality of children. In logarithmic terms, the demand for child services is the sum of these two equations, and has as arguments the variables listed in them (i.e., the variables listed for (3.1), which include those of (3.2) as a subset). The rationale underlying the choice of variables on the right of (3.1) and (3.2) is given below in our discussion of the variables themselves.

Equation (3.3) recognizes the fact that the data to which the model will be fitted are aggregative, rather than micro (i.e., the data consist of national averages, rather than a set of observations on individual households). The variance (as well as the mean) over households of implicit completed family size would be expected to change in response to changes in the average levels of the variables determining the mean values of family size and average quality of children.

Finally, equation (3.4) represents the demand for first (nuptial) confinements. While our model is primarily concerned with variables that influence completed family size, it is also necessary to consider the factors which have a bearing on the initial decision to consume child services. For this reason we include an equation to explain first nuptial confinements. Since first nuptial confinements could be argued to be related to the product of the probability of recent marriages resulting in first nuptial confinements and the number of recent marriages, the equation is specified in a linear form. In addition to recent first marriages, it is expected that those factors which determine the volume of child services demanded will also influence this initial decision to begin consuming child services.

All explanatory variables, with the exception of weighted first marriages in the first nuptial confinements equation, are lagged one year in order to reflect the social and economic environment at the time at which the decision to have an additional child was made.

We now consider suitable definitions for the variables introduced above in the context of making our theory operational.

<u>Mean $(N)_t$ and variance $(Nv)_t$ of implied completed family size for a family having their first child in year t</u>

These two variables are derived from parity progression data.[1] If $p_{\tau t}$ is the probability, estimated at period t of a married female with τ children (with $\tau \geq 1$) having at least one additional confinement, then, given that a couple make a decision to have children the probability, $f_t(n)$, of having a completed family size of n children is

$$(3.5) \qquad f_t(n{:}n \geq 1) = (1 - p_{nt}) \left(\prod_{\tau=0}^{n-1} p_{\tau t} \right) ,$$

where $p_{0\tau} \equiv 1$.

Among families having children, therefore, the mean and variance of implied completed family size are

$$(3.6) \qquad N_t^* = \sum_{n=1}^{k} nf_t(n)$$

and

$$(3.7) \qquad (Nv)_t^* = \sum_{n=1}^{k} (n - N_t)^2 \;,\; f_t(n) \quad ,$$

where k is the upper limit to completed family size.

1. Annual parity progression information for Australia was kindly supplied to us by Geraldine Spencer.

Quality per child (Q)

Constructing an operational measure of quality per child is a complex task. We use the amount of private and government expenditures on education at constant prices per child aged 5 to 19 as a proxy for the quality or resource intensity with which children are produced. It is clear that this variable has several limitations. First, in the household production model, child quality includes all expenditures on children, whereas the scope of the measure used here is more limited. We assume, however, that quality per child is highly positively correlated with education expenditures per child aged 5 to 19. Second, the chosen variable does not distinguish between private and government school education where some of the variation in child quality may be occurring.

Real female hourly wage rate (Wf)

The demand for child services is determined by the costs and benefits of bearing and rearing children. There are two sorts of costs : opportunity costs of time parents spend with their children and pecuniary costs of goods and services needed to feed, clothe and educate a child.[1] The opportunity cost of parents' time is a significant cost of children, since children are time-intensive commitments. Because the wife is usually in charge of child care, the opportunity cost of her time in child care could be expected to be more important than the opportunity cost of the husband's non-market time.

An increase in the market value of the wife's time would lead to a substitution away from child services toward the aggregate commodity S if the structure of the household utility function were such that the substitution effect of the increase outweighed the income effect. The structure of the utility function could well involve net substitutability between N and

1. T. Paul Schulz, "An Economic Model of Family Planning and Fertility," Journal of Political Economy, Vol. 77, No. 2, March/April, 1969, p. 154.

Q and between N and S , but net complementarity between Q and S . Then a utility-compensated rise in the female wage would involve a fall in N but a rise in Q . This would be one factor generating a tendency for Q and S to move in the same direction.[1]

In the model the operational measure of the price of child services is the female hourly wage rate. We expect that as the real opportunity cost of non-market time rises, demand for child services will fall and that the reduction in quantity demanded will be mainly in N rather than Q.

Full income (Y)

An increase in full income is expected to increase desired family size and quality per child at a specified set of 'prices'. But since full income consists of wage income as well as non-wage income, the source of change in family income is likely to affect the direction of change in demand for child services. Suppose that the consumption of market goods and services involves complementary inputs of time (tourist accommodation is a case in point). Then, for example, if an increase in full income is attributable to a rise in real female wage rates, the initial positive income effect might be offset by a negative substitution effect because the increase in female wages could also increase the value of time and hence the 'full prices' of commodities, especially those whose consumption is time-intensive. On the other hand, it is usually assumed that an increase in non-wage income, because it does not increase the implicit costs of household production, will give rise to a 'pure' income effect.[2] Unfortunately, data on non-wage income are only available for part of the period of the study. In the model we use real gross domestic product per head as a surrogate variable for full income.

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1. Willis, op. cit., p. S.28.

2. Da Vanzo, op. cit., p. 32.

Level of social security (R)

Factors which reduce the benefits of children operate, *ceteris paribus*, to reduce the demand for children. The prediliction of the new home economics toward the cost-of-time hypothesis has led to a comparative neglect of factors that have a bearing on returns from children. It is quite possible that the secular decline in fertility and the reduction in the variance of completed family size may partly be due to the diminished importance of children as a source of economic security to their parents, especially in old age. In this regard the extension of government into the provision of social security would appear to have been of significance in lowering the returns to child services realized by parents.[1,2] We therefore include the old age pension in equations (3.1), (3.3) and (3.4).

World War II dummy variable (Z) and postponed births (A)

Parents can be expected to desire fewer children in times of international conflict. Whilst this factor may affect the overall demand for child services it is most likely to result in a reduction in N rather than in Q, since in these circumstances parents may well consider that expenditure per unit must be maintained in order to increase the probability that their children eventually will be able to fend for themselves successfully in an increasingly difficult environment.

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1 Zvi Griliches, "Comment," *Journal of Political Economy*, Vol. 82, No. 2, Part 11, March/April, 1974, p. S.220.

2 A recent cross-sectional study of 67 countries concluded that social security programs have had a significant negative effect on subsequent fertility levels. See C. F. Hohm, "Social Security and Fertility : An International Perspective," *Demography*, Vol. 12, No. 4, November, 1975, p. 629.

To some extent the reluctance to undertake additions to the family in times of uncertainty is not a permanent decision but rather a postponement of a decision to increase family size. This is particularly true in the case of first births where it is unlikely that a family would, as a result of war, make a permanent decision not to have any children. It is more likely that their decision will involve a postponement until they are more optimistic about the future. We therefore include a postponed births variable, A, in the first nuptial births equation (3.4).

It might be that uncertainties arising from the international situation would induce a downward revision of intended family size in those families where there had previously been plans for a larger than average size family, since the risks of having a large family in such times could be perceived as being high. A reduction in planned family size would be a relatively simple matter for these types of families. It is for these reasons that the war dummy has been included in the variance of family size equation.

Level of oral contraceptive usage (O)

This variable is included in equations (3.1), (3.2), (3.3) and (3.4). Whilst there is a cost involved in having additional children, there is also a cost involved in refraining from having children. Fertility control cannot be regarded as costless. Willis has demonstrated that the marginal fertility-control cost per birth averted operates effectively as a per unit subsidy to childbearing. This means that a decrease in the marginal cost of fertility control, caused by an improvement in birth control technology will increase the price of quantity, N, relative to quality, Q, and thereby reduce desired family size and induce substitution toward quality in the production of child services.[1]

Infant mortality rate (I)

This variable is included in equations (3.1), (3.2) and (3.4). Fluctuations in child mortality rates have an influence both on the desired family size and the amount of expenditures per child. A decrease in child mortality rates reduces the tendency for parents to have more children than are actually desired in order to compensate for any losses which may occur through child mortality.[2,3] In addition to this, a decrease in child mortality changes the certainty-equivalent relative price ratio between quantity and quality. A given family size needs relatively less risk discounting to allow for prospective infant mortality than previously; to the extent that this effect is proportionately greater in small than in large families, higher quality smaller families gain in attractiveness vis-à-vis larger lower quality families yielding the same expected flow of child services.[4] These two considerations would suggest that decreases in child mortality rates would be associated with smaller family sizes. However, there is a third consideration which could lead to a positive relationship between child mortality and family formation. Child mortality (and maternal mortality associated child birth) represent one of the pecuniary and psychic costs associated with having children. If child mortality is reduced then the cost of having an additional child is reduced and this, in

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1. Willis, op. cit., p. S29.
2. Schultz, op. cit., pp. 160-161.
3. De Tray, op. cit., p. S79.
4. Donald J. O'Hara, Changes in Mortality Levels and Family Decision Regarding Children. R-914-RF. Santa Monica, California : RAND Corporation, February, 1972.

turn, could lead to an increase in desired family size. It can be seen therefore that the net effect of child mortality on desired family size cannot be predicted a priori but depends on the relative strengths of the three factors discussed above.

Weighted first marriages (wMf)

This variable is included in equation (3.4), because the number of first nuptial births occurring in any period obviously depends on the number of recent first marriages and on the decisions about the timing of children taken by the recently married couples. In order to cater for this the weights used in the construction of the variable represent the frequency of various intervals between first marriage and birth.[1] If marriage is regarded as the initial step in a sequential process which may lead to a demand for child services, then it would seem appropriate to incorporate such a variable in the first nuptial confinements equation.

3.2 Marriage

Patterns of marriage behaviour have important implications for the number of births, labour force participation of women and the distribution of income. The economic analysis of marriage behaviour is closely identified with the work of Gary S. Becker.[2] The Becker model of marriage applies the framework of constrained choice to the marriage decision. According to this model, people decide to marry when they expect to enjoy some flow of

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1. L. T. Ruzicka, "Age at Marriage and Timing of the First Birth," Population Studies, Vol. XXX, No. 3, November, 1976, pp. 527-38.

2. Op. cit..

'real' income which is greater than that which they could receive if they remained single. Children provide an important source of psychic income to their parents and it is argued that the demand for child services provides a major impetus to the decision to get married not only in the first instance but also in remarriage decisions.

Becker asserts that since many men and women compete as they seek mates, a market in marriages can be presumed to exist. The decision to marry can then be viewed in two stages. First, a person decides when to enter the marriage market. The age of entry into the marriage market would be earlier the larger the demand for child services and the higher the expected lifetime income. On the other hand, as alternatives to marriage become more attractive to women, they will postpone entry at the margin. Obvious alternatives are schooling and labour force participation. Second, once in the marriage market, a person searches for an appropriate partner. The length of period of search will be influenced by the perceived additional benefits of searching to find an improvement in the prospective mate relative to the cost of time and other inputs necessarily involved in further search.[1] The model of marriage presented below concentrates on the factors which might influence the age of entry into the marriage market and the length of the period of search.

First marriage and remarriage

First marriages (variables prefixed M) and remarriages (variables prefixed R) are treated separately in the model. Separate equations are developed for propensity to marry ((Mp and Rp)), age at marriage ((Ma) and (Ra)),

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1. Becker, "A Theory of Marriage : Part II," op. cit., p. S21-22.

and variance among individuals of age at marriage ((Mv) and (Rv)). The equations are :

(3.8) $(Mp)_t = f_5\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (H/Wf)_t\ X^*_t, (O)_t, Z^*_t\}$;

(3.9) $(Ma)_t = f_6\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (H/Wf)_t, X^*_t, (O)_t, Z^*_t, (Ma)_{t-1}\}$;

(3.10) $(Mv)_t = f_7\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (H/Wf)_t, X^*_t, (O)_t, Z^*_t\}$;

(3.11) $(Rp)_t = f_8\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (O)_t, Z^*_t\}$;

(3.12) $(Ra)_t = f_9\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (O)_t, Z^*_t\}$;

(13.13) $(Rv)_t = f_{10}\{(Wf/Wm)_t, Y_t, (NQ)_t, (Ef)_t, (O)_t, Z^*_t\}$,

where the f_j are all linear functions including constants, and where all all unstarred variables are in logarithmic form. Thus, (Mp) is the log of the propensity to marry a first time; (Ma) represents the log of a measure of age of females at first marriage; (Mv) is the log of the variance of age at first marriage; (Rp) is the log of the propensity to remarry; (Ra) is the log of the age of females at remarriage; (Rv) is the log of the variance of age at remarriage; (Wf/Wm) is the log of the female/male hourly wage relativity; (Ef) is the log of a measure of female educational attainment; H is the log of the real pecuniary cost of divorce; X^* is a conscription variable; and all other variables are defined as previously. The inter-relationships between these variables are discussed below.

Divorce costs relative to real female wages (H/Wf)

The benefits from search will be greater the longer the expected duration of marriage. We would anticipate that marriage-interested persons will search more carefully and marry later (if at all) when they expect to be married longer - for example, when divorce is more difficult. In communities where divorce laws are rigid we would expect consensual unions to be more common, so that when divorce becomes easier, the proportion of persons legally married may actually increase.[1]

Conscription into the armed services (X) and effect of major international conflicts (Z)

It has been argued elsewhere[2] that conscription had an important effect on the level and timing of marriages in Australia over the period 1965-1972. In this period males who married before National Service registration were execmpt from call-up. We also include a dummy variable for the second World War.

Level of contraceptive usage (O)

An improvement in contraceptive technology might reduce the necessity to marry and consequently encourage females to delay marriage or, alternatively abstain entirely from legal marriage. This effect may be particularly important in societies where illegitimacy is anathema. We would anticipate that an improvement in contraceptive efficiency would lower the propensity to marry and increase the age and variance of age at marriage.

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1. Becker, "A Theory of Marriage : Part II," op. cit., p. S22.

2. Glenn A. Withers, "The Australian Marriage Market 1956-1986," paper read to the Conference of Economists, Hobart, May 1977; Department of Economics, Research School of Social Sciences, Australian National University, (mimeo).

Age at first marriage (Ma)

This variable, lagged one year, is incorporated into the age at first marriage equation as a surrogate for possible changes in social attitudes and institutional arrangements that might have a bearing on age at marriage.

3.3 Divorce

Divorce and separation are the result of conscious choice on the part of at least one spouse to terminate the marriage. Data limitations prevent us from modelling separation and we therefore concentrate on divorce. The factors which influence the divorce decision are basically asymmetrical to the decision to get married.

We specify three equations, one each for propensity to divorce, mean age at time of divorce, and variance among individuals of the latter variable :

$$(3.17) \qquad (Dp)_t = f_{11}\{(Wf/Wm)_{t-2}, Y_{t-2}, K_{t-2}, (H/Wf)_{t-2}, (Ma)_{t-2}\} \;;$$

$$(3.18) \qquad (Da)_t = f_{12}\{(Wf/Wm)_{t-2}, Y_{t-2}, K_{t-2}, (H/Wf)_{t-2}, (Ma)_{t-2}\} \;;$$

$$(3.19) \qquad (Dv)_t = f_{13}\{(Wf/Wm)_{t-2}, Y_{t-2}, K_{t-2}, (H/Wf)_{t-2}, (Ma)_{t-2}\} \;,$$

where each f_j is a linear function including a constant and where all variables are in logarithmic form. (Dp) is the log of the propensity to divorce, (Da) is the log of a measure of mean age at the time of divorce, (Dv) is the log of the variance of age at divorce, K is the log of the number of dependents per married female, H is the money cost of an undefended divorce; all other variables are as defined previously.

All explanatory variables are lagged two years in order to reflect the social and economic environment at the time at which the decision to separate was made. The inter-relationships between each of these variables are discussed below.

Propensity to divorce (Dp), age at divorce (Da) and variance of age at divorce (Dv)

Analogous to our treatment of first marriages and remarriages, we define $d_t(x)$ as the ratio of divorces for females of age x to the number 'at risk' (i.e., married) females in that age group, and define the propensity for divorce as :

$$(3.20) \qquad (Dp)^*_t = \int_{15}^{60} d_t(x).dx \quad .$$

The 'age at divorce' indicator is :

$$(3.21) \qquad (Da)^*_t = \int_{15}^{60} [x.d_t(x)/(Dp)^*_t].dx \quad ,$$

and the variance of age at divorce is :

$$(3.22) \qquad (Dv)^*_t = \int_{15}^{60} \{[x - (Da)^*_t]^2 \, d_t(x)/(Dp)^*_t\}.dx \quad .$$

Ratio of female to male wage rate (Wf/Wm)

For a given level of marital disharmony, a woman is more likely to seek to dissolve her marriage if she is less dependent on her husband for financial support.[1] We anticipate, *ceteris paribus*, that the incidence of divorce will be higher for women who experience better labour market opportunities. An increase in the female wage will involve a positive income effect in the demand for divorce as well as a positive substitution effect if the woman perceives marriage and workforce activity as incompatible. In addition, a woman is more likely to be dissatisfied with her husband if he is unable to provide financial support for the family; therefore, we would expect that a rise in the male wage rate would give rise to a negative income effect in the demand by women for divorce.[2] Although a rise in the male wage rate, by virtue of making the payment of alimony more feasible, would be expected to lead to a positive income effect on the demand by males for divorce, on balance we expect the oppositely signed effect on the demand for divorces by women, to dominate.

Full income (Y)

If changing from one conjugal state to another - for example, never married to married or married to divorced - involves financial costs, then, as income rises, other things being equal, there will be an

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1. Ross and Sawhill refer to this as the 'independence effect.' See H. L. Ross and I. V. Sawhill, Time of Transition (Washington, D.C.: Urban Institute), p. 52.

2. Da Vanzo, *op. cit.*, p. 28.

increased demand for changes in conjugal state. Thus we hypothesise that, a rise in income, ceteris paribus, will not only increase marriages, but also the incidence of divorce.

Number of dependents per married woman (K)

The greater the number of dependents in the family the greater the family trauma associated with a marital breakdown. It is argued, therefore, that this factor increases the (psychic) costs of divorce which would tend both to delay the timing of, and to decrease the overall propensity for, divorce.

Cost of divorce (H/Wf)

We would expect that higher real monetary costs of divorce (legal fees, etc.) will be associated with a lower incidence of divorce.

Age at first marriage (Ma)

Increases in the age at first marriage are expected to raise the age at divorce and lower the propensity to divorce, ceteris paribus. This is because marriages contracted at very young ages historically have had a very high failure rate.

3.4 The Supply of Female Labour

The supply of labour can change as a result of variation in the average hours worked by a fixed labour force, or by a change in the size of the workforce, or both. Much of the empirical work in recent years in labour economics has concentrated on labour force participation and, in particular, the activity rates of married women.[1] Several studies have analysed the decision by married women to participate in the workforce in the household production context.[2] This approach sees married women as choosing not simply between work and leisure, but between work in the home, market work, and leisure. In contrast to the married women group which consists overwhelmingly of secondary (i.e., non-head of household) workers, the group 'other women'[3] includes a significant number of primary (i.e., head of household) workers, as well as secondary labour. The workforce participation rate of single women tends to be dominated by movements in the activity rates of young workers, especially those of never married women, and of primary workers in the older age groups. Because of differences in the nature and relative importance of factors affecting the activity rates of married women and other women, we specify separate labour force participation rate equations for married women and other women. We further disaggregate these into three age groups. The six behavioural equations postulated are :

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1. B. D. Haig and M. Wood, "The Participation of Married Women in the Australian Work-Force 1961 to 1972," Institute of Labour Studies, Flinders University, Bedford Park, Working Paper Series, September 1973; also William Bowen and Aldrich Finegan, The Economics of Labour Force Participation (Princeton, 1969); Glen Cain, Married Women in the Labour Force (Chicago : University of Chicago Press 1966); Jacob Mincer, "Labour Force Participation of Married Women," in Aspects of Labour Economics, N.B.E.R., Princeton, 1962.

2. Thomas J. Kneiser, "An Indirect Test of Complementarity in a Family Labour Supply Model," Econometrica, Vol. 44, No. 9, July 1976; Arthur Kraft, "Preference Orderings as Determinants of the Labour Force Behaviour of Married Women," Western Economic Journal, Vol. XI, September 1973; Glen G. Cain and Martin D. Dooley, "Estimation of a Model of Labour Supply, Fertility and Wages of Married Women," Journal of Political Economy, Vol. 84, No. 4, Part 2, August 1976.

3. Never married, widowed and divorced.

(3.23) $[Lmw(15\text{-}24)]_t = f_{14}\{(PWf)_t,\ (PY)_t,\ U_t,\ B_t, Q_t,\ (O)_t,\ Z^*_t,\ [Lmw(15\text{-}24)]_{t-1}\}$

(3.24) $[Lmw(25\text{-}54)]_t = f_{15}\{(PWf)_t,\ (PY)_t,\ U_t,\ B_t,\ Q_t,\ (O)_t,\ Z^*_t, [Lmw(25\text{-}54)]_{t-1}\}$

(3.25) $[Lmw(55\ +)]_t = f_{16}\{(PWf)_t,\ (PYf)_t,\ (PY)_t,\ U_t,\ Z^*_t,\ [Lmw(55\ +)]_{t-1}\}$;

(3.26) $[Low(15\text{-}24)]_t = f_{17}\{(PWf)_t,\ (PY)_t,\ U_t,\ Z^*_t,\ [Low(15\text{-}24)]_{t-1}\}$;

(3.27) $[Low(25\text{-}54)]_t = f_{18}\{(PWf)_t,\ (PY)_t,\ U_t,\ (G/PWf)_t,\ Z^*_t,\ [Low(25\text{-}54]_{t-1}\}$;

(3.28) $[Low(55\ +)]_t = f_{19}\{(PWf)_t,\ (PY)_t,\ U_t,\ (G/PWf)_t,\ Z^*_t,\ [Low(55\ +)]_{t-1}\}$,

where the f_j are all linear functions including constants, and where all unstarred variables are in logarithmic form. (Lmw) is the log of workforce participation of married women (by age group); (Low) is the log of the workforce participation rate of other women (by age group); (PWf) is the log of the expected real wage rate of females; G is the log of the amount of widows' pension; (PY) is the log of a measure of permanent income; U is the log of the unemployment rate; B is the log of the number of nuptial births per married women aged 15 - 44 years; and all other variables are as defined previously. The definition of, and inter-relationships among these variables are discussed below.

Participation rates (Lmw) and (Low)

These variables are calculated for each group as the number of women in the workforce expressed as ratio of total women in the same age and marital status group.

Expected real female hourly wage rate (PWf)

The conventional micro-theory of choice between market work and non-market activity predicts that a positive substitution effect in the supply of female labour to the market will be associated with an increase in the female wage rate, but that such an increase will have a negative income effect on female labour supply if the demand for non-market activity by females is a normal good. Hence, the uncompensated wage effect cannot be predicted *a priori* since it may be of either sign. However, the traditional theory is not particularly helpful to the analysis of participation decisions because it is couched in terms of hours of work supplied, whereas

> "the participation decision is one which usually involves non-marginal changes in the allocation of time."[1]

We expect that increases in the female wage will lead to at least a small increase in offered participation on the part of those females not presently in the workforce, without any short-run effect on the participation of those who are already members of the workforce.[2,3]

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1. Laurence C. Hunter, "Some Problems in the Theory of Labour Supply," *Scottish Journal of Political Economy*, September 1970, p. 42.

2. Yoram Ben-Porath, "Labor-Force Participation Rates and the Supply of Labor," *Journal of Political Economy*, Vol. 81, No. 3, May/June 1973, p. 703.

3. Sustained higher wage rates could, through increasing the ability to save, lead to earlier withdrawal or retirement from the labour force in the longer run.

In the case of married women and single female household heads the effect of an increase in the female market wage rate will depend on the marginal rates of substitution between market work and leisure and between household work and market work and on the strength of the income effect. The important price relationship is that between the value of work in the home and in the market. The reduction in time spent at home brought about by the substitution of time from household to market activity will have to be offset by the substitution of goods or of hired labour services for the female's time in household work. If wage goods can be substituted for home goods, and their relative price has fallen due to the increase in the female wage rate, then substitution of market produced goods for home produced goods and increased female workforce participation are more likely.[1] Because this is the key trade-off, the female wage rate should be expressed relative to the price of consumer goods and services : that is, the real female hourly wage rate is the relevant variable. Furthermore, because the decision to participate in the workforce involves major changes in how women allocate their time, labour force participation is more likely to take place if the change in wage rates is regarded as permanent. It is for this reason that we include an 'expected' female wage rate variable, which is a weighted average of previous wage rates.[2]

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1. Hunter, op. cit., p. 42.

2. A truncated lag scheme was adopted such that

$$(PWf)_t = \sum_{\tau=1}^{5} w_\tau \, (Wf)_{t-\tau} \; ,$$

where

$$w_1 = .2403, \; w_2 = .23256, \; w_3 = .21706,$$

$$w_4 = .18605, \; w_5 = .12403 \; .$$

(These weights follow the mirror image of a cumulative geometric distribution.)

Unemployment (U) and Permanent Income (PY)

The most frequently used measure of job opportunity is the unemployment rate and there are several empirical studies which indicate that activity rates of females are negatively associated with increases in the rate of unemployment.[1] Cyclical changes in unemployment affect the probability of an attempt to find a job being successful; so that, if the rate of unemployment rises, the expected return from attempting to find a job will fall. This can be expected to have a negative effect on participation, the so-called 'discouraged worker effect.' On the other hand, a decrease in family incomes brought about by an increase in unemployment will generate an 'additional worker effect' as secondary workers are induced to enter the labour force to compensate for the loss of family income. Because transitory income is likely to be highly correlated with changes in the unemployment rate in time series data, we do not attempt to include both the unemployment rate and a measure of transitory income. In fact, we have included the unemployment rate only. Of course, the sign of this variable's coefficient cannot be predicted *a priori* because it will represent the net outcome of discouraged and additional worker effects.

It is expected that longer run increases in the unemployment rate will lead to higher rates of participation of secondary workers because of lowered family permanent incomes (particularly of married women and of some categories of young single women). For this reason, a permanent income variable is included in the married women labour force participation equations.[2]

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1. See for instance, Haig and Wood, *op. cit.*, Bowen and Finegan, *op. cit.*, Mincer, *op. cit.*, and Cain, *op. cit.*.

2. The procedure for computing a permanent income variable was analogous to the method used to estimate the expected female wage rate, with the exception that the observation period included current income as well as the previous four years.

In the case of young single women students, we assert that since the indirect costs of education (loss of earned income) as well as the direct costs (fees, stationery, etc.) are borne mainly by the parents, the period of time spent by dependents in full-time education will be positively related to family permanent income, so that we would expect the labour force participation rate of single women aged 15-24 to be negatively related to permanent income.

Fertility (B), (Q)

A woman is less likely to be in the labour force the greater are the opportunity costs of her participating. The opportunity costs of market work will be foregone household production, and these are likely to be high if a woman is married and has children. However, the presence of children has a substitution effect and an income effect on labour participation. Because young children require personal care (especially female time) which cannot be achieved by the purchase of wage goods, the additional responsibility associated with bearing and rearing children raises a woman's opportunity costs of participating in the workforce which could be expected to lead to a substitution away from market work to home production. Put in another way, a significant cost of fertility is the loss of earned income to the family brought about by the reduction in female labour force participation. This substitution effect suggests a negative relation between nuptial fertility and the activity rates of married women aged 15-54. On the other hand, the income effect works in the other direction. For a given level of family income the presence of additional children raises family consumption requirements while also lowering income per family member : hence the need for the wife or female head to work to supplement family income.[1] It is anticipated

1. Da Vanzo, op. cit., pp. 14-15.

that, as the demand for child quality Q increases, there will be a strong income incentive for women to participate in market work to raise family income.

Wealth effects (PY)

For older workers it is necessary to allow for the possibility that rising real wage rates, by accelerating asset accumulation may induce an increase in leisure through earlier retirement rather than simply through a reduction in average hours of work. It is quite likely that there is a trade-off between current leisure (reduced hours of work per week or per year) and leisure in the future (earlier retirement) over a given span of working life. If labour does forego current leisure potential for greater future leisure in the form of earlier retirement, then, as income increases over the life cycle, we could expect this to be reflected in falling participation rates around the conventional retirement age. We would expect that the labour force participation rates of married women and single women 55 and over will be inversely related to non-wage related income. It is also possible that activity rates of single women in the 25 to 54 age group will decline at the margin when asset income increases. Unfortunately, there is very little statistical information available on non-wage income in Australia, and we use a permanent income variable as a surrogate variable for asset income.

Government widow pension (G/PWf)

For other women in the older age groups it is necessary to allow for the possibility that governmental assistance to widows may reduce the incentive to participate in market work.[1] The opportunity cost of non-

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1. The widow pension covers divorced and deserted mothers as well.

participation for a large proportion of other women in the older age groups may not be adequately reflected in the current wage rate since the amount of earned income foregone from non-participation will be at least partially offset by government income subsidies. It is expected that activity rates of single women 25 and over will be negatively related to the widow pension deflated by the expected female wage rate.

Effect of major international conflicts (Z^*)

In times of war when significant numbers of males are engaged in the armed services we expect an increase in the participation rates, both of married and other women.

Labour force participation rates (Lmw), (Low)

Labour force participation rates, lagged one year, are included in each equation because movement into and out of the work force is not considered to be an instantaneous process.[1]

Contraception (O)

Improvement in contraceptive efficiency, by lowering the probability of unanticipated pregnancies, facilitates the entry of females into the workforce. Females could be expected to find the option of workforce participation relatively more desirable in an environment where they can plan ahead and make conscious decisions regarding their length of stay in the workforce. We therefore expect improvements in contraceptive efficiency to cause a positive shift in the labour supply curve for married females in the 15-24 and 25-54 age groups.

1. See Ben Porath, "Labor-Force Participation Rates and the Supply of Labor," op. cit., pp. 700-1.

4. EMPIRICAL ESTIMATION OF THE MODEL

4.1 Estimation Technique

The simultaneous system described above was estimated separately in two structurally unrelated blocks from annual data for Australia covering the period 1922-1974 using Full Information Maximum Likelihood (FIML).[1,2] Ordinary least squares (OLS), the most commonly used single-equation regression technique, will yield optimal estimators under certain conditions. In particular, it is necessary that the explanatory variables appearing in an equation are predetermined outside that equation, which implies (at least in the probability limit) that these variables are uncorrelated with its stochastic error term. If, however, some of the explanatory variables are endogenous to the model, it is a matter of logical necessity that they will be correlated with the structural error term in every equation. In this case, OLS will produce biased and inconsistent estimates.

The FIML technique is a systems method designed for estimating the structural coefficients of a simultaneous equation system. It involves the application of the maximum likelihood principle to all stochastic equations of the system simultaneously, which guarantees the consistency of the estimates of the structural coefficients. Because FIML takes into account the correlations between the disturbances of different structural

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1. C. R. Wymer, Computer Programs : Resimul Manual, London School of Economics, 1973 (mimeo).

2. Unfortunately, the divorce equations had to be estimated separately for the period 1949-50 to 1973-74 because of data lacunae. While H. P. Brown has estimated a divorce series for females prior to 1950, this series is unsatisfactory for our purpose because he assumed a constant age distribution of divorces in order to convert total divorces into divorces by age of female.

equations, its estimators are more efficient in large samples than limited information (e.g., single equation) techniques.

Child services, marriage, divorce and female labour force participation are considered to be subject to family choice and therefore endogenous to the model. An equation for each of these endogenous variables is estimated to close the model. The female wage rate, income per head, old-age pension, infant mortality, contraception, unemployment rate, sex-specific relative wage rates, female education, conscription, international conflict, number of dependents per married female, the widow pension and the nuptial birth rate are treated as exogenous to the model.[1]

All equations, with the exception of the first nuptial births equation, are assumed to be log-linear in all variables. The specification of this functional form is based on both theoretical arguments[2] and empirical evidence[3] which support non-linearity between explanatory variables and family size. The specification of each equation in the model is presented in Table 4.1. OLS and FIML estimates of the parameters of each of these equations are presented in Tables 4.2 to 4.5 below. The discussion of results refers to the FIML estimates except where comparisons are made.

Whilst the specification of the model as described in Section 3 requires a cost of divorce series in both the marriage and divorce equations,

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1. The current nuptial birth rate which appears as an explanatory variable in equations Lmw (15-24) and Lmw (25-54) was 'purged' because it is an output of the fertility model; that is, the birth rate was initially regressed on all of the predetermined variables (instruments) and was replaced by its reduced form estimate. This procedure ensures that the estimated values of the birth rate will be uncorrelated in the probability limit with the structural terms in our model, and hence FIML will yield consistent estimators.

2. Willis, "A New Approach to the Economic Theory of Fertility Behaviour," op. cit., pp. S14-64.

3. Ben Porath, "Economic Analysis of Fertility in Israel : Point and Counter-point," Journal of Political Economy, suppl. 81:2, II, March/April 1973, pp. S202-33.

TABLE 4.1 : THE MODEL: A LIST OF THE VARIABLES [a]

Implied completed family size is estimated as a function of:

- Real female hourly wage (lagged one period)
- Real income per head (lagged one period)
- Real old-age pension (lagged one period)
- Infant mortality rate (lagged one period)
- Contraception (lagged one period)
- World War II dummy (lagged one period)

Child quality is estimated as a function of:

- Real female hourly wage (lagged one period)
- Real income per head (lagged one period)
- Infant mortality rate (lagged one period)
- Contraception (lagged one period)

Variance of implied completed family size is estimated as a function of:

- Real female hourly wage (lagged one period)
- Real income per head (lagged one period)
- Real old-age pension (lagged one period)
- Contraception (lagged one period)
- World War II dummy (lagged one period)
- Child quality (lagged one period)

Table 4.1 (Cont'd)

First nuptial confinements are estimated as a function of:

Real female hourly wage (lagged one period)

Real income per head (lagged one period)

Real old-age pension (lagged one period)

Infant mortality rate (lagged one period)

World War II dummy (lagged one period)

Postponed births (lagged one period)

Weighted first marriages

Contraception (lagged one period)

Propensity to first marriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [(b)]

Female education

Conscription dummy

Contraception

World War II dummy

Age at first marriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [(b)]

Female education

Conscription dummy

Contraception

Age at first marriage (lagged one period)

World War II dummy

Table 4.1 (Cont'd)

Variance of age at first marriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [b]

Female education

Conscription dummy

Contraception

World War II dummy

Propensity to remarriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [b]

Female education

Contraception

World War II dummy

Age at remarriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [b]

Female education

Contraception

World War II dummy

Table 4.1 (Cont'd)

Variance of age at remarriage is estimated as a function of:

Female-male relative wage rate

Real income per head

Child services [(b)]

Female education

Contraception

World War II dummy

Propensity to divorce is estimated as a function of:

Female-male relative wage rate (lagged two periods)

Real income per head (lagged two periods)

Dependents per married female (lagged two periods)

Age at marriage (lagged two periods)

Age at divorce is estimated as a function of:

Female-male relative wage rate (lagged two periods)

Real income per head (lagged two periods)

Dependents per married female (lagged two periods)

Variance of age at divorce is estimated as a function of:

Female-male relative wage rate (lagged two periods)

Real income per head (lagged two periods)

Dependents per married female (lagged two periods)

Table 4.1 (Cont'd)

Labour force participation rates of married women aged 15-24 and 25-54 are estimated as functions of:

Expected real female hourly wage

Unemployment rate

Permanent income per head

Nuptial birth rate

Child quality [(b)]

Contraception

World War II dummy

Labour force participation, age-specific (lagged one period)

Labour force participation rate of married women aged 55 and over is estimated as a function of:

Expected real female hourly wage

Unemployment rate

Permanent income per head

World War II dummy

Labour force participation (lagged one period)

Labour force participation rate of other women aged 15-24 is estimated as a function of:

Expected real female hourly wage

Unemployment rate

Permanent income per head

World War II dummy

Labour force participation (lagged one period)

Table 4.1 (Cont'd)

Labour force participation rates of other women aged 25-54 and 55 and over are estimated as a function of:

Expected real female hourly wage

Unemployment rate

Permanent income per head

Widow pension relative to the expected female wage

World War II dummy

Labour force participation (lagged one period)

Notes: [a] Only variables that appear in the following tables of results are listed here.

[b] This explanatory variable is endogenous.

TABLE 4.2 ESTIMATES OF STRUCTURAL PARAMETERS OF THE FERTILITY EQUATIONS

Structural Equation for:	Constant Term	$(Wf)_{t-1}$	$(Y)_{t-1}$	$(R)_{t-1}$	$(I)_{t-1}$	$(O)_{t-1}$	$(Z)_{t-1}$	$(Q)_{t-1}$	$(wMf)_t$	A_{t-1}	R^2
N											
OLS	1.842 (2.34)	-.381 (3.31)	.448 (5.32)	-.492 (3.95)	-.290 (3.11)	-.007 (3.14)	-.115 (4.19)				.614
FIML	.1695 (0.63)	-.455 (5.71)	.365 (6.29)	-.370 (4.99)	-.333 (5.03)	-.007 (4.25)	-.090 (4.67)				.611
Q											
OLS	2.358 (2.11)	.351 (2.06)	.593 (4.68)		-.529 (4.45)	.017 (5.28)					.982
FIML	-.494 (1.78)	.212 (1.98)	.569 (6.53)		-.703 (9.38)	.016 (5.88)					.980
Nv											
OLS	2.408 (4.03)	-1.237 (6.23)	.330 (1.92)	-.664 (3.92)		-.021 (5.35)	-.089 (1.84)	.530 (4.10)			.929
FIML	-7.307 (15.79)	-1.304 (7.21)	.447 (2.83)	-.643 (4.22)		-.026 (6.05)	-.111 (2.48)	.487 (4.17)			.934
C											
OLS	156.187 (2.06)	-115.78 (1.93)	32.955 (7.81)	-669.402 (1.91)	-211.560 (2.76)	-519.987 (4.36)	-51.362 (3.51)		.462 (6.26)	73.280 (5.18)	.986
FIML	185.97 (2.62)	-109.70 (2.25)	34.157 (8.96)	-675.908 (2.18)	-218.452 (3.19)	-499.836 (4.65)	-39.11 (7.02)		.385 (6.82)	78.22 (7.02)	.986

Notes:

1. R^2 is not formally defined in FIML. A 'quasi' R^2 was estimated as (variance of endogenous variable - variance of structural residual)/variance of endogenous variable.

2. 't-values' are in parentheses. (In the case of the FIML estimates, value shown is ratio of estimated parameter to estimated asymptotic standard error.)

Equation	Constant Term	$(Wf/Wm)_t$	$(Y)_t$	$(NQ)_t$	$(EF)_t$	$(X)_t$	$(O)_t$	$(Z)_t$	$(Ma)_{t-1}$	R^2
Mp										
OLS	-3.921	-.450	.789	.157	-.400	-.004	-.012	.209		.965
	(6.27)	(3.51)	(8.42)	(2.89)	(4.23)	(1.38)	(4.01)	(4.36)		
FIML	-8.554	-.421	.614	.259	-.320	-.002	-.012	.205		.964
	(16.90)	(4.41)	(6.92)	(4.58)	(4.08)	(1.46)	(4.59)	(5.81)		
Ma										
OLS	.280	-.008	-.006	$.3x10^{-3}$	.019	$-.5x10^{-3}$	$.9x10^{-4}$	-.005	.9082	.992
	(1.08)	(1.29)	(1.15)	(.06)	(4.16)	(2.47)	(.34)	(2.47)	(12.09)	
FIML	-.078	-.005	-.006	$.7x10^{-3}$	.019	$-.3x10^{-3}$	$-.1x10^{-3}$	-.005	.9338	.993
	(1.27)	(1.01)	(1.25)	(.18)	(4.62)	(3.02)	(.82)	(2.90)	(20.66)	
Mv										
OLS	4.315	.237	-.006	-.104	.059	$-.4x10^{-3}$	-.002	-.042		.637
	(12.80)	(3.53)	(.12)	(3.53)	(1.14)	(.18)	(.59)	(1.67)		
FIML	1.308	.292	-.049	-.101	.050	.002	$-.5x10^{-3}$	-.020		.547
	(4.83)	(5.64)	(1.08)	(3.34)	(1.29)	(1.80)	(.40)	(1.16)		
Rp										
OLS	-3.342	-.054	1.041	.174	-1.006		-.028	.403		.898
	(2.78)	(.22)	(5.09)	(1.37)	(5.16)		(4.04)	(4.27)		
FIML	-7.816	-.077	.614	.418	-.769		-.029	.389		.898
	(7.49)	(.40)	(3.13)	(3.30)	(4.89)		(4.87)	(5.42)		
Ra										
OLS	3.243	-.024	-.008	-.020	.064		.005	-.012		.516
	(19.89)	(.72)	(.29)	(1.17)	(2.41)		(2.91)	(.93)		
FIML	-1.271	-.031	.025	-.036	.057		.002	-.016		.510
	(8.51)	(1.12)	(.90)	(1.98)	(2.51)		(2.86)	(1.57)		
Rv										
OLS	3.477	-.103	-.014	.011	.257		-.003	-.183		.702
	(11.51)	(1.70)	(.27)	(.34)	(5.23)		(1.04)	(7.71)		
FIML	-.449	-.082	.159	-.101	.170		$-.2x10^{-3}$	-.160		.740
	(1.95)	(1.81)	(3.48)	(3.37)	(4.74)		(.18)	(9.47)		

TABLE 4.4 ESTIMATES OF STRUCTURAL PARAMETERS OF THE DIVORCE EQUATIONS *

Equation	Constant Term	$(Wf/Wm)_{t-2}$	$(Y)_{t-2}$	$(K)_{t-2}$	$(Ma)_{t-2}$	R^2
Dp OLS & FIML	-23.265 (2.59)	3.189 (3.99)	.812 (4.95)	-.582 (5.58)	4.328 (1.75)	.909
Da OLS & FIML	-1.470 (.71)	-.481 (2.62)	.142 (3.77)	.074 (3.09)	1.259 (2.21)	.459
Dv OLS & FIML	-2.21 (.49)	-.646 (1.60)	.305 (3.67)	.202 (3.83)	1.456 (1.17)	.765

* Since only predetermined variables appear on the right of the structural equations in this block and since, further, the right hand variables are identical in each of the three equations, OLS and FIML are equivalent. t-values based on the small sample (i.e., degrees-of-freedom corrected) formula are given in parentheses.

TABLE 4.5 ESTIMATES OF STRUCTURAL PARAMETERS OF THE FEMALE LABOUR FORCE PARTICIPATION EQUATIONS

Equation	Constant Term	$(PWF)_t$	$(PY)_t$	$(U)_t$	$(B)_t$	$(Q)_t$	$(O)_t$	$(Z)_t$	$(G/PWF)_t$	L_{t-1}	R^2
Lmw(15-24)											
OLS	15.532 (1.34)	-2.175 (1.35)	1.562 (.72)	-.479 (1.62)	-4.362 (2.96)	1.082 (.88)	-.146 (2.08)	-.323 (.78)		.1395 (.29)	.703
FIML	-.346 (.77)	.497 (3.27)	-.709 (3.39)	-.255 (10.72)	-.772 (5.38)	.496 (3.05)	.001 (.35)	.263 (5.99)		.5153 (13.51)	.993
Lmw(25-54)											
OLS	3.472 (2.63)	.238 (1.28)	-.865 (3.54)	-.136 (4.22)	-.270 (1.56)	.716 (4.60)	.020 (2.44)	.162 (3.53)		.5188 (6.79)	.992
FIML	-.044 (.10)	.501 (3.42)	-.561 (2.84)	-.198 (9.15)	-.609 (4.66)	.250 (1.69)	.015 (3.90)	.096 (2.57)		.5443 (12.93)	.987
Lmw(55+)											
OLS	.737 (.84)	.149 (1.33)	-.185 (.98)	-.049 (1.76)				-.031 (1.00)		1.018 (17.086)	.986
FIML	.592 (1.08)	.201 (1.93)	-.212 (1.21)	-.035 (1.40)				.044 (1.62)		1.029 (18.49)	.986
Low(15-24)											
OLS	1.678 (5.19)	.165 (3.80)	-.202 (4.36)	-.043 (4.28)				.043 (3.45)		.7873 (15.78)	.972
FIML	.316 (3.59)	.156 (4.35)	-.192 (4.90)	-.042 (4.79)				.050 (5.16)		.8045 (19.65)	.976
Low(25-54)											
OLS	.679 (2.28)	.037 (1.23)	-.031 (1.39)	-.001 (.24)				.007 (.98)	.002 (1.49)	.8539 (11.13)	.986
FIML	.054 (1.09)	.048 (1.78)	-.033 (1.64)	$.6 \times 10^{-3}$ (.14)				.012 (1.90)	.003 (2.17)	.8150 (11.37)	.987
Low(55+)											
OLS	2.248 (4.09)	-.026 (4.40)	-.170 (2.28)	-.029 (1.77)				-.061 (2.48)	.010 (2.17)	.6566 (6.75)	.839
FIML	-.281 (1.38)	.002 (.03)	-.166 (2.34)	-.030 (1.87)				-.053 (2.39)	.006 (1.69)	.673 (7.35)	.835

this series has, to date, not been compiled. The model has therefore been estimated without the divorce cost series. It is intended to re-estimate the model incorporating divorce costs in the near future.

4.2 Fertility

The family size quation, reported together with the other fertility equations in Table 4.2, provides several interesting results. The female wage, which we interpret as the opportunity cost of bearing and rearing children, has a negative influence on the demand for number of children. It is clear from an inspection of the equations for both the number of children and child quality that an increase in the price of child services relative to the price of market goods and services leads parents to reduce ultimate completed family size rather than child quality; the coefficient of the female wage rate is positive in the Q equation. This result may reflect the possibility that the female wage is acting as a proxy for female education. If education has the non-neutral effect of differentially raising productivity in child quality production relative to productivity in the production of numbers of children, then a similar increase in female educational attainment will induce substitution to higher quality smaller family sizes. In addition, it is possible that parents' material standard of living and child quality are net complements. Increases in the female wage rate are estimated to have a substantial negative effect on the variance of family size and on the number of first nuptial confinements.

Numbers of children and child quality are normal goods, i.e., their demands are positively and significantly related to income. Elasticities associated with the income variable are 0.37 for numbers of children, 0.57 for quality per child and hence 0.94 for child services. The magnitude of the derived income elasticities for N and Q provide some joint support for the ideas

(a) that (NQ) is an appropriate measure of child services from the viewpoint of the household utility function,

and

(b) that the utility function is (approximately) homothetic.

In comparing the estimated income elasticities with those derived in other studies it should be noted that the relationship between fertility and income is sensitive to whether the model is based on cross-section or time-series data and also to the particular fertility and income variables used. Gregory et al.[1] and Wilkinson,[2] using non-Australian time-series data on the crude birth rate, obtained income elasticities of .021 and 1.01 respectively. However, our measure of implicit completed family size is more closely related to cross-section studies based on children-ever-born in the married women group aged 35-44. In the United States Cain and Weininger,[3] and Gardner[4], using a children-ever-born variable, found income elasticities of 0.2 or 0.3 and 0.26 to 0.35

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1. Paul Gregory, J. Campbell and B. S. Chang, "A Simultaneous Equation Model of Birth Rates in the U.S.," Review of Economics and Statistics, November 1972, pp. 374-380.

2. Maurice Wilkinson, "European Migration to the U.S. : An Econometric Analysis of Aggregate Labour Supply and Demand," Review of Economics and Statistics, Vol. 52, No. 3, August, 1970, pp. 272-279.

3. Glen G. Cain and Adriana Weininger, "Economic Determinants of Fertility : Results Using Cross-Sectional Data," Demography, Vol. 10, No. 2, May 1973, pp. 205-223.

4. Bruce Gardner, "Economics of the Size of North Carolina Rural Families," Journal of Political Economy, Vol. 81, No. 2, Part 11, March/April, 1973.

respectively. Our estimate of 0.37 is compatible with these latter studies. With regard to the price variables, Gregory et al. obtained a negative demand elasticity of .004, which is substantially below this study's estimate of - .455. However, our figure again is compatible with Cain and Weininger's (- .4 to - 0.5) and with Gardner's (- .2 to - .6).

Increases in real income have a significant positive effect on the variance of ultimate family size and on the number of first nuptial confinements.

The negative coefficient of the old-age pension variable in the numbers of children, variance of family size, and first nuptial confinements equations, suggests that the provision of welfare services lowers the expected benefits from children as an old-age support to parents and thereby reduces the demand for numbers of children.

An increase in infant mortality has a substantial negative and significant effect on the demand for child services and quality per child. Assuming movements in infant mortality are positively correlated with changes in child mortality, then in a situation of high infant mortality parents may be reluctant to increase expenditures on child quality because of the lower probability of their children surviving to older age. Furthermore, a higher rate of infant mortality induces smaller family sizes, implying that the negative effect of increased psychic and pecuniary costs associated with higher infant mortality outweighs the positive replacement effect.

An improvement in birth control technology, by lowering the marginal cost of fertility control, acts as an increase in the price of numbers of children relative to the price of quality per child and induces a substitution away from N to Q. In addition, gains in contraceptive efficiency exert a negative effect on the variance of ultimate family size and on first nuptial confinements.

As anticipated, the introduction of the World War II dummy variable exerts a negative influence on the number of children, variance of family size and on first nuptial confinements. The coefficient of postponed births in the first nuptial births equation has been constrained so that the negative influence of the World War II variable is exactly counterbalanced by the postponed births variable. This means that the combined effect of the two variables in the equation is not to alter total births but simply the timing of those births.

Quality per child has a positive and significant effect on the variance of ultimate family size. It is possible that an increase in child quality tends to reduce the size of small families while at the same time having little or no effect on larger families.

The weighted first marriage variable, where weights were expected intervals between marriage and first births, enters the first nuptial confinements equations with the expected positive sign.

4.3 Marriage

The effect of an increase in the female wage relative to the male wage is to reduce the propensity of never married, widowed and divorced women to marry, although the coefficient of the relative wage rate variable in the remarriage propensity equation is not significantly different from zero. The relative wage rate exerts a weak negative influence on the age at first marriage and remarriage which is inconsistent with our *a priori* expectation. We anticipated a positive coefficient on the relative wage variable in the age at marriage equations, since an increase in the ratio of the female wage to the male wage implies a decrease in the gains from marriage and hence later entry into the marriage market. It should be noted that the use of current wage rates ignores life-cycle changes in earnings, and it is possible that at the time of marriage the lifetime wage rate of males may be higher than the permanent female wage rate, although the current male wage rate may be lower. The relative wage rate variable produces opposite signs in the variance of age at first marriage and remarriage equations.

The propensity to marry is positively related to income. An increase in income, as expected, lowers the age and variance of age at first marriage. The age at remarriage and variance of age at remarriage are positively related to income in the FIML equations, but negatively related in the OLS equations.

We have argued previously that marriage is in part a derived demand for own child services, and the statistical results reveal a significant positive relationship between the demand for child services and the propensity for both first marriage and remarriage. However, an increase in the demand for child services has an inconsequential effect on the age at first marriage. This result may reflect the possibility that Q and N exert opposite effects on the age of marriage but not necessarily on the propensity to marry. People desiring a large family will have both a biological and economic incentive to marry earlier since time is cheaper earlier in life. On the other hand, if people have preferences for high-quality children they may decide to defer marriage until sufficient savings have been accumulated.

Education is found to reduce the propensity to marry and increase the age and variance of age at marriage. The derived elasticities of female education are consistently larger in the remarriage equations. Extending the period of education could be expected to increase the age at first marriage of young single women because the attainment of an education is time-intensive. This effect is likely to be of less importance to previously married women. It is possible that increased levels of female education attainment make women more aware of alternatives to legal marriage, and this effect is likely to be of greater significance in the case of previously married women. It is particularly interesting to observe that an improvement in birth control technology tends to increase the age at marriage and reduces the variance of age at marriage but, most importantly, lowers the propensity to marry. Once again, our results show that the influence of contraception is more important for the women who had been previously married. We interpret these results as indicating that a more efficient method of contraception provides women with wider options for role development.

4.4 Divorce

The divorce equations are currently estimated without the pecuniary cost of divorce series. When this series has been developed and incorporated into the model we could expect significant changes to the coefficients in these equations. Most of the coefficients in the currently estimated propensity to divorce equation have the expected signs and are highly significant. There is a positive income and substitution effect of the female wage and a negative effect of the male wage. Our results indicate that changes in the sex-specific relative wage rate are a major determinant of the propensity to divorce. For example, a ten per cent rise in the relative wage rate is associated with a 21 per cent increase in the propensity to divorce. The positive sign of the income variable is consistent with the argument that change in marital status is a normal good. An increase in the number of dependents per married female, by raising the psychic costs of divorce, lowers the overall divorce propensity. The effect of an increase in the age at first marriage is to raise the propensity to divorce. This is obviously in conflict with our *a priori* expectation. It would seem likely that the equation is incomplete.

Although the explanatory power of the age at divorce equation is quite low, the estimated coefficients conform closely to our expectations. An increase in the female-male relative wage rate lowers the age and variance of age at divorce, whereas increases in real income and the number of dependents raises age and variance of age at divorce.

4.5 Married Women Labour Force Participation

The expected positive relationship is observed between the long-term wage rate and activity rates of married women in all age groups in the FIML equation. Although insignificant, the OLS estimate has the wrong sign in the [Lmw 15-24] equation. A feature of the FIML results is the relative sensitivity of the labour force participation of younger married women to changes in the expected female wage rate as compared to older married women.

The labour market pressure of demand variable indicates the existence of a net discouraged worker effect in all age groups of married women. The fall in the responsiveness of activity rates in higher age groups suggests that current labour market conditions may be more important for new entrants rather than for women who are already in the work force.

The labour force participation rates of married women are inversely related to permanent income, although the estimated coefficient is not individually significant for the age group 55 and over. The OLS estimate has the incorrect sign in the 15-24 age group.

The negative coefficient for the fertility variable indicates that the decision to have an additional child may have a major influence on reducing the supply of married women labour in the 15-24 and 25-54 age groups. For example, the equations imply that a ten per cent rise in the nuptial birth rate lowers married women labour force participation by more than 17 per cent in both age groups. The large negative substitution effect brought about by an increase in fertility is partially offset by a positive income effect associated with an increase in the demand for total child services. This could be interpreted as an indication that one of the reasons females participate in the workforce is to supplement family income in order to provide a better standard of living for their children. The effect of an improvement in contraceptive technology is to raise the workforce activity rate of married women below 55 years of age. The negative coefficient in the OLS equation for married women aged 15-24 seems quite implausible.

The values of the lagged workforce participation variables would, with the exception of that shown for women 55 years and over, seem plausible. They indicate that labour force participation adjusts to economic circumstances fairly rapidly in the two younger age groups, with about 90 per cent of the total adjustment being estimated to take place within three years. In the 55 and over age group, on the other hand, adjustment is extremely slow.

4.6 Other Women

The wage variable as anticipated has a positive sign in all equations, but is individually insignificant for the age group 55 and over. It is noticeable that as in the case of the married women equations the magnitudes of the wage coefficient are lower for older age groups. Furthermore, activity rates of single women show less sensitivity to changes in the female wage than for married women in all age groups.

There is evidence of a net discouraged worker effect in the age group 15-24 which includes a significant proportion of secondary family workers. On the other hand, there is little or no indication of responsiveness of activity rates of single women aged 25-54 to variations in labour market conditions. This is not surprising since this group contains a much higher proportion of family heads. However, the negative coefficient for the age group 55 and over indicates the increased difficulty experienced by older persons re-entering the workforce when labour market conditions are unfavourable. It is also possible that single women of retirement age are more likely to be responsive to variations in unemployment because of greater availability of non-wage income. Indeed, this hypothesis is supported by our results. The estimated coefficients of the permanent income variable reveal that participation rates of single women 55 and over are more responsive to changes in permanent income than for single women in the 25-54 age group.

The negative coefficient of the permanent income variable for the age group 15-24 could be interpreted as support for the hypothesis that higher family income will tend on average to be associated with lower workforce participation and longer education of young single women.

The widow pension deflated by the expected female wage rate does not have the expected sign in either the 25 to 54 years and the 55 years and over categories. This may be due to the inadequacies in the series which has been used. Further work is currently being carried out to derive a more reliable series for earlier years.

5. CURRENT PERFORMANCE AND DIRECTION OF FUTURE DEVELOPMENT OF THE MODEL

In Section 5.1 we describe how the estimated means and variances of implied completed family size, and of age of females at first marriage and at remarriage, can be used to project respectively :

(a) parity progression ratios ;

(b) age-specific ratios of numbers of first marriages to number of females at risk ;

(c) similar ratios for remarriages and divorces.

Then, in Section 5.2, we discuss the within-sample period performance of the model in the light of simulations of the time-paths of the endogenous variables based on the estimated structure. Finally, in Section 5.3 we comment briefly on the scope for further development and improvement of the model.

5.1 Derivation of parity progression and marital status ratios from the model

The model which has been outlined in previous sections of the paper is designed to provide some of the information required to make projections of the population classified by age, sex, conjugal condition and participation in the work force. In order to make these projections, procedures have been developed to derive parity progression ratios, and marital status ratios (e.g., ratio of first marriages to females at risk, ratio of remarriages to females at risk and ratio of divorces to females at risk) by age of female from the model.

In Section 3.1 the procedure for calculating mean and variance of implied completed family size from parity progression data was outlined. The derivation of parity progression ratios from the model output (i.e., mean and variance of implied completed family size) is the reverse of the earlier procedure. We recall that, if $P_{\tau t}$ (the parity progression ratio) is the probability of a married female with τ children (with $\tau \geqslant 1$) having an additional confinement, the conditional probability of having a completed family size n (given $n \geqslant 1$) is

$$(5.1) \qquad f_t \; (n : n \geqslant 1) \;=\; (1 - p_{nt})\left(\prod_{\tau=0}^{n-1} p_{\tau t}\right) ,$$

where $p_{0\tau} \equiv 1$. The mean and variance for implied completed family size, we recall, were

$$(5.2) \qquad N_t^* \;=\; \sum_{n=1}^{k} n \; f_t(n) \quad ,$$

and

$$(5.3) \qquad (NV)_t^* \;=\; \sum_{n=1}^{k} (n - N_t^*)^2 \; . \; f_t(n) \quad .$$

The reverse procedure for deriving the $p_{\tau t}$ series from estimates of N_t^* and $(NV)_t^*$ involves the use of a gamma density function, namely,

$$(5.4) \qquad f_t(n) \;=\; \int_{n-1}^{n} \frac{1}{\beta^{\alpha}\Gamma(\alpha)} \; x^{\alpha-1} \; e^{-x/\beta} \; dx \quad ,$$

as an approximation to the distribution of implied completed family size.[1] The parameters of this distribution, α and β, are related to the mean and variance of implied family size, as follows[2] :

$$N_t^* = \alpha\beta + 0.5 \quad ; \tag{5.5}$$

$$(Nv)_t^* = \beta^2 \alpha \ . \tag{5.6}$$

In the case of ages at first marriage of females, empirical analysis of the distributions observed in the Australian population between 1921 and 1960[3] indicated that neither the gamma, nor any other standard density function, would serve as an adequate approximation. This led to the following empirical approach to the problem. First, a catalogue of historically-observed distributions with each based on data for one year, was collated. Each distribution was then standardized by dividing the ratio of first marriage to females at risk by the propensity for first marriage for that particular year.[4] The mean and variance of each distribution were calculated in accordance with the definitions described previously and were entered in the catalogue as summary measures of that distribution. Finally, that standardized (empirically fitted) distribution in the catalogue having mean and variance closest to the mean and

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1. For an elementary discussion of the gamma random variate, see J. E. Freund, Mathematical Statistics, 2nd edn. (New York : Prentice-Hall, 1971), p. 112.
2. The term 0.5 appears in (5.4) and (5.5) in order to reconcile the use of a continuous distribution function defined over the range 0 to ∞ to model a discrete random variable defined over the range 1 to ∞ .
3. The data base for these empirical analyses was H. P. Brown, Demographic Data Bank, Australian National University, unpublished mimeograph and associated computer tapes.
4. As defined earlier, the propensity for first marriage is equal to the sum of the ratios of first marriage to females at risk for each individual age group.

variance estimated as described above for a particular year, was chosen to represent the estimated standardized distribution of age at first marriage in that year.[1] Each standardized ratio in the selected distribution was then multiplied by the model estimate of the propensity for first marriage to yield the estimated ratios of first marriages to females at risk. Not surprisingly, within that part of the sample period spanning 1921 to 1960, this procedure tends to choose the actual empirically-observed age distribution in any year for which estimates are computed.

The approach adopted for deriving ratios of remarriages and divorces to the female population at risk for individual ages was to use a gamma approximation. If $(rp)_t(x)$ represents the ratio of remarriages to females at risk -- in this case widowed and divorced females -- for age group x in year t, then[2]

$$(5.7) \qquad (rp)_t(x) = (Rp)_t^* \int_{x-15}^{x-14} \frac{1}{\beta^\alpha \Gamma(\alpha)} y^{\alpha-1} e^{-y/\beta} dy \quad ,$$

where

$$(5.8) \qquad \alpha\beta = (Ra)_t^* - 15.0 \quad ,$$

and

$$(5.9) \qquad \alpha\beta^2 = (Rv)_t^* \quad .$$

Divorce to at risk population ratios were calculated in an identical manner.

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1. The procedure used was to select the standarized distribution which minimized the sum of squares of the percentage error between the estimated mean and variance indicators and the mean and variance indicators of a standardized distribution from the catalogue.

2. The origin of the variable, age at remarriage, is 15 years. This accounts for the term - 15.0 in equation (5.8).

5.2 Operation of the model over the sample period

As a test of overall performance, the model was solved annually over the period 1925-1974. Perfect knowledge of all exogenous variables was assumed. Lagged variables took the estimated value from earlier period solutions of the model so that estimates for any given period were influenced by estimation errors in earlier periods.

Graphs 5.1 to 5.12 summarize the results of operating the model over the sample period. The results with respect to fertility indicate that the model adequately tracks first nuptial confinements and, in the case of parity progression ratios captures the marked decline over the last decade in the higher parity progression rations.[1] The estimated parity progression series for the movement between the first and second child severely underestimates over the period 1925 to 1947. However, the estimated series performs well over the period 1947 to 1974.

Graphs 5.4 to 5.6 summarize the performance of the model with respect to change in marital status. The predicted data are calculated on an individual year basis. In order to make comparisons with the observed data which are in grouped form, the estimated single-year information was combined by calculating the mean ratio for the age group. This procedure makes it difficult to accurately compare actual and observed data.

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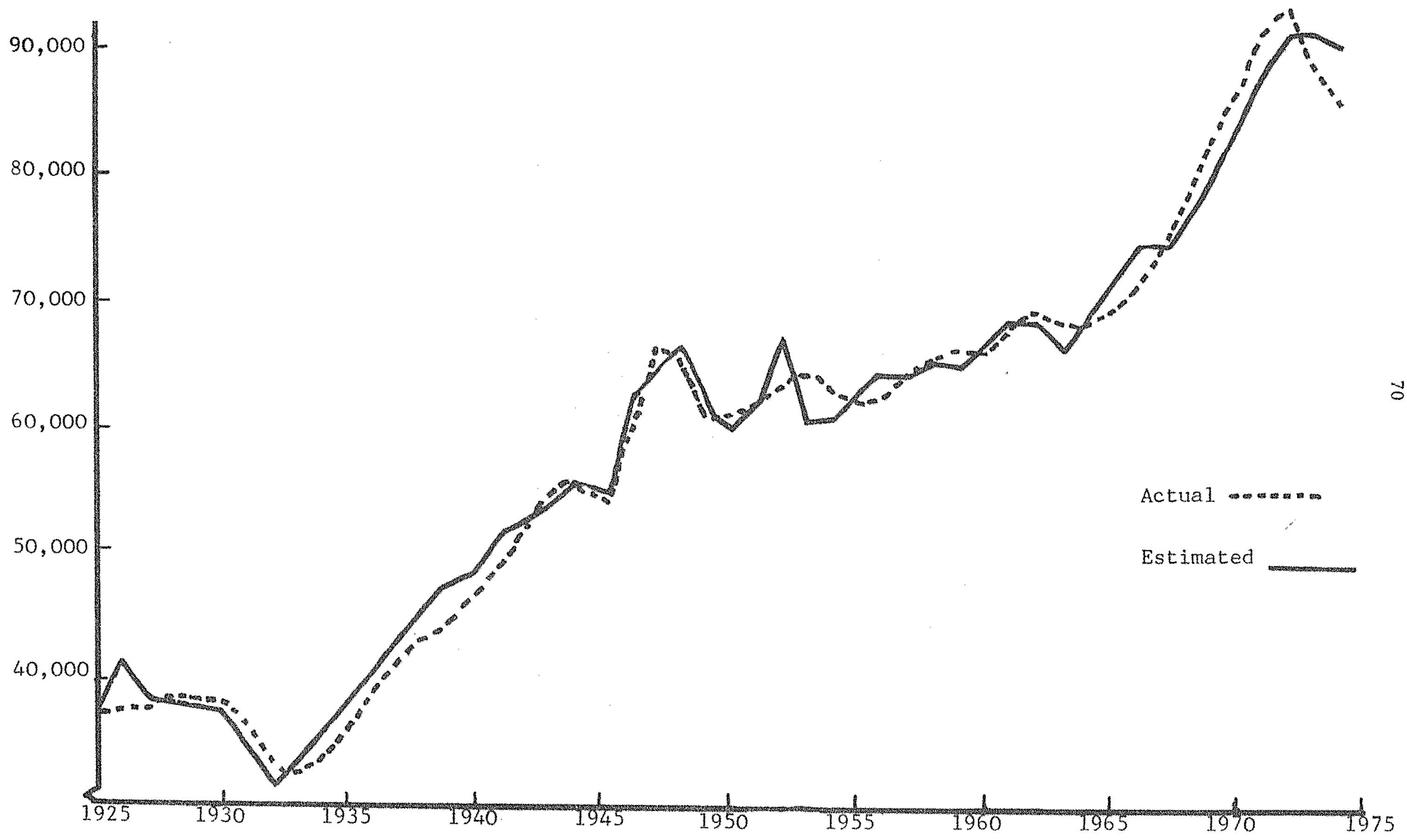
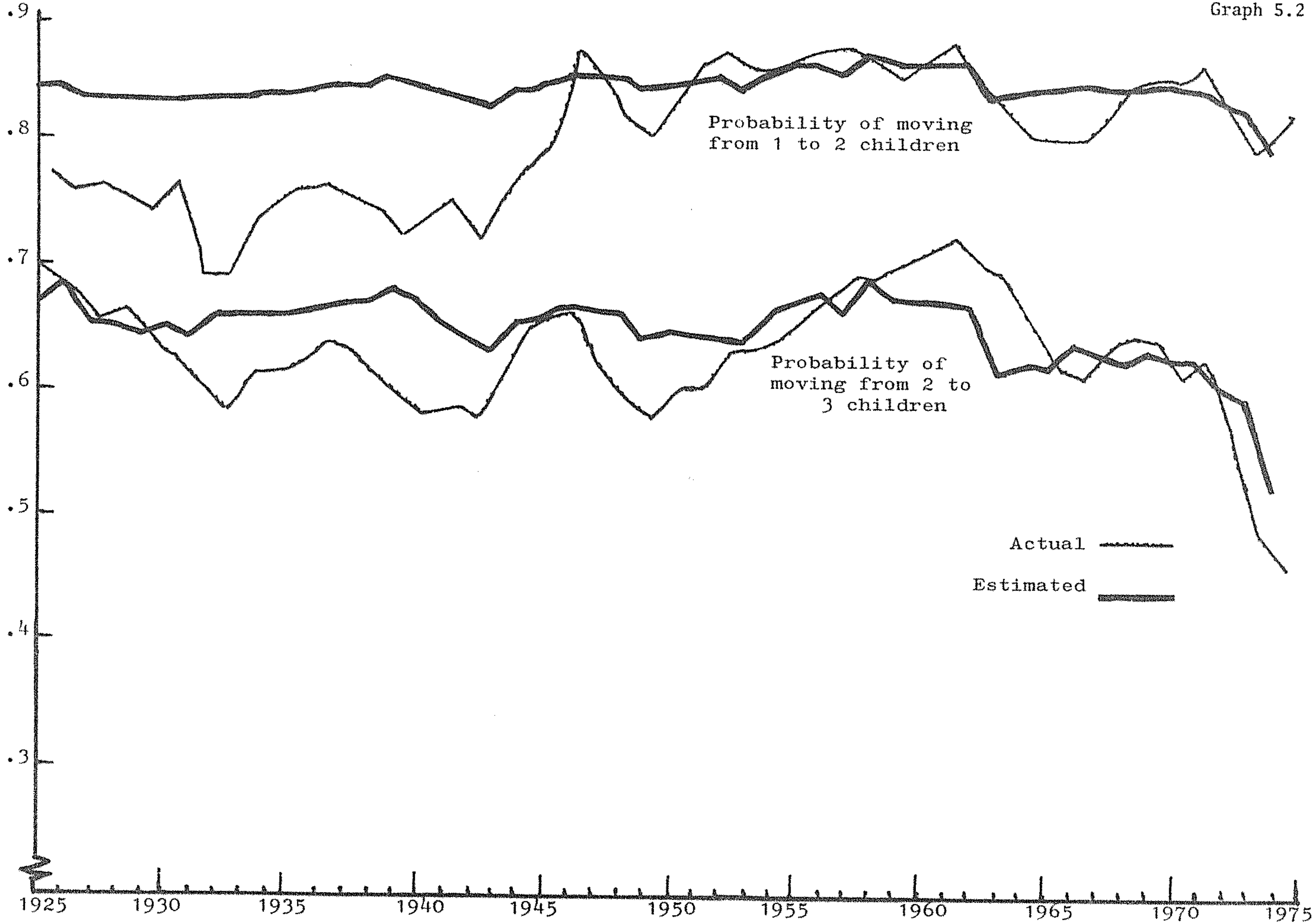
1. Whilst the model produces parity progression ratios for all birth orders, only the first three progression ratios have been graphed. In the case of higher parity progression ratios a similar performance to that shown in 5.3 is achieved.

FIRST NUPTIAL CONFINEMENTS - ACTUAL AND ESTIMATED (1925 - 1974)

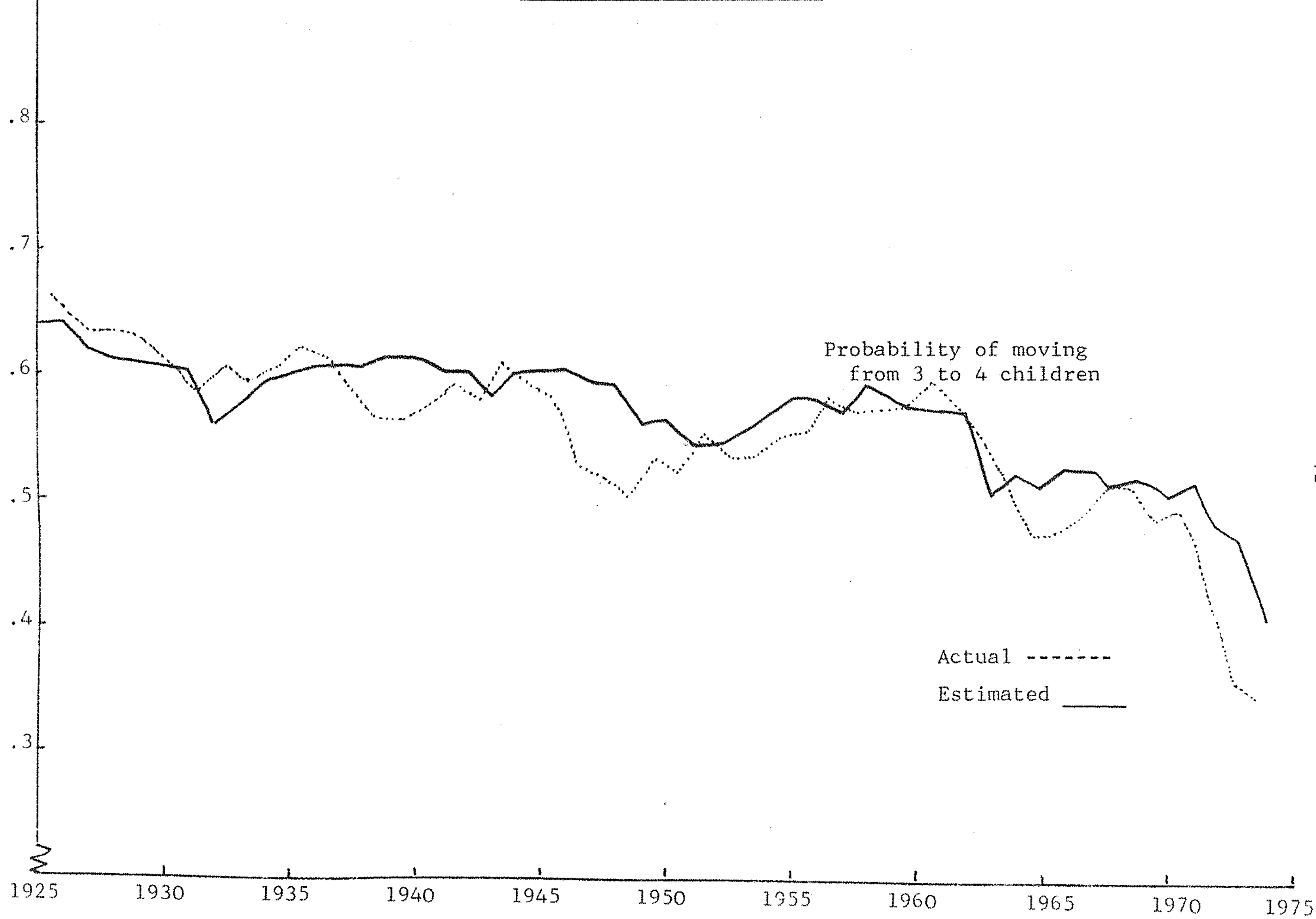


Graph 5.2

PARITY PROGRESSION RATIOS

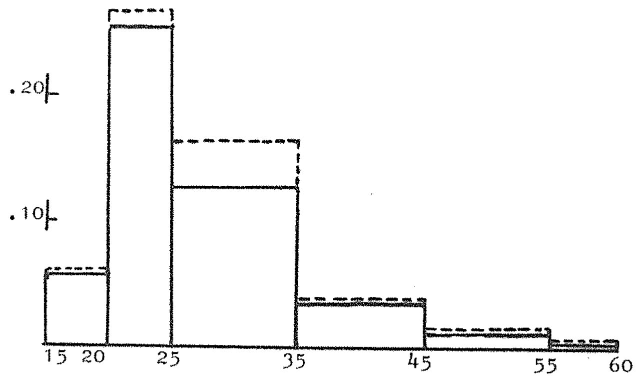


PARITY PROGRESSION RATIO

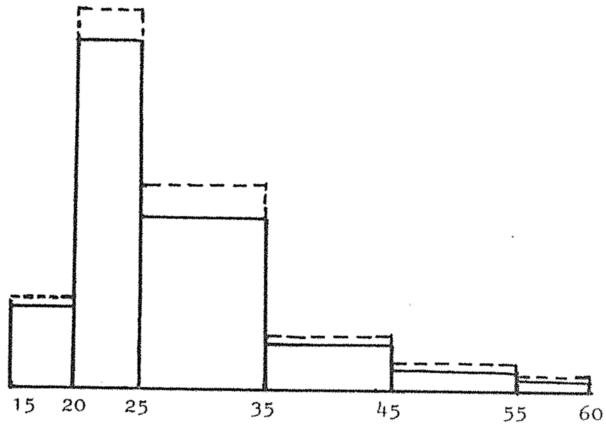


RATIO OF FIRST MARRIAGES TO NEVER MARRIED FEMALES CLASSIFIED BY AGE

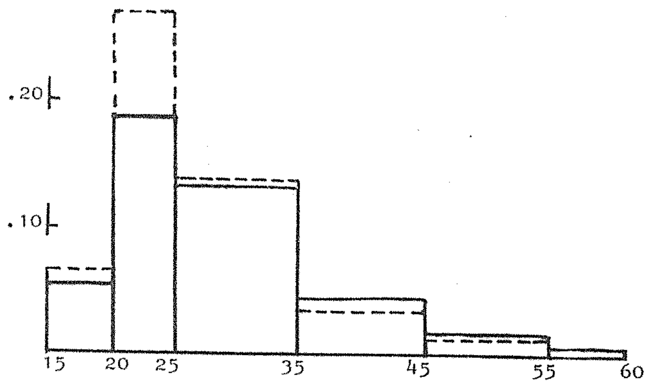
Graph 5.4



1965



1970



1974

Notes:

(a) Actual are for years ending December; estimated for year ending June.

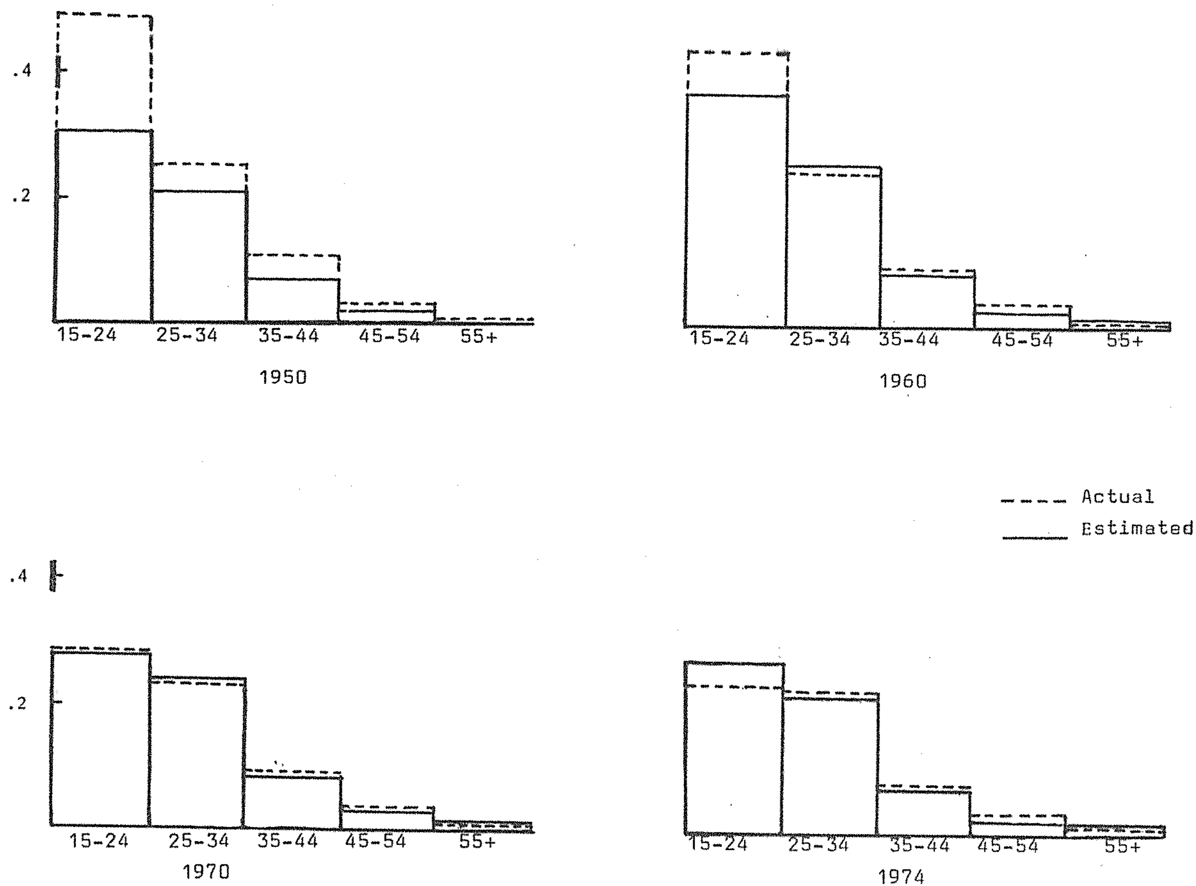
(b) Estimated figure for each age group is the average of the ratio of each individual age group.

——— estimated

------- actual

Graph 5.5

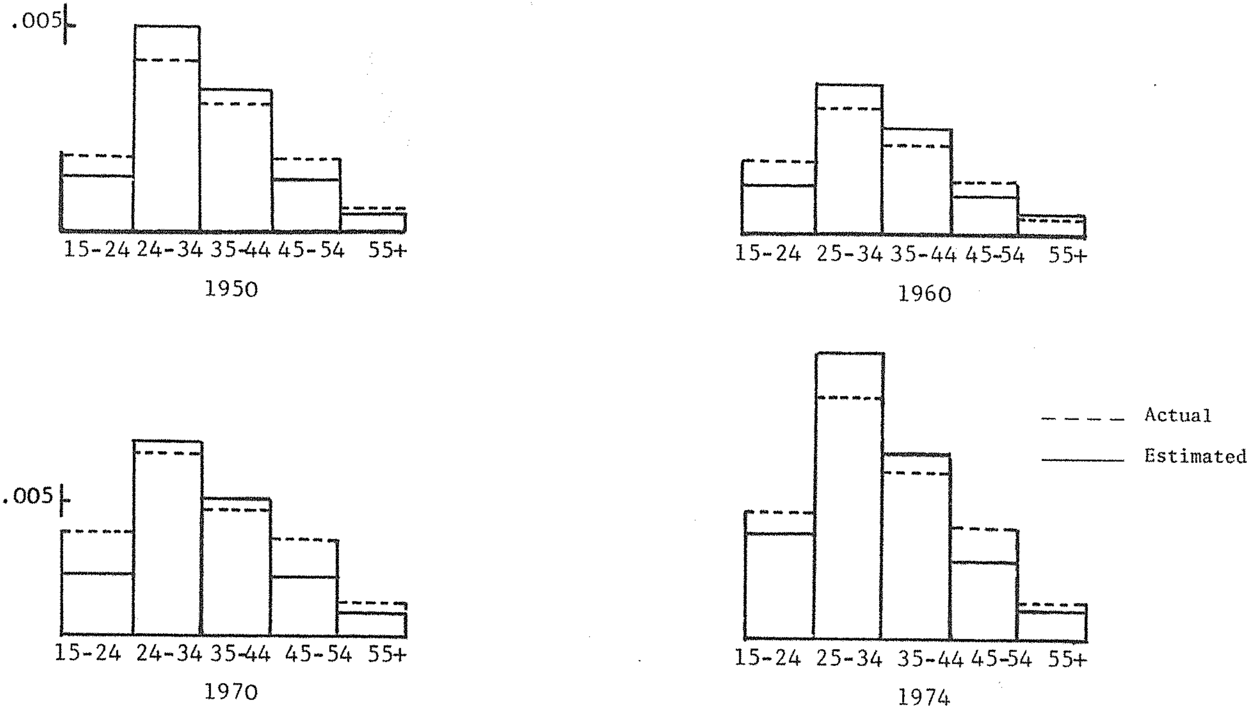
RATIO OF REMARRIAGES TO DIVORCED AND WIDOWED FEMALES
CLASSIFIED BY AGE - ACTUAL & PREDICTED (a)



Note: (a) Actual are for years ending December; estimated are for year ending June.

Graph 5.

RATIO OF DIVORCES TO MARRIED FEMALES CLASSIFIED BY AGE OF FEMALE ACTUAL AND PREDICTED (a), (b)

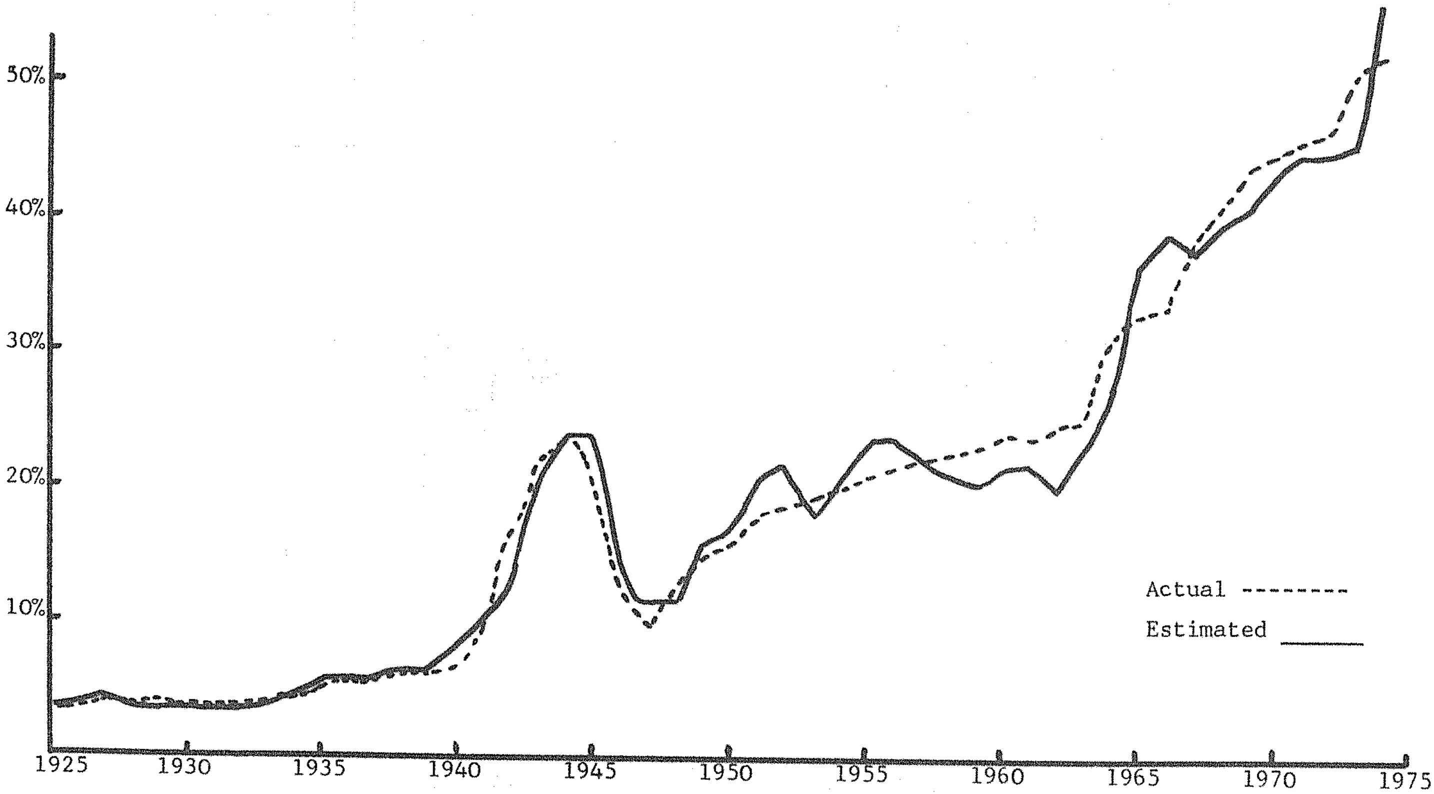


Notes:

(a) Actual are for years ending December; estimated are for year ending June

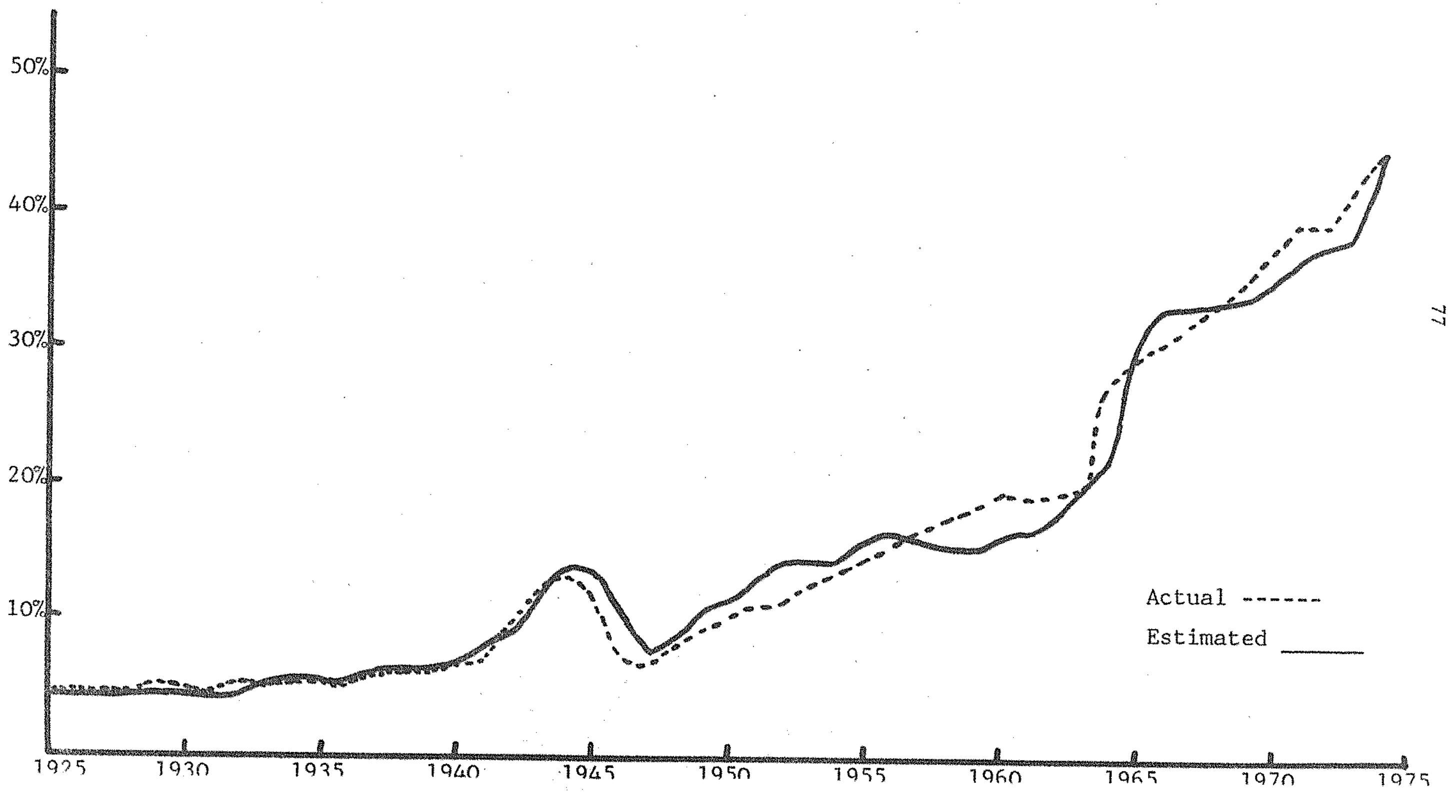
Graph 5.7

MARRIED WOMEN LABOUR FORCE PARTICIPATION AGES 15-24 - ACTUAL AND ESTIMATED
1925-1974

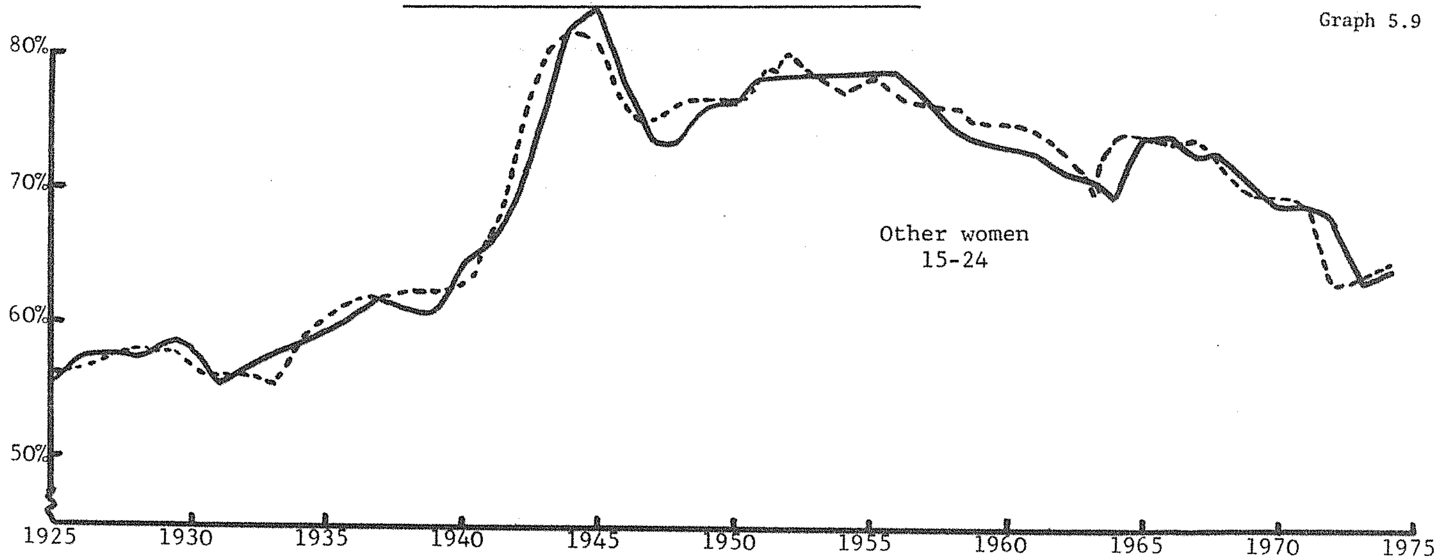


Graph 5.8

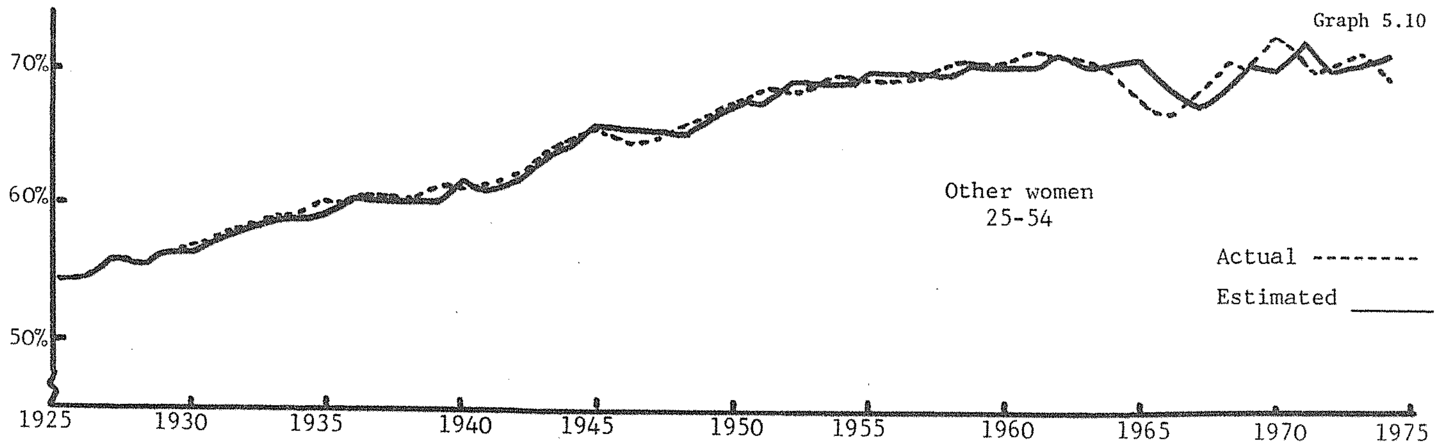
MARRIED WOMEN LABOUR FORCE PARTICIPATION AGES 25-54 - ACTUAL AND ESTIMATED
1925-1974



Graph 5.9

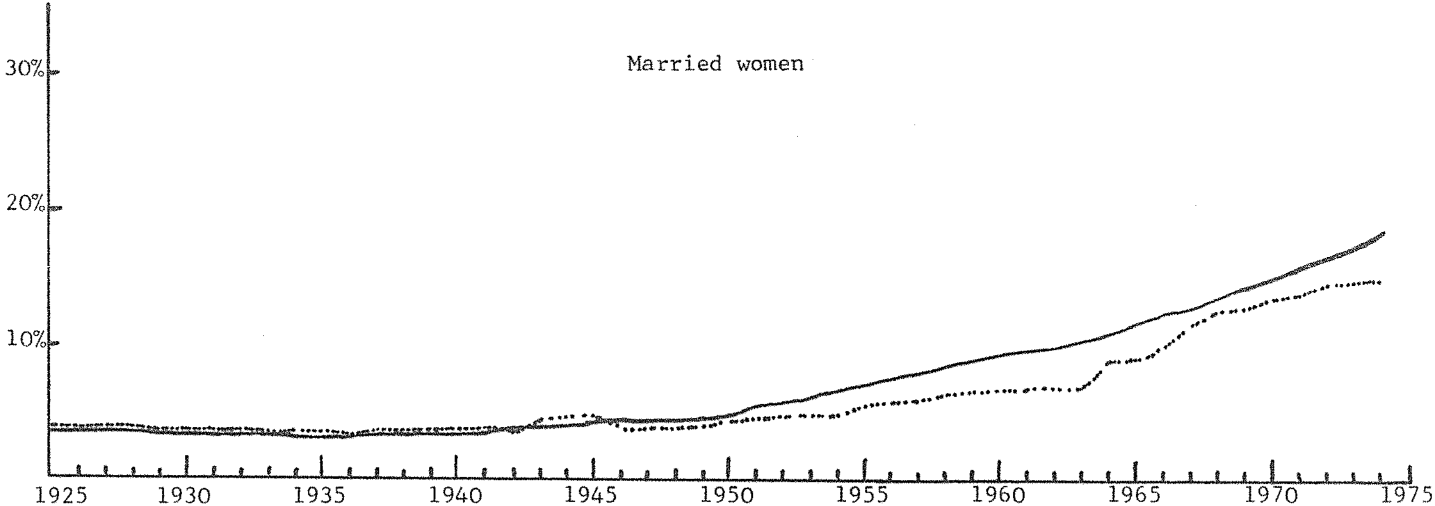


Graph 5.10

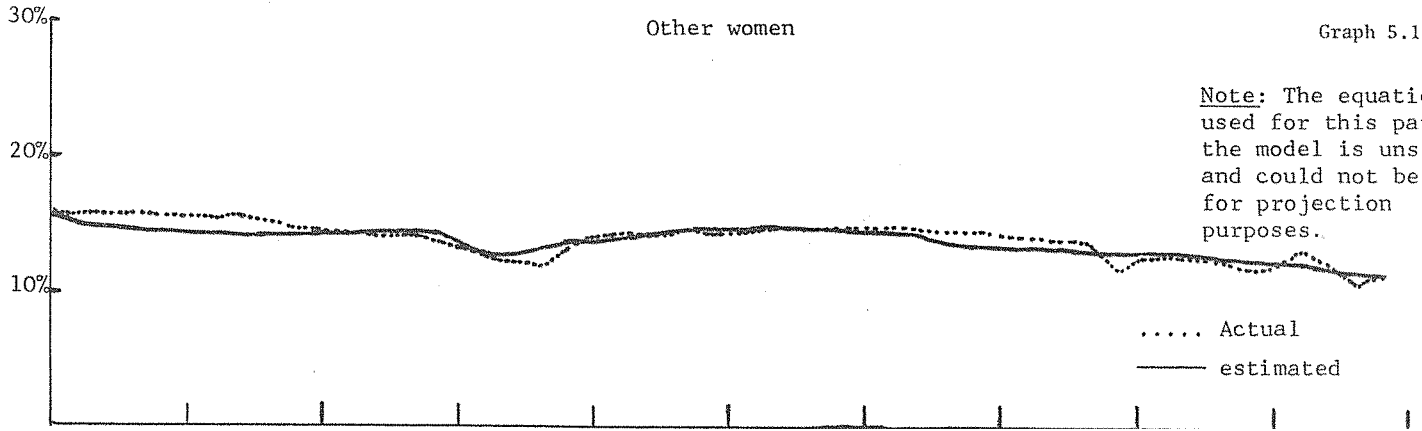


LABOUR FORCE PARTICIPATION WOMEN 55 YEARS AND OVER ACTUAL AND ESTIMATED

Graph 5.11



Graph 5.12



Note: The equation used for this part of the model is unstable and could not be used for projection purposes.

With respect to labour force participation the model performs fairly well, particularly in the key areas of married women 15-54 and other women 15-24 where large changes have been observed.

5.3 Further development of the model

A computer program has been developed so that projections of the variables shown in Graphs 5.1 to 5.12 can be derived from the model. Projections to the year 2000 yield plausible results.

While projections from the model when used on a 'stand alone' basis may be of some interest the ultimate intention is to use the model as part of a full-scale demographic model which has the capability to produce detailed population projections classified by age, sex, conjugal condition and work-force status. The results of this exercise will be the subject of a forthcoming paper.

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