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AN ECONOMETRIC MODEL OF FERTILITY, MARRIAGE, DIVORCE AND LABOUR FORCE PARTICIPATION FOR AUSTRALIAN WOMEN, 1921/22 TO 1975/76

by

Clive Brooks

Industries Assistance Commission, Canberra

Dennis Sams and Lynne S. Williams

IMPACT Research Centre

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IMPACT PROJECT RESEARCH CENTRE 153 Barry Street, Carlton 3053

Postal Address: Impact Centre, University of Melbourne, Parkville, Vic., 3052, Australia

Phones: (03) 345 1844 extensions 7417 & 7418
After hours (03) 341 7417 or 341 7418.

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1. INTRODUCTION

In recent years, economists have entered into the study of several areas of personal decision making conventionally reserved for demographers. In particular, the "new home economics", developed from the work of Becker[1] and firmly grounded in a microeconomic interpretation of behaviour, has been applied to the analysis of fertility, marriage, divorce and the labour force participation decisions of married women.

In this paper we present the details of an econometric model of fertility, marriage, divorce and female labour force participation inspired by the "new home economics" and developed as part of the IMPACT Project's Population Projection Facility.[2] The model is based on Australian data

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1. The two seminal articles are G.S. Becker, "An Economic Analysis of Fertility" in National Bureau of Economic Research, Demographic and Economic Changes in Developed Countries (Princeton, N.J.; Princeton University Press, 1960), pp.209-240; and G.S. Becker, "A Theory of the Allocation of Time", Economic Journal, Vol.75, September 1965, pp.493-517.

2. For a discussion of the IMPACT Project's Population Projection Facility, see Dennis Sams, "The Demographic Core of the IMPACT Project: An Overview", IMPACT Preliminary Working Paper No.BP-18, Industries Assistance Commission, Melbourne, September 1979, and Dennis Sams and Pam Williams, "The IMPACT Project's Facility for Disaggregated Population Projections : A Brief Exposition and Progress Report", IMPACT Preliminary Working Paper No.BP-22, University of Melbourne, Melbourne, May 1980.

for 1921/22 to 1975/76 and is derived substantially from the model of Filmer and Silberberg reported in an earlier IMPACT Working Paper.[1] However, the Filmer-Silberberg model has been significantly revised to integrate it more fully with the Population Projection Facility and its database. In addition, the estimation period for the current model is slightly longer than that used by Filmer and Silberberg; the database has been revised and updated[2]; and the opportunity afforded by the need to re-estimate has been used to respecify several equations, particularly those relating to female labour force participation.

The Population Projection Facility forms part of the IMPACT Project's demographic and labour supply module BACHUR00.[3] The Facility consists of five submodules:

(i) the econometric model discussed in this paper, which relates a set of variables characterising fertility, marriage, remarriage, divorce and female labour force participation to each other and to a further set of economic and social variables;

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1. R. Filmer and R. Silberberg, "Fertility, Family Formation and Female Labour Force Participation in Australia, 1922-1974", IMPACT Preliminary Working Paper No. BP-08, Industries Assistance Commission, Melbourne, December 1977 (henceforth referred to as the Filmer-Silberberg model).

2. For details of the revised database see Clive Brooks, "The Database of the Econometric Model of Fertility, Marriage, Divorce and Labour Force Participation for Australian Females", IMPACT Research Memorandum, BACHUR00 Module, November 1981(b).

3. For a full discussion of the IMPACT Project and the BACHUR00 module see Alan A. Powell, The IMPACT Project : An Overview, First Progress Report of the IMPACT Project, Volume 1 (Canberra : AGPS, 1977), and Alan A. Powell, "Aspects of the Design of BACHUR00, an Economic-Demographic Model of Labour Supply", in A.C. Kelley, W.G. Sanderson and J.G. Williamson (eds), Modeling Growing Economies in Equilibrium and Disequilibrium : Proceedings of an IIASA Meeting, 10-13 November 1980 (Oxford : Pergamon Press, forthcoming).

(ii) a submodule in which the marital status change variables projected by the econometric model are disaggregated into age specific rates of marital status change (that is, of marriage, remarriage and divorce);

(iii) a submodule in which the fertility variables projected by the econometric model are used to calculate the number of births of each sex;

(iv) a demographic accounting submodule in which the end-of-year population by sex, age and marital status is calculated on the basis of the start of year population and the demographic flows throughout the year; and

(v) a submodule in which the female labour supply is calculated by applying the labour force participation rates for each demographic group to the appropriate populations.

Thus, by extending conventional demographic techniques and integrating them with an econometric model which determines the levels of fertility and marital status change, the Population Projection Facility produces highly disaggregated projections of the Australian population. This treatment differs significantly from standard methods of producing demographic projections which have avoided any explicit attempt to incorporate the

influence of economic and social factors within a systematic framework.[1]

Within this approach participation in the labour force by married women is related directly to child bearing and rearing. Given that the "new home economics" literature does not deal extensively with the labour market decisions of women who are not married or who are past child bearing and rearing ages, equations for the participation rates of these women are based on a more conventional approach.

The structure of this paper is as follows. The basic characteristics of the Filmer-Silberberg model and their relationship to the "new home economics" are discussed in Section 2, which also includes a summary of the major revisions incorporated in the current model. Section 3 contains details of the current model specification while Section 4 summarises its data requirements. The estimated equations are presented and discussed in Section 5. The within-sample historical performance of the fitted model is analysed in Section 6. Concluding remarks are offered in Section 7.

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1. For Australian examples see National Population Inquiry (W.D. Borrie, Chairman) Population and Australia : A Demograhic Analysis and Projection, Vols. 1 and 2 (Canberra : AGPS, 1975); pp.XXXIV + 760; Australian Bureau of Statistics, Projection of the Population of the States and Territories of Australia, 1978 to 2011, Catalogue No.3214.0, (Canberra : ABS, May 1979) and Dennis C. Sams, Lynne S. Williams, Pamela J. Williams and Jim D. Stevenson, "A Comparison Between the ABS Population Projection 1980 to 2001 and a Compatible Projection using the IMPACT Population Projection Facility", IMPACT Preliminary Working Paper, No.BP-27, University of Melbourne, July 1981.

2. OVERVIEW OF THE MODEL

2.1 The "New Home Economics"[1]

Traditionally, economists have tended to believe that the determinants of demographic behaviour are largely non-economic or, at least, that the analysis of demographic change is outside the scope of economic theory. Willis has explained this attitude as follows:

> "In part, these beliefs were fostered because the neo-Malthusian proposition that increases in income tend to stimulate fertility conflicted with the facts that income growth has been accompanied by secular decline of fertility and that family income is inversely associated with cross-section fertility differentials in the industrialised countries".[2]

However, following the work of Becker[3] and Lancaster[4] on the extention of consumer theory to deal with the allocation of time and the specific application of economic analysis to fertility by Becker[5], there has developed an extensive literature of theoretical and applied economics,

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1. This section provides only a brief summary of the main characteristics of the theory. For a more detailed exposition see Filmer and Silberberg, op. cit., pp.6-13, and for a collection of papers defining the scope of the "new home economics", see Theodore W. Schultz (ed.), Economics of the Family (Chicago : University of Chicago Press, 1974).

2. Robert J. Willis, "Economic Theory of Fertility Behaviour", in Schultz (ed.), op. cit., pp.25-75.

3. Becker (1965), op. cit..

4. Kelvin J. Lancaster, "A New Approach to Consumer Theory", Journal of Political Economy, Vol.74, April 1966, pp.132-157.

5. Becker (1960), op. cit..

known as the "new home economics", which embraces the analysis of demographic, sociological and biomedical aspects of behaviour within a unified theory of household decision making.

The "new home economics" approach to demographic behaviour treats the individual - or, where appropriate, the family - as a decision making unit which maximises its utility by producing "household commodities" formed by combining goods and services purchased in the market and the time of individual or family members subject to explicit constraints of budget and time. The latter constraints may be multiple since, in the new analysis, the time of each member of the family unit becomes one of the primary scarce resources of the household. This extends the neoclassical theory of microeconomic behaviour in which the household derives its utility solely from the consumption of commodities purchased in the market. It is the introduction of the non-pecuniary costs of consumption, such as the opportunity cost of time, which enables the "new home economics" to deal with demographic topics.

The "new home economics" approach to fertility recognises that although children are not purchased in the market place, they are "produced" in the sense of requiring inputs of market goods and services and of time and thus have a shadow price, part of which reflects the time intensity of the production process and the opportunity cost of that time. The "new home economics" associates the shadow price of the time invested

in children with the available wage rate in the labour market.[1] Thus a rise in the wage rate of one family member relative to another would lead to substitution of the latter's time for the former's in the rearing of children. Since the value of the time of parents, especially of mothers, is a major cost of having and rearing children, then it is expected that the number of children a family has will decline with the increasing cost of the wife's time, as measured by her wage rate in the labour force. There is, however, an offsetting income effect from a change in the mother's wage rate and so the net effect on the demand for children of a rise in her wage is ambiguous. The generally held expectation is that the substitution effect will dominate in the case of the wife's wage but that the income effect will dominate in the case of the husband's. This is confirmed empirically by several studies.[2]

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1. See Jacob Mincer, "Market Prices, Opportunity Costs and Income Effects", in Carl Christ (ed.), Measurement in Economics : Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld (Stanford : Stanford University Press, 1963). Note, however, that the opportunity cost of time for women in and out of the workforce need not be the same. For a discussion of this see James Heckman, "Shadow Prices, Market Wages and Labour Supply", Econometrica, Vol.42, July 1974, pp.674-694, and for an application to fertility see William P. Butz and Michael P. Ward, "The Emergence of Countercyclical U.S. Fertility", American Economic Review, Vol.69, June 1979, pp.318-328.

2. For example, see Maurice Wilkinson, "An Econometric Analysis of Fertility in Sweden, 1870-1965", Econometrica, Vol.41, July 1973, pp.633-642; June A. O'Neill, "A Times-Series Analysis of Women's Labor Force Participation", American Economic Review, Vol.71, No.2, May 1981, pp.76-80 and Belton M. Fleisher and George F. Rhodes, Jr., "Fertility, Women's Wage Rates and Labor Supply", American Economic Review, Vol.69, No.1, March 1979, pp.14-24.

Within the "new home economics", a critical distinction is made between the number of children a family has and the resource intensity, or "quality", of each child.[1] The combination of these form the "household commodity", called "child services", produced by the family. Our prejudices suggest that when all relevant prices (including shadow prices) are held constant, the effect of income on the quantity of "child services" consumed should be positive. However, the growth in "child services" with rising income may be preferentially directed to a growth in child quality rather than the number of children. Thus the neo-Malthusian proposition mentioned by Willis is rescued by recognising that, firstly, the rise in income has been accompanied by a rise in the shadow price of the inputs to child bearing and rearing and, secondly, that there has been a preferential allocation of resources to raising child quality rather than quantity. The "new home economics" theory of fertility can incorporate also non-economic variables such as contraception, and infant mortality rates via the effects of these on the trade off between the number and quality of children.

The "new home economics" has also been applied to marriage[2] and divorce[3]. Marriage (divorce) is assumed to occur if, and only if, both parties expect their union (divorce) to increase their utility levels

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1. See Gary S. Becker and H. Gregg Lewis, "On the Interaction between the Quantity and Quality of Children" in Schultz (ed.), op. cit., pp.81-90, and Dennis N. de Tray, "Child Quality and the Demand for Children", in Schultz (ed.) op. cit., pp.91-116.

2. See Gary S. Becker, "A Theory of Marriage" in Schultz (ed.), op. cit., pp.299-344.

3. See Gary S. Becker, Elizabeth M. Landes and Robert T. Michael, "An Economic Analysis of Marital Instability", Journal of Political Economy, Vol.85, 1977, pp.1141-1187; and Robert M. Hutchens, "Welfare, Remarriage and Marital Search", American Economic Review, Vol.69, June 1979, pp.369-379.

above what they would otherwise have been. The benefits of marriage are postulated to be related to the gains from specialisation in the production of household commodities by the husband or the wife. Such benefits will be high at large relative wage differentials for the two partners and will diminish with increasing equality of the market price of their labour. As well, the desire to bear and raise one's own children, and the complementarity of inputs of the partners in doing this, would imply that the demand for children and "child services" will act as an incentive to marry and to remain married. However, marriage is also a two stage process:[1]

> "First, a single person decides whether or not to enter the marriage market and spend resources searching for a spouse, and second, if the person enters, he or she pursues an optimal sequential search for a spouse. Age at first marriage then depends on age at entry and duration of search. Both age at entry and duration of search depend on the gains to marriage and the costs of search".[2]

Thus factors which lead to an increase in the gain from search lead to a greater probability of persons entering the marriage market and longer expected searches, while those that increase the cost of search lead to a lower probability of entering the marriage market and shorter expected

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1. See Michael C. Keeley, "The Economics of Family Formation", Economic Inquiry, Vol.XV, April 1977, pp.238-250, and Michael C. Keeley, "An Analysis of the Age Pattern of First Marriage", International Economic Review, Vol.20, June 1979, pp.527-544.

2. Keeley (1979), op. cit., p.528.

searches. Both the rate of and age at marriage are postulated to be functions of those variables which influence the gains from marriage and the direct costs of search.[1] Reported empirical evidence[2] suggests that variables which increase marital "income" relative to single "income" lead to earlier entry, longer search, and a larger percentage ever marrying.

The above brief description hopefully has demonstrated the potential of the "new home economics" as a basis for the development of a model of fertility, marriage, divorce and labour force participation. In the following sections, we explain its application in the Filmer-Silberberg model and the current model.

2.2 The Filmer-Silberberg Model

The Filmer-Silberberg model[3] is based on the utility maximisation approach adopted by the "new home economics" but no attempt is made to map explicitly the constrained optimisation problem into the behavioural equations. The "new home economics" is used, however, to determine which variables appear in the equations, and to classify these variables into endogenous and exogenous categories. The critical insights

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1. See ibid. for an application of this to the age at first marriage.
2. See ibid., p.538.
3. Filmer and Silberberg, op. cit..

from the "new home economics" embodied in the Filmer-Silberberg model are that:

(i) child rearing is intensive in the use of the time of women who face a choice in allocating their time between child rearing, labour force participation and leisure;

(ii) the shadow price of a woman's time is her labour market wage rate;

(iii) the demand for child services is a normal good when all prices and shadow prices are held constant;

(iv) the flow of child services is defined by the product of the number and the quality of children -- thus numbers and quality of children substitute for each other (with unitary elasticity) in the demand for child services;

(v) the benefits of marriage depend on the relative prices of the time of the partners and the demand for child services;

(vi) biological factors such as the infant mortality rate and contraceptive effectiveness can alter the prices of the inputs to child bearing and the returns on children and through this affect the demand for child services.

In addition, the Filmer-Silberberg model goes beyond these features of the "new home economics" and, within a simultaneous framework, attempts to capture some of the dynamic elements of family formation, family size and

female labour force participation and their interactions.[1] In particular, the model attempts to explain the changes in the probability of marital status changes (that is, marriage, remarriage and divorce) and the age distribution of these changes as a consequence of changing economic conditions and changes in the demand for child services. Fertility decisions are treated as a set of sequential decisions consisting of the decision to have a first nuptial confinement and then to have higher order confinements. In parallel with these fertility decisions, the model also determines the desired level of child quality. As well, the labour force participation rates for women are disaggregated by age and marital status to allow for differing influences at different stages of the lifecycle.

The equations of the Filmer-Silberberg model can be grouped into four blocks, endogenizing respectively:

(a) a set of fertility variables;

(b) a set of marriage variables;

(c) a set of divorce variables;

and

(d) a set of female labour force participation variables.

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1. However, the optimisation problem underlying the model is still derived from a static, lifetime utility function, as in most of the "new home economics" studies, and the model does not attempt to place the decisions under consideration within an intertemporal context of expected lifetime incomes and relative costs. See Marc Nerlove, "Toward a New Theory of Population and Economic Growth" in Schultz (ed.), op. cit., pp. 527-545, for some early comments on the lack of a dynamic dimension in the "new home economics", and for a fertility model which does explore the effects of expected lifetime wage rates and incomes, see Michael P. Ward and William P. Butz, "Completed Fertility and its Timing", Journal of Political Economy, Vol.88, October 1980, pp.917-940.

2.2.1 The fertility equations

The fertility equations explain the following variables;

(i) the mean implied completed family size (M_N) ;

(ii) the variance of the implied completed family size (V_N) ;

(iii) the number of first nuptial confinements (C_1) ;

and

(iv) a proxy for child quality (Q) .

The mean and the variance of the implied completed family size are derived from parity progression data. The parity progression ratio, $\rho_{\tau t}$ is defined as the probability, at time t, of a married female with $\tau (\tau \geq 1)$ children having at least one additional confinement. If this probability remains unchanged for the remainder of the married female's lifetime, then the probability, at time t, of her having a completed family size of n children is defined as:

$$f_t(n) = (1 - \rho_{nt}) \left[\prod_{\tau=0}^{n-1} \rho_{\tau t} \right] \text{ for } n>1 \qquad \ldots \qquad (1)$$

where $\rho_{ot} = 1$.

The mean and variance of the implied completed family size can be calculated as follows:

$$M_{Nt} = \sum_{n=1}^{k} n f_t(n) \qquad \ldots \qquad (2)$$

and

$$V_{Nt} = \sum_{n=1}^{k} (n - M_{Nt})^2 f_t(n) \qquad \ldots \qquad (3)$$

where k is the upper limit for completed family size.

The mean and variance of implied completed family size are modelled in the first two fertility equations (not reproduced here). The number of confinements can be obtained if both the number of first nuptial confinements and the parity progression ratios for all higher order births are known. The former is obtained from the third fertility equation while the latter are obtained by assuming that the mean and variance of implied completed family size are the parameters of a known, two parameter probability function which approximates the actual distribution of implied completed family size. Thus, given the estimated mean and variance, an approximation, $\hat{f}_t(n)$ to the implied completed family size distribution can be obtained and, in turn, the parity progression ratios can be derived from this approximate distribution by inverting equation (1)[1].

As there is no readily available measure of quality per child, it is proxied by the total of government and private education expenditure at constant prices per child aged 5 to 19 years. This measure does have limitations. Firstly, child quality is determined by total children, whereas the proxy only captures educational expenditures. However, to the extent that there is a high positive correlation between quality per child and educational expenditures per child aged 5 to 19 years, this deficiency is reduced. Secondly, the proxy variable does not distinguish between private and government education where some of the variation in child quality may be occurring. No immediately obvious solution exists to correct for this problem.

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1. See Sams op. cit., for a full description of the calculation of the number of confinements and of births.

2.2.2 The marriage equations

The marriage equations endogenise variations over time in the following six variables:

(i) an index of the propensity to first marry (P_F) ;

(ii) the mean of the age distribution of the age specific rates of first marriage (M_F) ;

(iii) the variance in age of the age distribution of the age specific rates of first marriage (V_F) ;

(iv) an index of propensity to remarry (P_R) ;

(v) the mean of the distribution of the age specific rates of remarriage (M_R) ;

and

(vi) the variance in age of the distribution of the age specific rates of remarriage (V_R) .

Variables (i) to (iii) and (iv) to (vi) form two sets which characterise, respectively, the distributions across ages of first marriages and of remarriages.

These variables are defined as follows. If $p_{it}(x)$ is the age specific rate at age x of marriages of type i in year t, where i=F (for first marriage) or R (for remarriage), then the indexes of the propensities to first marry and to remarry are defined as:

$$P_{it} = \int_{x_0}^{100} p_{it}(x)dx \quad ; \quad i = F \text{ or } R , \quad \ldots \quad (4)$$

where x_0 is the minimum age of marriage.

The mean age and the variance in age of the distribution of each type of marriage are defined as:

$$M_{it} = \int_{x_0}^{100} x\, p_{it}(x)dx \Big/ P_{it} \quad , \quad i = F \text{ or } R \ , \quad \ldots \quad (5)$$

and

$$V_{it} = \int_{x_0}^{100} (x - M_{it})^2\, p_{it}(x)dx \Big/ P_{it} \ , \quad i = F \text{ or } R \ , \quad \ldots . \quad (6)$$

2.2.3 The divorce equations

The divorce equations explain the three variables characterising the distribution of the age specific rates of divorce, namely:

(i) an index of the propensity to divorce (P_D) ;

(ii) the mean of the age distribution of the age specific rates of divorce (M_D) ;

and

(iii) the variance of the age distribution of the age specific rates of divorce (V_D) .

The age specific rate of divorce in year t, $p_{Dt}(x)$, is the ratio of the number of females of age x who divorce to the number of married females of age x. The definitions of P_{Dt}, M_{Dt} and V_{Dt} are analogous to those given above for marriage.

2.2.4 The labour force participation rate equations

The equations for female labour force participation explain the labour force participation rates for six demographic groups of women:

(i) married women aged 15 to 24 years ($\ell_{m,\ 15\ -\ 24}$) ;

(ii) married women aged 25 to 54 years ($\ell_{m,\ 25\ -\ 54}$) ;

(iii) married women aged 55 years and over ($\ell_{m,\ 55+}$) ;

(iv) unmarried women aged 15 to 24 years ($\ell_{u,\ 15\ -\ 24}$);

(v) unmarried women aged 25 to 54 years ($\ell_{u,\ 25\ -\ 54}$);

and

(vi) unmarried women aged 55 years and over ($\ell_{u,\ 55+}$) .

The labour force participation rate is defined as the proportion of women in a given demographic group who are in the labour force, whether employed or not.

In total, the model consists of 19 equations. The explanatory variables for each equation are given in Table 4.1 of Filmer and Silberberg[1]. The reasons for including each explanatory variable is discussed in detail in Filmer and Silberberg[2] and will not be repeated in this paper, except to the extent that those variables which are common to both models appear in the discussion below of our respecified model.

With one exception, the general functional form adopted in the Filmer-Silberberg model is linear in the natural logarithms of all variables. The exception is the first nuptial confinements equation which

1. Filmer and Silberberg op. cit., pp.45-50.

2. Ibid., pp.14-42.

is linear in the variables. The model was estimated using annual data for 1921/22 to 1973/74. The results of the estimation of the model using both Full Information Maximum Likelihood and single equation Ordinary Least Squares techniques are reported and discussed in Filmer and Silberberg.[1] The in-sample performance of the estimated model is generally adequate and forms an acceptable basis for the development of the model reported in this paper.

2.3 Revisions to the Filmer-Silberberg Model

The econometric model of fertility, marriage, divorce and labour force participation for women reported in this paper differs from that of Filmer and Silberberg in several major respects. To achieve its integration with the more conventional demographic accounting features of IMPACT's Population Projection Facility[2], the Filmer-Silberberg model required respecification and revision of the database used in its estimation. Such revisions were necessary to ensure consistency between the econometric model and the other submodules within the Facility. This section outlines the major revisions which have been made in the development of the current model.

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1. Ibid., pp.43-65.

2. See Sams op. cit., for details of the interconnections within the Facility.

Firstly, the database has been revised, principally to ensure:

(i) consistency with the ANU Demographic Databank[1] used in the rest of the Facility;

and

(ii) internal consistency between the variables in the database[2].

The database has been extended by two years so that it now covers the period 1921/22 to 1975/76. Minor definitional changes have been made to some variables to make them easier to interpret and, in general, the definition and the method of construction of each of the variables has been clarified.

Secondly, the variables characterising the distributions of the age specific rates of marriage, remarriage and divorce have been obtained by fitting smooth approximating curves to the observed distributions of these rates and calculating the propensity, mean age and variance in age for each distribution from the smooth approximating distribution rather than from the raw data[3]. It is the time-dependent parameters of these fitted distributions which appear as endogenous variables in the current

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1. The Databank is documented in H.P. Brown and A.R. Hall, Australian Demographic Databank, Volume 1 : Recorded Vital Statistics 1921-1976, (Canberra : Research School of Social Sciences, Australian National University, 1978) and H.P. Brown and A.R. Hall, Australian Demographic Databank, Volume 2 : Population Estimates and Demographic Rates 1921-1976, (Canberra : Research School of Social Sciences, Australian National University, 1980), and has been supplemented by unpublished information kindly provided by Alan Hall. The methods used to derive the data series actually used are detailed in Pam Williams, Clive Brooks and Dennis Sams, "The Data Requirements of the Population Submodule of the Demographic Core", IMPACT Research Memorandum, BACHUROO Module, University of Melbourne, May 1980.
2. See Brooks, 1981(b), op. cit..
3. See Pamela Williams, "Marriage and Divorce in Australia : A Time Series of Fitted Distributions, 1921/22 to 1975/76", IMPACT Working Paper No.B-20, University of Melbourne, Melbourne, November 1981.

econometric model. In Filmer and Silberberg, on the other hand, these parameters were estimated directly from the data without optimising the fit of the age distributions corresponding to them. Further, all the observed rates have been calculated using data from the ANU Demographic Databank.

Thirdly, the original model does not distinguish between the remarriage rates of divorcees and of widows. Examination of the data showed a marked difference in the remarriage behaviour of these two groups. The model presented in this paper therefore has separate equations for the variables relating to the remarriages of divorcees and of widows.

Fourthly, first nuptial confinements are now modelled as the rate of first nuptial confinements per thousand married females aged 15 to 44 years rather than as the number of first nuptial confinements. This change relieves the econometric model of the burden of explaining the changes in the number of first nuptial confinements arising simply from changes in the population at risk.

Fifthly, the labour force participation rate equations have been modified so that the participation rates are restricted to the range zero to one. This is achieved by applying an inverse logistic transform, details of which are given below in Section 3.

Sixthly, the explanatory variables have been respecified to ensure a greater consistency in approach across the equations of the model. A detailed discussion of this is postponed to the next section.

3. SPECIFICATION OF THE MODEL

The equations of the respecified model are discussed in this section. A list of all the endogenous and explanatory variables is presented in Table A1.1 of Appendix 1.

3.1 The Fertility Equations

The fertility equations explain (a) the mean and the variance of implied completed family size, (b) the number of first nuptial confinements per thousand married women aged 15-44 years, and (c) quality per child.

The variables chosen to explain the mean and variance of the implied completed family size are:

(i) the real female hourly wage rate (W) ;

(ii) real GDP per head (Y) ;

(iii) the infant mortality rate (ϕ) ;

(iv) the oral contraceptive usage rate (Ω) ;

(v) the real old age and invalid pension rate (G_a) ;

(vi) a dummy variable for World War II (Z_2) ;

and

(vii) a dummy variable for the immediate post-war period (Z_1) (introduced in order to allow for the 'catching up' of postponed births).

All these variables enter the equations with a one period lag in order to reflect the situation at the time the decision was made in regard to having

a further confinement. The equations are specified to be linear in the logarithms of all variables except the dummies.

The variables chosen to explain the first nuptial confinement rate include the above seven variables and an additional variable, the number of weighted first marriages per thousand married women aged 15 to 44 years ($\hat{f}$). This variable, which is not lagged, is included since the first nuptial confinement rate occurring in any period is related to the timing decisions about children taken by recently married couples.

Since it is generally the wife who shoulders the responsibility of rearing children, the real hourly female wage rate is chosen to represent the opportunity cost of having children. As noted above, however, there is also an income effect associated with any change in the wife's wage rate. Our prior expectation, which conforms to the conventional wisdom, is that the substitution effect will outweigh the income effect at typical levels of incomes and female wages, so we expect an increase in the real hourly wage rate for females to have negative effects both on the first nuptial confinement rate and on implied completed family size.

Real GDP per head is introduced into the model in an attempt to measure real family income. Since children are considered a normal good, then a rise in real GDP per head at a given level of the real hourly wage rate of females is expected to lead to rises both in the rate of first nuptial confinements and in the mean implied completed family size.

The infant mortality rate can be perceived as having two opposing effects on the demand for children. If there is a loss of children through infant deaths, couples may respond by having more confinements so that, by compensating for infant mortality, they can achieve their desired family size. However, child mortality also represents a pecuniary and psychic cost of having children. Thus, if increases in infant mortality represent an increase in the cost of children, then the demand for children will fall. Consequently, no prior expectation can be held confidently for the effect of this variable on the demand for first nuptial confinements, or on the mean implied completed family size.

The cost of fertility control can be regarded as a subsidy to having children.[1] If improvements in birth control technology reduce the cost of fertility control, then the value of this subsidy is diminished, and as a result the demand for children will fall. Thus, it is expected that an increase in the oral contraceptive usage rates of married females will cause a fall in the first nuptial confinement rate, and in the mean implied completed family size.

If couples are encouraged to have children to provide financial security for when they become aged or infirm, the provision by the government of old age and invalid pensions will reduce the demand for children. Therefore, a negative relationship is expected between this variable and the first nuptial confinement rate, and the mean implied completed family size.

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1. A theoretical discussion of this aspect of fertility control can be found in Willis, op. cit..

We expect that the dummy variables for World War II and for postponed births will have a negative and a positive effect, respectively, on the first nuptial confinement rate, but we are uncertain of the effect of these on the mean and variance of the implied completed family size distribution since it is unclear whether high or low order births will be more affected by the War and its cessation.

It is relatively easy to postulate the direction of the effects of the explanatory variables on the first nuptial confinement rate. However, predicting these effects on the mean and variance of implied completed family size is more difficult as each variable may not affect married females of all parities equally. For example, an increase in the female wage rate may cause a reduction in the parity progression ratios at low parities but leave virtually unaffected the ratios at higher parities since, at high parities, the marginal cost of an extra child may be insensitive to the female wage rate. In this case the mean implied completed family size will rise.

The variables chosen to explain the proxy variable for quality per child are:

(i) the real female hourly wage rate (W) ;

(ii) real GDP per head (Y) ;

(iii) the infant mortality rate (ϕ) ;

and

(iv) the oral contraceptive usage rate (Ω) .

Since quality and number of children are considered substitutes, the equation for average child quality is treated similarly to the fertility equations already described in that each of the exogenous variables listed above enters with a lag of one year. This equation is specified to be linear in the logarithms of all the variables.

The production of child quality, as well as requiring the input of the parents' time, also requires the input of market commodities. As a result, the real female hourly wage rate can have two opposing effects on the production of child quality. A rise in the real female wage rate represents a rise in the opportunity cost of the female's time and thus will cause a reduction in her input of time into child rearing. With a rise in her real wage rate, however, the female can now purchase more market commodities for a given number of work hours. If female time and market commodities are substitutes in the production of child quality, then the effect of a rise in the real female hourly wage rate cannot be signed a priori. Since child quality is considered to be a normal good, a rise in real GDP per head is expected to have a positive effect on the production of quality per child at a fixed value of the real female hourly wage rate.

Infant mortality can be regarded as a risk in investing in the quality of children. If infant mortality rates are high then parents may be unwilling to make large investments, since premature death prevents the realisation of this investment. Consequently, a negative relationship is expected between the infant mortality rate and quality per child.

If parents can better control their fertility through greater use of contraception, they will be able to devote more resources towards the production of child quality. Therefore, an increase in the oral contraceptive usage rates of married females is expected to cause a rise in the production of quality per child.

3.2 The Marriage Equations

The marriage equations explain the index of the propensity, and the mean and variance of the age distributions of the age specific rates, of first marriage, of remarriage of divorcees, and of remarriage of widows.

Each of the marriage/remarriage equations has the same set of explanatory variables. These are:

(i) the demand for child services (S) ;

(ii) the female/male relative wage rate $(W/\tilde{W})$;

(iii) real GDP per head (Y) ;

(iv) an index of female educational attainment (E) ;

(v) the oral contraceptive usage rate (Ω) ;

(vi) a dummy variable for World War II (Z_2) ;

and

(vii) a dummy variable for conscription in the 1965/66 to 1972/73 period (Z_3) , (for first marriage only) .

The equations are linear in the logarithms of all the explanatory variables except the dummies and all the explanatory variables enter contemporaneously.

If the consumption of child services, defined as the product of the mean implied completed family size and quality per child, provides utility to a married couple, the demand for marriage can be considered as being in part a derived demand for child services. Thus as the demand for child services increases, so does the demand for marriage. Being the only form in which this demand can be observed, the variable used to proxy the demand for child services is the level of such services being consumed by couples already married. However, if the demand by existing married couples is seen as representing a general "community" demand for child services, then it adequately will represent the demand of marrying couples for child services.

Single males and females have to divide their time between both market and non-market activities, but when married they can combine resources with their spouse and specialise in the activities in which they have comparative advantages. The wage rate of females relative to males indicates the gains which can accrue to the husband and wife in the specialisation of their use of time. The combined gain of both partners will be greater the larger the difference between the male wage rate and the female wage rate, and vice versa. Therefore, as the wage rate of females relative to that of males increases, it is expected that the demand for marriage will fall.

Since marriage is taken to be a normal good, the demand for it is expected to be positively related to real GDP per head, given fixed values of all of the relevant prices and shadow prices. The inclusion of the female/male relative wage rate helps to give us confidence that the coefficient of real GDP per head in the propensity to marry and remarry

equations should be positive. We would be justified in having greater confidence if a larger set of relative price variables had been included. Such inclusion is made econometrically difficult because of colinearity problems.

Increased levels of education for females are expected to reduce the demand for marriage. With increased levels of education, females may consider other opportunities, such as labour force participation, to be more appealing than marriage. Education may also have a deferring effect on marriage if females postpone the decision to marry until they have completed their education.

The ready availability of contraception is expected to both reduce the demand for marriage, and lead to a reduction in unplanned pregnancies which bring about marriages. Also, the reduction in the possibility of unplanned pregnancies may induce some couples to abstain from legal marriage. The only data available for this variable is oral contraceptive usage rates of married females, which is assumed to be representative of all females in the community and of contraceptive use in general.

Two dummy variables are also included. The first, for World War II, captures the disruptions to the marriage market which resulted from that war. The other allows for the effect on the demand for marriage of conscription of males over the period 1965/66 to 1972/73. During this period males who married before their National Service registration were

exempt from conscription. As only young males (20 years old) were conscripted, this dummy variable is only included in the equations relating to first marriage.

In general, no prior expectations on the coefficients in the variance equations are postulated.

3.3 The Divorce Equations

The divorce equations explain the index of the propensity to, and the mean and variance of the distributions of age specific rates of, divorce. As for the marriage equations, it is relatively easy to see a direct relationship between the demand for divorce and the index of the propensity to divorce. However, the relationship between the demand for divorce and the mean and variance of the distribution of age specific divorce rates is not as clear. A simple hypothesis would be that, as the demand for divorce increases, the timing of divorce is brought forward, thus lowering the mean age, and the certainty regarding the decision to divorce increases, thus lowering the variance in age. However, if the factors influencing the demand for divorce affect some age groups more than others, this simple analysis may not hold. For example, an increase in the widows' pension would only affect those potential divorcees who are eligible for such a pension--those with children or who are over 50 years of age. If the affected group are old, relative to the mean age of potential divorcees, then the mean and variance of the age distribution may increase in response to an increase in demand for divorce from this source.

The variables chosen to explain the demand for divorce are:

(i) the female/male relative wage rate $(\bar{W}/W)$;

(ii) real GDP per head (Y) ;

(iii) the number of dependents per married female (K) ;

(iv) the real widows' pension (G_W) ;

and

(v) a dummy variable for the introduction of the Family Law Act (Z_4) .

The three equations are specified to be linear in the logarithms of all the variables except the dummy variables. All variables are lagged by two periods in order to reflect the situation at the time the decision to divorce was taken, since the granting of the divorce decree occurs approximately two years after the initial decision to divorce is made.

Changes in the relative wage rates of husbands and their wives are expected to have effects on the demand for divorce opposite to those on the demand for marriage. In Section 3.2 it was argued that differentials in male and female wage rates produced gains from marriage. If these differentials are reduced, the gains from existing marriages will decline and more couples may decide to divorce. Therefore, a positive relationship is expected between the demand for divorce and the female/male relative wage rate.

If divorce is a normal good, the demand for divorce will be positively related to real GDP per head but the positive effect of a rise in the wage component of GDP per head, which leaves the female/ male

relative wage rate unchanged, can be offset by a corresponding rise in the opportunity cost of the time necessary to obtain a divorce. However, a rise in the non-wage component would have purely a positive income effect. Whilst, the effect of changes in real GDP per head cannot be determined a priori, it is likely that the positive income effect will predominate.

The greater the family trauma and psychic costs associated with divorce, the lower the likelihood of a divorce proceeding. The number of dependents per married female is used as a proxy variable for the psychic costs of divorce. The higher the number of dependents, the greater the psychic cost. Thus it is expected that the demand for divorce will be inversely related to the number of dependents per married female.

The availability of a government pension after divorce may provide an incentive to divorce for those females who are dependant upon their husbands for financial support. The widows' pension is available to divorced females with dependent children, or who are over 50 years of age. It is expected that this pension will be positively related to the demand for divorce.

A dummy variable is included for the introduction of the Family Law Act which came into operation at the end of the sample period. This legislation had two effects on the divorce "market". First, it lead to an increase in the number of divorces due to efforts to clear the backlog prior to the introduction of the new Act. Second, it may have lead to some deferment of potential divorces to take advantage of the more lenient provisions of the new Act. These deferments and the increased ease of divorce are expected to increase the propensity to divorce after the introduction of the Act.

A variable which could have been expected to have a negative effect on the demand for divorce is the cost of divorce. Unfortunately, data were not available to create a time series for this variable and it could not be included.

3.4 The Female Labour Force Participation Rate Equations

The female labour force participation rate equations explain the labour force participation rates of females disaggregated by two marital states (married and unmarried[1]) and by three age groups (15 to 24 years, 25 to 54 years and 55 years and over).

The labour force participation rate for a female of a given age group and marital status is defined as the proportion of females of that age group and marital status who are in the labour force, whether employed or unemployed. There are two important consequences of this definition of the female labour force participation rate. First, the female labour force participation rate is an indicator of the supply as opposed to the employment of female labour and a transfer of females from being employed to being unemployed will leave the participation rate unchanged. Second, the female labour force participation rate is unaffected by changes in the number of hours of labour being offerred.

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1. "Unmarried" includes never married, divorced and widowed.

In the "new home economics", the labour force participation of married females is related to their participation in household activities. Married females choose to allocate their time between labour force participation, participation in household activity and leisure. This additional choice concerning the allocation of time to household activity is assumed not to apply to unmarried females. Thus the specification of the equations for married females aged 15 to 24 years and married females aged 25 to 54 years differs from the other equations. Decisions regarding fertility are expected to influence labour force participation decisions only for these married females, whereas married females aged 55 years and over are treated in the same manner as unmarried females.

As the labour force participation rate has a theoretical maximum of unity (that is, when all the females in a particular group are in the labour force), it is transformed prior to estimation to ensure that its estimated value does not exceed a designated maximum. The transformed variable used for estimation is:

$$\ell^* = \ell \Big/ (\ell_u - \ell) \ ,$$

where ℓ^* is the transformed variable, and

ℓ_u is the upper limit set for the labour force participation rate.

Hence,

$$\hat{\ell} = \hat{\ell}^* \ \ell_u \Big/ (\hat{\ell}^* + 1) \ ,$$

where the circumflex denotes the estimated value.

Typically, ℓ_u has a value of unity, although in the case of unmarried females aged 15 to 24 years it is set to one minus the education participation rate of unmarried females aged 15 to 24 years. These transformed variables and all the explanatory variables, except the dummies, enter the equations as their natural logarithms.

The variables chosen to explain the labour force participation rates for married females aged 15 to 54 years are:

(i) the total demand for child quality per married female (KQ) ;

(ii) weighted nuptial confinements per thousand married females ($\hat{c}$) ;

(iii) the oral contraceptive usage rate (Ω) ;

(iv) the real female hourly wage rate (W) ;

(v) an indicator of the demand for female labour (L_D) ;

(vi) the unemployment rate of all persons (u);

and

(vii) a dummy variable for World War II (Z_2) .

The total demand for child quality per married female is obtained as the product of the number of dependents per married female (K), and the demand for quality per child (Q). Increased demand for child quality raises the demand for market commodities, which, in turn, requires a shift in the allocation of expenditure within the household, or an increase in the income of the household. Household income can be increased by the wife joining the workforce and/or working more hours (if she is

already in the labour force) and/or by the husband working more hours. The increased demand for total child quality per married female is expected to increase the labour force participation rates of married females.

Weighted nuptial confinements per thousand married females are obtained by taking a weighted average of the number of nuptial confinements per thousand married females in the current and previous four years. This variable provides an indication of the recent fertility behaviour of married females. As the care of young children is intensive in the use of parents' (usually the mother's) time, the presence of young children in the household may result in the wife withdrawing from the labour force. Therefore, it is expected that there will be a negative relationship between weighted nuptial confinements and the labour force participation rates of married females.

The use of contraception helps to create an environment in which married females can plan ahead and make conscious decisions regarding their length of stay in the labour force. It is expected that the oral contraceptive usage rate of married females will be positively related to their labour force participation rates. However, some of the effect of contraceptive usage will be captured through the total demand for child quality and the weighted nuptial confinement variables, thus weakening the direct effect of the contraceptive variable.

Conventional microeconomic analysis predicts that an increase in the wage rate will tend to induce a person to supply more hours to labour force activity (the positive substitution effect) but the resultant

increase in income will also enable this person to "purchase" more leisure time (the negative income effect). The outcome of this situation is unclear. In the case of married females there is an additional choice available for the allocation of time besides work and leisure: participation in household activity. This further choice can be analysed in an analogous way to leisure. The additional income from an increase in the wage rate will increase the demand for home commodities. However, as the production of home commodities involves the use of female time, the cost of these commodities will increase. The magnitude of the negative income effect on labour force participation will depend on the extent to which leisure time and time spent in household production are substitutable, and on the extent to which market commodities and female time are substitutable in household activity. Overall it is difficult to determine a priori the effect of an increase in the wage rate on the number of hours spent in the labour force. However, the effect on labour force participation rate is more clearly defined. The substitution effect will result in some married females transferring from being not in the labour force to being in the labour force, but the income effect will not cause women to withdraw from the labour force since this would deprive them of their income and their ability to "purchase" any leisure time or home commodities. Therefore, a positive relationship is expected between the real female hourly wage rate and the labour force participation rates of married females.

The ratio of total employment to the male labour force is used as an indicator of the demand for female labour. If it is assumed that

employers initially satisfy their demand for labour through the employment of males, as the availability of jobs increases relative to the number of men in the workforce, more employment opportunities become available to females. This increased availability of jobs may induce more females into the labour force, especially in the case of secondary workers such as married females who tend to leave the labour force in times when there is no prospect of readily obtaining employment. Therefore, a positive relationship is expected between the indicator of demand for female labour and the labour force participation rates of married females.

Conventional analysis of the effect of the unemployment rate on labour force participation postulates the existence of two opposing effects. If an increase in the unemployment rate is perceived as lowering the probability of obtaining a job, some females may decide to withdraw from the labour market--the so-called "discouraged worker" effect. On the other hand, if an increase in the unemployment rate is due to an increase in the unemployment of the "primary" worker in the household (typically the husband in a married household) then other household members may be induced to enter the labour force to compensate for the loss in income -- the "additional worker" effect. Therefore, the effect of the unemployment rate on the labour force participation rates of married females cannot be predicted a priori.

A dummy variable for World War II is included to allow for disruptions in the labour market which occurred during the war. The effect of this dummy is expected to be positive.

The variables chosen to explain the labour force participation rates of married females 55 years and over, and unmarried females of all age groups include some of the variables discussed above, as well as some additional variables. The total set of explanatory variables are:

(i) the real female hourly wage rage (W) ;

(ii) an indicator of the demand for female labour (L_D) ;

(iii) the unemployment rate for all persons (u) ;

(iv) the real old age and invalid pension (G_a) ;

(v) the real widows' pension (G_w) ;

(vi) the education participation rate of females aged 15-24 years ($e_{u,\ 15\ -\ 24}$) ;

(vii) a dummy variable for World War II (Z_2) ;

and

(viii) a dummy variable for the years prior to the introduction of the widows' pension (Z_5) .

The effect of the real hourly wage rate on the allocation of time by females has been discussed above. The females now being considered are assumed not to be engaged in the production of "child services"; their choice is between labour force participation and leisure. As discussed above, although a change in the real female hourly wage rate will have two opposing effects on the supply of working hours, it is expected to have a positive effect on the labour force participation rates of females.

The effect of the indicator of the demand for female labour is the same in this case as was discussed above for married women, that is, a positive relationship is expected between the indicator of the demand for female labour and female labour force participation rates.

The effects of the unemployment rate on labour force participation rates were discussed above. In the case of unmarried females who are more likely to be "primary" workers than are married females, the additional worker effect may be quite small. However, the effect of the unemployment rate on the labour force participation rates of the females under consideration still cannot be predicted a priori.

If females are able to obtain an income from a government pension, they may prefer this income to that earned in the labour force. Two government pensions are considered to affect female labour force participation rates--the real old age and invalid pension which is included in the equations for both married and other females 55 years and over and the real widows' pension which is included in all three equations for unmarried females. A negative relationship is expected between these pensions and labour force participation rates.

For young females participation in the education system is an alternative to participation in the labour force. If it is assumed that participation in the education system precludes participation in the labour force[1], the upper limit for the labour force participation rate can be reduced by the education participation rate (that is, $1 - e_{u,\ 15-24}$). Although, there is obviously a strong simultaneity in the determination of the labour force participation rate and the education participation rate for young women, the education participation rate is treated as exogenous in this study.

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1. The education participation rate variable was calculated on this basis and included only full-time students not in the workforce. See Brooks, 1981(b), for details.

Information concerning the marital status of female students is scarce, but the 1971 Census of Population and Housing did show that 98.4 per cent of full time female students not in the labour force were not married.[1] As it is likely that this high proportion would have persisted over the 1921/22 to 1975/76 sample period, the education participation rate is used to reduce the upper limit of the labour force participation rate only for unmarried females aged 15 to 24 years.

The dummy variable for World War II is included to allow for the disruption in the labour market which occurred during the war. As the widows' pension was not introduced until 1943/44 a dummy variable is specified for the years prior to its introduction to proxy for other forms of financial assistance which were available to widows.

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1. Australian Bureau of Statistics, 1971 Census of Population and Housing, Bulletin 3 - Demographic Characteristics, Catalogue No.2239.0, Canberra, 1972.

4. DATA REQUIREMENTS OF THE MODEL

The variables which comprise the model have been listed in Table A1.2. Their partitioning into endogenous and exogenous variables is presented in Table A1.1. With the exception of the equations relating to divorce, the model is estimated using annual time series data for the period 1921/22 to 1975/76. Assembling a data base over such a lengthy period presents continuity problems. Of necessity, some variables have been constructed on the basis of more than one primary source of data. Moreover, due to changes in definitions, sampling procedures and the like, discontinuities can arise even within one source of primary data.

Although data relating to divorce were available prior to 1950/51, these provide no useful information because the age distribution was manufactured.[1] Hence the years prior to 1950/51 were omitted from the time series used to estimate the divorce equations.

Many of the endogenous variables of the model are annual flows measured over financial years. As a consequence, the exogenous variables used are flows over financial years (possibly lagged) or estimates of stocks at mid-points of financial years. Full details concerning the construction of the variables may be obtained from a separate document.[2]

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1. For more details refer to Williams, op. cit., pp.30-33.
2. Brooks, 1981(b), op. cit..

5. EMPIRICAL ESTIMATION OF THE MODEL

The econometric model specified in Section 3 comprises twenty-two equations, of which thirteen form a simultaneous system.

The equations of the simultaneous system are those for mean implied completed family size, and for "child quality"; for the propensities, mean ages and variances in age for each of first marriages, remarriages of divorcees and remarriages of widows; and for the labour force participation rates for married women aged 15 to 24 years and 25 to 54 years. In order to ensure consistent parameter estimates for the simultaneous system it is necessary to use a simultaneous equation estimating technique such as Two Stage Least Squares (2SLS), Three Stage Least Squares (3SLS) or Full Information Maximum Likelihood (FIML). Both 3SLS and FIML utilise the information contained in the covariance matrix of the residuals, and thus provide parameter estimates which are more efficient than those produced using the 2SLS technique if the maintained specification is correct. However, mis-specification in any of the equations in the simultaneous block estimated under either 3SLS or FIML will feed through to the remaining equations and may result in biased parameter estimates. In this case, the 2SLS estimates (which do not take account of cross equation error relationships) would be preferred.

Estimation of the remaining equations could be undertaken using the Ordinary Least Squares (OLS) technique, as no simultaneity is involved. If the errors from any given equation are contemporaneously uncorrelated with those in all other equations and are otherwise classical, then OLS is equivalent to FIML; if correlations did exist between the errors of the

equations, the Seemingly Unrelated Regressions approach and the FIML estimation procedures would provide estimates which were asymptotically more efficient than OLS.

The approach adopted in estimating the model is a compromise between seeking maximum efficiency and avoiding potential mis-specification bias. The block of simultaneous equations is estimated by Two Stage Least Squares (2SLS) using Wymer's SIMUL computer package.[1] The remaining non-simultaneous equations are estimated in four blocks; one consisting of the four remaining labour force participation rate equations; another containing the three divorce equations; and two single equation blocks composed, respectively, of the equations for the variance of implied completed family size, and for the rate of first nuptial confinements.[2] All the equations are assumed to be linear in the logarithms of all the explanators except the dummy variables, while all the endogenous variables, except the labour force participation rates, also enter in logarithmic form. (Note that the labour force participation rates are first transformed according to the procedure outlined in Section 3.) All equations, except the three divorce equations, are estimated for the period 1921/22 to 1975/76. The divorce block is estimated for only 1950/51 to 1975/76 since the data prior to 1950/51 were thought to be unreliable.

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1. C.R. Wymer, "Computer Programs : SIMUL Manual", International Monetary Fund, Washington D.C., 1977 (mimeo).

2. The computer implementation of the estimation is described in a separate document : Clive Brooks, "Computing Notes for the Estimation of the Econometric Model of Fertility, Marriage, Divorce and Female Labour Force Participation for Australian Females", IMPACT Research Memorandum, BACHUROO Module, June 1981(a).

5.1 The Fertility Equations

The estimated equations for the mean and variance of implied completed family size, the first nuptial confinement rate and the proxy for child quality are presented in Table 1. The actual and estimated values over the sample period for each endogenous variable are illustrated in Figures A2.1 to A2.4 of Appendix 2.

In general the results support our *a priori* expectations regarding the signs of the estimated parameters. Further, with the exception of the equation for mean implied completed family size, the majority of the coefficients are significant at the 5 per cent level.

The influence of real GDP per head is significant and positive in all equations, while the influence of the female wage rate is negative in the equations for the mean and variance of implied completed family size and for the first nuptial confinement rate, but positive in the child quality equation. Thus, according to these estimates, the demands for children and child quality increase with increasing income, while the demand for children decreases with the increasing cost of females' time. However, the effect of female wage rates on child quality, which could not be determined *a priori*, indicates that women substitute market commodities for their own time in producing child quality as the cost of their time increases.

No prior expectations were given for the influence of these variables on the variance of implied completed family size. The coefficients for both real GDP per head and for the female wage rate are

TABLE 1 : ESTIMATED FERTILITY EQUATIONS

Equation for	EXPLANATORY VARIABLES									Coefficient of determination
	Y	W	G_a	ϕ	Ω	$\hat{f}$	Z_2	Z_1	Constant	
Mean implied completed family size(a)	0.2544* (0.0844)	-0.1710 (0.1321)	-0.2928* (0.1461)	-0.0965 (0.1010)	-0.0094 (0.0135)		-0.0790* (0.0297)	-0.0408 (0.0390)	0.3417 (1.0724)	0.3300
Variance of implied completed family size(b)	0.4909* (0.1605)	-1.0932* (0.2575)	-0.6718* (0.2848)	-0.3126 (0.1968)	0.0442 (0.0263)		-0.1539* (0.0579)	-0.2507* (0.0760)	-0.1108 (2.0912)	0.8246
First nuptial confinements per thousand married females aged 15 to 44 years(b)	0.3294* (0.0503)	-0.1312 (0.0840)	-0.3933* (0.0837)	-0.1237* (0.0576)	-0.0172 (0.0090)	0.3390* (0.0708)	0.0071 (0.0201)	0.1613* (0.0237)	1.6410 (0.6393)	0.8689
Child quality proxy (a)	0.3648* (0.1148)	0.7073* (0.1601)		-0.5787* (0.1125)	0.0503* (0.0168)				4.5581* (1.0105)	0.9835

(a) - equation estimated using 2SLS.
(b) - single equation estimated using FIML.

NOTES: 1. All variables, with the exception of the dummy variables and the constant, enter the equations as their natural logarithms. The explanatory variables are: real gross domestic product per head, Y, lagged one period; the real female hourly wage rate, W , lagged one period; the real old age and invalid pension, G_a , lagged one period; the infant mortality rate , ϕ , lagged one period; the oral contraceptive usage rate , Ω , lagged one period; weighted first marriages of females per 1000 married females aged 15 to 44 years , $\hat{f}$; the dummy variable for World War II , Z_2 , lagged one period; and the dummy variable for the immediate post War period, Z_1 , lagged one period. Refer to text for explanation of variables.

2. The values in brackets are asymptotic standard errors.

3. An asterisk indicates the parameter estimate is significant at the 5 per cent level.

significant and indicate an increase in variance with income and a decline in variance with the rising cost of women's time.

A rise in the real old age pension was expected to diminish the demand for children and this is borne out by the coefficients which are negative and significant in all the family size equations.

The effect of an increase in the infant mortality rate is negative in all the equations but only significant in the equations for "child quality" and for the rate of first nuptial confinements. Thus as infant mortality declines, the consequent reduction in the potential psychic costs of having children causes the demand for children to increase while encouraging further expenditure to raise "child quality".

As expected, an increase in oral contraceptive usage is estimated to lower the demand for children and to raise "child quality". However, only the coefficient in the equation for "child quality" is significant.

The rate at which first-born children are produced is expected to respond positively to an increase in the proportion of newly-weds amongst marrieds. This is confirmed by the positive and significant estimated coefficient of the proportion of newly-weds in the equation for first nuptial confinements.

The World War II dummy exerts a negative and significant influence on the mean implied completed family size and its variance, and a

small positive, but insignificant, influence on the first nuptial confinement rate. The postponed births dummy is insignificant in the equation for the mean but significant and negative in the equation for the variance. In the first nuptial confinement rate equation, the postponed births dummy has a positive and significant coefficient.

Excepting the equation for mean implied completed family size, at a descriptive level the fertility equations track fertility behaviour well, with coefficients of determination ranging from 0.82 to 0.98, and the signs on the significant coefficients being in keeping with those postulated above. However, the in-sample tracking of the equation for the mean implied completed family size is poor, with a coefficient of determination (R^2) of only 0.33. It is useful to consider more fully the reasons for the failure of this equation.

From figure A2.1 of Appendix 2, it is clear that the estimated equation fails to capture the rise in mean implied completed family size from the end of World War II to 1961/62 and its fall from there to the end of the sample period. Part of the difficulty in capturing this movement arises from the nature of the implied completed family size distribution, which is calculated using information on the current age distribution of fertility rates. If in a given year the fertility of older women is high, it is assumed in the calculations that currently young women will have the same high fertility when they reach the age of the currently older women. If cohorts are exhibiting different patterns of fertility over their life cycles, as indeed they are within our sample period, the mean of the

implied completed family size distribution can show variations which reflect more these inter-cohort differences than actual trends in intended family size for the youngest child bearing cohort. In particular, at times when births are being deferred, the mean implied completed family size can rise and then fall when births recover. During the Great Depression and World War II, the mean rose because the fertility rates at lower birth orders declined while those for higher orders were maintained. With the recovery of lower birth order fertility after the Depression and the War, the mean family size fell. However, this is not the principal cause of the difficulty in the post-War period.

The rise and fall in the mean implied completed family size since World War II parallels that of other fertility measures, such as the total fertility rate.[1] Ruzicka and Choi[2] have explained the movement in the total fertility rate as follows:

> "The shift of childbearing towards younger ages was partly responsible for the very high levels of fertility in the 1950-65 period. While fertility of those aged 30 and over remained still comparatively high in this period (over 120 per 1,000 women aged 30-34) reflecting the late completion of childbearing of the older generations, the younger generations had started their families early and attained high fertility

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1. The total fertility rate is the sum of the age specific fertility rates in a given year.

2. L. T. Ruzicka and C.Y. Choi, "Recent Decline in Australian Fertility", in Australian Bureau of Statistics, Year Book Australia, No.65, 1981, pp.114-127.

> while they were still in their 'twenties'. The joint effect of these two generational patterns of childbearing gave rise to a very high level of fertility and contributed to the 'baby boom' of this period. Similarly the rapid decline in fertility in the 1970s reflects not only the reduction in generational fertility but also the effects of the low fertility of the older women who had completed much of their family formation in the 1960s and the low fertility of the younger women who had postponed their childbearing."[1]

Thus, since the implied completed family size measure is based on cross-sectional fertility rates in each year and the assumption that these rates are the age specific rates facing a woman over all her reproductive life, the measured value of the mean implied completed family size rises dramatically with the joint occurence of high fertility rates for both younger and older women. The implied family size measure used here is no better or worse in this regard than most other fertility measures, but its failure to capture the details of fertility change over part of the sample period reduces confidence in the specification of the equation for the mean. In particular, Ruzicka and Choi point out that:

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1. Ibid., p.117.

"It is worth noting that the high fertility level of the 1950-65 period does not mean that there had been a sudden increase in the family size of the generations of women who passed through their childbearing ages in those years. None of these generations ever reached the completed fertility suggested by the time-period rates (total fertility rates) for these years. The highest generational fertility of 3,077 children per 1,000 women born in 1928-33 was considerably less than the total fertility rates of the 1951-65 period. The change in the timing of childbearing of successive generations of women had gradually concentrated more of their births into a shorter span of years, creating a sharp increase in time period fertility, particularly in 1956-60."

5.2 The Marriage Equations

The estimated equations for the index of the propensity, the mean and the variance of the distribution of age specific rates for each of first marriage, remarriage of divorcees and remarriage of widows are presented in Table 2. The actual and estimated values of these variables are illustrated in Figures A2.5 to A2.13 of Appendix 2.

Examination of Table 2 reveals that the three propensity equations perform well. Not only do the majority of signs concur with *a priori* expectations, but most of the coefficients are well determined. As well, the overall explanatory power of each equation is high, ranging from an R^2 value of 0.89 for the propensity to first marry to 0.74 for the propensity of widows to remarry.

TABLE 2 : ESTIMATED MARRIAGE EQUATIONS

Equation for	EXPLANATORY VARIABLES								Coefficient of determination
	S	Y	$W/\tilde{W}$	E	Ω	Z_2	Z_3	Constant	
Index of propensity to first marry	0.3918* (0.0699)	0.4272* (0.1022)	-0.8198* (0.2064)	-0.4713* (0.0956)	-0.0920* (0.0183)	0.3178* (0.0439)	0.0013* (0.0005)	-3.2949* (0.6983)	0.8898
Mean of the age distribution of age specific rates of first marriage	-0.0307* (0.0070)	-0.0493* (0.0103)	0.0090 (0.0208)	0.0212* (0.0096)	0.0125* (0.0018)	-0.0124* (0.0044)	-0.0003* (0.0001)	3.8242* (0.0703)	0.9517
Variance of the age distribution of age specific rates of first marriage	-0.2262* (0.0362)	-0.1724* (0.0528)	0.6101* (0.1067)	0.3216* (0.0494)	0.0376* (0.0095)	-0.1904 (0.0227)	-0.0007* (0.0002)	6.3219* (0.3610)	0.8269
Index of propensity to remarry for divorcees	0.3971* (0.1405)	0.5938* (0.2056)	-0.4553 (0.3963)	-0.6687* (0.1918)	-0.1518* (0.0330)	0.2826* (0.0884)		-2.5437 (1.3951)	0.8275
Mean of the age distribution of age specific rates of re-marriage of divorcees	-0.1509* (0.0332)	0.1337* (0.0486)	-0.1677 (0.0936)	0.1588* (0.0452)	0.0172* (0.0078)	-0.0799* (0.0209)		2.7623* (0.3267)	0.7549
Variance of the age distribution of age specific rates of re-marriage of divorcees	-0.3583* (0.1073)	0.7756* (0.1570)	-0.3031 (0.3027)	0.3879* (0.1461)	-0.0111 (0.0252)	-0.4529* (0.0676)		0.3314 (1.0658)	0.6432
Index of propensity to remarry for widows	-0.0111 (0.1228)	0.6100* (0.1797)	0.0233 (0.3465)	-0.7945* (0.1672)	-0.1165* (0.0288)	0.1111 (0.0773)		-0.7756 (1.2198)	0.7412
Mean of the age distribution of age specific rates of remarriage of widows	-0.0195 (0.0348)	0.1193* (0.0509)	-0.1398 (0.0981)	0.1089* (0.0473)	0.0043 (0.0082)	-0.0239 (0.0219)		2.2877* (0.3453)	0.6448
Variance of the age distribution of age specific rates of remarriage of widows	0.2267* (0.0463)	-0.2859* (0.0677)	0.1610 (0.1305)	0.2674* (0.0630)	0.0219* (0.0109)	0.0263* (0.0291)		4.6490 (0.4594)	0.8892

TABLE 2 : (Cont'd)

NOTES:
1. All variables, with the exception of the dummy variables and the constant, enter the equations as their natural logarithms. The explanatory variables are: child services, S; real gross domestic product per head, Y; the female/male relative hourly wage rate, W/W; an indicator of female educational attainment, E; the oral contraceptive usage rate, Ω; the dummy variable for World War II, Z_2; and the dummy variable for conscription, Z_3. Refer to text for explanation of variables.
2. The values in brackets are asymptotic standard errors.
3. An asterisk indicates the parameter estimate is significant at the 5 per cent level.
4. All equations are estimated using 2SLS.

The indices of the propensity for first marriage and remarriage of divorcees are positively related to the demand for child services and real GDP per head, and, where significant, negatively related to the female/male relative wage rate, female education and the rate of contraceptive usage. Contrary to prior expectations, the demand for both types of marriages are positively related to the World War II dummy variable. Unlike the other indices, the index of propensity of widows to remarry is estimated to decrease with the demand for child services and to increase with the female/male relative wage rate, although the parameter estimates in both cases are insignificant at the 5 per cent level. All the parameter estimates in the equation for first marriages are well determined, and all except that for the female/male relative wage rate are significant in the equation for the remarriage of divorcees. Only the parameter estimates for real GDP per head, the index of female educational attainment and the oral contraceptive usage rate are significant in the equation for remarriages of widows.

To the extent that the opportunity cost of time is embodied in real GDP per head, the positive influence of the latter variable in the index of propensity equations tends to suggest that the income effects outweigh the increase in the own time cost of searching for a partner. The elasticity with respect to real GDP per head is highest for the remarriage of widows and lowest for first marriage, although the difference is not great. If real GDP per head primarily captures non-wage effects, then these results may reflect the greater importance of non-wage income to divorcees and widows. This hypothesis is supported by the fact that the female/male relative wage is only significant in determining the propensity

to first marry. These results also may be due to the weaker labour force attachment of divorcees and widows, which is a result of their access to alternative means of financial support (such as the widows' pension).

The signs of the parameters in the equations for the mean and variance of the distribution of the age specific rates of first marriage are in accordance with the priors specified in the simple analysis presented in Section 3.2. That is, the signs of the parameters in these two equations are the opposite to those in the equation for the index of the propensity to first marry. The mean and variance are positively related to the female/male relative wage rate, the index of female educational attainment and the oral contraceptive usage rate and negatively related to the demand for child services and real GDP per head. All the parameter estimates, with the exception of that for the female/male relative wage rate in the equation for the mean, are significant at the 5 per cent level. There is a positive relationship between the means of the distribution of the age specific remarriage rates of both divorcees and widows and real GDP per head, the index of female educational attainment and the oral contraceptive usage rate. There is a negative relationship between these means and the demand for child services and the female/male relative wage rate, but only the coefficient on the demand for child services in the remarriage of divorcees equation is well determined. The signs of the estimated parameters for the relative wage rate and real GDP per head were opposite to those expected under the simple analysis presented in Section 3.2.

5.3 The Divorce Equations

The estimated equations for the index of the propensity to divorce, the mean and the variance of the distribution of age specific divorce rates are presented in Table 3. The actual and estimated values for each of these variables are illustrated in Figures A2.14 to A2.16 of Appendix 2.

The signs of the parameters in the equation for the index of the propensity to divorce are in accordance with prior expectations. There is a positive relationship between the index and the female/male relative wage rate, real GDP per head and the real widows' pension, while the relationship between the index and the number of dependents per married female is negative. Only the estimated parameters for the number of dependents per married female, the real widows' pension and the Family Law Act dummy are significant at the 5 per cent level, although the R^2 value is satisfactory at 0.95.

The mean of the distribution of age specific divorce rates is positively related to the number of dependents per married female and the real widows' pension, and negatively related to the female/male relative wage rate, the number of dependents per married female and real GDP per head. The only significant variable is the number of dependents per married female, and the R^2 value is low at 0.52.

There is a positive relationship between the variance of the distribution of age specific rates of divorce and the female/male relative wage rate, the number of dependents per married female and the real widows' pension, and a negative relationship between the variance and real GDP

TABLE 3 : ESTIMATED DIVORCE EQUATIONS

Equation For	EXPLANATORY VARIABLES						Coefficient of determination
	Y	$W/\bar{W}$	G_W	K	Z_4	Constant	
Index of propensity to divorce	0.2331 (0.3666)	0.4483 (0.6272)	0.5060* (0.2204)	-2.0816* (0.4258)	0.5812* (0.1078)	-4.4722 (2.2773)	0.9527
Mean of the age distribution of age specific rates of divorce	-0.0557 (0.1420)	-0.1624 (0.2429)	0.0749 (0.0854)	0.4675* (0.1649)	-0.0014 (0.0417)	3.6785* (0.8820)	0.5154
Variance of the age distribution of age specific rates of divorce	-0.4867 (0.6631)	0.9359 (1.1346)	0.4846 (0.3986)	1.8496* (0.7707)	-0.0541 (0.1949)	7.3695 (4.1196)	0.5920

NOTES: 1. All variables, with the exception of the dummy variables and the constant, enter the equations as their natural logarithms. The explanatory variables are: real gross domestic product per head , Y , lagged two periods; the female/male relative hourly wage rate , $W/\bar{W}$, lagged two periods; the real widows pension , G_W , lagged two periods; children under 15 years per married female 15 years and over , K , lagged two periods; and the dummy variable for the Family Law Act , Z_4 , lagged two periods. Refer to the text for explanation of variables.

2. The values in brackets are asymptotic standard errors.

3. An asterisk indicates the parameter estimate is significant at the 5 per cent level.

4. All equations are estimated using FIML.

per head. However, the number of dependents per married female is the only significant variable at the 5 per cent level and the R^2 value was only 0.59.

The performance of the propensity equation is satisfactory, but that of the mean and variance equations is less so. The only significant coefficient in the latter equation is that for the number of dependents per married female. Over the 1950's increases in the propensity to divorce were predominantly composed of increases in the age specific divorce rates for persons aged 40 years and older but from 1965 onwards the rising propensity to divorce reflected a relative rise in divorce rates at younger ages[1]. This initial impetus to divorce among older couples may have reflected an increasing readiness to divorce amongst those whose dependents had grown up, while the rise in divorce amongst younger couples did not occur until the number of dependents per married woman fell. Thus, although the number of dependents is able to capture some of these effects on the timing of divorce it is not able to account for all the details of the changes.

5.4 The Labour Force Participation Rate Equations

The estimated equations for the labour force participation rates of married women aged 15 to 24 years and 25 to 54 years are presented in Table 4 while those for married women aged 55 years and over, and for unmarried women aged 15 to 24 years, 25 to 54 years and 55 years and over

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1. See Pamela Williams, op. cit., Section 3.2.

TABLE 4 : ESTIMATED EQUATIONS FOR LABOUR FORCE PARTICIPATION RATES - MARRIED FEMALES 15 TO 54 YEARS

Equation for	EXPLANATORY VARIABLES								Coefficient of determination
	W	L_D	u	KQ	Ω	$\hat{c}$	Z_2	Constant	
Married females aged 15-24 years	0.9634* (0.2310)	0.9288 (0.8187)	-0.3659* (0.0556)	0.5454* (0.1424)	-0.0038 (0.0377)	-1.9938* (0.2732)	0.3305* (0.0930)	6.1596* (1.2942)	0.9850
Married females aged 25-54 years	0.2933 (0.1830)	0.7631 (0.6485)	-0.1091* (0.0441)	0.8077* (0.1128)	0.1233* (0.0298)	-1.2369* (0.2164)	0.3621* (0.0737)	0.1348 (1.0250)	0.9845

NOTES: 1. All explanatory variables, with the exception of the dummy variables and the constant, enter the equations as their natural logarithms. The labour force participation rates enter as their inverse logistic transform. The explanatory variables are: the real female hourly wage rate, W ; an indicator of demand for female labour, L_D ; the unemployment rate, u ; children under 15 years per married female 15 years and over, K ; child quality proxy, Q ; the oral contraceptive usage rate, Ω ; weighted nuptial confinements per thousand married females aged 15 to 44 years, $\hat{c}$; and the dummy variable for World War II, Z_2 . Refer to text for explanation of variables.

2. The values in brackets are asymptotic standard errors.

3. An asterisk indicates the parameter estimate is significant at the 5 per cent level.

4. All equations are estimated using 2SLS.

are presented in Table 5. The actual and estimated values for all the labour force participation rate equations are illustrated in figures A2.17 to A2.22 of Appendix 2.

The labour force participation rates are transformed before estimation[1] and it is the transformed variables, ℓ^*_{ij} , which enter the estimated equations in log-linear form. The transformed variable is defined as:

$$\ell^*_{ij} = \ell_{ij} \Big/ (1 - \ell_{ij}) \qquad i,j \neq u,\ 15\text{-}24 \ ;$$

and

$$\ell^*_{u,\ 15\text{-}24} = \ell_{u,\ 15\text{-}24} \Big/ (1 - e_{u,\ 15\text{-}24} - \ell_{u,\ 15\text{-}24}) \ ,$$

where

ℓ_{ij} is the labour force participation rate for women of the i^{th} age and j^{th} marital status group;

ℓ^*_{ij} is the corresponding transformed variable; and

$e_{u,15\text{-}24}$ is the education participation rate of unmarried woman aged 15 to 24 years.

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1. See Section 3, pp. 34-35.

TABLE 5 : ESTIMATED EQUATIONS FOR LABOUR FORCE PARTICIPATION RATES - MARRIED FEMALES 55 YEARS AND OVER, UNMARRIED FEMALES 15 YEARS AND OVER

Equation For	EXPLANATORY VARIABLES								Coefficient of determination
	W	G_a	G_W	L_D	u	Z_2	Z_5	Constant	
Married females aged 55 years and over	0.5120* (0.2325)	-0.0883 (0.2505)		5.6770* (0.6008)	0.2975* (0.0426)	-0.1131 (0.0730)		-3.9343* (0.8201)	0.9301
Unmarried females aged 15-24 years	0.5601 (0.2949)		0.2523 (0.1311)	1.2324 (1.0550)	-0.0315 (0.1021)	0.1608 (0.1194)	-0.3099 (0.2977)	1.2883* (0.6047)	0.9310
Unmarried females aged 25-54 years	0.4948* (0.0982)		0.0292 (0.0448)	-0.6333 (0.3454)	-0.0298 (0.0341)	0.1089* (0.0387)	-0.1524 (0.1024)	1.0704* (0.2019)	0.9215
Unmarried females aged 55 years and over	0.1078 (0.0768)	-0.4351* (0.0904)	-0.0417 (0.0295)	0.0487 (0.2165)	0.0167 (0.0229)	-0.1052* (0.0238)	-0.2293* (0.0631)	-0.3756 (0.2621)	0.7903

NOTES: 1. All explanatory variables, with the exception of the dummy variables and the constant, enter the equations as their natural logarithms. The labour force participation rates enter as their inverse logistic transform. The explanatory variables are: the real female hourly wage rate , W ; the real old age and invalid pension , G_a ; the real widows' pension , G_W ; the indicator of demand for female labour L_D ; the unemployment rate , u ; the dummy variable for World War II , Z_2 ; and the dummy variable for no widows' pension, Z_5 . Refer to text for explanation of variables.

2. The values in brackets are asymptotic standard errors.

3. An asterisk indicates the parameter is significant at the 5 per cent level.

4. All equations are estimated using FIML.

Thus, the elasticities of the labour force participation rate with respect to each explanatory variable are no longer simply the estimated coefficients of that explanatory variable in the appropriate equation but instead are:

$$\eta_{ijk} = \partial \ell n(\ell_{ij}) \Big/ \partial \ell n(X_k)$$

$$= (1-\ell_{ij}) \partial \ell n(\ell^*_{ij}) \Big/ \partial \ell n(X_k) \text{ for i, j} \neq \text{u, 15-24}$$

$$= (1-\ell_{ij}) \eta^*_{ijk} \quad ;$$

and

$$\eta_{u,15-24,k} = (1-e_{u,15-24} - \ell_{u,15-24}) \Big/ (1 - \ell_{u,15-24}) \eta^*_{u,15-24,k},$$

where η^*_{ijk} is the estimated coefficient (that is, the elasticity of the transformed variable with respect to the explanatory variable) in the equation for the jth age and ith marital status group. The elasticity of the labour force participation rate of unmarried women 15 to 24 years with respect to their education participation rate is:

$$\eta_{u,15-24,e} = e_{u,15-24} \Big/ (1-e_{u,15-24}) \quad .$$

Thus, the elasticities of the labour force participation rates vary according to the level of the participation rate. At low participation rates, the elasticities will be close to the values of the corresponding estimated coefficients, but will decline with increasing participation rates. As these rates approach their ceiling values (unity, except in the case of unmarried women aged 15 to 24) the elasticities tend to zero. The values of the multiplicative factors used in calculating the elasticities for selected years are given in Table 6. Where relevant, the elasticity

TABLE 6 : MULTIPLICATIVE TERMS FOR CALCULATION OF ELASTICITIES OF LABOUR FORCE PARTICIPATION: SELECTED YEARS

	Year	Labour force participation rate	Education participation rate	Multiplicative factors		$\eta_{u,15-24,e}$
Married females aged 15 to 24 years	1921/22	3.39		0.966		
	1950/51	17.50		0.825		
	1975/76	54.18		0.458		
Married females aged 25 to 54 years	1921/22	4.39		0.956		
	1950/51	11.10		0.889		
	1975/76	46.69		0.533		
Married females aged 55 years and over	1921/22	3.87		0.961		
	1950/51	4.33		0.957		
	1975/76	14.75		0.853		
Unmarried females aged 15 to 24 years	1921/22	55.04	8.27		0.400	0.090[a]
	1950/51	77.15	10.80		0.135	0.121
	1975/76	64.85	32.16		0.044	0.474
Unmarried females aged 25 to 54 years	1921/22	52.91		0.471		
	1950/51	68.70		0.313		
	1975/76	71.46		0.285		
Unmarried females aged 55 years and over	1921/22	15.58		0.844		
	1950/51	14.89		0.851		
	1975/76	11.55		0.885		

(a) Value shown is the elasticity of the labour force participation rate of unmarried women aged 15-24 years with respect to their education participation rate.

with respect to the education participation rate is also shown. Excluding 15-24 year old unmarried females, these factors range from just under one to just over one quarter. For the excluded group, the multiplier is 0.4 in 1921/22 and the elasticity, with respect to the education participation rate, is 0.09. By 1975/76, this multiplier has diminished to 0.04 and the elasticity, with respect to the education participation rate, has risen to 0.47. Thus by the end of the sample period, it is only with respect to those variables with very large estimated coefficients that the elasticities of labour force participation will be comparable in size to the elasticity with respect to the education participation rate. In interpreting the estimated equation for unmarried women aged 15-24 years it should be remembered that the dominant influence towards the end of the sample period is the education participation rate of this group. This is a particularly important consideration for out-of-sample projections.

Overall, the labour force participation equations fit well with R^2's greater than 0.92 for five of the estimated equations, but only 0.79 for unmarried women aged 55 years and over. The estimated coefficients for married women are nearly all significant at the 5 per cent level; for unmarried women, however, fewer of the coefficients are well determined. With a few exceptions, the signs of the coefficients are in keeping with a priori expectations.

The signs of all the estimated coefficients in the equations for married women are in keeping with our expectations, excepting that of the oral contraceptive usage variable in the equation for the labour force participation rate of married women aged 15 to 24 years. However, this

coefficient is small and insignificant at the 5 per cent level. A positive relationship exists between the labour force participation rates of married women aged 15 to 24 years and 25 to 54 years and the total demand for child quality, while a negative relationship exists between the labour force participation of these groups and the weighted nuptial confinement rate. The coefficient of the oral contraceptive usage rate is significant and positive for married women aged 25 to 54 years. The coefficients for the female wage rate, and for the indicator of the demand for female labour, are both positive in all the equations for married women, while the coefficients for the unemployment rate are negative for the two younger groups of married women (indicating that the "discouraged worker" effect dominates in these groups), but positive for the older group. This "encouraged worker" effect for older married women may reflect the substitution by households at high levels of unemployment of participation by females for that of older men who experience greater than average difficulty in finding new employment. The real old age pension rate has a small and, as expected, negative relationship with the participation rate of older married women but the coefficient is not significant at the 5 per cent level. The dummy for World War II increases the participation rates of married women aged 15 to 54 years, but the coefficient is small, negative and insignificant in the equation for married women 55 years and over.

In summary, the influence of fertility on the participation rates of young married women is such as to discourage them from working in the years soon after the birth of their children, but then to encourage them to undertake paid work in order to supply the level of child services demanded for their children. The oral contraceptive variable has the

expected effect for the case of married women aged over 25 years, but not in the case of younger married women. Given that the influence of this variable must be reflected to a considerable extent in the first nuptial confinement rate, its status in these equations is less clear than is desirable.

The participation rate equations for married women provide a plausible interpretation of the relationship between labour market participation and fertility, the real female wage rate, overall labour demand, unemployment, and the real old age pension. The performance of the equations for other unmarried women, however, is not as satisfactory. The majority of coefficients are not significant (despite high R^2 values). The coefficients for the real female wage rate display the expected positive signs in all equations but the only significant case is the equation for unmarried women aged 25 to 54 years. The coefficient for labour demand is positive for the youngest and oldest age groups but has a perverse negative sign for the women aged 25 to 54 years. However, none of these coefficients are significant. Similarly, none of the coefficients on the unemployment rate are significant, although the estimates suggest a small "discouraged worker" effect for the two younger groups and a small "encouraged worker" effect for the other women aged 55 years and over. The latter is unexpected but not significant.

As expected, the real old age pension has a significant negative effect on the participation rate of unmarried women aged 55 years and over. Further, the real old age pension is estimated to have a greater effect on the participation rate of old unmarried women than on that of old married women.

6. HISTORICAL PERFORMANCE OF THE MODEL

As a test of the overall performance of the model, each of the 22 equations in the model has been simulated over the sample period, assuming perfect knowledge of the predetermined variables. The time paths of both the actual and estimated values of the endogenous variables are illustrated in Figures A2.1 to A2.22 of Appendix 2. In this section we present an explanation of the historical changes in the endogenous variables in terms of the changes in the explanatory variables[1] and their effects on the estimated values calculated by the model.

6.1 The Fertility Variables

The performance of the equation for the mean implied completed size is poor, especially after World War II. The estimated equation for the variance of implied completed family size also fails to track very precisely in the post-War period, although it does capture the general secular decline exhibited over most of the sample period. Because of the failure of the equations for the mean and variance to track satisfactorily over the sample period, it is not possible to offer the model as providing plausible explanations of the movements in these variables. However, the performances of the first nuptial confinement rate equation and the "child quality" equation are very satisfactory.

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1. The explanatory variables are tabulated and plotted in Clive Brooks and Dennis Sams, "Tables and Graphs of the Database for a Model of Fertility, Marriage, Divorce and the Labour Force Participation of Australian Women", IMPACT Research Memorandum, BACHUROO Module, November 1981.

Throughout the sample period, the changes in the actual rate of first nuptial confinements have closely followed those of the weighted number of first marriages per married women aged 15 to 44 years and the latter would appear to be sufficient to explain the movements in the estimated confinement rate. However, on average only about one third of the year-to-year percentage change in the weighted marriage variable is transferred by the model into variations in the first nuptial confinement rate. The movements are also influenced by positive contributions from the rising real GDP per head and the falling infant mortality rate and negative contributions from the rising real old age and invalid pension and the real female wage rate. By the end of the period, the direct effect of the contraceptive variable is to adjust the first nuptial confinement rate to a level 5 per cent below what it would have been if the contraceptive variable had not increased after 1961/62.

Over the sample period, the "child quality" index has generally risen with a steeper rise after World War II. In the pre-War period, the growth in the estimated index arises principally from the growth in real GDP per head and the decline in the infant mortality rate, while over the period 1924/25 to 1931/32, the fall in the infant mortality rate is sufficient to overcome the depressing effect of the fall in real GDP per head. The greater rate of increase in the index after World War II arises from the accelerated growth in real GDP per head and the rising real female wage rate. The rapid rise at the end of the period is due to the joint effect of a rapid rise in the real female wage rate and an increase in the rate of decline of the infant mortality rate.

6.2 The Marriage Variables

In general, the marriage equations are successful in capturing the historical movements in the propensities, mean age and variances in age of the three types of marriage[1].

The propensity to first marry increased slightly from 1921/22 to 1927/28, then declined before following a rising trend from 1932/33 to 1957/58 except during the War and its aftermath when there was a pronounced rise followed by a fall. From 1958/59 onwards, the propensity declined, initially slowly and then at a greater rate after 1971/72. Prior to World War II, the estimated propensity is determined predominantly by the level of real GDP per head, while after World War II, the propensity is increased by the growing demand for "child services" as well as by rising real GDP per head but this increase is opposed by the rises in the index of female educational attainment and the relative female/male wage rate. After 1957/58, the effect of rising educational attainment dominates and the propensity begins a slow decline which accelerates with the rapid increase in the relative wage at the end of the period. The rapid rise in the oral contraceptive usage variable after 1960/61 causes the estimated value to overreact and the equation seriously underestimates in the early 1960's.

Similarly, the movements in the estimated mean age and variance in age of first marriage can be explained by the movements in the same variables as for the propensity excepting that the influences all have the opposite effect. Before the War both the mean age and variance in age

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1. See Pamela Williams op. cit., for a detailed discussion of the historical movements of the marriage variables.

rise with the decline in real GDP per head during the Depression and then fall as incomes recover. After the War, they continue to decline because of the effect of rising real GDP per head and the increasing demand for child services, until rising female educational attainment dominates and the mean age and variance in age begin to rise with increasing encouragement from the rising relative wage rate. The rapid rise in the contraceptive variable caused the equations to overestimate in the early 1960's.

The propensity of divorcees to remarry rose from 1921/22 then fell in the Depression years before rising to a peak in 1949/50, followed by a slow decline to 1973/74 and an accelerated decline thereafter. The mean age of remarriage of divorcees followed a generally declining trend to 1956/57 then a fluctuating upward trend to 1975/76, while the variance followed a more variable course finishing in an upward trend after 1959/60. Prior to the War, the dominant influence on the estimated values of the propensity is the real GDP per head. After the War, the effects of rising real GDP per head and the rising demand for child services are offset by the increase in the indicator of female educational attainment. The net effect is for the estimated propensity to remain moderately constant from 1951/52 to 1961/62 then to decline rapidly to a lower level in the early 1960's because of the rapid rise in the contraceptive variable. However, this sudden drop is not matched by the actual values so the equation for the propensity tracks very badly for this period.

The gradual fall in the estimated values of the mean age of divorcees to remarry from 1921/22 to 1939/40 is due to the negative effect of the increasing demand for child services which is opposed by the

positive effects from the rises in real GDP per head and the index of female educational attainment. The rapid decline in the immediate post-War years comes from the sharp fall in the index of female educational attainment. From 1951/52 to 1967/68, the estimated values rose because the positive effects of the increasing real GDP per head and female educational attainment dominated the negative effect of the rise in the demand for "child services". After 1971/72, a negative effect from the rise in the relative female/male wage rate caused the estimated value to decline and diverge from the actual values for this period.

The remarriage of widows variables exhibit similar movements to those for remarriages of divorcees except that the propensity fell more dramatically from the early 1960's due to the greater effect of the rising educational attainment index and the rising contraceptive usage variable, while the mean and variance show a more pronounced rise than that for divorcees from the joint effect of rising real GDP per head and educational attainment.

6.3 The Divorce Variables

The estimated equation for the propensity to divorce performed very well in capturing the changes in this variable over the sample period. However, the equations for the mean age and the variance in age of divorce did not track very well, although they did capture the broad movements in these variables.

The actual values for the propensity to divorce followed a slightly declining trend from 1950/51 to 1960/61 and then an increasing trend for the remainder of the sample period. This increasing trend was

slight at first but accelerated after 1973/74. The estimated values for the propensity to divorce fell gradually from 1950/51 to 1956/57 mainly because of the effects of a rise in the number of dependents per married female, a slight drop in the real widows' pension and a small fall in the female/ male relative wage rate. From 1956/57 to 1964/65, the estimated values remained constant due to the offsetting effects of rises in the number of dependents per married woman and the real widows' pension, but, after 1964/65, increased because of a decline in the number of dependents per married female, a rise in real GDP per head, a rise in the real widows' pension, and - especially after 1970/71 - a rise in the relative female/male wage rate. The peak in 1975/76 is produced by the dummy variable for the Family Law Act.

The mean age of divorce increased from 1950/51 to 1954/55, fell from 1955/56 to 1958/59, then underwent a major rise and fall over the rest of the period with a maximum in 1966/67 although there was an abrupt drop in 1965/66 and a rise in 1975/76. The variance in age of divorce exhibits a similar set of changes over the sample period. The increasing trend in the estimated values for 1950/51 to 1966/67 arises principally from the positive effects of rises in the number of dependents per married woman and the real widows' pension which are sufficiently large to offset the negative effect of rises in the real GDP per head. After 1966/67, the estimated values fall because of the fall in the number of dependents per married woman while the other variables continue to have a positive effect. The model fails to explain the rise and fall in the mean age and the variance in age from 1950/51 to 1958/59, but the explanation for the major movement does seem plausible although the success is limited.

6.4 The Labour Force Participation Rate Variables

The performance of the labour force participation rate equations are satisfactory for all six of the marital status/age groups. The participation rates for married women have risen for most of the sample period except for the rapid fall after the War. In the pre-War period, the principal influences on the estimated participation rates for married women aged 15 to 24 years and 25 to 54 years are the falling weighted nuptial confinement rate, and the fall in the demand for female labour and the rise in unemployment during the Depression. The rise in the estimated rates during the War years arises simply from the dummy variable and the rise in the index of the demand for female labour. After the War, the rising demand for female labour and for "child services" plus the increasing real female wage rate encourages these married women into the workforce, while the fluctuations are due mainly to changes in the unemployment rate. After 1961/62, the weighted nuptial confinement rate declines and this, together with the increases in the demand for "child services", the real female wage rate and the demand for female labour, causes the estimated values to rise for the remainder of the sample period. At the end of the period, the estimated rates exceed the actual rates because of the rapid rise in the female wage rate at this time. The changes in the estimated participation rates for married women aged 55 and over, arise nearly entirely from the changes in the demand for female labour except at the end of the period when the rapid rise in the real female wage rate causes a rapid rise in the estimated rate.

For unmarried women aged 15 to 24 years, the movements in the estimated values before the War arise almost entirely from movements in the indicators of the demand for female labour, while, after the War, the

influence of the education participation rate dominates and the estimated rate falls steadily from 1947/48 because of the rise in this variable. The principal determinant of the rate for unmarried women aged 25 to 54 years is the rising real female wage rate with some small changes caused by the changes in the unemployment rate and the demand for female labour. The movements in the estimated rate for unmarried women aged 55 years and over are produced by the rising real old age and invalid pension, which is causing the participation rate to decline, and the rising real female wage rate and demand for female labour which nearly offset the former effect. The decline in the War years is produced by the War dummy, while the greater rate of decline from 1972/73 to 1975/76 is caused by the rapid rise in the real old age and invalid pension over these years.

7. CONCLUSIONS

This paper contains the specification and estimation of an econometric model of fertility, marriage, divorce and female labour force participation for Australian women based on data from 1921/22 to 1975/76. The model derives its inspirations from the "new home economics" and from the previous model of Filmer and Silberberg[1], and illustrates the appropriateness of this approach both to modelling demographic behaviour and to including the influence of fertility variables in a simultaneous model of female labour force participation.

Two principal justifications for the work reported in this paper were to improve on the specification of Filmer and Silberberg and thereby to develop an econometric model of demographic and labour force behaviour suitable for interfacing with the IMPACT Population Projection Facility. Although the model reported above has several weaknesses, it does provide a suitable vehicle for integration with the Population Facility. It also will allow further investigations of economic-demographic interactions within a simultaneous framework.

The least satisfactory element of the econometric model is the poor performance of the mean implied completed family size equation. In order to improve on the model's performance in this area we need to develop a fertility model which allows for changes in both the desired completed family size and in the life cycle timing of confinements.[2]

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1. Filmer and Silberberg, op. cit..
2. For an econometric model which does take account of this see Ward and Butz, op. cit..

As can be inferred, without any need for formal testing, from inspection of Figures A2.1 to A2.22 of Appendix 2, serial correlation in the residuals is very pervasive in the results. Doubtless the within-sample tracking of the endogenous variables could be improved by using any of the standard statistical approaches. It would be preferable (although more ambitious) to attempt to correct the problem by identifying those weaknesses in the data and/or the specification responsible for the observed autocorrelation.

However, at this stage, it is planned to incorporate the econometric model reported here into the IMPACT Population Projection Facility and to report the results of the integrated simulations in forthcoming papers.

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APPENDIX 1 : THE VARIABLES APPEARING IN THE MODEL

TABLE A1.1 : ENDOGENOUS VARIABLES OF THE ECONOMETRIC MODEL

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1. Fertility:

Mean implied completed family size	(M_N)
Variance of implied completed family size	(V_N)
Child quality proxy	(Q)
First nuptial confinements per thousand married females aged 15 to 44 years	(c_1)

2. Marriage of females:

Index of propensity to

first marry	(P_F)
remarry for divorcees	(P_{RD})
remarry for widows	(P_{RW})

Mean of the age distribution of age specific rates of

first marriage	(M_F)
remarriage of divorcees	(M_{RD})
remarriage of widows	(M_{RW})

Variance of the age distribution of age specific rates of

first marriage	(V_F)
remarriage of divorcees	(V_{RD})
remarriage of widows	(V_{RW})

3. Divorce of females:

Index of propensity to divorce	(P_D)
Mean of the age distribution of age specific rates of divorce	(M_D)
Variance of the age distribution of age specific rates of divorce	(V_D)

TABLE A1.1 : (Continued)

4.	Female Labour Force Participation Rates:	
	Married females aged 15-24 years	$(\ell_{m,15-24})$
	Married females aged 25-54 years	$(\ell_{m,25-54})$
	Married females aged 55 years and over	$(\ell_{m,55+})$
	Unmarried females aged 15-24 years	$(\ell_{u,15-24})$
	Unmarried females aged 25-54 years	$(\ell_{u,25-54})$
	Unmarried females aged 55 years and over	$(\ell_{u,55+})$

TABLE A1.2 : EXOGENOUS VARIABLES OF THE ECONOMETRIC MODEL

1	Weighted first marriages of females per thousand married females aged 15 to 44 years	$(\hat{f})$
2	Weighted nuptial confinements per thousand married females aged 15 to 44 years	$(\hat{c})$
3	Children under 15 years per married female 15 years and over	(K)
4	The oral contraceptive usage rate	(Ω)
5	The infant mortality rate	(ϕ)
6	Real gross domestic product per head	(Y)
7	The real female hourly wage rate	(W)
8	The female/male relative hourly wage rate	$(W/\tilde{W})$
9	The real old age and invalid pension	(G_a)
10	The real widows' pension	(G_W)
11	The unemployment rate	(u)
12	An indicator of demand for female labour	(L_D)
13	An indicator of female educational attainment	(E)
14	The education participation rate of other females aged 15 to 24 years	$(e_{u,15-24})$
15	The dummy variable for World War II	(Z_2)
16	The dummy variable for the immediate post War period	(Z_1)
17	The dummy variable for conscription	(Z_3)
18	The dummy variable for the Family Law Act	(Z_4)
19	The dummy variable for the widows' pension	(Z_5)

APPENDIX 2 : GRAPHS OF THE HISTORICAL PERFORMANCE OF THE MODEL

FIGURE A2.1 MEAN IMPLIED COMPLETED FAMILY SIZE

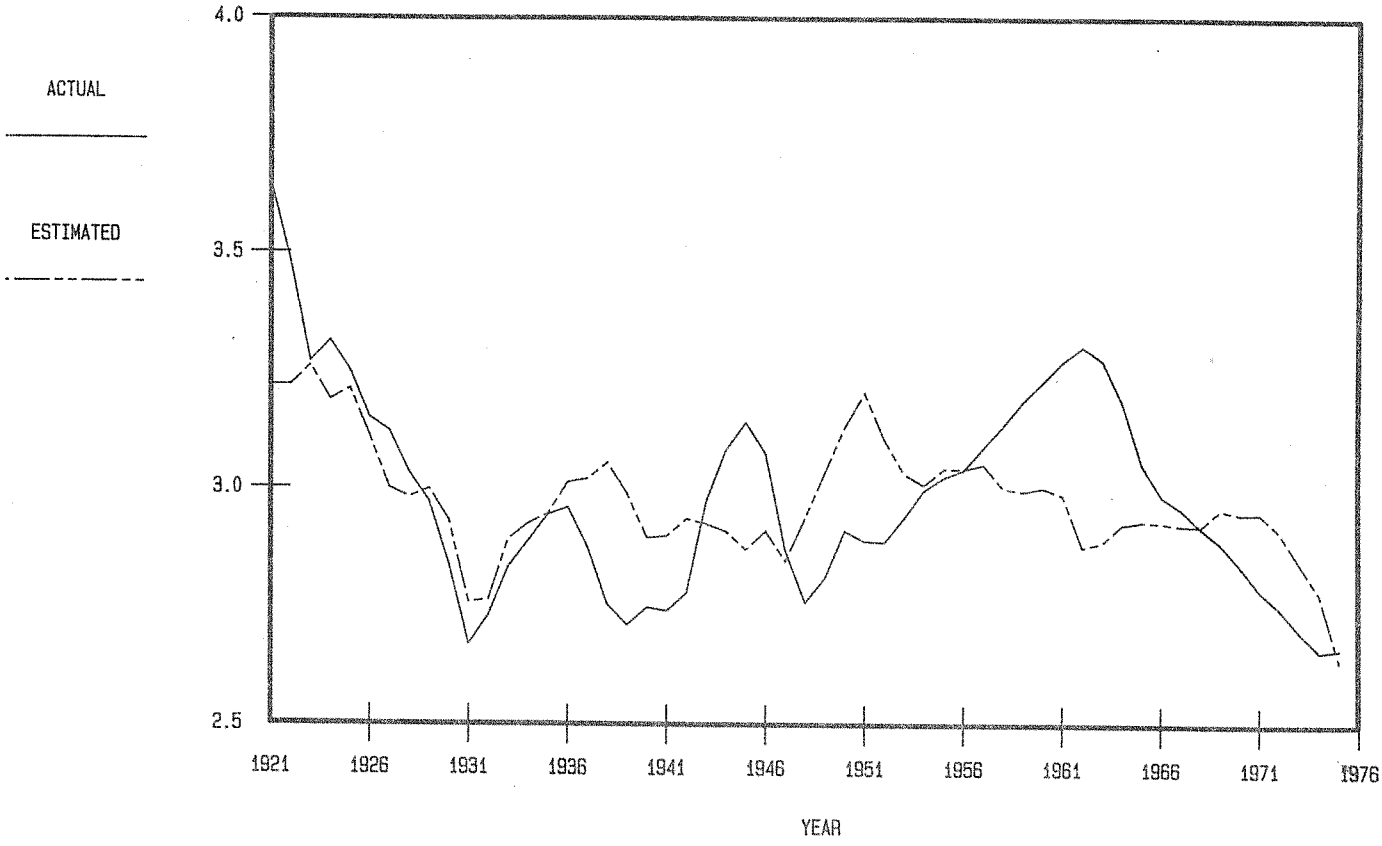

FIGURE A2.2

VARIANCE OF THE IMPLIED COMPLETED FAMILY SIZE

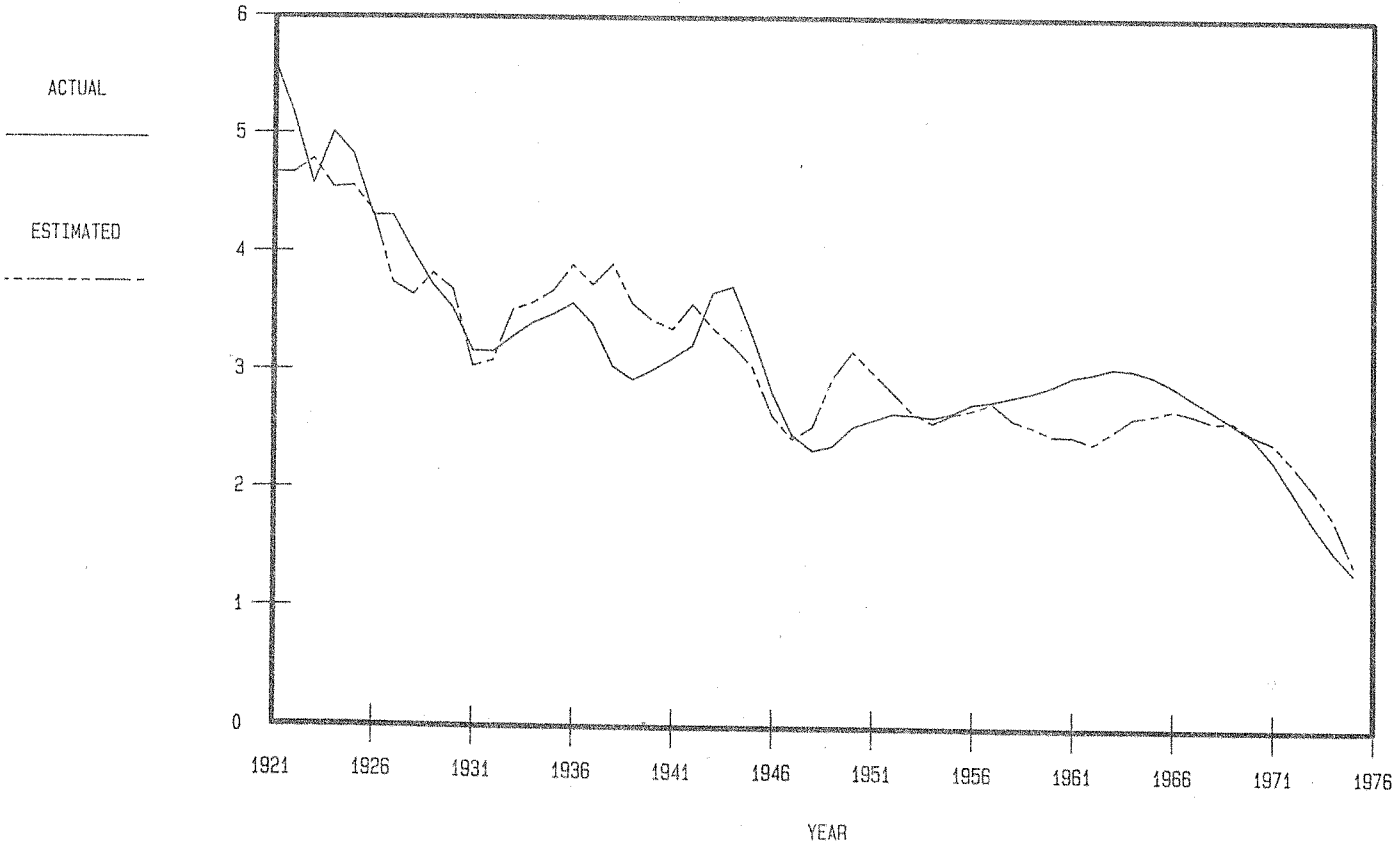

FIGURE A2.3

FIRST NUPTIAL CONFINEMENTS
PER 1,000 MARRIED FEMALES

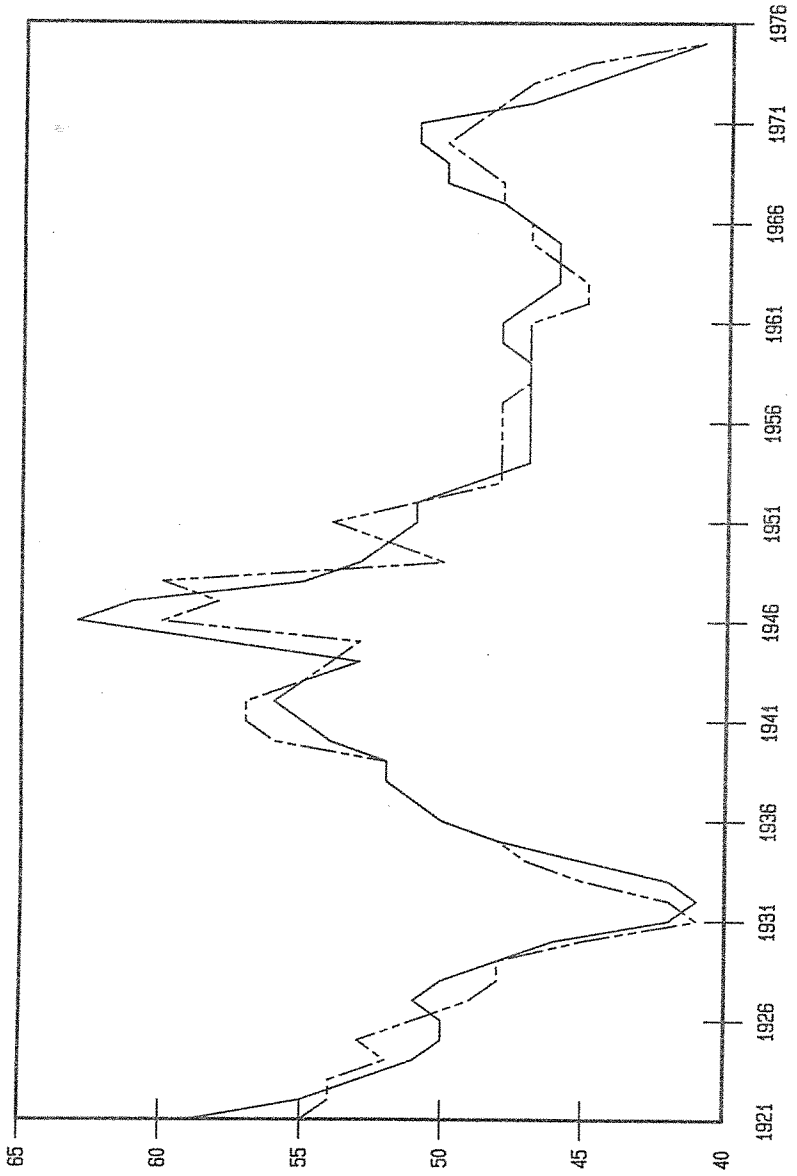

FIGURE A2.4

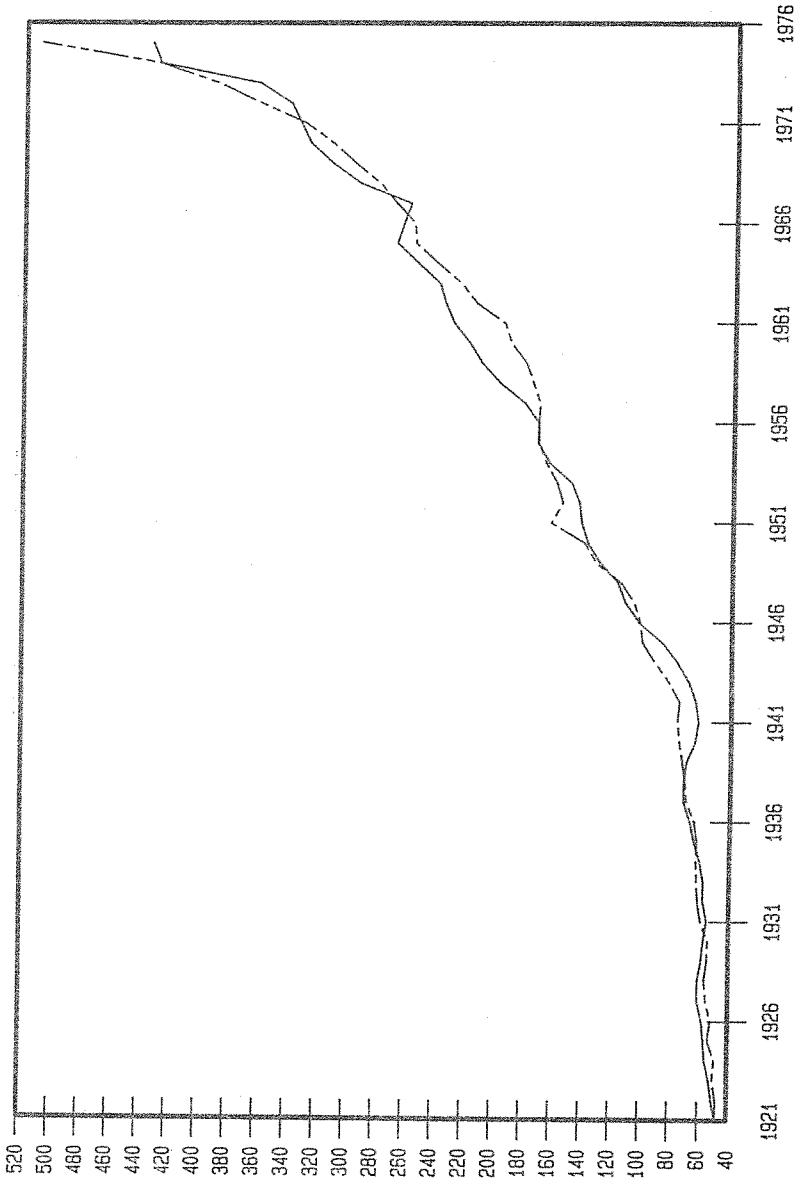
CHILD QUALITY
ACTUAL
ESTIMATED
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
1921
1926
1931
1936
1941
1946
1951
1956
1961
1966
1971
1976
YEAR

FIGURE A2.5 INDEX OF THE PROPENSITY TO FIRST MARRY

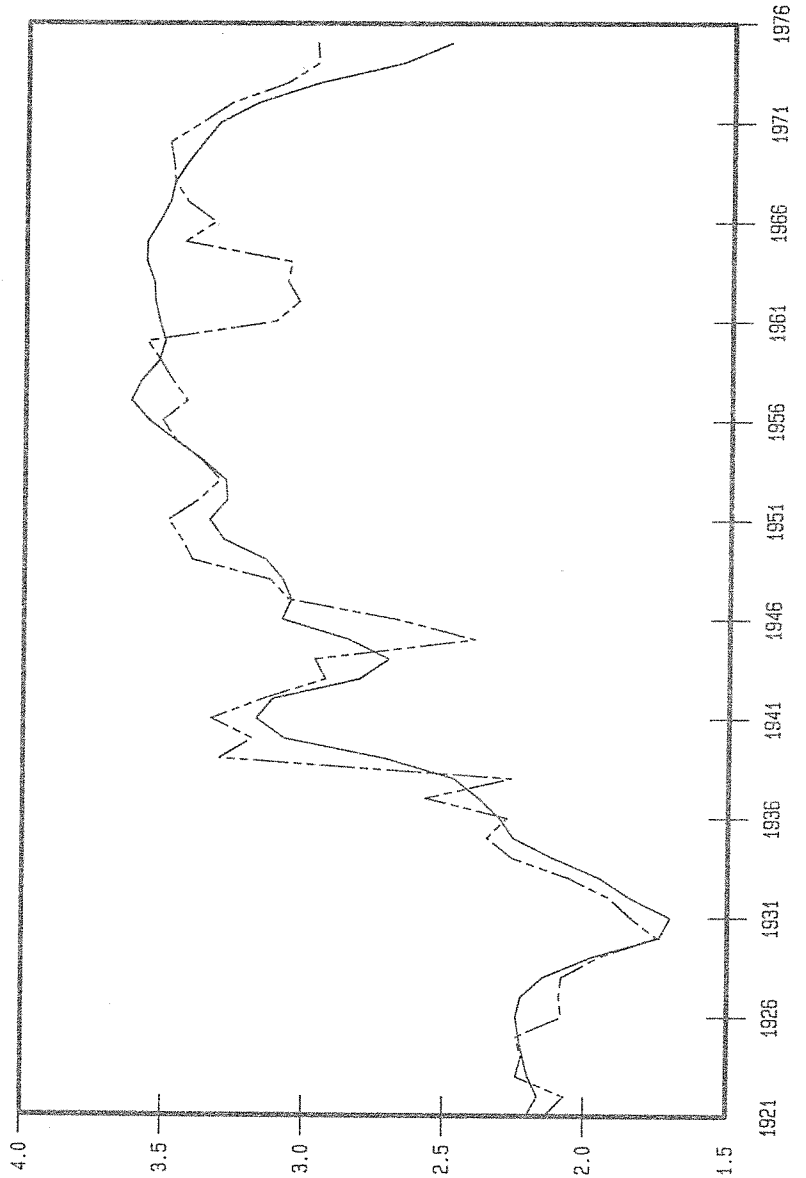

FIGURE A2.6

MEAN OF THE DISTRIBUTION OF AGE SPECIFIC RATES OF FIRST MARRIAGE

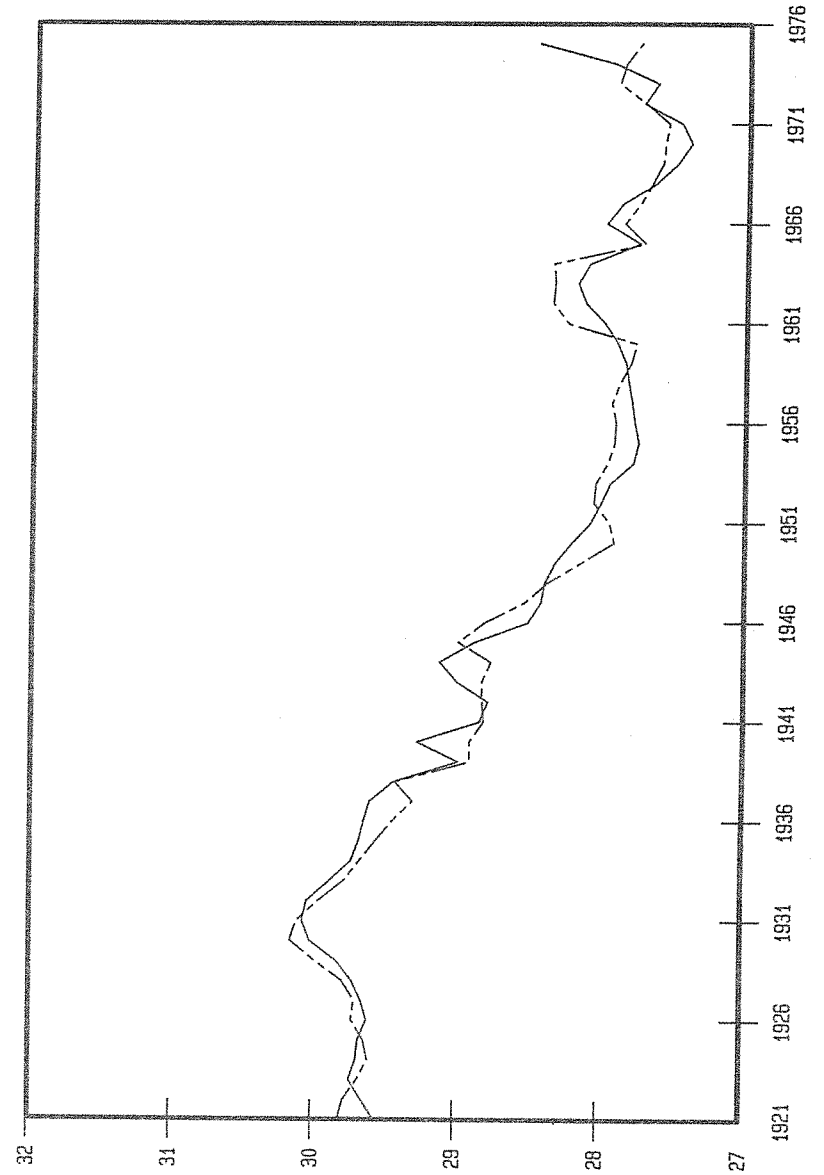

FIGURE A2.7

VARIANCE OF THE DISTRIBUTION OF AGE
SPECIFIC RATES OF FIRST MARRIAGE

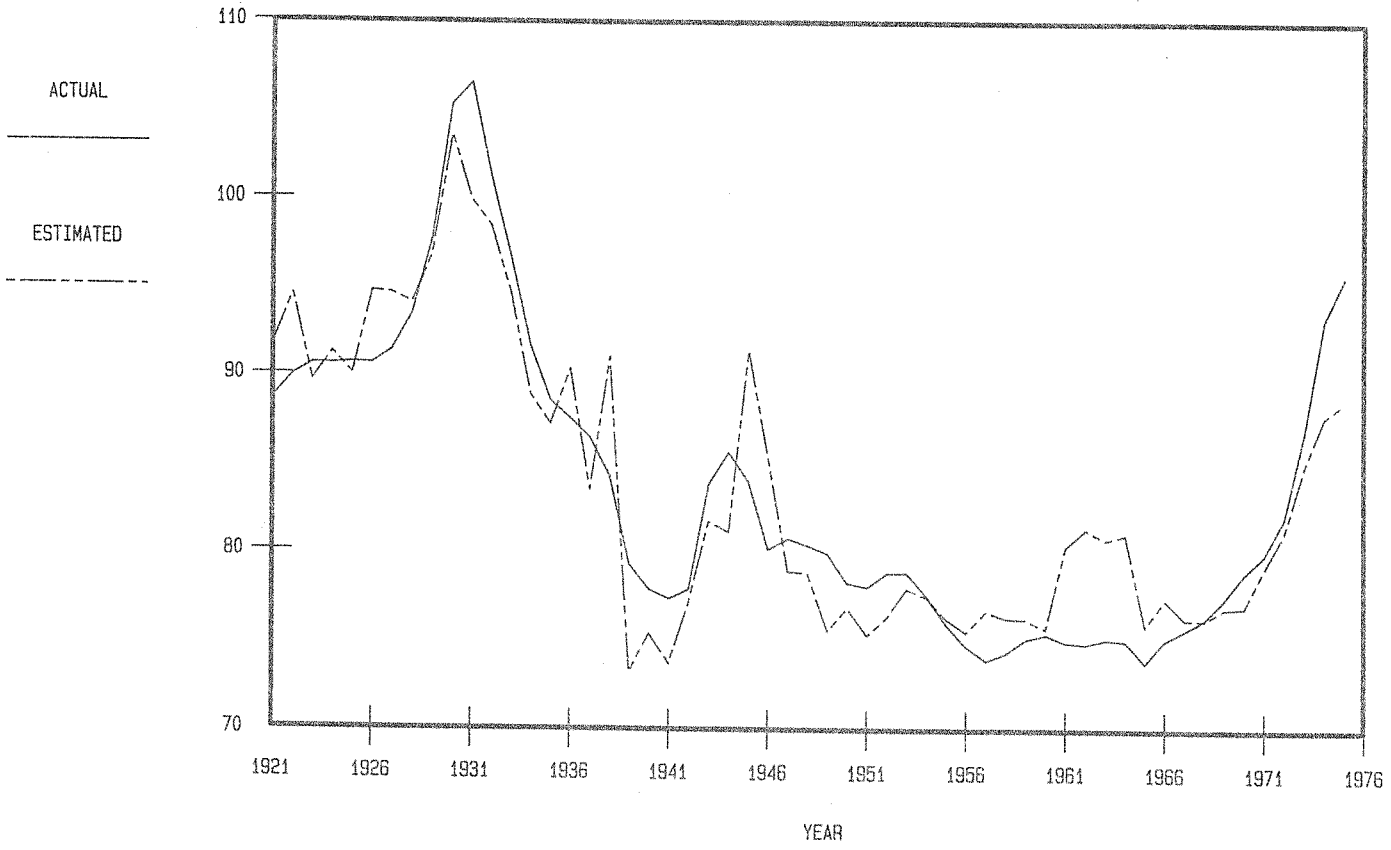

FIGURE A2.8

INDEX OF THE PROPENSITY OF DIVORCEES TO REMARRY

FIGURE A2.9

MEAN OF THE DISTRIBUTION OF AGE SPECIFIC RATES OF REMARRIAGE OF DIVORCEES

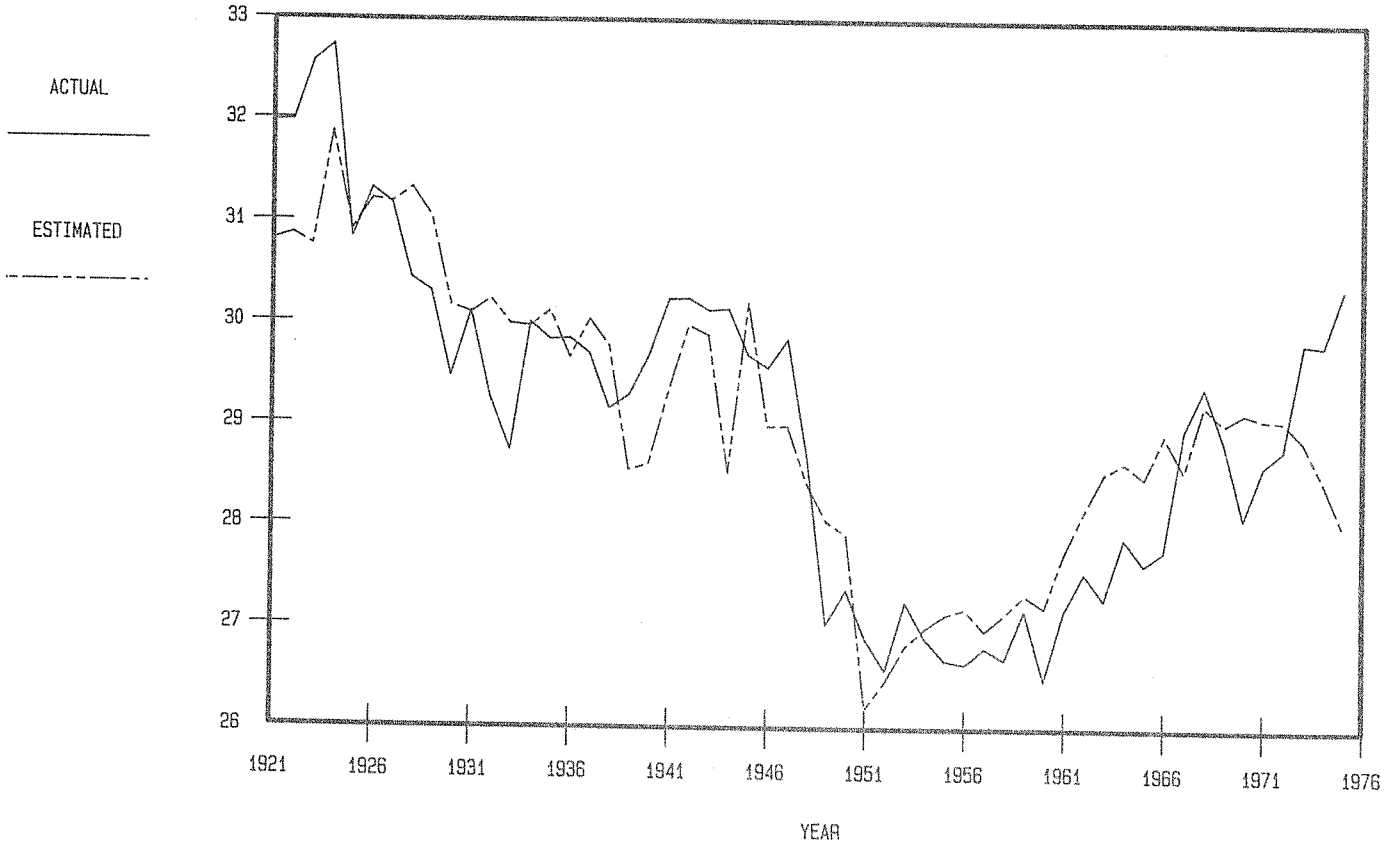

FIGURE A2.10

VARIANCE OF THE DISTRIBUTION OF AGE SPECIFIC REMARRIAGE RATES OF DIVORCEES

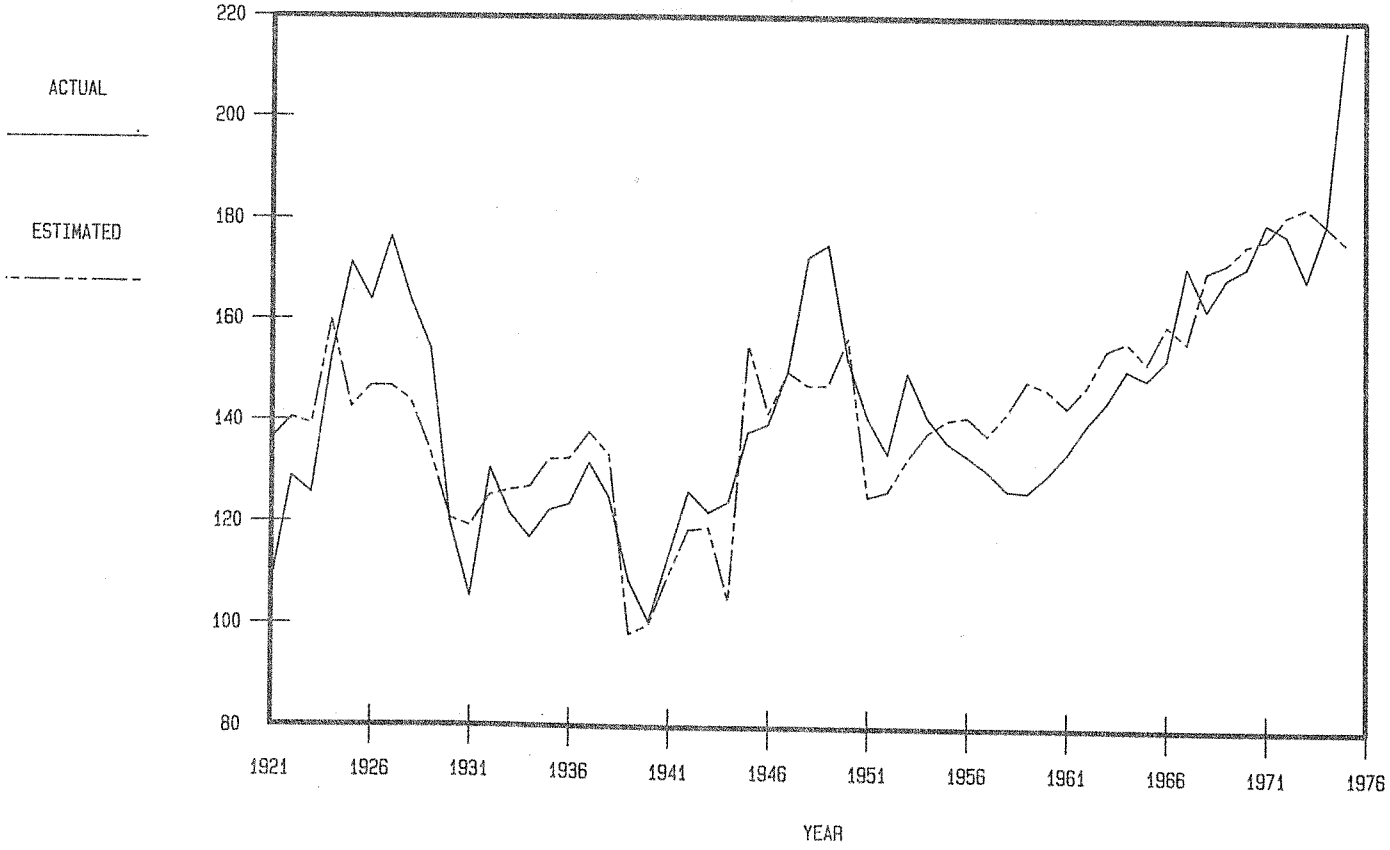

FIGURE A2.11

INDEX OF THE PROPENSITY OF WIDOWS TO REMARRY

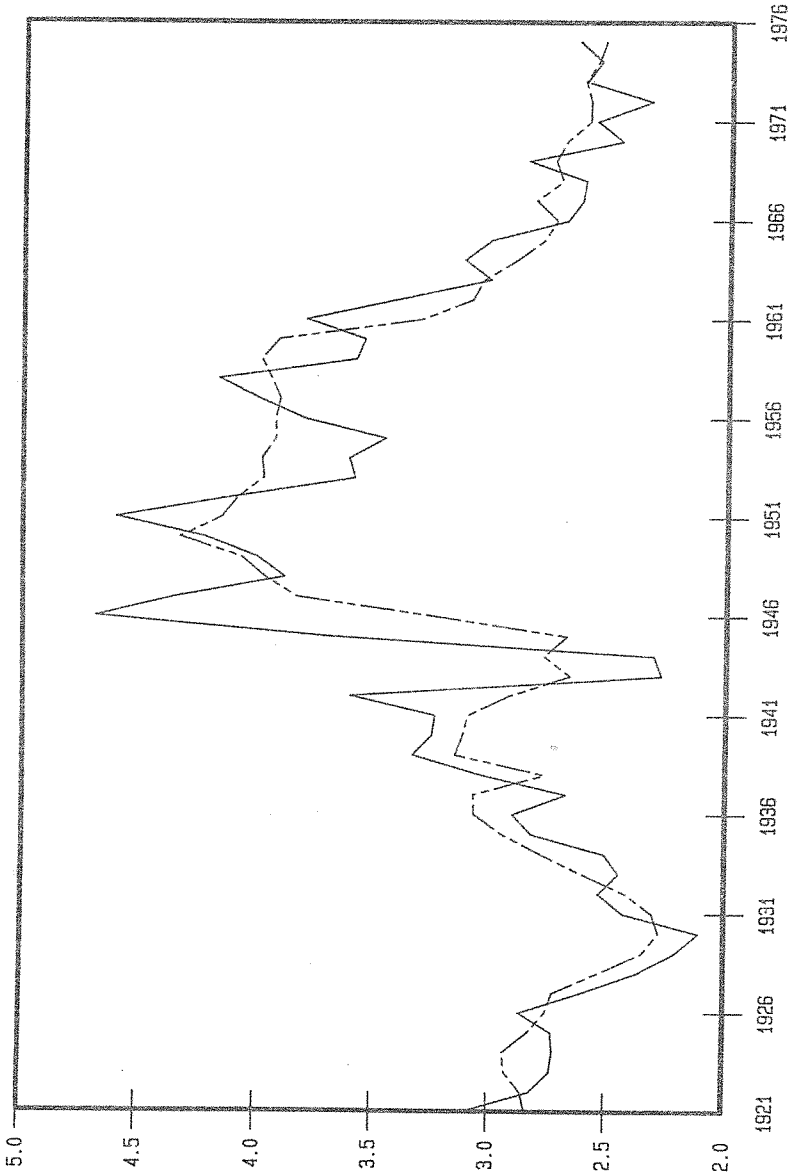

FIGURE A2.12

MEAN OF THE DISTRIBUTION OF AGE SPECIFIC RATES OF REMARRIAGE OF WIDOWS

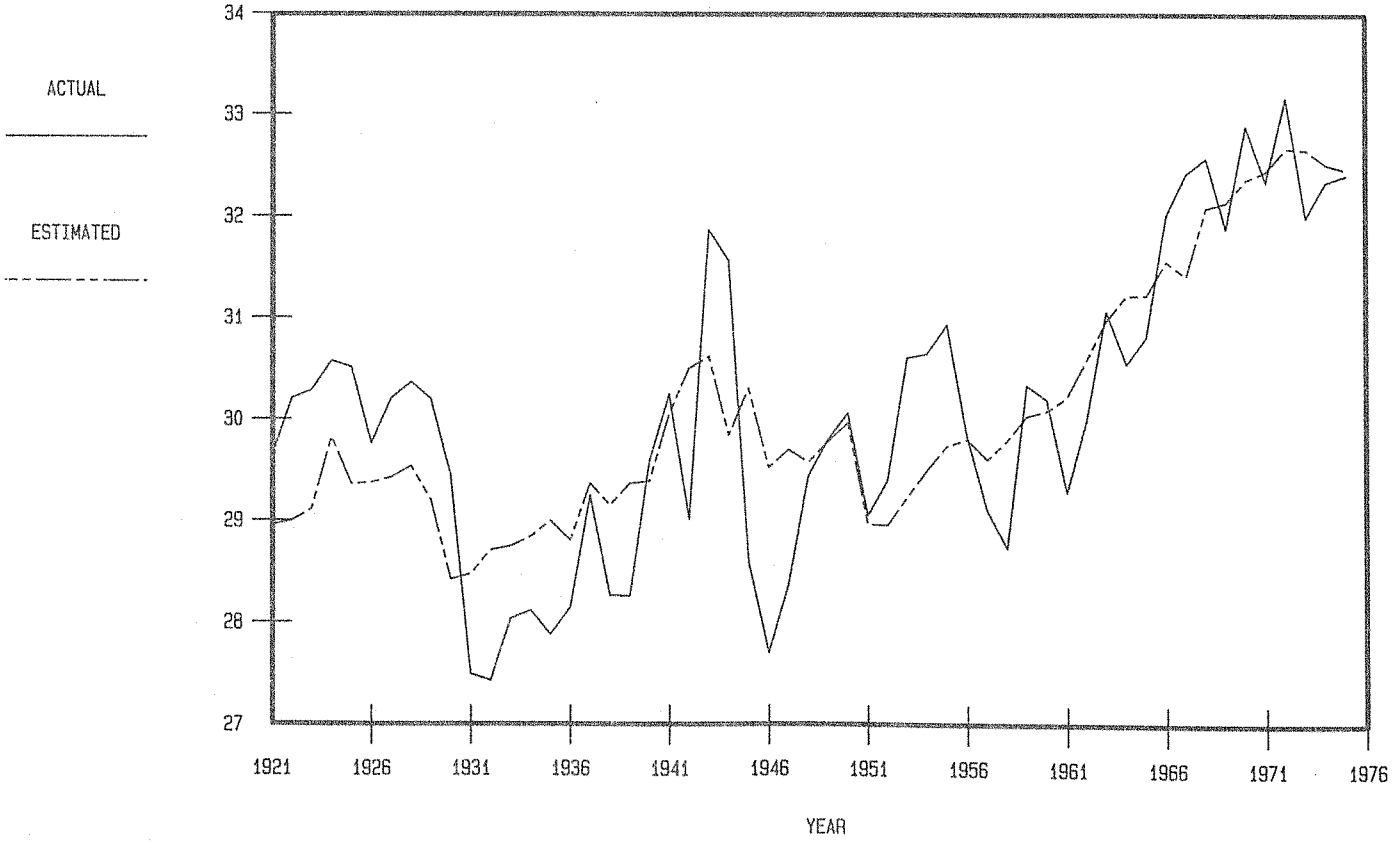

FIGURE A2.13

VARIANCE OF THE DISTRIBUTION OF AGE
SPECIFIC RATES OF REMARRIAGE OF WIDOWS

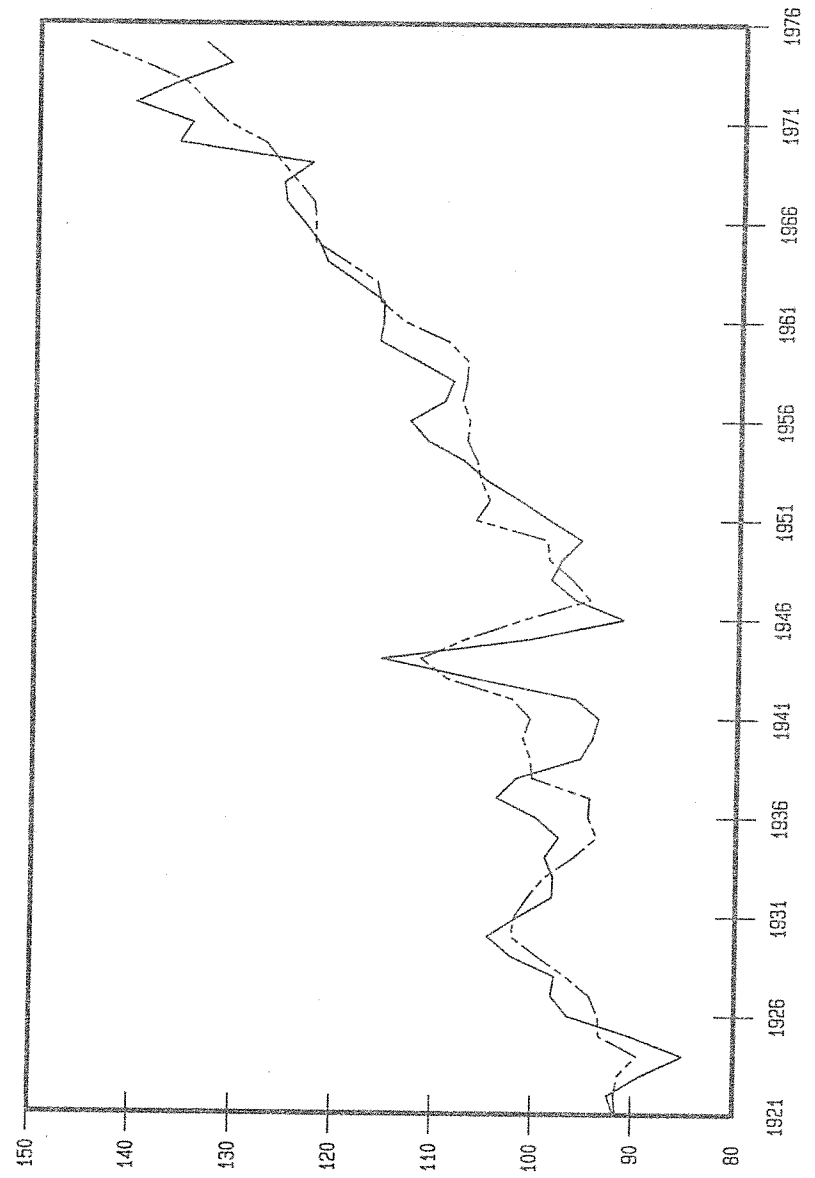

FIGURE A2.14 INDEX OF THE PROPENSITY TO DIVORCE

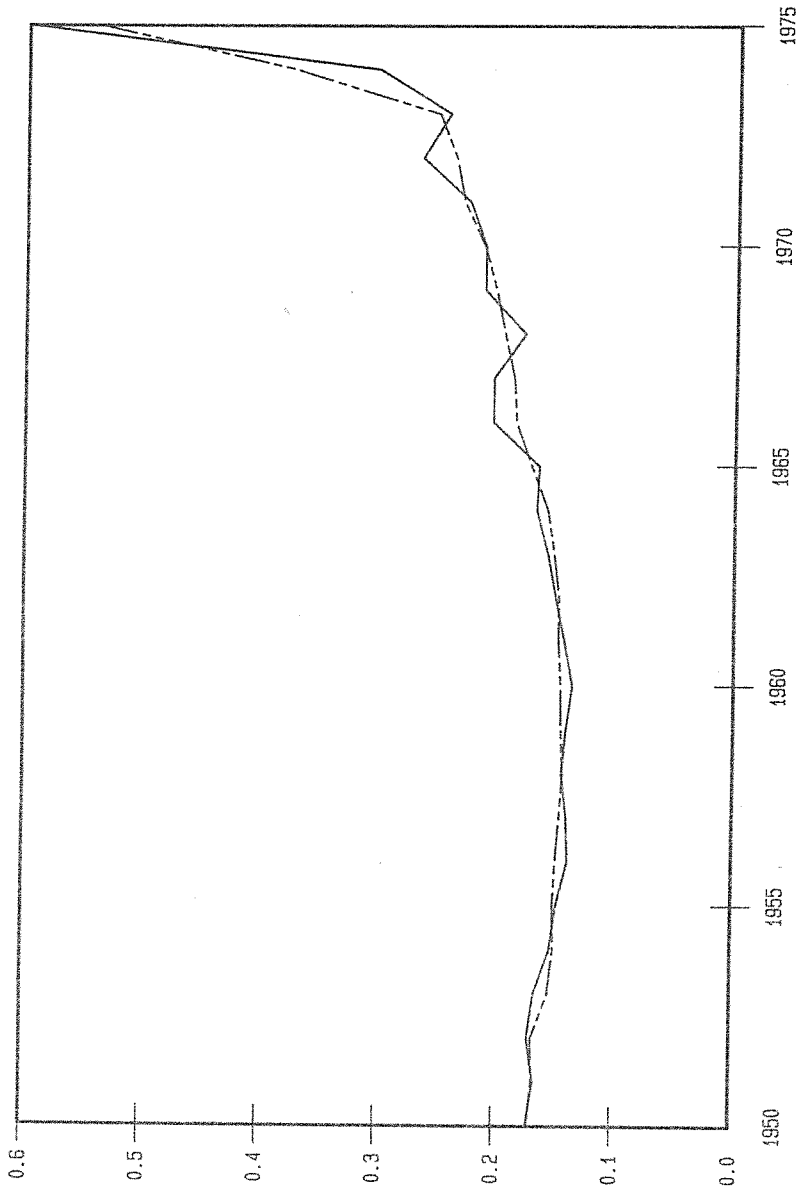

FIGURE A2.15

MEAN OF THE DISTRIBUTION OF AGE
SPECIFIC RATES OF DIVORCE

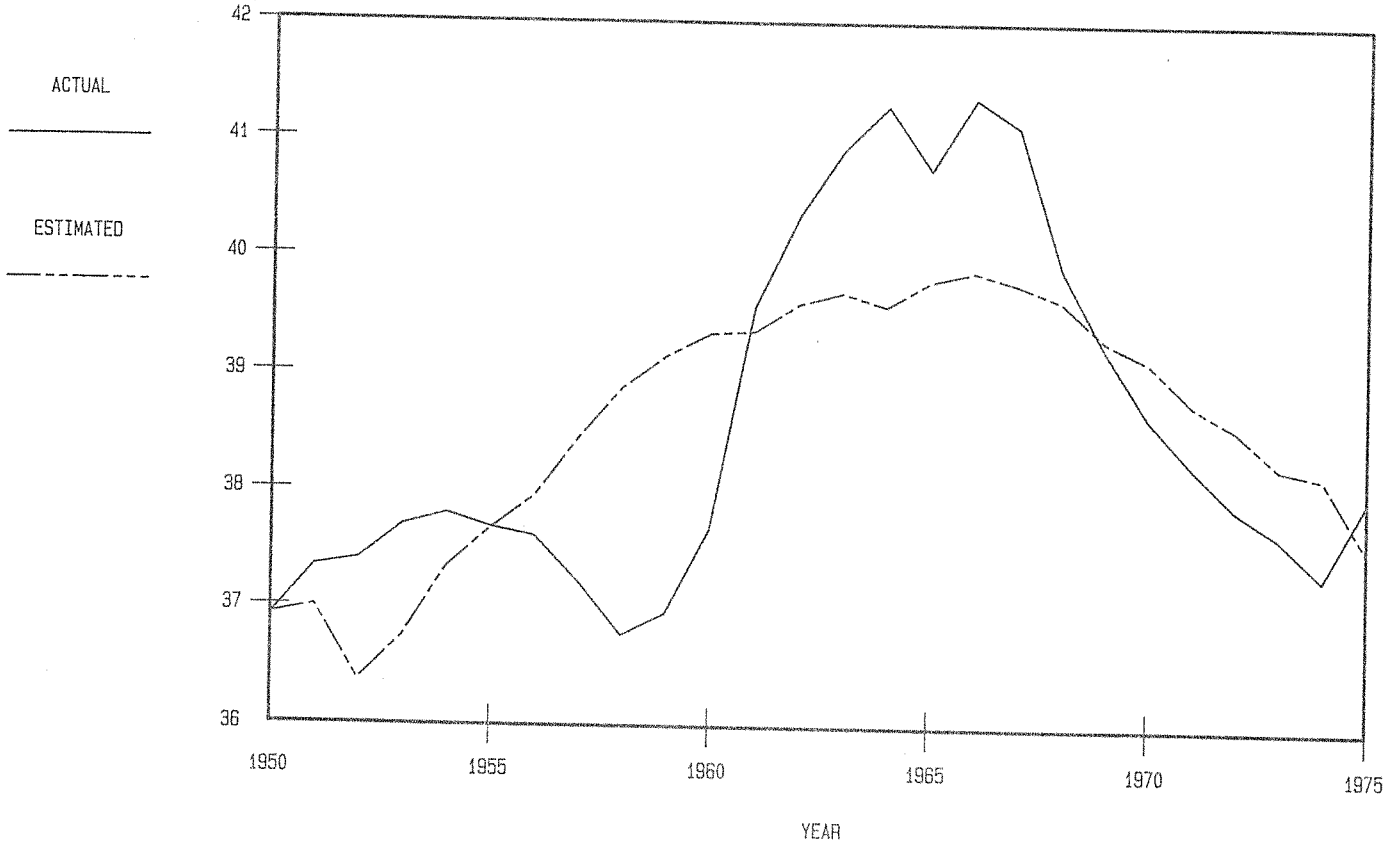

FIGURE A2.16

VARIANCE OF THE DISTRIBUTION OF AGE SPECIFIC RATES OF DIVORCE

FIGURE A2.17

LABOUR FORCE PARTICIPATION RATE OF
MARRIED FEMALES 15 TO 24 YEARS (%)

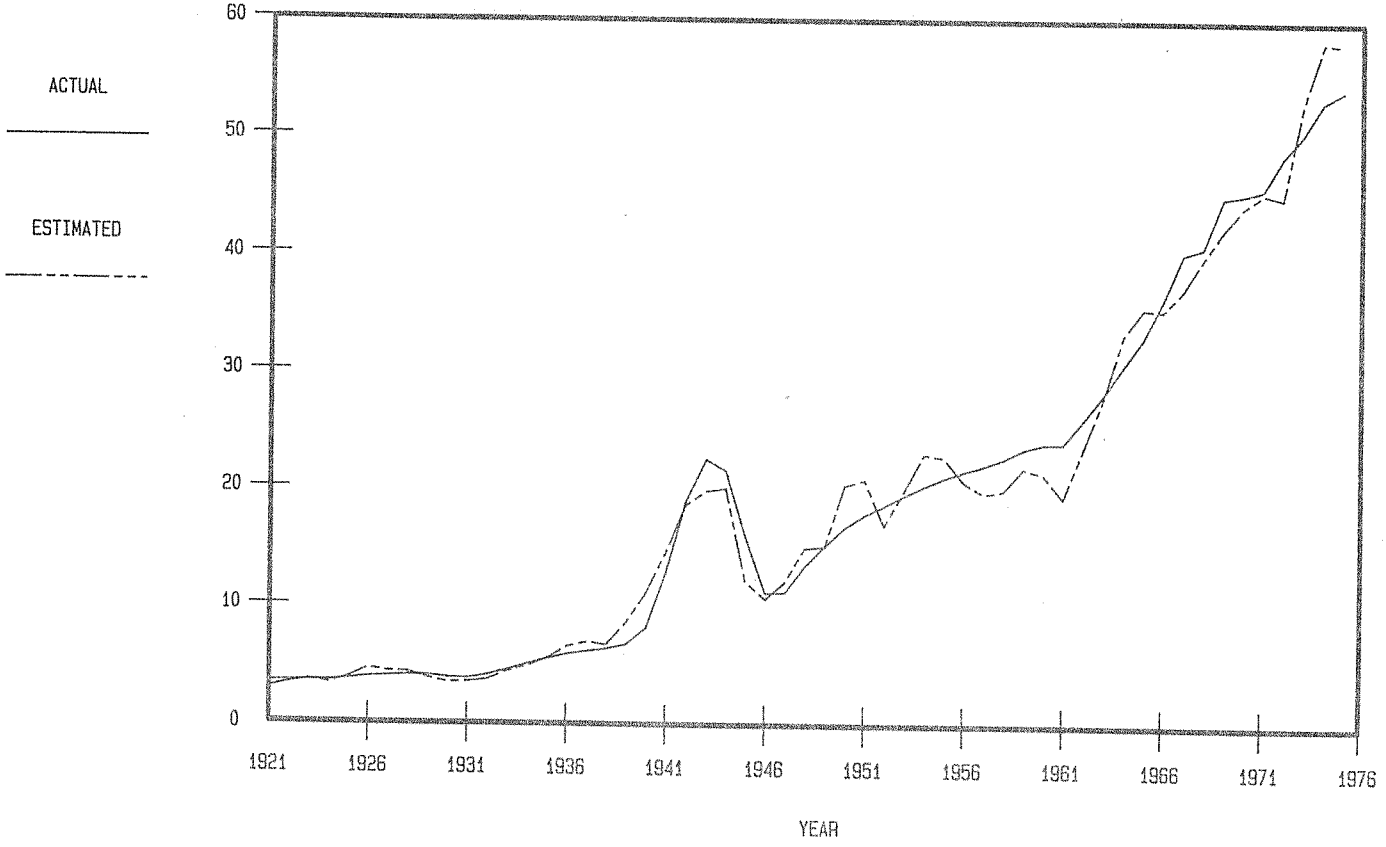

FIGURE A2.18

LABOUR FORCE PARTICIPATION RATE OF MARRIED FEMALES 25 TO 54 YEARS (%)

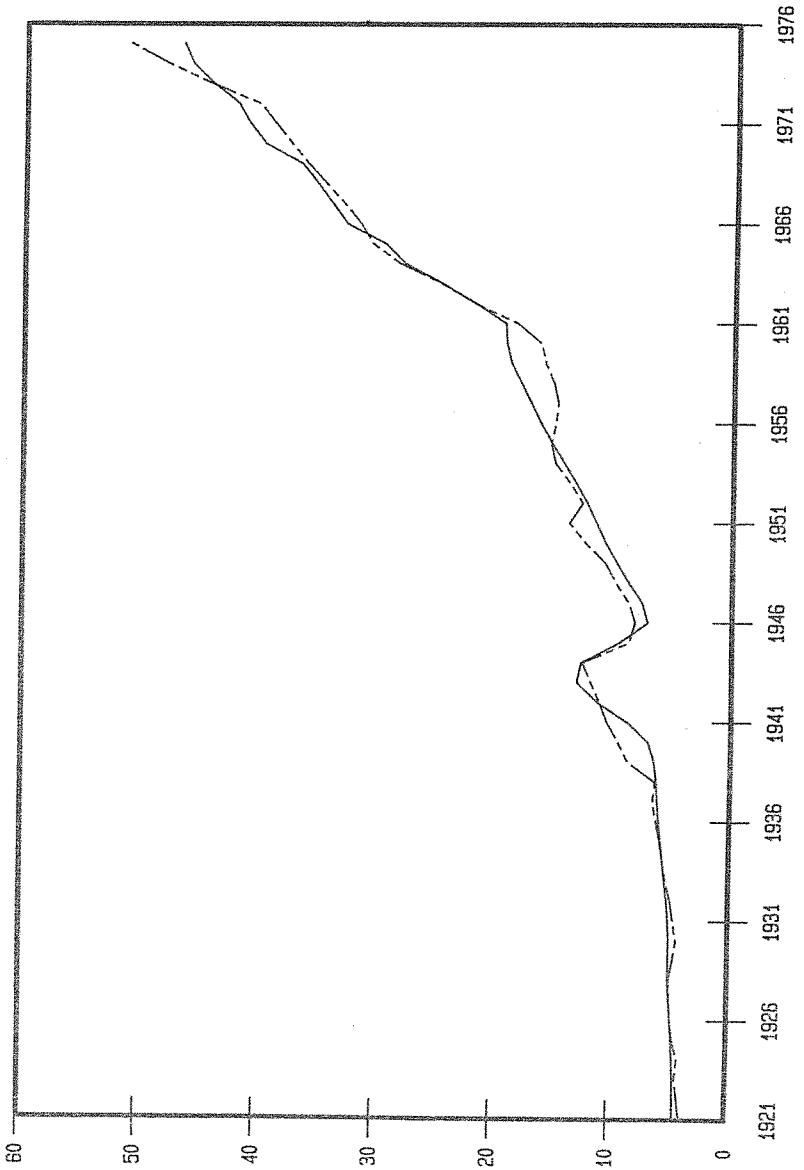

FIGURE A2.19

LABOUR FORCE PARTICIPATION RATE OF MARRIED FEMALES 55 YEARS AND OVER (%)

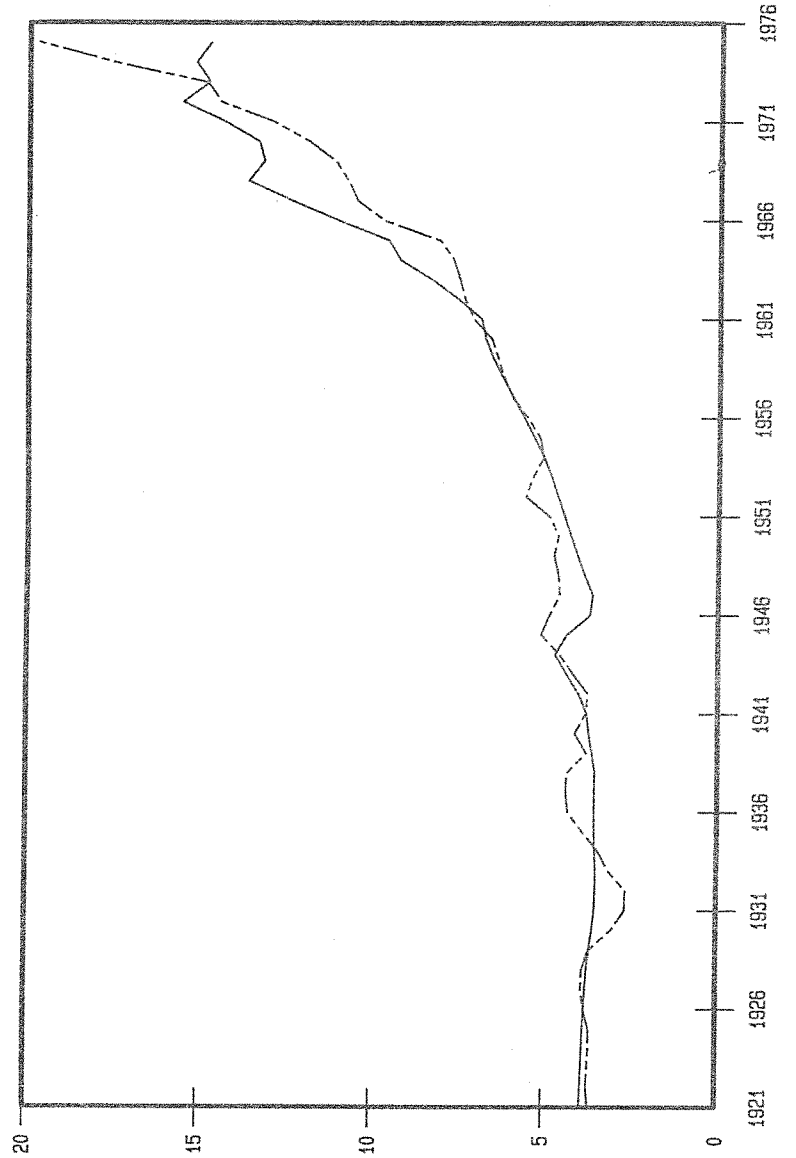

FIGURE A2.20

LABOUR FORCE PARTICIPATION RATE OF
UNMARRIED FEMALES 15 TO 24 YEARS (%)

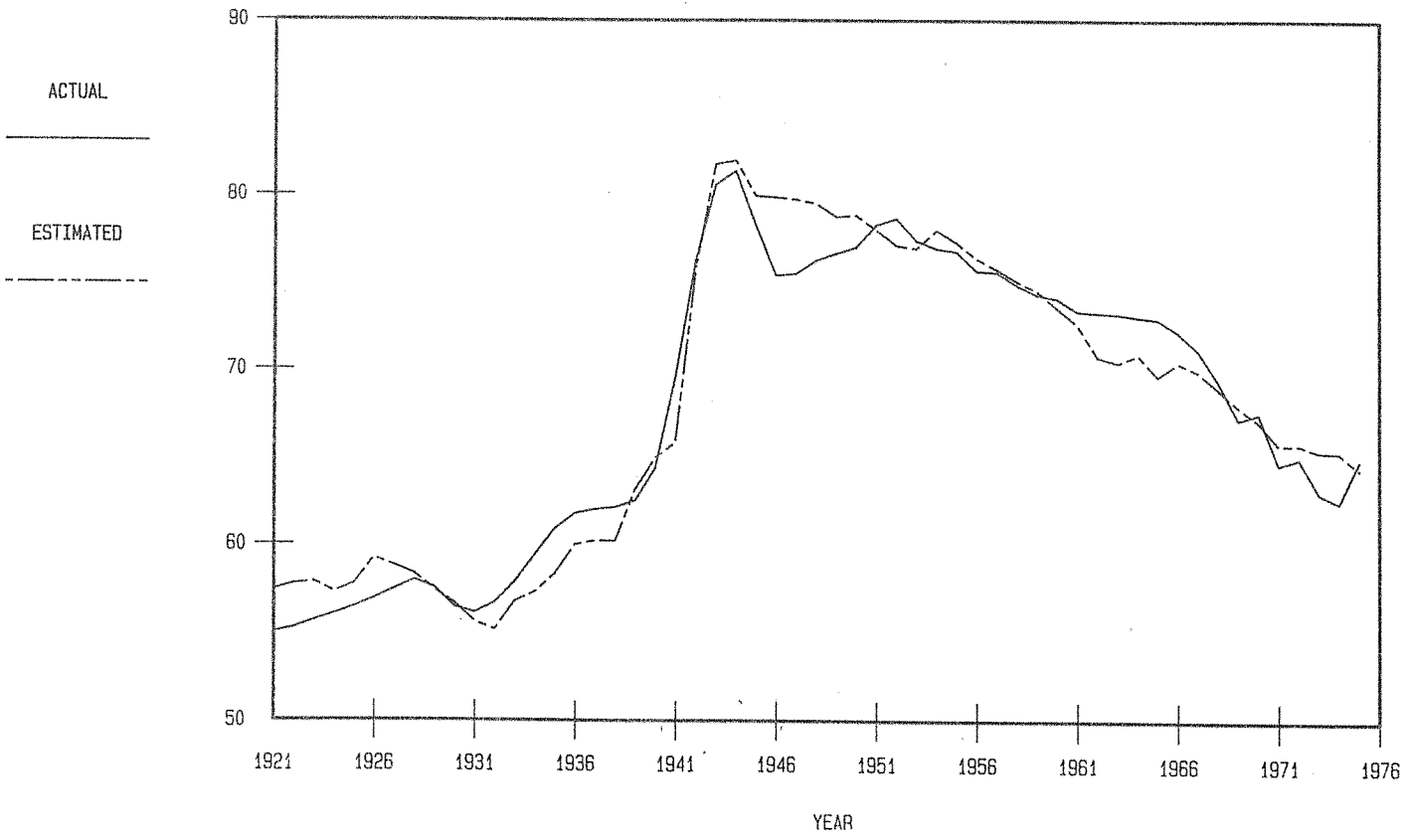

FIGURE A2,21 LABOUR FORCE PARTICIPATION RATE OF UNMARRIED FEMALES 25 TO 54 YEARS (%)

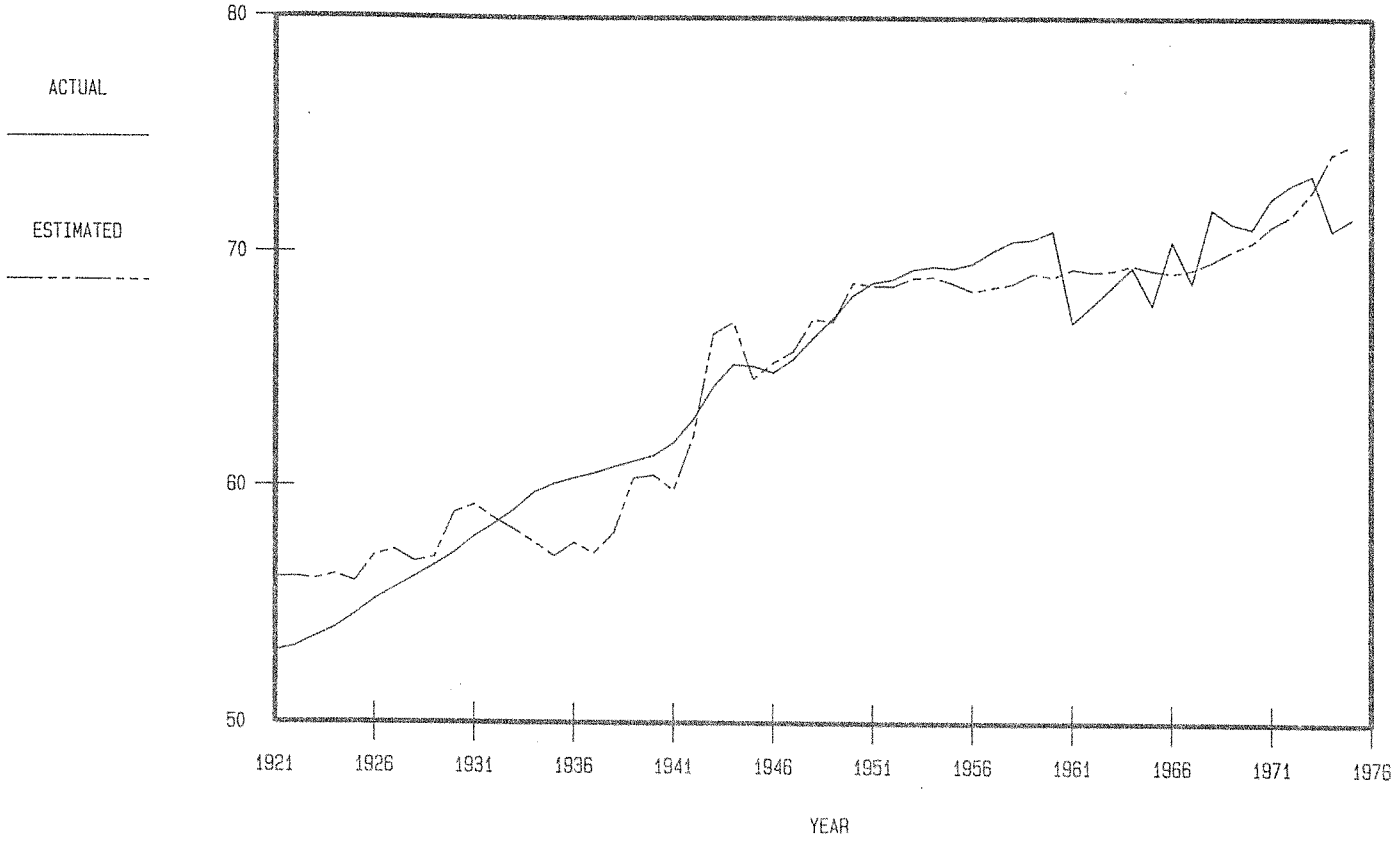

FIGURE A2.22

LABOUR FORCE PARTICIPATION RATE OF UNMARRIED FEMALES 55 YEARS AND OVER (%)