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THE NEXT BIRTH AND THE LABOUR MARKET: A DYNAMIC MODEL OF BIRTHS IN ENGLAND AND WALES

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ABSTRACT

The object of this paper is to see how far developments in the labour market can help to explain the fluctuations in births which have been experienced over the period 1952-1980 in England and Wales. We examine separately the period rate of childless women proceeding to the first birth, mothers of one child proceeding to a second birth, mothers of two proceeding to a third birth, and mothers of three proceeding to a fourth birth.

Our analysis shows that different birth orders respond differently to economic variables, and different age groups within a parity also exhibit varying responses. We have found that growing real wages for both men and women tend to deter older parents from adding to existing families. In the early stages of family building, births are inhibited by labour markets favourable to women. But conditions in the male labour market have the reverse effect on early breeding.

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NON-TECHNICAL SUMMARY

The object of this paper is to see how far developments in the labour market can help to explain the fluctuations in births which have been experienced over the period 1952-1980 in England and Wales. The labour market helps to determine the resources available and those which would have to be foregone if any women at the margin of indecision were to have or to defer a birth in a given year. We examine separately the period rate of childless women proceeding to the first birth, mothers of one child proceeding to a second birth, mothers of two proceedings to a third birth, and mothers of three proceeding to a fourth birth. The labour market is characterised by the series of wage rates for men and women, the male unemployment rate and a measure of women's attachment to paid work which is independent of their current family responsibilities, and therefore of their current and recent fertility. We allow for the size, direction and speed of any influence of these factors to vary over different stages of the life cycle, and for the internal dynamics of the demographic series catching-up or correcting for deviations from the path towards family size norms. The latter seem to be changing only very slowly, and our analysis of a mere 30 years can offer relatively little explanation for them.

We posit a model of sequential decision-making, so that the ultimate number, timing and spacing of births are the outcome of a series of decisions, failures to decide and accidents, rather than necessarily the successful implementation of a grand strategy, formulated once and for all with perfect foresight. This framework allows for couples changing their reproductive goals during their childbearing careers, but it is still more general because it does not insist that couples need have any explicit reproductive goals at all.

Our analysis shows that different birth orders respond differently to economic variables, and different age groups within a parity also exhibit varying responses. We have found that growing real wages for both men and women tend to deter

older parents from adding to existing families. In the early stages of family building, births are inhibited by labour markets favourable to women. But conditions in the male labour market have a reverse effect on early breeding. Higher men's wages and lower male unemployment, other things being equal, bring forward first and second births to women under 30. The trend towards greater labour market participation by wives seems to have encouraged a compression of childbearing into a few years in women's late twenties and early thirties, but there is also evidence of decompression as labour force attachment increases beyond a certain point.

Even in a society with very little female participation in the labour market, the complexity of reactions to the male labour market could generate booms and busts in birth rates, but the reactions are intensified and complicated where the labour market is also relevant for women. Our estimates suggest that the unusually favourable labour market for women in Britain around the time that the Equal Pay Act was implemented account for much, though not all, of the drop in fertility in the mid-seventies.

The fertility reactions to economic changes are likely to be in opposite directions by couples at different stages in family building. The net outcome would depend upon the relative numbers at various stages as well as the relative impact of the change on the labour markets for men and women. Many of these induced changes would be self-correcting within 5 years and make little ultimate difference to completed fertility but they seem nevertheless to account for substantial year-to-year instability in the numbers of births.

THE NEXT BIRTH AND THE LABOUR MARKET: A DYNAMIC ECONOMETRIC MODEL OF BIRTHS IN ENGLAND AND WALES

Introduction

The object of this paper is to see how far developments in the labour market can help to explain the fluctuations in births which have been experienced over the period 1952-1980 in England and Wales. It is not our contention that these particular economic variables, or economic considerations in general, can provide a complete explanation of all reproductive behaviour, rather that it is worth considering whether year-to-year changes in fertility rates reflect year-to-year fluctuations in one part of the economic environment.

The labour market helps to determine the resources available and those which would have to be foregone if any women at the margin of indecision were to have or to defer a birth in a given year. We examine separately the period rate of childless women proceeding to the first birth, mothers of one child proceeding to a second birth, mothers of two proceeding to a third birth, and mothers of three proceeding to a fourth birth. The labour market is characterised by the series of wage rates for men and women, the male unemployment rate and a measure of women's attachment to paid work which is independent of their current family responsibilities, and therefore of their current and recent fertility. We allow for the size, direction and speed of any influence of these factors to vary over different stages of the life cycle, and for the internal dynamics of the demographic series catching-up or correcting for deviations from the path towards family size norms. The latter seem to be changing only very slowly, and our analysis of a mere 30 years can offer relatively little explanation for them.

The cohorts of women born between the two World Wars in England and Wales have all by now completed their childbearing years, which mostly fell in the postwar period. Within this generation average completed fertility has changed very little, rising from 2.0 children per woman born in 1920 to 2.4 for those born 1933-1939, re-establishing 'replacement', which the preceding generation just failed to 'achieve'. The distribution of different family sizes around the average also changed: fewer women remained childless, or produced very large families of five or more offspring. More and more of each cohort produced exactly two children. The fertility to date and the expressed intentions of the cohorts still in their childbearing years are consistent with this trend continuing - a high proportion (around 9 out of 10) of all women eventually becoming mothers, in most cases of a two child family, and average family size remaining just over 2. See Table 1.

Contrast these very gradual changes with the fairly jagged switchback in the annual number of births or the period fertility rate which is illustrated in Figure 1. Up to a point, hindsight can confirm that these fluctuations have been mainly produced by different patterns of the timing and spacing of childbearing ('tempo' in the terminology of Ryder, 1980) rather than variations in cohorts' ultimate family size ('quantum'). It is important to understand factors which influence tempo as well as quantum, but it is difficult in practice to be certain whether changes in contemporary fertility will actually turn out to be adjustments of one or the other. Potential parents, too, may be unaware during the process that failure to conceive in any particular month would ultimately result in a smaller completed family or a longer wait until the next birth. Many authors - for example Namboodiri (1972), Leibenstein (1974) and Ryder himself (loc cit) - have suggested that it is more sensible for theories about the influences of socio-economic factors on fertility to posit sequential decision-making, so that the ultimate number, timing and spacing of births are the outcome of a series of decisions, failures to decide and accidents, rather than necessarily the successful implementation of a grand strategy, formulated once and for all with perfect foresight. That would only be a special case of a more general model of decision-making, whose framework would also allow for couples changing their reproductive goals during their childbearing careers, as in Lee's 'Aiming at a Moving Target' (1980), and Barrett (1984), but it is still more general because it does not insist that couples need have any explicit reproductive goals at all. Examining the fertility rates parity by parity allows different stages of family formation to respond differently to explanatory variables, and makes full use of the available information on family size achieved to date.

We use our models for four age groups in each of the first four birth orders to attempt to account for these fluctuations. We begin the development of these models by discussing economic theories of reproductive behaviour. We then consider the implications of these theories for the specification of our econometric models. The next part of the paper describes the data with which we estimated the models and discusses the results from estimating their parameters. We conclude by using the estimated models to simulate births under various counter-factual economic scenarios.

Table 1 Completed and expected cohort fertility: England and Wales

	Sample nos =100%	Don't know	Family size distribution per cent 0	1	2	3	4+	Average number of children per woman
Completed cohort fertility								
Women born:								
1920			21	21	26	17	15	2.00
1925			17	22	27	18	16	2.12
1930			14	18	29	20	19	2.35
1935			12	15	31	23	19	2.42
1940			10	14	35	24	17	2.37
Expected numbers of children (including those already born)								
1935 - 39	899	3	9	14	33	21	20	2.4
1940 - 44	984	6	9	11	39	19	16	2.3
1945 - 49	1184	14	6	11	41	18	10	2.3
1950 - 54	1066	20	4	8	44	17	5	2.2
1954 - 59	1081	20	5	6	45	15	6	2.2

Source: Completed fertility: Barry Werner, 'Family size and age at child birth: trends and projections', Population Trends 33, Table 3.
Expected fertility: Reconstructed from Table 2.36 and text on p.17 of General Household Survey 1981. Average family size in the last column is only for those respondents who gave a precise answer to the question. The proportions who were not able to answer appear in column 1 and the proportions stating each expected family size are out of the base which includes those giving no answer.

Theoretical Background

To guide the specification of our econometric models we draw on a number of economic theories of reproductive behaviour. As is common in economics, most of the theoretical development in the economics of fertility is in terms of static, steady-state equilibrium models. This is the case in models of birth timing over the life cycle as well as family size models. We shall first summarise the static theories of fertility from which we draw for our econometric models and then indicate how they can be modified to pertain to the changing and uncertain world in which we live.

Appendix II shows that the static 'new home economics' model of fertility yields two family size functions for two types of couple: one for couples in which only the husband is employed outside the home, his wife being predisposed to remain out of employment whatever the fertility decision, and one for couples where both spouses participate in the labour market. Women's earning opportunities only affect family size among the latter type of couples. In this model, factors which increase(decrease) desired family size also increase(decrease) the probability of an i-th birth, if they affect this probability at all. So as to facilitate discussion in terms of elasticities, let us assume that the two i-th birth probability functions are log-linear:

(1) $\ln P_i = B_o + B_1 \ln Y$ for one earner couples;

(2) $\ln P_i = B_w + B_2 \ln Y + B_3 \ln W$ for two earner couples;

Where P_i is the probability of an i-th birth; Y is men's real hourly earnings and W is women's real hourly earnings. As Appendix II shows, there is a presupposition that B_1 and B_2 are positive and B_3 negative under plausible assumptions concerning spouses' time allocations and the time intensity of raising children, if 'child quality' (which depends upon the time and other resources devoted to each child) is treated as exogenous. But when 'child quality' is endogenous, Appendix II also shows that it is more likely for B_1 and B_2 to be negative, particularly at higher birth parities, because higher income raises the cost of an additional child by raising desired quality.

This model resembles that applied to British period fertility rates by Ermisch (1982, 1983) and by Butz and Ward (1979) to US data. The current exercise differs from both of these in that it allows for the size (and dynamics) of the effects of economic factors to vary for births of different order and from the second in that it has a measure of permanent female labour force attachment (as well as better founded evidence on the wage series).

In a dynamic, life cycle context the distinction between one and two earner couples is less clear. Even among our sample's earliest cohort (1920) at least 82 per cent of women worked sometime after marriage; and at least 95 per cent of women of the 1946 birth cohort worked sometime after marriage**(1)**. Since later cohorts are unlikely to have participated less than this in paid work, almost all couples in at least half of the cohorts in our sample are two earner couples, but there are differences in the degree of their post-marriage participation, or in the strength of their labour force attachment. It would appear that the stronger a woman's labour force attachment, the more she will take labour market opportunities into consideration in fertility decisions; that is, just as women's earning opportunities do not affect the fertility of one earner couples, their effect will be smaller among earning wives whose labour force attachment is weaker. Given that most women take paid employment after marriage, there is less reason however to suggest that the impact of husband's earnings on the probability of a(nother) birth varies with the wife's labour force attachment**(2)**; making this assumption also helps reduce the problems of collinearity among independent variables in the estimation of the impacts of men's and women's earning opportunities on birth frequencies.

When we think of this model as applying to a birth cohort of women, the 'lifetime labour force participation rate' of the cohort is probably a good indicator of the strength of the cohort's attachment to the labour force. We base our measure of the lifetime labour force participation rate on the 'lifetime employment rates' estimated by Joshi, Layard and Owen (1985). Instead of extrapolating the actual average lifetime employment rates for each cohort however, the estimated effects of dependent children on employment are 'removed' to obtain the rate for hypothetical childless women. The estimated lifetime employment rates for cohorts born since 1944 are more doubtful because there was only their employment experience during their twenties to go on. A relationship between a cohort's participation in education at age 17 and its lifetime employment rate is used to estimate the lifetime employment rates for cohorts born after 1942, as Appendix III explains. The results are shown as Series II in Figure 2, which also shows the original estimates for comparison (Series I). New estimates by Joshi and Overton (1984) are consistent with Series II.

This estimated lifetime employment rate, denoted as K, is taken as our measure of the labour force attachment of a cohort of women. It is highly correlated with the cohort's educational attainments, but its upward trend is open to a number of different interpretations. One is that it reflects a response to a long-run trend in the demand for women's labour outside the home, reflected in rising real wages;

another is that it reflects changes on the 'supply side' as attitudes to women's roles have changed, or a very long-run response to changes in mortality. Improvements in household technology may have played an active or passive role in the story, as may increases in education. As is argued by Joshi, Layard and Owen (1985), it is not possible statistically to choose between these explanations, or indeed any other in terms of highly trended phenomena, and doubtless a number of factors have played a part in the historical process.

One rather specific interpretation of K arises because of the tendency of women with higher educational attainments and other investments in skills which are of value in the labour market to be more strongly attached to paid employment. Furthermore, women who anticipate a strong attachment are more likely to make such investments in their 'human capital'. Thus, women's labour force attachment, and therefore K, is strongly related to the idea of 'initial human capital at marriage', which appears in a number of models of birth planning. By coincidence, Cigno (1983) used 'K' to denote this particular concept.

This model of the optimal time profile of fertility suggests that, for a given family size, women with higher earning capacity at marriage (and higher K) would have steeper fertility profiles, as illustrated in Figure 3. Note that B in Figure 3 denotes the probability of any order birth, but the steeper profile suggests that women with higher initial earning capacity would have births earlier in marriage. In addition, women with more rapid rates of depreciation in earning capacity tend to have flatter fertility profiles in this model. These predictions contrast with the model of Happel et al (1984).

The model of Happel et al (1984) focuses on the timing of the first birth, with the desired number of children and birth spacing after the first treated as exogenous. In their model, the best time to begin childbearing is either very early or very late in marriage; how late depends on the intended number of children and the wife's age at marriage. More pre-marital work experience, which raises the woman's earning capacity at marriage, is shown to increase the probability of a delayed first birth. Higher initial earning capacity through more education or ability would also tend to delay the onset of childbearing since it is less likely that immediate childbirth would result in complete loss of their earning capacity 'premium.' Only when immediate childbirth results in the complete loss of a woman's skill premium, is it possible that immediate childbirth is optimal. Early timing patterns become more attractive the more rapid is the depreciation in earning capacity during periods out of employment.

If a cohort of women are more strongly attached to the labour force and/or have higher educational attainments (higher K), then it can be expected that a larger proportion of them will enter occupations with more training opportunities, which have steeper earnings-experience profiles(3). An interval out of employment for these women entails a larger earnings loss from work experience missed. According to Razin's (1980) model, higher K tends to delay the onset of childbearing, and under plausible assumptions, compresses the span of childbearing into fewer years: that is, shorter intervals between a given number of births and/or lower family size. These higher training occupations may, however, be characterised by more rapid depreciation of earning capacity during periods of absence from employment, which could encourage earlier childbearing according to the model of Happel et al. There is the strong possibility that higher earning capacity at marriage may go together with more rapid depreciation when out of employment. This possible correlation and the different models do not suggest to us a clear prediction of the effect of K on timing or spacing.

The models from which hypotheses about birth timing have been derived so far have assumed that capital markets are perfect. Happel et al have examined the implications of being unable to borrow against future income. In this situation couples have an incentive to synchronise the costs of child care with a period in which the husband's earnings are relatively high; thus in the absence of perfect capital markets there is a consumption-smoothing motivation in the timing of the child bearing. Higher earning capacity of the wife and higher pecuniary costs of rearing a child raise the cost of a child and delay the start of childbearing, and the faster the rate of increase in husband's earnings the greater the incentive to delay. Factors which raise the desired family size would also produce an incentive to delay, as would increases in the husband's income to the extent that they raise the demand for 'child quality', which raises the cost of a child.

There is also the possibility (which plays an important part in Razin's model) that the length of a birth interval itself affects child quality, suggesting that, all else equal, couples would prefer not to space births too closely. However economies of scale in childcare as well as any depreciation of a woman's human capital while out of the labour market could generate offsetting incentives to compress a given number of births into as short a span as biologically possible, particularly for women with greater than minimal labour force attachment. That these incentives obtain in Britain is suggested in Joshi (1984) and the consequences for modelling the probability of the next birth in micro-data is discussed in Newman and McCulloch (1984).

Ni Bhrolchain (1980, 1982, 1983, 1984) provides evidence that increased female employment in post-war Britain is associated (at the individual level) with a shortening of birth intervals, which facilitates mothers' eventual return to work, but she also points out that inter-birth employment has been increasing and could be causally associated with a lengthening of birth intervals. To illustrate by oversimplifying, consider three hypothetical women who have each recently had a first baby, are each considering proceeding to produce a second and are alike in all respects other than their attitude to paid employment. Woman A has no intention to return to the labour market so that her preferred birth interval would not be affected by considerations of her own employment. Woman B intends to resume employment only after her childbearing is complete. If she also wants to minimise her time out of employment, she would tend to want a shorter birth interval than Woman A. This strategy would not necessarily apply to Woman C who considers returning to paid work before her second birth (perhaps because more recent work experience has a stronger effect on earning capacity). She would not want such a short interval as Woman B and might even want (or end up with) a longer space between births than Woman A, if the fact of employment after the first birth itself creates an inducement to delay the next one. The relationship between employment propensity and birth spacing is likely to be non-linear - U shaped if not J shaped.

It is clear then that changes in men's and women's earning capacities over time and differences among cohorts of women in their lifetime labour force attachment (K) can affect the onset of childbearing and birth spacing in either direction as well as affecting desired family size. In particular, the preceding discussion of timing has indicated that a cohort's labour force attachment would influence the level and the slope of the age pattern of parity-specific birth probabilities for that cohort independently of the general level of women's real earnings in the economy. In addition, the two family size equations (1) and (2) can be combined by using (1-K) and K as weights respectively. In light of all of these considerations and suppressing the parity subscript i (which would appear next to each j), the model for a cohort when in age group j is

$$(3)\ \ln P_j = f_j\,(A,K) + B_{1j}K + B_{2j}\ln Y + B_{3j}K.\ln W$$

where $f_j(A,K)$ is a function showing the effect of age (A) on the parity-specific birth probability, with the slope of this age-fertility profile being dependent on K, as suggested by the preceding discussion.

Equation (3) also allows the responses to the economic variables (the B_{kj}s) to vary with the age group. Such variation can be expected from the discussion of birth timing. For instance, a higher W raises women's earning capacity, which leads to a change in the age profile (across age groups j) of fertility; for example, postponement of first birth in women's early 20s may raise the probability of a first birth in their late 20s, making the effect of higher W different for different age groups.

Hourly earnings are an important, but not the only, aspect of income or costs of childbearing. The likelihood of getting a job could also be important. For instance, a higher unemployment rate could reduce income prospects, but it could also make it a less costly time to have a child. We therefore introduce the unemployment rate among men (U) into equation (3) as an indicator of job availability:

$$(4)\ \ln P_j = f_j(A,K) + B_{1j}K + B_{2j}\ln Y + B_{3j}K.\ln W + B_{4j}\ln U$$

The model of equation (4) is still clearly an over-simplification. There are many possible influences on fertility behaviour which are not specified. Some may be effectively controlled for if they are highly correlated with age, or like many long-term social trends, vary with cohort in a manner similar to K. A list of period-varying factors which might explain variance not accounted for by the labour market model include the cost or availability of housing, taxes and benefits associated with children, exogenous changes in contraceptive practice, changes in the prevalence of family break-up and changes in the climate of opinion about fertility (or about the relevance of materialistic considerations to childbearing (Simons 1984)). How much such omitted factors add to or substitute for the explanation to be offered here remains open to further investigation.

Thus our theoretical discussion has left us with a set of static models of parity-specific birth probabilities for each cohort: one of the form of equation (4) for each age group j and each parity i. Each cohort is characterised solely by their lifetime labour force attachment K. But Y, W and U vary over time, and there also are likely to be demographic feedbacks through changes in the composition of the population at risk for an i-th birth. An econometric model of parity-specific birth probabilities must take these dynamics into account.

Dynamic specification

The heterogeneity of the population at risk by duration in the state and its relation to the dynamics of fertility is an important consideration in specifying our model (see Appendix I). First, recent inflows into the population at risk (PR) may depress the birth probability, all else equal, because the probability of going on to another birth is small at low durations in the PR. To control for this effect, we include the ratio of births of the previous order (B_{i-1}) to the PR of order i at various lags in each equation of the model. We denote these ratios as F_{it-k} (which equals $B_{i-1,t-k}/PR_{it-k}$) where k is the order of lag.

Recent outflows from the population at risk, as indicated by the lagged dependent variables ($\ln P_{it-k}$) also affect the composition of the population at risk by duration; thus lags of these are also included. But these lags may also reflect a distributed lag response to changes in the economic environment. The first three lags of these and the indicator of inflows (F_{it-k}) are included in each equation.

Having accounted for recent inflows to and outflows from the population at risk, we try to capture the remainder of a cohort's previous childbearing history by including the fourth lag of the share of the cohort's population in the particular population at risk, denoted as S_{it-4} (which equals PR_{it-4}/N_{t-4}). An abnormally high lagged PR_i could raise or lower P_i depending upon the particular age group involved and the variability in the proportion of a cohort ever achieving a given parity. For instance, since the proportion of women having at least one child does not vary a great deal among recent cohorts, an abnormally large lagged PR (stock of childless women) would tend to raise the first birth probability as women 'catch up' in having first births. On the other hand, an abnormally large lagged PR for fourth births could reflect a cohort whose tastes are less favourable to families larger than three than is normally the case for the PR for fourth births; thus the probability of a fourth birth would be lower than usual, all else equal.

While the theories discussed in the preceding section give us some hypotheses about equilibrium relationships and lead us to equations like(4), they tell us nothing about the dynamics of economic responses - the distribution of responses over time. These could be related to the formation of expectations about economic variables in an uncertain world, to behavioural inertia, or to biological factors delaying conception. In light of our general ignorance in this regard we start with a relatively general rational lag model and let the data indicate the dynamics. We do however use our one bit of dynamic information: because of the time to conception and gestation the first response takes at least one year. Our most general model is, for a cohort in age group j,

(5) $$\ln P_{jt} = f_j(A,K) + B_{1j}K + B_{2j}(L)\ln Y_t + B_{3j}(L)K.\ln W_t + B_{4j}(L)\ln U_t + C_{1j}(L)\ln P_{jt} + C_{2j}(L)F_{jt} + C_{3j}S_{jt-4} + u_t$$

where the $B_{kj}(L)$ and $C_{kj}(L)$ are polynomials in the lag operator L and the lags run from 1to 3 (for example $B_{2j}(L) = \sum_{q=1} B_{2jq}L^q$). While the coefficients vary with birth order we have omitted the i subscript for simplicity. The variable u_t is a zero mean random variable.

It should be stressed that lags in (5) are taken <u>within</u> cohorts when cohort-specific variables are involved. This applies to the S_{jt-4}, the $\ln P_{jt-k}$, the F_{jt-k} and $K.\ln W_{t-k}$. The last variable varies because of changes in W_{t-k} and because of differences in K among cohorts.

<u>Estimation</u>

We assume that the parameters are the same within an age group defined over 4 to 6 ages. The age groups we have chosen are 21-25, 26-29, 30-35 and 36-39. In future work we plan to test these definitions of age groups empirically, but for now we impose these groups. If the parameters are constant over a number of consecutive ages, then these parameters can be estimated by simple averaging of variables within each age group and applying the model to these averages. To see this, distinguish between variables which vary over time only and those which vary with cohort as well. In terms of these two types of variables we can write equation (5) for each age <u>a</u> as:

(5a) $$\ln P_{at} = b_0 + b_1X_t + b_2Z_{at} + b^*_a + u_{at}$$

Averaging over N ages in a given age group we obtain

(5b) $$\frac{\Sigma \ln P_{at}}{N} = b_0 + b_1X_t + b_2 \frac{\Sigma Z_{at}}{N} + \frac{\Sigma b^*_a}{N} + \frac{\Sigma u_{at}}{N}$$

b^*_a is an age-specific constant)

Thus in our estimation procedure the variables in equation (5) are averages for the age group j. We were concerned about estimating the parameters in (5) in levels because the parity-specific birth frequencies which appear on the left hand side of (5) exhibit very strong autocorrelation (within cohorts). Noting that sample autocorrelations are biased downwards, the first order coefficient was close enough to one to suggest that the birth frequency series are not stationary. Also, initial regressions in levels yielded sums of the coefficients on the lags of the dependent variable not significantly different from 1.

It is also noteworthy that men's and women's real earnings (Y and W) are approximately random walks with drift; thus they are non-stationary series. In the estimation of the parameters in (5) it is necessary that the error structure of the equation be stationary. A sufficient condition for the error structure to be stationary is that all the variables in the equation are stationary. First differencing achieves this here. It also helps avoid the danger of spurious regressions, which is very high when the variables have the time series properties which characterise the fertility and real earnings variables here. In addition, Granger and Newbold (1974) point out that estimation using first-differenced data generally uses the available data more efficiently since a new term of a differenced series adds information almost uncorrelated with that already available (in contrast to data in levels). The typically lower R^2 values associated with estimation in differences also allow for experimentation and testing. But most importantly, if we took the levels option we would need to be sure that we modelled the dynamics correctly, and that is a lot to ask when our theoretical knowledge concerning the dynamics is so slim.

Taking first differences of equation (5) we obtain

$$(6) \qquad \Delta \ln P_{jt} = d_{0j}+d_{1j}K_{jt} + B_{2j}(L)\, \Delta \ln Y_t + B_{3j}(L)\, \Delta K.\ln W_{jt} + B_{4j}(L) \Delta \ln U_t + C_{1j}(L)\, \Delta \ln P_{jt} + C_{2j}(L) \Delta F_{jt} + C_{3j} \Delta S_{jt-4} + u_{jt}$$

where $\Delta X_t = X_t - X_{t-1}$, and the lags still run from 1 to 3 (thus the fourth lag in levels is included in the differencing operation). The first two terms on the right hand side of (6) reflect the hypothesis derived in the theoretical section that K affects the slope of the fertility-age profile; we have assumed that this slope depends on K in a linear manner.

Our main estimation procedure was to start with the general model in equation (6), and then eliminate statistically insignificant variables as long as the elimination reduced the standard error of the equation. We also allowed for a first order autoregressive process in the error term u_{jt} if there was evidence of one in the general model. The sequential testing procedure then proceeded as above with an autoregressive process in the error term. We call this estimation procedure the integrated approach.

As a 'test' of the robustness of the results from the integrated approach, we use what we call a two block approach. In the first stage we try to explain as much variation as possible with the past childbearing history (the variables in equation (6) with C_{kj} parameters - ln P_{ijt}, F_{ijt} and S_{ijt-4}) and the cohort - specific trend factor, K. In the second stage we try to explain variation in the residual from the first stage with the block of current economic variables - Y_t, W_t and U_t (which are close to being random walks). The second stage is carried out like the integrated approach, starting from a general model having 3 lags of the independent variables and eliminating variables as long as they reduce the standard error of the second stage equation. The two block approach treats the data generating processes of the economic and 'history' variables as independent. It also tends to bias the analysis in the direction of not finding economic influences on parity-specific birth frequencies.

The estimation was carried out using annual observations during the period 1952-80. Either ordinary least squares or a Cochrane-Orcutt method was employed, depending upon the evidence of an autoregressive error process in the general model.

The phenomena to be explained

The data set which is used in this paper is based on the registration of legitimate births by birth order and single year of age of mother in years up to 1980 to women aged 16 in or after 1936, i.e. to the thirty-five cohorts born between 1919-20 and subsequent years up to 1964. As explained in Appendix 1 we have calculated from these the conditional rates of proceeding to first, second, third and fourth births at single years of age.

A detailed description of the patterns in these data in terms of age period and cohort effects was presented in Ermisch and Joshi (1983). This exercise confirmed that period effects dominated the fluctuations observed in the post-war period, with cohort effects adding little to statistical explanation of variations in (the logarithm of the) conditional birth rates. These conclusions are very similar to, though less decisive than, those reached on American parity specific data by Namboodiri (1981) and Issac et al (1982). Figure 4 shows age-standardised measures of the period variation in each birth order derived from one such analysis of our data set and the age effects (which are very similar whether or not cohort effects are included) are plotted in Figures 5 and 6.

The 1947 post-war baby boom is apparent for all four series plotted in Figure 4, though there is much less of a dip after the spike than in the numbers of live births plotted in Figure 1. Part of the difference between the two figures at this date may be that our data refer only to women aged 27 or less in 1947 and hence only to a subset of all births in the late 1940s but it is also likely that measurement in terms of conditional rates smoothes out some of the fluctuations. 'Postponement' of births during the War meant that there were unusually large numbers of women at risk to have each order of birth in the immediate post-war years, and as most of these 'postponed' births took place the numbers 'at risk' for first and second births fell back so much that numbers of births fell back until 1951, although the conditional rates fell back hardly at all. This illustrates one way in which the use of conditional rates allows for variations in the timing of family formation, but although they smooth out the spikes of the crude birth series somewhat the main features of subsequent post-war fertility history can still be discerned. The long upswing in births from 1951 to 1964 reappears in the conditional rates of proceeding to first and second births. Third and fourth birth probabilities however are almost level from 1947 to 1964. Although there was a rise in the number of third and fourth births, this is largely attributable to the extra numbers of women who had had two births and were therefore at risk to proceed to producing larger families - among mothers of two and three the chances of having a next birth during these baby boom years did not rise. The 'baby bust' from 1964 to 1977 is however apparent in all of the birth orders as is the upturn in the late seventies.

The shape of the time series plotted in Figure 4 roughly resembles the shapes of the age-specific time series in levels which enter our econometric exercise. These series start in 1952 when the economic time series start, or in the year in which the 1920 age-cohort entered the age group in question if that is later. When disaggregated by age-group the patterns discernible in Figure 4 are weakened for first births to childless women aged 30-35, but if anything enhanced at higher ages for the higher order births (given that we measure them in logs).

Results

The two alternative approaches were used to estimate the parameters in equation (6) for first births among women aged 21-25 (the age band where the age effects of Figure 5 are upward sloping), 26-29 and 30-35. At age 36 and over the numbers of first births are very small and so is the proportion of most cohorts in our sample remaining childless. For second and third births we estimated the models for the three age bands 26-29, 30-35 and 36-39, and fourth births we looked only at the two age bands which cover the majority of fourth births occuring with our sample - 30-35 and 36-39. The estimates of these 22 models are presented in Tables 2-5(4).

Table 2 Estimates of the models for First Births
(Dependent variable = $\Delta \ln P_t$) (t-statistics in parentheses)

	Integrated Method			Two block method		
Age group	21-25	26-29	30-35	21-25	26-29	30-35
Estimation period	1953-80	1954-80	1952-80	1952-80	1954-80	1952-80
SD of Dep. Var.	0.0425	0.0387	0.0333			
(2nd stage)				0.0215	0.0182	0.0231
Independent variables						
'History' variables						
D7172	0.059	0.065	-	0.044	0.056	-
	(5.60)	(7.40)		(2.62)	(3.77)	
$\Delta \ln P_{t-1}$	0.486	0.516	0.304	0.404	0.595	0.553
	(5.16)	(4.77)	(1.64)	(2.48)	(3.82)	(2.96)
$\Delta \ln P_{t-2}$	-0.173	-0.608	-0.222	-0.248	-0.411	-0.297
	(3.18)	(5.83)	(1.53)	(1.93)	(2.51)	(1.54)
ΔS_{t-3}	2.201	-	-	2.823	-	0.254*
	(6.46)			(3.58)		(1.41)
ΔS_{t-4}	-	3.995	-	-	2.604	-0.724
		(5.33)			(4.04)	(0.90)
K	-	-0.216	-0.378	-0.359	-0.228	-0.161
		(1.03)	(2.91)	(1.68)	(1.95)	(0.91)
Period economic variables						
$K \Delta \ln W_{t-1}$	-1.600	-1.013	-0.300	-1.273	-0.807	-0.282
	(6.75)	(4.59)	(1.39)	(5.68)	(4.01)	(1.43)
$K \Delta \ln W_{t-3}$	0.792	-	-	0.572	-	0.446
	(5.36)			(4.06)		(1.34)
$\Delta \ln Y_{t-1}$	0.763	0.603	-	0.675	0.375	-
	(3.79)	(3.45)		(3.95)	(2.28)	
$\Delta \ln Y_{t-2}$	-	-	-	-	-0.190	-0.229
					(2.05)	(1.47)
$\Delta \ln Y_{t-3}$	-	0.464	-0.322	-	0.360	-0.343
		(3.68)	(1.78)		(3.48)	(1.29)
$\Delta \ln U_{t-1}$	-0.065	-	-	-0.023	-	-0.023
	(5.54)			(1.560		(1.19)
$\Delta \ln U_{t-3}$	-	-	-	0.032	-	-
				(2.33)		
Constant						
1st stage	0.087	0.481	0.272	0.384	0.387	0.077
	(3.67)	(6.31)	(2.98)	(2.19)	(3.20)	(0.51)
2nd stage	-	-	-	-0.001	0.006	0.011
	.			(0.35)	(1.10)	(1.65)
Diagnostic statistics						
R^2 (overall)	0.939	0.914	0.595	0.914	0.905	0.686
Overall degree of freedom	19	18	23	17	16	17
Final stage						
SE	0.0125	0.0136	0.0234	0.0138	0.0130	0.0206
DW	2.02	1.67	1.84	2.01	1.75	2.27
ρ	-0.376	0.604	-	-	0.446	-

* coefficient of $\Delta \ln P_{t-3}$

Table 3 Estimates of the models for Second Births
(Dependent variable = $\Delta \ln P_t$) (t-statistics in parentheses)

	Integrated Method			Two block method		
Age group	26-29	30-35	36-39	26-29	30-35	36-39
Estimation period	1953-80	1953-80	1956-80	1953-80	1953-80	1957-80
SD of Dep. Var.	0.0270	0.0421	0.0504			
(2nd stage)				0.0164	0.0232	0.0204
Independent variables						
'History' variables						
D7172	0.040	-	-	0.049	-	-
	(3.44)			(3.42)		
$\Delta \ln P_{t-1}$	-	0.362	-0.632	-0.321	-0.048	-0.174
		(3.16)	(4.07)	(1.31)	(0.21)	(0.85)
$\Delta \ln P_{t-2}$	-	-	-	0.534	0.339	0.111
				(2.64)	(1.45)	(0.54)
$\Delta \ln P_{t-3}$	-0.498	0.254	-	-0.220	0.295	0.300
	(2.24)	(1.94)		(0.94)	(1.14)	(1.46)
ΔF_{t-1}	1.259	6.535	17.453	3.260	8.826	25.724
	(2.21)	(4.40)	(3.97)	(3.71)	(3.01)	(4.12)
ΔF_{t-2}	-1.268	-5.878	-	-1.753	-3.494	0.853
	(2.68)	(4.86)		(2.69)	(1.50)	(0.12)
ΔF_{t-3}	1.219	3.490	-8.895	1.882	2.188	-8.808
	(2.58)	(4.00)	(2.73)	(3.28)	(1.23)	(1.66)
ΔS_{t-4}	3.520	2.172	7.812	3.456	2.455	9.289
	(2.47)	(5.10)	(3.05)	(2.55)	(1.92)	(2.37)
K	0.736	-	-1.752	0.242	0.150	-0.856
	(2.41)		(8.49)	(0.92)	(0.68)	(2.54)
Period economic variables						
$K \Delta \ln W_{t-1}$	-1.014	-	-	-0.417	-	-
	(3.49)			(2.02)		
$K \Delta \ln W_{t-2}$	-	-	-	0.412	-	-0.338
				(1.82)		(1.87)
$\Delta \ln Y_{t-1}$	0.694	-	-	0.313	-	-0.153
	(2.71)			(1.77)		(1.29)
$\Delta \ln Y_{t-2}$	-0.244	-0.393	-	-0.470	-0.348	-
	(2.07)	(4.01)		(2.68)	(3.19)	
$\Delta \ln Y_{t-3}$	-	-	-0.750	-	-	-0.154
			(4.07)			(1.12)
$\Delta \ln U_{t-3}$	-	-	-0.045	-	-	-0.026
			(2.76)			(1.56)
Constant						
1st stage	-0.564	0.110	1.364	-0.130	0.056	0.785
	(2.98)	(2.30)	(9.50)	(0.57)	(0.45)	(2.87)
2nd stage	-	-	-	0.004		0.017
				(0.79)		(2.24)
Diagnostic statistics						
R^2 (overall)	0.763	0.869	0.934	0.761	0.805	0.891
Overall degree of freedom	17	20	17	13	18	10
Final stage						
SE	0.0166	0.0177	0.0159	0.0143	0.0190	0.0183
DW	2.12	2.33	2.24	1.95	2.05	2.13
ρ	0.276	-0.725	-	0.248	-0.355	-0.301

Table 4 Estimates of the models for Third Births
(Dependent variable = $\Delta \ln P_t$) (t-statistics in parentheses)

	Integrated Method			Two block method		
Age group	26-29	30-35	36-39	26-29	30-35	36-39
Estimation period	1952-80	1952-80	1956-80	1953-80	1953-80	1957-80
SD of Dep. Var.	0.0569	0.0630	0.0787			
(2nd stage)				0.0316	0.0346	0.0320
Independent variables						
'History' variables						
$\Delta \ln P_{t-1}$	0.551	-	-	0.885	1.110	0.841
	(3.69)			(3.54)	(3.89)	(2.45)
$\Delta \ln P_{t-2}$	-0.281	-	-	-0.682	-0.172	-0.965
	(1.68)			(2.33)	(0.45)	(1.88)
$\Delta \ln P_{t-3}$	-	-	-	0.203	-0.465	0.459
				(0.78)	(1.58)	(1.13)
ΔF_{t-1}	-1.156	-	-	-1.810	-5.925	-6.210
	(2.03)			(1.91)	(2.04)	(0.61)
ΔF_{t-2}	-	-	-	1.048	1.775	7.915
				(1.45)	(1.41)	(0.86)
ΔF_{t-3}	-	1.444	-	-0.635	2.066	7.705
		(2.920		(1.45)	(2.13)	(1.53)
ΔS_{t-4}	-6.062	-	-	-7.479	0.090	11.462
	(3.73)			(3.10)	(0.03)	(1.79)
K	0.811	-0.971	-2.070	1.003	-0.378	-0.688
	(3.21)	(4.02)	(12.65)	(2.13)	(1.18)	(1.30)
Period economic variables						
$K\Delta \ln W_{t-1}$	-0.450	-	0.910	-0.367	-0.560	-
	(2.00)		(1.96)	(1.70)	(1.87)	
$K\Delta \ln W_{t-2}$	-	-2.454	-	-	-	-
		(3.81)				
$K\Delta \ln W_{t-3}$	-	-	-	-	-	-0.462
						(1.88)
$\Delta \ln Y_{t-1}$	-	-	-1.228	-	-	-0.459
			(3.87)			(2.44)
$\Delta \ln Y_{t-2}$	-0.830	1.631	-1.000	-0.566	0.584	-
	(4.66)	(3.30)	(6.19)	(3.31)	(2.22)	
$\Delta \ln Y_{t-3}$	-	-1.027	-1.569	-	-0.673	-
		(3.52)	(8.07)		(3.05)	
$\Delta \ln U_{t-1}$	-	0.148	-	-	0.074	-
		(3.19)			(1.94)	
$\Delta \ln U_{t-2}$	-0.034	-0.048	-0.060	-0.022	-0.034	0.029
	(1.53)	(3.19)	(2.82)	(1.07)	(1.23)	(1.19)
$\Delta \ln U_{t-3}$	-	0.096	-	-	0.057	-
		(2.27)			(1.62)	
Constant						
1st stage	-0.444	0.724	1.465	-0.588	0.230	0.535
	(2.41)	(4.02)	(12.85)	(1.68)	(1.03)	(1.35)
2nd stage	-	-	-	0.023	0.007	0.020
				(3.03)	(0.69)	(1.89)
Diagnostic statistics						
R^2 (overall)	0.864	0.745	0.941	0.828	0.823	0.894
Overall degree of freedom	20	20	18	15	12	11
Final stage						
SE	0.0248	0.0377	0.0221	0.0251	0.0301	0.0275
DW	2.02	1.83	1.87	1.97	2.27	2.05
ρ	-	-	-	-0.162	-0.688	-0.201

Table 5 Estimates of the models for Fourth Births
(Dependent variable = $\Delta \ln P_t$) (t-statistics in parentheses)

	Integrated Method		Two block method	
Age group	30-35	36-39	30-35	36-39
Estimation period	1952-80	1956-80	1952-80	1957-80
SD of Dep. Var.	0.0697	0.0834		
(2nd stage)			0.0341	0.0364
Independent variables				
'History' variables				
$\Delta \ln P_{t-1}$	0.360	-	0.0555	0.286
	(2.03)		(1.88)	(1.10)
$\Delta \ln P_{t-2}$	-0.284	-	0.226	0.305
	(1.70)		(0.60)	(0.77)
$\Delta \ln P_{t-3}$	-	-0.419	-0.373	-0.282
		(2.16)	(0.85)	(0.63)
ΔF_{t-1}	-	-	-1.306	7.623
			(0.57)	(1.01)
ΔF_{t-2}	-	-	-1.071	-7.536
			(0.54)	(0.97)
ΔF_{t-3}	-	-2.989	1.241	-0.800
		(1.23)	(0.92)	(0.11)
ΔS_{t-4}	-13.838	-47.030	-17.030	-43.125
	(3.81)	(3.33)	(3.09)	(1.48)
K	-	-2.087	0.333	-1.272
		(6.00)	(0.82)	(2.31)
Period economic variables				
$K\ \Delta \ln W_{t-1}$	-1.550	-	-0.841	-
	(2.18)		(1.79)	
$K\ \Delta \ln W_{t-3}$	-0.522	-1.667	-	-0.693
	(1.45)	(5.02)		(2.13)
$\Delta \ln Y_{t-1}$	1.191	-	0.669	-0.398
	(2.28)		(1.86)	(2.14)
$\Delta \ln Y_{t-2}$	-	-1.335	-	-0.980
		(6.95)		(4.64)
$\Delta \ln Y_{t-3}$	-	-	-	0.586
				(2.22)
$\Delta \ln U_{t-1}$	-	-0.100	-	-0.063
		(3.29)		(1.87)
$\Delta \ln U_{t-2}$	0.042	-0.040	0.040	-0.066
	(1.49)	(1.73)	(1.46)	(2.80)
$\Delta \ln U_{t-3}$	-	-0.147	-	-0.068
		(4.74)		(2.12)
Constant				
1st stage	0.198	1.802	-0.008	1.178
	(3.84)	(8.87)	(0.03)	(3.24)
2nd stage	-	-	-0.001	0.048
			(0.14)	(3.54)
Diagnostic statistics				
R^2 (overall)	0.831	0.957	0.804	0.949
Overall degree of freedom	21	15	16	7
Final stage				
SE	0.0331	0.220	0.0326	0.0226
DW	2.04	2.18	2.26	2.16
ρ	-	-	-	-0.614

The variation in first differences that is to be explained falls with age for first births and rises with age for higher order births. Excluding first births, it also rises with birth order within an age group of women. The series with the highest raw standard deviations are those at the latest stages of family formation that we examine - fourth births to women aged 36-39, third births to women in that age group followed by fourth births to mothers of three aged 30-35 and so on. The initial stages of childbearing (first births to childless women aged 21-25) are also relatively volatile, and the least variable series we examine is second births to mothers of one aged 26-29. On the whole the success of either approach at accounting for the variation is greatest where there is the most variation to be explained, at the extreme ends of the family building process. The proportions of variance in annual percentage changes explained (.6 to .95) are remarkably (if not suspiciously) high for models in first differences and on the whole above those reported by Ermisch (1983) for age-specific period fertility rates which did not specify birth order.

The contribution made to these explanations by the period economic variables entered in the second stage of the two-block method is not on the whole particularly big. Their largest independent contribution appears to be at the two extremes of family formation - first births to childless women aged 21-25 and fourth births to mothers of three aged 36-39. However, this method of partitioning explanatory power understates the contribution of period economic variables to the model as it does not allow for their having influenced the lagged dependent variables which enter at the first stage. In any case the results of estimating the integrated models suggest that our attempt to partition explanatory power in this way was not appropriate.

The negative effect of women's wages on birth probabilities emerges in all but one of the models. It has its strongest and most immediate impact on first births to women under 30. At ages 21-25 there are positive signs on the later lags of Δ lnW, which confirms that the reaction is transient rather than permanent because we have been able to detect 'catching up' behaviour even while the cohorts concerned remain within the age group. There are weaker negative effects without explicit catching up effects on all estimated orders of births to women aged 26-35 and the effect on fourth births over age 36 takes place with more of a delay, but the negative association posited by the New Home Economics appears to be confirmed. Increases in women's wages clearly have the effect of postponing first births - whether they defer or deter later births at later ages is not so clear.

The predictions of economic theory about the effect of increasing men's wages on fertility are not unanimous and we find evidence for effects in both directions. Increases in men's wages are associated with more first and second births to women under 30, more third and fourth births to women aged 30-35, but otherwise a reverse effect. It therefore looks as though improved men's wages speed up the early stages of childbearing but also reduce the numbers of couples ultimately wanting larger families. The slower pace of reproduction at the later stages induced by higher men's wages could, of course, also be a spacing phenomenon, but it is consistent with an increase in desired 'child quality' with rising income and the effect this has on raising the direct cost of an additional child. Since the achievement of desired child quality (per child) is more costly the more children the couple has already, the negative effect of income would tend to grow stronger with parity, and there is some evidence of this occurring. However, the negative income effect, particularly for second births, could reflect the interaction of higher desired child quality and constraints on borrowing against future income, causing postponement of the birth until income is higher.

The negative impact of growth in men's earnings may also be related to the large differences in family building patterns and completed fertility between the two major housing tenures in Britain, which have been demonstrated by Murphy and Sullivan (1983). Higher income may induce couples to move into owner-occupation. Initially, owner-occupation can entail significant burdens on a household's cash flow because of the presence of constraints on borrowing. This could inhibit family building and result in lower family size. The difference between the two tenures in the cost of housing an additional child could have a longer-lasting effect. As an owner, this cost is determined in the housing market, and while there are economies of scale in housing consumption, it is undoubtedly positive and significant. In local authority housing, rents are, at best, weakly-related to the size and quality of the dwelling. An additional child would generally result in a transfer by the local authority to a larger dwelling, often at little or no additional rent. If the family were poor enough, the majority of any rise in rent that occurred would be covered by 'housing benefit'(5). While the effects of a tenure switch have been discussed in relation to second and higher order births, Murphy and Sullivan also found tenure differences in the timing of the first birth, owner-occupiers starting later. If rising women's labour force attachment and earnings induce more couples to become owners, then the strong negative effect of women's wages on the timing of the first birth could also reflect this tenure switching effect.

The ambiguous effect of men's wages on births was also apparent in the analysis of all-birth-order fertility rates reported by Ermisch (1983). Fertility rates to women under 30 were positively affected, as they are for the first and second births here, and for women aged 30-34 the sign of the men's wage term depended upon cohort.

Male unemployment generally had a weak effect on the parity-specific birth rates. It only was significant for young childless women and for women aged 36-39 at risk for second or higher order births, but particularly for fourth births. In each case, increases in the unemployment rate reduced the probability of another birth.

The New Home Economics account of the rise and fall of births during the 1960s - the positive effects of men's wage growth becoming swamped by the negative effects of women's wage growth as K increased - would therefore seem to apply largely to the advancing and then delaying of first and second births which hindsight tells us were to occur anyway. The models do not however offer a convincing account of very sharp discontinuity in 1964 for third and fourth birth probabilities evident in Figure 4 - on the whole, the models suggest these series should have been sloping down throughout the 50s and 60s.

The increasing attachment of successive cohorts to the labour force (K) not only intensifies the effect of women's wages but is associated with differences in the effect of ageing on the chances of progressing to the next birth, as illustrated in Figures 5 and 6. Higher labour force attachment reduces the chance of childless women becoming mothers and of older mothers, especially those aged 36-39, progressing to second, third and fourth births. At intermediate stages of childbearing - especially for mothers of one and of two aged under 30 the chances of progressing to the next birth are higher among cohorts with higher labour force attachment.

We have the independent evidence of Table 1 to suggest that most of the effect on first births has been one of timing, although we cannot be certain that the higher labour force attachment of most recent cohorts may not eventually result in fewer of them entering motherhood. The lower rates of adding to existing families by older women in cohorts with higher labour force attachment is more likely to have a quantum element, reflecting the negative association that there is normally supposed to be between family size and labour force participation, but it is also possible that it could partly reflect the longer birth intervals experienced by women who re-enter the labour force between births, if such inter-birth workers do not reach the populations at risk for higher order births until higher ages. The reverse effect of high K, raising the chances of second and third births to women who are already mothers of one or two children before age 30, is more likely to be an effect on spacing rather than quantum. Given that the proportion of women ever progressing to a third birth has been declining, this is almost certainly a spacing effect on third births, and there is also likely to be a spacing element in the effect on second births. As suggested on pages 6-7, better long-run labour market opportunities provide an inducement to compress child-bearing into as short a span as possible. Our findings are consistent with a U-shaped relationship between labour force attachment and birth spacing as suggested by Ni Bhrolchian, more certainly of the left-hand branch of the U, but not inconsistent with a reversal at levels of labour-force attachment high enough to produce inter-birth employment. The effects we have estimated on the life-cycle pattern of birth spacing bear some resemblance to those posited by Cigno's model of the optimal age-fertility profile (see Figure 3) and the apparent postponement of first births by the cohorts with higher labour force attachment is consistent with the model of Happel et.al, particularly where capital markets are imperfect.

Another variable which appears in the first block of the two block model is a dummy variable, D7172, inserted after examining residuals, which takes the value of unity in 1971, -1 in 1972 and 0 elsewhere. Inclusion of this dummy improved the standard error of the equation and raised the t-values on the other coefficients for first and second births to women under 30. Its coefficient indicates that, all else equal, the likelihood of a first birth is about six per cent higher in 1971 and about six per cent lower in 1972. Thus it appears that first births were shifted forward by a year, but we are unclear about the reason. There was a slight increase in fertility in 1971, which represented a pause in the decline between 1964 and 1977, in a number of countries of Western Europe and North America, suggesting that this shift of births may be a more general phenomenon. Bone (1982) offers an account of a scare about the contraceptive pill as an explanation both of the blip in 1971-2 and of the end of the baby-bust in 1976-7. We have not investigated whether a 'pill scare' effect is present at the later of these two dates. If the pill scare was responsible for the 1971-2 episode, it is not clear why it should not have affected women at higher parities as well.

Finally, our econometric analysis demonstrates the importance of taking account of changes in the composition of the population at risk when modelling the dynamics of fertility. For the first two parities, where there is less variation in the proportion ultimately having a first or second birth, an abnormally large population at risk 3 to 4 years earlier raises the likelihood of a birth, all else equal.

This suggests that economic and other factors mainly shift births around by a few years. These changes in the composition of the population at risk appear less important for third births among women over 29, but for younger women at risk for a third birth and all women at risk for a fourth birth, an unusually large population at risk reduces the likelihood of an additional birth. The reason appears to be that when unusually large numbers of women reach these populations at risk, a lower proportion of them than usual want 'large' families; that is, these additional women are not representative of the women that normally progress to this stage.

While the parameter estimates in Tables 2-5 suggest the different influences which may come to bear on childbearing decisions at different stages in family building they are less indicative of how particular economic changes affected the path of fertility in England and Wales. The complicated dynamic structure of our models makes it difficult to trace through the effect of particular economic developments on the actual number of births. In order to do so we have constructed a simulation model based on our parameter estimates.

Dynamic Simulation

The simulation model was constructed from the parameter estimates in Tables 2-5. Estimates for each age group and parity were taken from whichever method (integrated or two block) produced the lower standard error. For age groups lacking a model to predict their conditional birth frequency of a particular order actual values were used. The parameters for an age group (and parity) were applied to predict birth frequencies for each age in that group. Thus we needed to estimate the 'normal' effect of ageing on birth frequencies within a group. We used estimates of age profiles derived from an age-period-cohort model in Ermisch and Joshi (1983). These are illustrated in Figures 5 and 6. Besides errors due to the omission of relevant non-random variables, there are, therefore, two identifiable sources of error in our simulated values: the standard errors of the model's equations and the standard errors of the estimated 'normal' age effects. The latter source is generally larger. Another source of inaccuracy arises because the constant in each equation should be single-year age-specific, but we have in fact only estimated the average for the age group. The final ingredients to the simulation are starting values for the economic and fertility variables on the right hand side of the equations and initial values of the birth frequencies in levels to which the changes in these predicted by the equations are applied. From these initial values onward the simulation is fully dynamic - it predicts lagged dependent variables, populations at risk and inflows to the population at risk. The model's predictions of conditional frequencies are converted into simple numbers of births, the sort of magnitude with which one is more generally familiar. Our simulation exercise is performed for the 1970s, a period of rapid economic changes and a fertility fall and subsequent rise. Figure 7 shows the actual and simulated numbers of all births of orders 1-4 over the ages 21-39 (the actuals are designated by squares and the simulated values by crosses; the other two lines, linking triangles and diamonds illustrate counterfactual scenarios to be described below).

With the exception of going 'off track' in 1971 the model simulates total births fairly well. It should, however, be noted that the simulated values contain actuals for the age/parity groups that were lacking models (that is, those groups omitted in Tables 2 to 5). Figure 8 shows simulations for the 30-35 age group, for which there is a model for each of the first four parities. While the model underestimates the post-1977 rise in births among this age group it also tracks births fairly well. In both Figures 7 and 8 the bottom half of the Figure shows proportional deviations from actual births in each of the simulations. Figures 9 and 10 show the 'best' component model for each parity. Note that even though none of the equations upon which the models are based have standard errors in excess of three per cent the simulation errors sometimes rise above 10 per cent. This is because of the errors in estimating the age effects on fertility within age groups, and the cumulative errors that can arise in dynamic simulation. But even though the models sometimes get far off track in a given year or years their dynamic feedback mechanisms tend to push them back on track. Finally, Figures 11 and 12 show actual and simulated births by birth order.

Having established that the simulation model can track actual fluctuations in births with a fair degree of accuracy, we use the model to trace out the implications of some 'counter-factual hypotheses.' These counter-factuals should provide some insight into the causes of birth fluctuations during the 1970s, as well as summarising the implications of the magnitudes of the estimated parameters.

The Equal Pay Act 1970 specified that women should be paid the same pay as men if they do the same job. Its provisions were phased-in over the period 1970-75, and at least partly, if not mainly, as a consequence, women's real hourly earnings rose from 63 per cent of men's in 1970 to 74 per cent of men's in 1977 (in manual occupations they increased from 59 per cent to 71 per cent, and in non-manual occupations from 53 per cent to 63 per cent)(6). We examine the implications of this change in women's relative pay for fertility by simulating what would have happened to births if women's hourly earnings had grown at the same rate as men's during the 1970s. Because of the association of the rise in women's relative pay with the Equal Pay Act, we designate this as the 'No Equal Pay Act' scenario, denoted as NEPA and traced by the line through diamonds in Figures 8 through 13. The simulation model suggests (see Figure 7) that births during 1975-78 would have been about eight per cent higher in the absence of the rise in women's relative pay. Figures 11 and 12 indicate that this rise mainly affected first births, but second and third births would also have been substantially higher during 1976-79 and 1977-80 respectively. This partly reflects the higher populations at risk for second and third births that there would have been, given the increased chances of otherwise childless women having produced a first birth, but the simulations also indicate that the conditional probability of progressing to higher order births would have been raised for women at risk to produce second and third births aged 30-35 and those aged 36-39 at risk for a fourth. In none of these cases was the conditional rate raised by more than one percentage point; the effects were strongest in the last few years of the decade and their repercussions would not all have fed through by the end of the simulation period. It seems safe to say that the shortfall of births that the model attributes to the improvement in women's relative wages in the mid-seventies was mostly a timing effect - but there could also be some impact on eventual family sizes, especially if their relative pay - which has since stagnated - had continued to improve.

In light of the marked fluctuations in economic growth rates during the 1970s and the fears of economic stagnation, it is interesting to examine the implications of no growth in real earnings. This steady-state scenario (denoted in the Figures as SS0 for 'steady-state zero' and represented by a line through triangles) assumes no growth in earnings during 1970-80; it also assumes no change in unemployment, but that assumption has virtually no effect on fertility. Figure 7 shows that our model predicts that there would have been on average 10 per cent more births per annum during 1973-78 if there had been no growth in real earnings. All birth orders are substantially affected by zero growth, third births particularly (see Figure 12). Our model suggests that third births would have been over 30 per cent higher in 1977, the year of the fertility trough. This result arises because of the negative effect of earnings growth on third births, which we have suggested may be due to the rise in desired 'child quality' with income growth, which makes additional children more costly, and also to the increased numbers who would have already had two births under this scenario.

These simulations suggest that fluctuations in economic growth during the 1970s and the rise in women's earnings relative to men's made a major contribution to the steep decline and subsequent recovery in births during the 1970s. As Figure 11 shows, first births would have declined much less if women's relative earnings had not risen, and there would have been much less fluctuation. It appears that the post-1977 recovery in first births was a reaction to the postponement of first births earlier in the 1970s in response to the rise in women's relative earnings. In contrast, the decline in third births (see Figure 12) and their recovery after 1977 had little to do with changes in women's relative earnings, and more to do with fluctuations in economic growth. In the absence of changes in real earnings during 1970-80 third births would have stabilised after 1974. Economic growth during 1970-76 appears to have pushed third births to a steeper trough, which itself induced some recovery due to timing changes, but in addition the decline in real earnings during 1977 also appears to have played a role in the recovery in third births during 1978-80. Not only do economic developments affect different parities differently, they also have effects at different times, depending upon the parity and the age group. Finally, for births of order higher than the first there is considerable momentum from earlier periods, as Figures 11 and 12 illustrate for 1970-74, making fertility developments somewhat insensitive to contemporary economic developments. This has favourable implications for short-term forecasting of fertility.

Our final simulation exercise is designed to illustrate the effect of women's lifetime labour force attachment (K) on fertility developments. We have chosen a parity (third births) for which K is likely to have a strong effect, and it is illustrated for 2 age groups in Figure 13. Our simulation assumes that after 1970 K is either 10 per cent higher or lower than its actual value for all cohorts of women. This assumed discontinuity in a cohort's attachment after 1970 is somewhat dissatisfying, but the simulations should nevertheless indicate how sensitive birth rates are to labour force attachment. The high value of K is illustrated by a plot linking triangles and the low value by a string of diamonds. Note that in Figure 13 the strings of diamonds and triangles are in reversed position for the two age groups illustrated. Diamonds (low K) are associated with fewer third births to mothers of two aged 26-29 but more third births to mothers of two aged 36-39. This reversal with age group is also found for second and fourth births. As discussed above this would reflect inducements to reduce birth spacing among those who had started childbearing relatively early in cohorts with higher labour force attachment, inducements which may not be so relevant for those with relatively few children ten years later on. But spacing may be uniformly reduced at all ages by higher labour force participation and its effects swamped by a higher proportion of the populations at risk for another birth having effectively completed childbearing before their late thirties.

The rise in cohorts' labour force attachment has not (so far) had much of an impact on their completed fertility, but it is clear that the trend in employment propensity has been associated with changes in the pattern of childbearing over the life cycle and this has contributed to swings in period fertility rates, in addition to those generated by the swings in weighted sum of male and female wage growth.

Conclusion

Our econometric analysis has confirmed the importance of economic developments in augmenting a purely demographic model of fluctuations in fertility, particularly its timing. We would not contend that we have found the 'true' model of British period fertility, but we believe that the analysis has enhanced our understanding. In future work we plan to bring additional variables into the analysis; to re-estimate the model using panel data estimation methods in order to explore the robustness of the parameter estimates and test the validity of our assumption of parameter constancy within the designated age groups; to update the database and to experiment with forecasting.

From the point of view of modelling period fertility, our analysis shows that different birth orders respond differently to economic variables, and different age groups within a parity also exhibit varying responses. We have found that growing real wages for both men and women tend to deter older parents from adding to existing families. In the early stages of family building, births are inhibited by labour markets favourable to women. But conditions in the male labour market have a reverse effect on early breeding. Higher men's wages and lower male unemployment, other things being equal, bring forward first and second births to women under 30. The trend towards greater labour market participation by wives seems to have encouraged a compression of childbearing into a few years in women's late twenties and early thirties, but there is also evidence of decompression as labour force attachment increases beyond a certain point.

Even in a society with very little female participation in the labour market, the complexity of reactions to the male labour market could generate booms and busts in birth rates, but the reactions are intensified and complicated where the labour market is also relevant for women. Our estimates suggest that the unusually favourable labour market for women in Britain around the time that the Equal Pay Act was implemented account for much, though not all, of the drop in fertility in the mid-seventies.

The fertility reactions to economic changes are likely to be in opposite directions from couples at different stages in family building. The net outcome would depend upon the relative numbers at various stages as well as the relative impact of the change on the labour markets for men and women. Many of these induced changes would be self-correcting within 5 years and make little ultimate difference to completed fertility but they seem nevertheless to account for substantial year-to-year instability in the numbers of births, and it would be worthwhile investigating further the practical application of our econometric models to forecasting.

Notes

(1) See Joshi and Owen (1983), Table 5.

(2) See the penultimate paragraph of Appendix II for the reasons why $B_1=B_2$ is not an unreasonable assumption in the context of the static family size model.

(3) For evidence of this see S.H. Sandell and D. Shapiro (1980).

(4) We did not have a great deal of confidence in our estimates of the second birth frequencies and populations at risk for teenagers; thus we have not included a model for women aged 21-25 at risk for a second birth in Table 3. Our best model for them (lowest SE) came from the integrated method:

$$\Delta \ln P_t = \underset{(3.60)}{-0.475} + \underset{(2.85)}{0.57K} \; \underset{(2.56)}{-0.978} \, \Delta F_{t-3} \; \underset{(3.09)}{-0.944K} \; \Delta \ln W_{t-1} + \underset{(2.19)}{0.575} \Delta \ln Y_{t-1}$$

SE=0.0200 R^2=0.352 F=4.67 DW=2.00 ρ_1=0.23 (t-values in parentheses)

(5) An important feature of housing in Britain is the large role of the public sector. Dwellings provided by local authorities (councils) have been let at rents below the 'economic cost' of supplying the dwellings. At these subsidised rents, there has been a continual excess demand for local authority housing units, and the units are rationed according to various criteria of 'housing need'. The entry rules generally give preference to families with children and pensioners, but once a family is in this housing sector they can remain, even though their circumstances change, and their seniority in the sector actually helps them obtain better housing through transfers. During our sample period, the percentage of dwellings in owner-occupation doubled to reach about 60 per cent at present while the local authority sector's share fluctuated between a quarter and a third of the housing stock.

(6) See Tzannatos and Zabalza (1984) for evidence that the Act was primarily responsible for the rise in women's relative earnings. Women's relative hourly earnings fell after 1977 to 72 per cent of men's in 1980 overall, and to 70 per cent in manual occupations and 61 per cent in non-manual occupations in 1980. Earnings data is for full-timers from the New Earnings Survey, 1970-1980.

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Appendix I On parity specific birth probabilities

Our raw data was compiled by OPCS in 1982 from birth registration sources, on births occurring up to 1980 to single year cohorts born since 1920. They have since revised their estimates of fertility rates to allow for revisions of the population denominators suggested by the 1981 Census of Population. The material we use in the regressions is consistent with that published by OPCS (1982) in Birth Statistics 1980. The revised material is published in Birth Statistics 1981 (OPCS, 1984) and quoted in Table 1. We are grateful to OPCS for releasing the 1982 data set and for offering to make their revised estimates available to us when we may have the time to digest them. We have been able to check that the main features of the time series survive the amendments, and an OPCS exercise to attribute birth order to illegitimate births.

A limitation of the information we have used is that birth registration data only specify birth order for legitimate births, and the place of the illegitimate birth in a woman's sequence of legitimate births, if any, is not known. In our calculations we have ignored all illegitimate births as well as making other simplifying assumptions specified below so our estimates of parity-specific birth probabilities are only approximate.

Our calculation of the parity-specific birth rate is as follows:

Let N_{ct} be the population of women of cohort c in year t, and let TB_{itc} be the total births of order i to cohort c in year t. Define $B_{itc} = TB_{itc}/N_{ct}$ is the ith order birth rate. The parity-specific birth probabilities for cohort c in year t, P_{itc}, are defined as follows:

First birth :

$$P_{itc} = \frac{B_{1tc}}{1 - \sum_{j}^{t-1} B_{1jc}}$$

Second and higher order births:

(i = 2,3,4)

$$P_{itc} = \frac{B_{itc}}{\sum_{j}^{t-1} B_{(i-1)jc} - \sum_{j}^{t-1} B_{ijc}}$$

These calculations implicitly assume that women who migrate into or out of England and Wales or who die have, on average, the same birth rates, B_{itc}, as the rest of their birth cohort, and assume that it is not possible for a woman to have two consecutive births in the same calendar year.

We found that in practice our simplifying assumptions may have affected the accuracy of the calculation of the populations at risk at the earliest ages, and in the age-period-cohort analysis we excluded ages 16 and 17 for second births, ages 16, 17 and 18 for third births and ages 16, 17, 18 and 19 for fourth births; ages at which in practice negligible numbers of higher order births occur.

It should be noted that although these conditional rates embody more information than crude birth numbers TB_{ict} or even age-specific birth rates B_{ict}, they do suffer from another deficiency of registration data that they do not control for the duration of exposure among the population at risk, except arguably, for first births. Among mothers at risk for higher order births we do not know the length of the intervals since the previous birth, upon which the probability of the next birth is known to be dependent. Perhaps for this reason this type of time series had not been very widely used by demographers.

Estimation of 'period effects' and 'age effects'

These conditional birth rates were calculated for each single year of age of mother (starting with 16) for each birth cohort of women born between 1919 and 1964. If these are treated as individual data points, then there are 899 observations on the conditional rate for each birth order. These observations were used to estimate 'dummy variable' regression equations. The dependent variable in these equations is the natural logarithmn of the conditional birth rate, and the independent variables are binary variables representing each single year of age and each calendar year. Thus we estimated models of the form

$$\ln P_{it} = C + a_i + b_t + e_{it}$$

where P_{it} is the conditional birth rate for a woman aged i in year t; a_i is the effect of being in the i-th age; b_t is the effect of being at risk for that order birth in year t; C is the conditional birth rate of the 'reference woman' in the omitted age (30) and year (1958) categories; and e_{it} is a stochastic disturbance term. These age and period effects alter the conditional birth rate by a constant proportion. For example, a woman of age i has a birth rate $\exp(a_i)$ times that of the reference woman (aged 30).

It is noteworthy that for years earlier than 1963 our set of observations does not contain observations on all ages of the childbearing period, 16-44. For instance, in 1955 only women aged 16-36 are observed, and in 1945 only women aged 16-26 are observed. Thus, as we go back in time the 'period effects' (b_t) are estimated using a sample increasingly truncated by age at the top. We have nevertheless computed predicted period birth rates at a specific age using the estimated parameters of the model (C, a_i, b_t), and these are plotted in Figure 4. The time pattern of period effects is independent of the age chosen. The age effects (a_i) are plotted in Figures 5 and 6. As noted above, some of the younger ages were excluded for birth orders above the first, which reduces the number of data points below 899. The coefficients of determination (R^2) for the first four birth order models are 0.982, 0.996, 0.994 and 0.988 respectively.

William Brass has proposed a method of controlling durations at risk (which is applied to Italian data in Pellizi, 1982) to produce period-specific measures of parity progression ratios. Attributing duration to England and Wales data by an indirect technique he has produced time series which, for first, third and fourth births over the period 1956-80, have a fairly similar shape to the 'period effects' of conditional rates presented in Figure 4. However the Brass measure of second births shows virtually none of the oscillation in our measure, just a gentle upward trend (from 73 per cent progression to second births in 1950 to 94 per cent in 1980). It would be more reassuring if these two very different methods of synthesising period measures resembled each other on all four rather than three counts. In our econometric analysis we attempt to make an allowance for the duration of exposure to risk. We should also note that our measure of first births treats all childless women as being at risk for a first legitimate birth whether or not they are married.

We do not bring any data on marriage into our analysis on the grounds that the first marriage which must by definition have preceded a first legitimate birth may well have been precipitated, if not by the impending birth itself, by the same sort of factors as we argue may influence a decision to start childbearing. Eldridge and Kiernan (forthcoming) suggests that the time series of first marriages closely resembled that of first legitimate births analysed here, and attributes the decline in the first part of the seventies to a postponement of marriage, which we have found reflected in a postponement of first births. See also Kiernan and Eldridge (1984).

Sources of Labour-Market data

Men's money wage: Average hourly earnings of full-time male manual workers aged 21 and over, all industries, UK (October): British Labour Statistics Historical Abstract, (BLSHA), Table 85 and Department of Employment Gazette, various issues.

Retail price index: 3rd Quarter, Economic Trends Annual Supplement, 1983, pp.115-117.

Men's unemployment rate: BLSHA, Tables 160, 161 and 166; and Department of Employment Gazette, various issues.

Women's money wage: Average hourly earnings of full-time female manual workers aged 18 and over, all industries, UK (October): BLSHA, Table 85 and Department of Employment Gazette.

Appendix II

Static Family Size Model

Following in the 'new home economics' tradition, let the enjoyment from each child, or 'child quality' (=Q) depend upon the time and other resources devoted to each child. Using the household production framework this can be formalised as:

(1) $Q = Q(X_c, L_{1c}, L_{2c})$

where X_c = purchased goods and services allocated to each child;
L_{ic} = the time of spouse i devoted to each child; (let 1 designate the wife and 2 the husband).

Each child is assumed to be treated the same, so we assume that Q(.) is homogeneous of degree one. In particular:

(1a) $NQ = Q(NX_c, NL_{1c}, NL_{2c})$

where N = the number of children, and NQ is total 'child enjoyment".

Other home production (e.g. meals, entertainment) also requires time and goods inputs. For simplicity we assume there is a single other composite commodity Z,

(2) $Z = Z(X_z, L_{1z}, L_{2z})$

where X_z, L_{1z}, L_{2z} are defined analagously to X_c, L_{1c}, L_{2c}.

Let w_i be the wage of spouse i if he/she is in paid employment. When T is the total time available to each spouse, the budget constraint is:

(3) $(W_1 + W_2)\cdot T \geq X_c N + W_1(NL_{1c}+L_{1z}) + W_2(NL_{2c}+L_{2z}) + X_z$

where X is the numerairé.

We assume that the couple has a preference ranking which can be represented by the ordinal utility function

(4) $U\{(N-M),\ Q, Z\}$

where M is minimum desired family size.

The couple's optimisation problem is to maximise (4) subject to (1),(2), (3) and

(5) $N \geq M$

$Xj \geq 0 \qquad j = z, c$

$Lij \geq 0 \qquad i = 1, 2$

$T \geq NL_{ic} + L_{iz}$

The solution to this problem entails a number of marginal conditions. When $Xj > 0$, $Lij > 0$:

(6) (a) $U_N + \mu_3 = \lambda X_c + (\lambda w_1 + \mu_1)L_{1c} + (\lambda w_2 + \mu_2)L_{2c}$

(b) $U_Q Q_i = (\lambda w_i + \mu_i)N \qquad i = 1,2$

(c) $\mu_3(N-M) = 0$

(d) $\mu_i(T-NL_{ic}-L_{iz}) = 0 \qquad i = 1,2$

(e) $\mu_3 = 0$ when $N > M$

$\mu_3 > 0$ when $N = M$

(f) $\left.\begin{array}{l}\mu_i = 0 \text{ when } T > L_{iz} + NL_{ic} \\ \mu_i > 0 \text{ when } T = L_{iz} + NL_{ic}\end{array}\right\} i = 1,2$

(g) $U_Q Q_x = \lambda N$

(h) $U_z Z_i = \lambda W_i + \mu_i$

(i) $U_z Z_x = \lambda$

where $U_N = \frac{\partial U}{\partial N}$, $Q_i = \frac{\partial Q}{\partial L_{ic}}$, $Z_x = \frac{\partial Z}{\partial X_z}$, etc.

and μ_i $(i = 1,2,3)$ and λ are Lagrangian multipliers which can be interpreted as shadow prices.

When the solution is such that both spouses are in paid employment (i.e. $\mu_i = 0$, $i = 1,2$), then the first and second order conditions for solution of the maximisation problem imply (by the implicit function theorem) the following demand function for children.

$$(7a) \quad N = \begin{cases} B_2(W_1, W_2) \; \ldots\ldots \text{ when } \mu_3 = 0 \\ M \; \ldots\ldots\ldots \text{ when } \mu_3 > 0 \end{cases}$$

when $\mu_1 > 0$, only the husband works outside the home, and by a similar argument

$$(7b) \quad N = \begin{cases} B_1(W_2) \; \ldots\ldots\ldots \text{ when } \mu_3 = 0 \\ M \; \ldots\ldots\ldots \text{ when } \mu_3 > 0 \end{cases}$$

Note that when $\mu_3 = 0$, the marginal utility of an additional child equals the marginal cost of children in terms of goods and time evaluated in utility terms (using the marginal utility of income, λ) - see equation (6a). When $\mu_1 > 0$ the shadow cost of the wife's time devoted to children exceeds the market wage which the wife can earn (evaluated in utility terms), and when $\mu_3 > 0$ the marginal utility of an additional child is less than the marginal cost of an additional child.

Clearly if the minimum family size M is one, then the economic variables W_1 and W_2 do not affect the probability of having a first birth in this family size model; they would only affect the probability of having subsequent births. These variables may however affect the timing of the first birth over the life cycle, but the model above does not deal with timing considerations.

It is helpful to interpret the demand functions (7a) and (7b) in terms of elasticities. In order to simplify matters, let us assume that 'child quality' is exogenous. This assumption is consistent with the view that 'child quality' is not chosen by couples, but is dictated by societal norms. It can then be shown that the demand elasticities for a two-earner couple are:

$$(8) \qquad E_i^2 = S_{L_i} \cdot e_y - S_z \cdot b(q_{ci} - q_{zi}), \; i=1,2.$$

where S_{L_i} is the share of the couple's full income $(=(W_1 + W_2)T)$ accounted for by the earnings of spouse i; S_z is the share of full income 'spent' on good Z; e_y is the full income elasticity of the demand for children; b is the elasticity of substitution in consumption between children and Z; and q_{ci} and q_{zi} are the shares of spouse i's time in the 'full cost' (time and goods) of children and good Z respectively. (Note that $b > 0$.)

In a one earner family, the elasticity of family size with respect to the husband's real wage rate is

$$(9) \quad E^1 = S_{L_2} \cdot e_y - S_z \cdot b \left[(q_{c2} - q_{z2}) + (q_{c1} - q_{z1}) V^* \right]$$

where V* is the elasticity of the wife's (shadow) value of time with respect to her husband's wage rate.

Equations (8) and (9) help clarify the factors conditioning the response of fertility to men's and women's real wages. Among two earner couples, if children are a normal good ($e_y > 0$), then a necessary condition for a spouse's real earnings to have a negative effect on desired family size is that children are more intensive in the use of the spouse's than is other home production ($q_{ci} > q_{zi}$)--see equation (8). This is not however a sufficient condition. Since it is generally thought that children are relatively intensive in the use of the mother's time ($q_{c1} > q_{z1}$), and since wives' contribute a smaller proportion of family income ($S_{L_1} < S_{L_2}$), there is a presumption that higher women's earnings opportunities will reduce the desired number of children ($E_1^2 < 0$). In that husbands contribute a larger share of family income and are involved less in child care, it is presumed that men's real earnings have a positive effect on family size ($E_2^2 > 0$).

Among one earner couples, women's real wages do not affect fertility, but the effect of men's wages depends upon how they affect the value of the wife's time. If the ranking of children and good Z by time intensity differs between spouses (that is, their time inputs are substitutes in consumption) and their time inputs are substitutes in household production (of Q and Z), then $V^* > 0$, which is the effect generally found in labour force participation studies. Thus equation (9) shows that even when children are <u>not</u> relatively intensive in the father's time ($q_{c2} < q_{z2}$) and children are a normal good, the income effect of higher real earnings is offset by their effect on the value of the wife's time and therefore the cost of children ($(q_{c1} - q_{z1})V^* > 0$). Thus higher husband's real earnings in one earner couples could reduce desired family size, although we now show why this is unlikely.

We now show why the effect of the husband's real wage is likely to be about the same in one and two earner couples. Let us assume that the father's relative involvement in child-rearing is the same in the two types of couples--that is, $q_{c2}-q_{z2}$ is the same. But S_{L_2} will be smaller in two earner couples because of the wife's contribution to family income, and in one earner couples there is the offset through the wife's value of time just discussed ($(q_{c1}- q_{z1})V^*$). Comparison of equations (8) and (9) indicates that these differences in the income and substitution effects respectively work in the opposite directions, so E^1 may well be equal to E^2_2; that is, the difference produced by the lower S_{L_2} in equation (8) is offset by the extra term $(q_{c1}- q_{z1})V^*$ in equation (9). Furthermore, husbands with wives in employment may devote more time to child-rearing so that $q_{c2}-q_{z2}$ is (algebraically) larger.

The preceding discussion has treated 'child quality' as exogenous. Relaxing this assumption affects the impacts of spouses' real wages on fertility, particularly the husband's. Rather than derive the impact of the husband's real wages when child quality is endogenous in a formal manner, we rely on a heuristic explanation, using the shadow prices of child quality (p_Q) and of an additional child (p_N). From the first order conditions (6) above,

$$p_Q = \frac{U_Q}{\lambda} = \frac{N}{Q_x} = \frac{N(w_i + \mu_i/\lambda)}{Q_i}$$

Thus the shadow price of child quality rises with the number of children. It costs a couple more to increase child quality if they have more children. In terms of parity-specific influences, the more children a couple have already, the more it will cost to raise child quality. This suggests that higher parity couples may choose lower quality children, but it also means that if higher husband's earnings raises the child quality desired, then the couple may only achieve the desired quality by limiting the size of their family. This suggests that to the extent that higher husband's earnings raise desired child quality, higher husband's earnings could reduce the probability of an additional birth and this negative income effect would rise with parity. The/potential negative income effect can be seen more clearly by looking at the shadow price of an additional child (p_N). Define the shadow price of quality per child as $p_Q^* = p_Q/N$. Then using the first order conditions and the linear homogeneity of the production function for quality (that is, the lack of scale economies or diseconomies in the production of child quality),

$$p_N = \frac{U_N + \mu_3}{\lambda} = p_Q^* Q$$

Thus the shadow price of an additional child rises with desired child quality. An increase in desired child quality arising from an increase in husband's earnings raises the price of an additional child, and if the increase in price is strong enough, higher husband's earnings could reduce the probability of an additional birth. (see Willis (1973))

Appendix III

Prediction of women's lifetime employment participation rates for cohorts born since 1942

The first step was to estimate a relationship between the lifetime employment rate of a cohort and the number per 1,000 in the cohort with 'particular qualifications' (denoted as E). The latter number is taken from the 1971 Census Qualified Manpower Tables (Table 1, for cohorts of women, as defined by their age in 1971. In that mortality and migration propensities may vary by educational attainments these cohort measures are only approximate, but should be close. The 'number with particular qualifications' is defined to include all women with qualifications above 'A' level (level a, b and c in Census terms) plus half of those with 'A' levels (d level in Census terms). This definition is used because the number per 1,000 in the birth cohorts of the 1940s included in the definition is approximately equal to the number of women per 1,000 in these cohorts in education at age 17: for the 1942-46 cohorts these ratios are 132 and 136 respectively.

After experimentation, the best 'fit' over the 8 groups of cohorts 1902-1906 to 1942-46.

$$\frac{K}{1-K} = -6.005 + 1.7565 \ln E \quad R^2 = 0.99$$

Where K is the average lifetime employment participation rate of the group of five birth cohorts.

This relationship has the properties that the impact of E on K, dK/dE, falls as K and E rise. Also, predictions of K are clearly confined to the 0,1 interval.

The next step is to substitute the number of women per 1,000 in a birth cohort in education at age 17 for E in the above relationship.

Figure 1 Live Births (England and Wales)

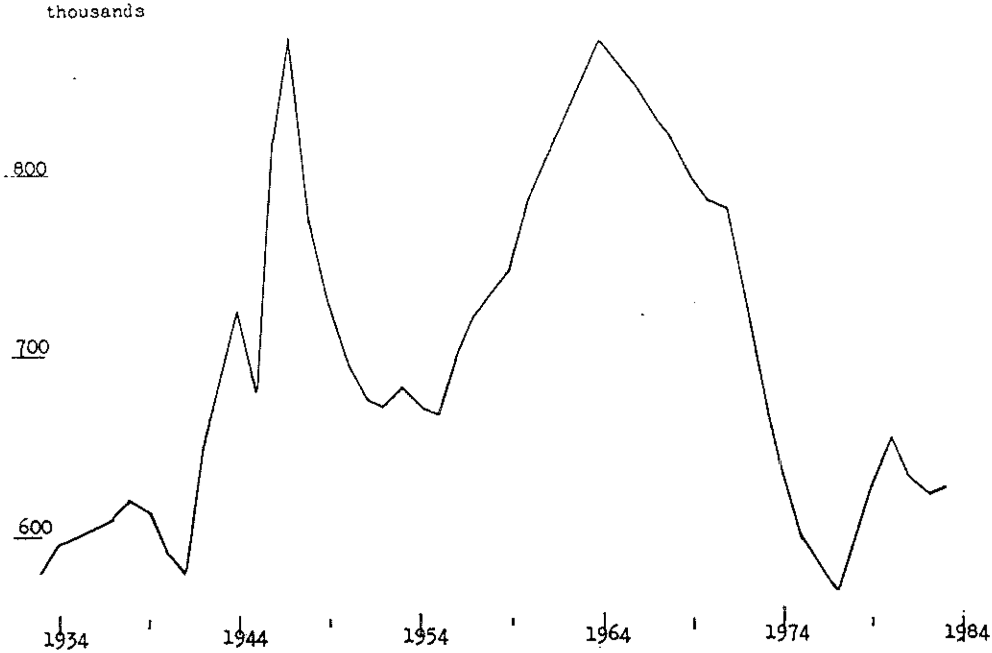


Figure 2

Women's lifetime employment rates by birth cohort

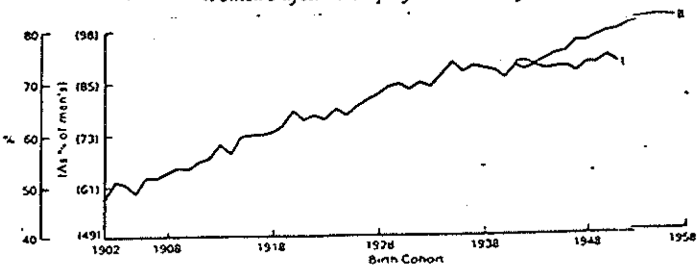


Figure 3

Age-fertility profile

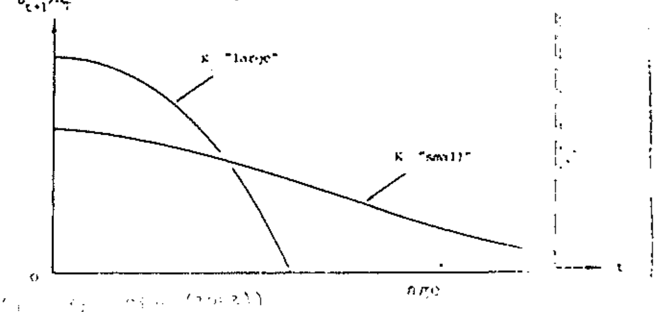
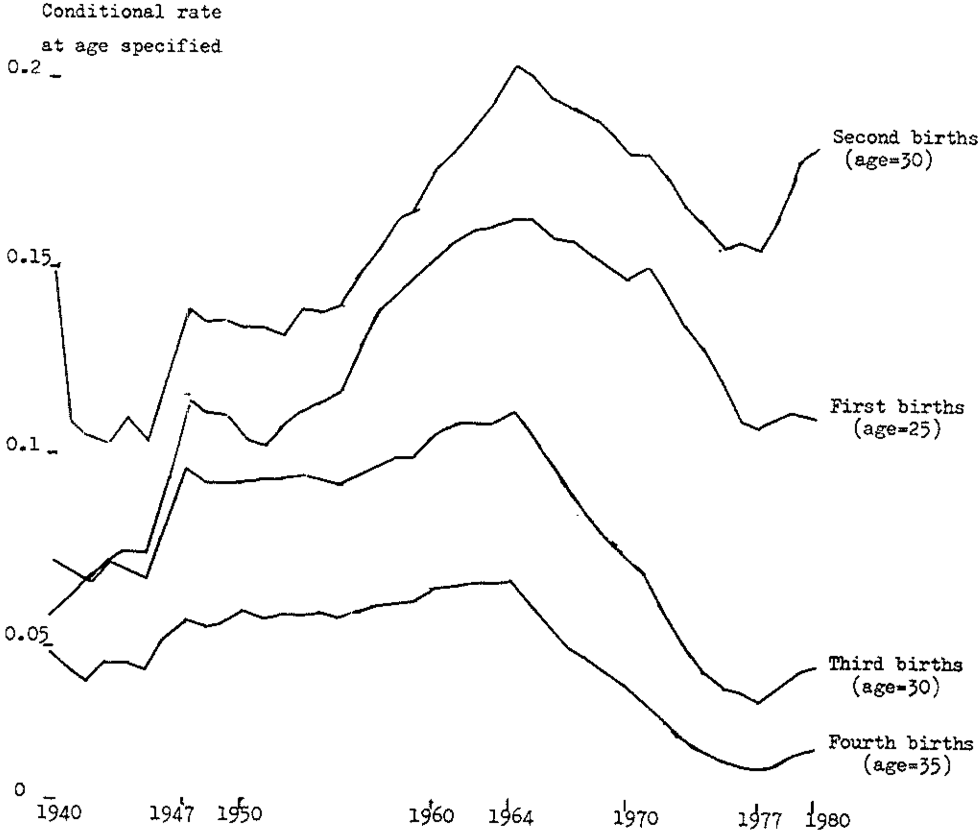
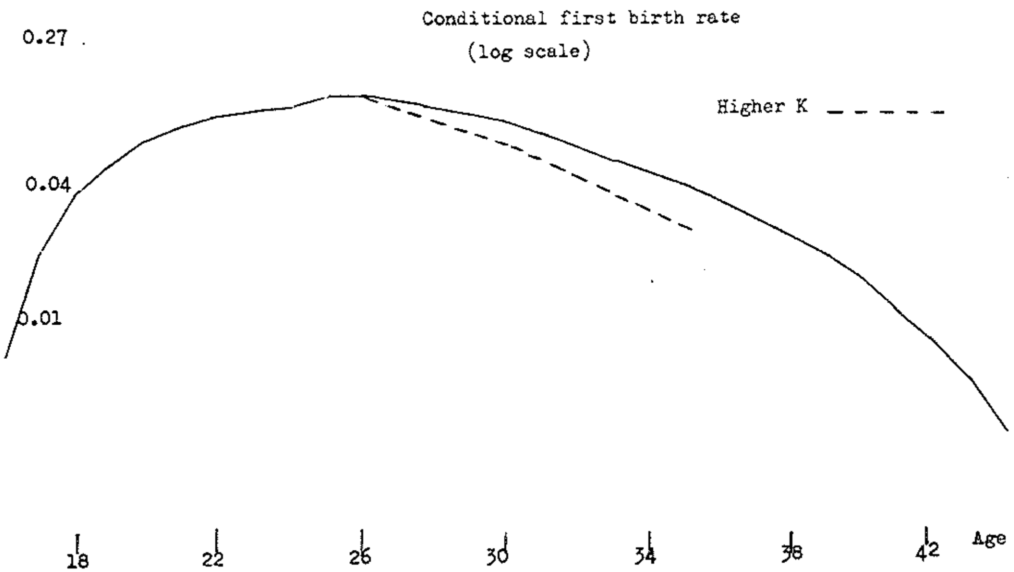


FIGURE 4: Time series of conditional birth rates by birth order: Natural values of 'period effects' in an age-period model of log rates, ohorts of women born since 1920*



*For years before 1964, these 'period effects' are estimated on an incomplete span of ages (i.e. less than the full childbearing period, 16-44). See Appendix I for details concerning estimation.

Figure 5 Age profiles



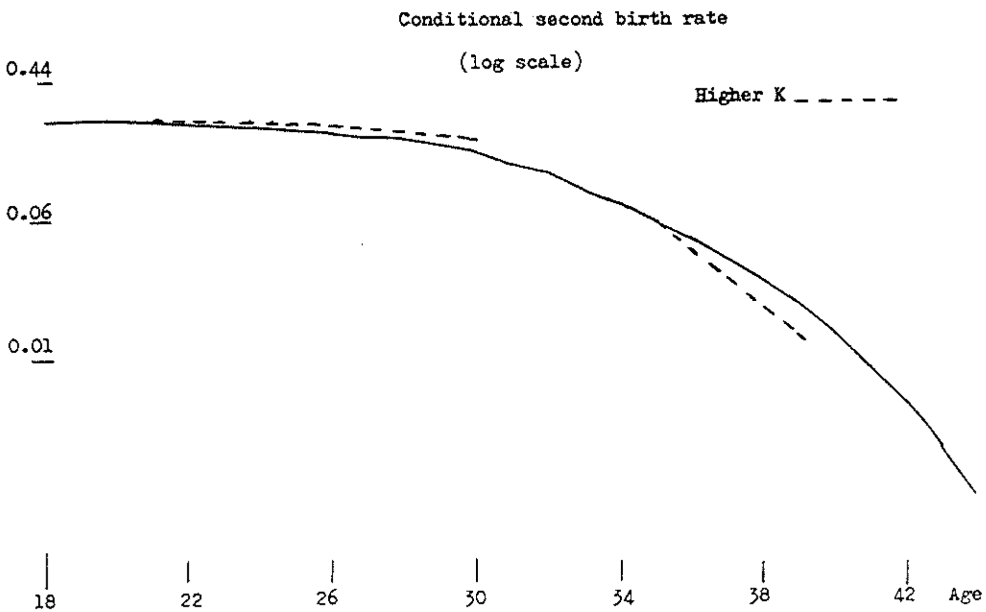
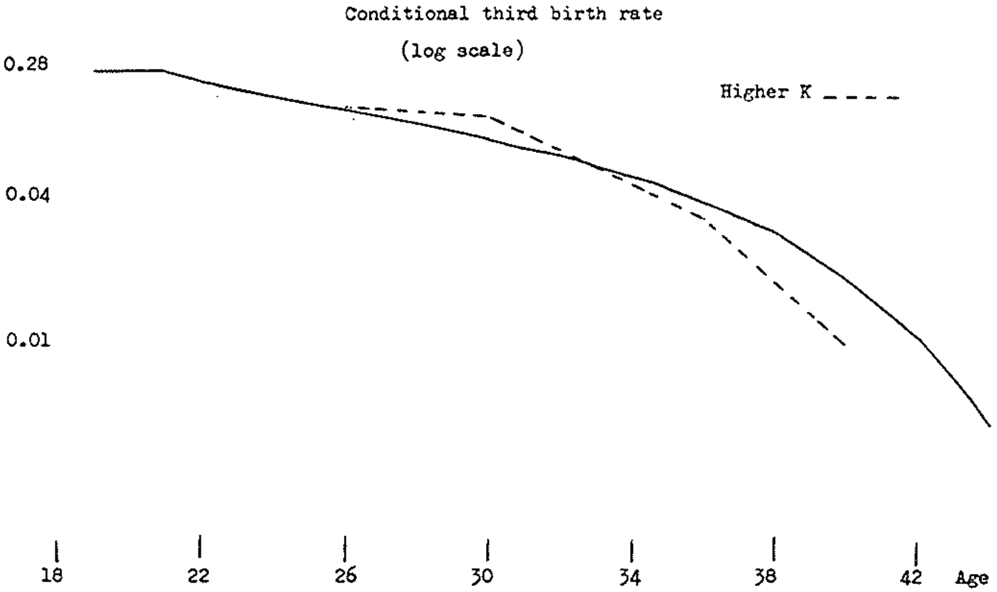


Figure 6 Age profiles



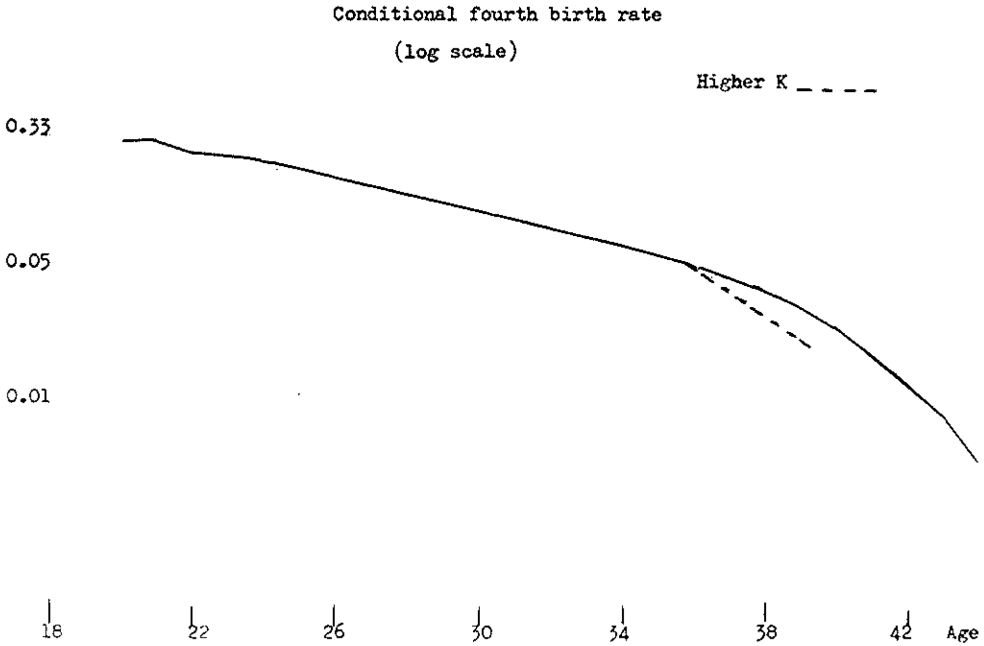
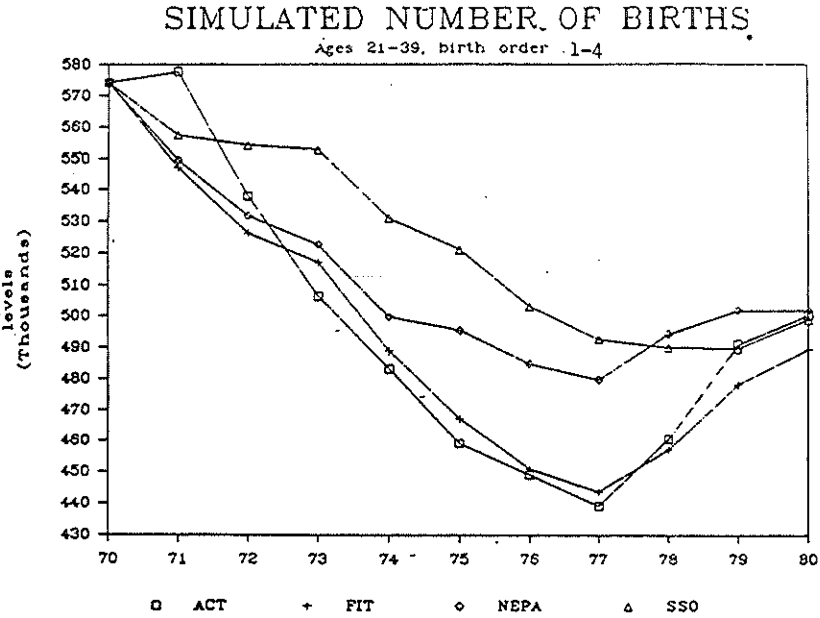


FIGURE 7: Number of births, orders 1-4, women aged 21-39



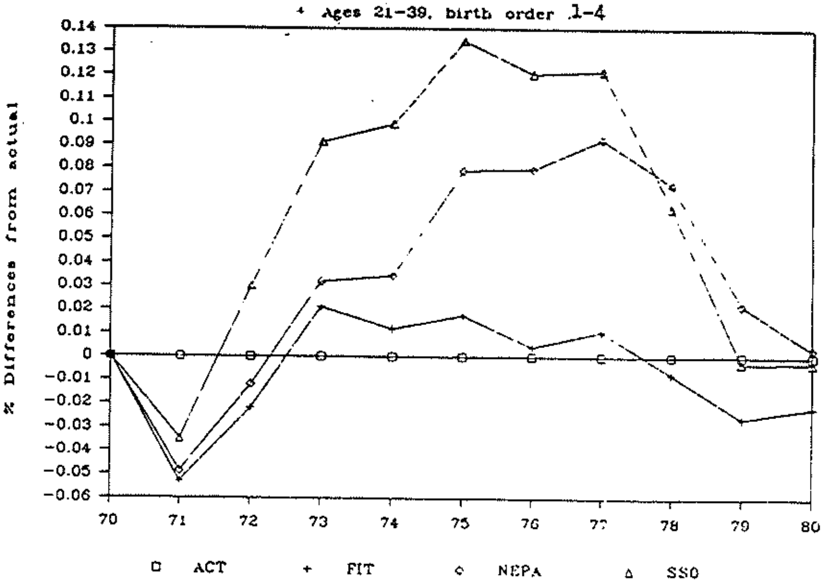
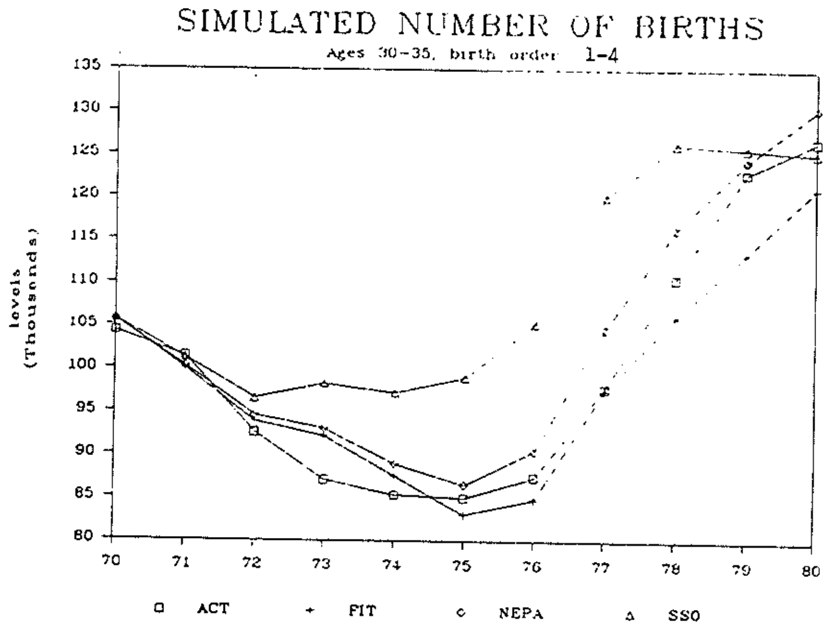


FIGURE 8: Ages 30-35, All birth orders modelled



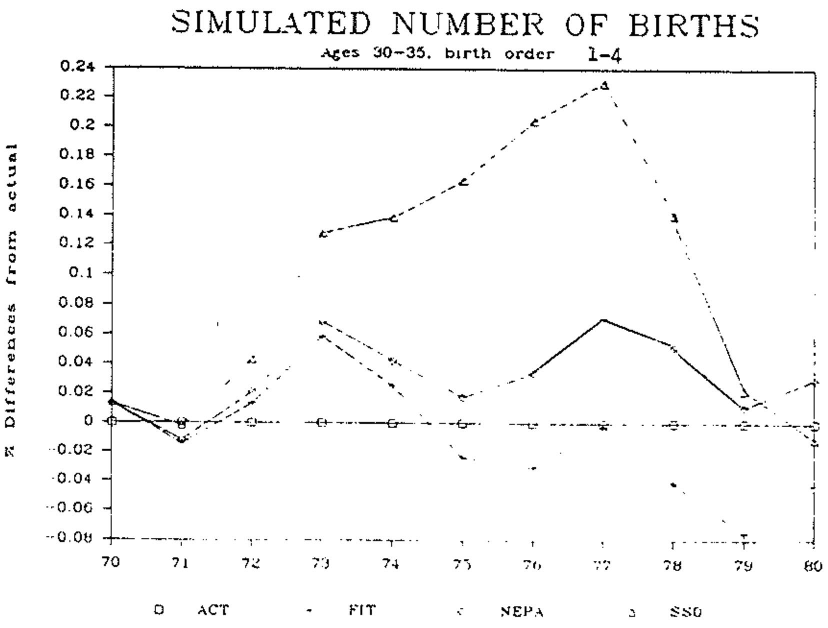
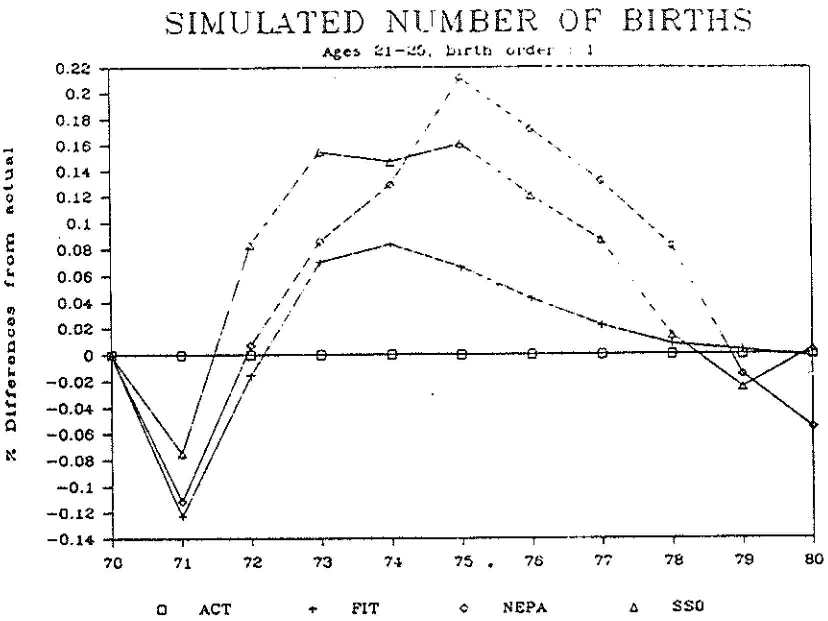


FIGURE 9: Best component age band, first and second births



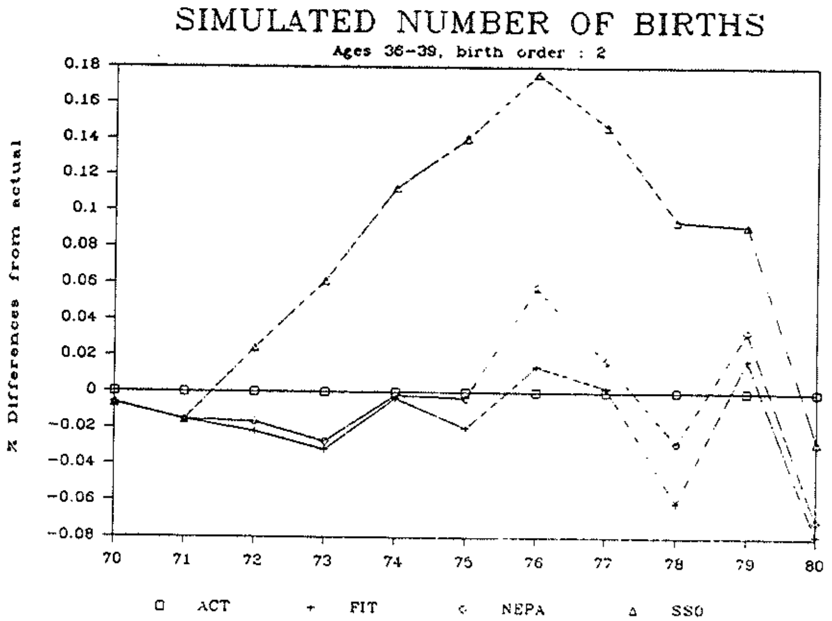
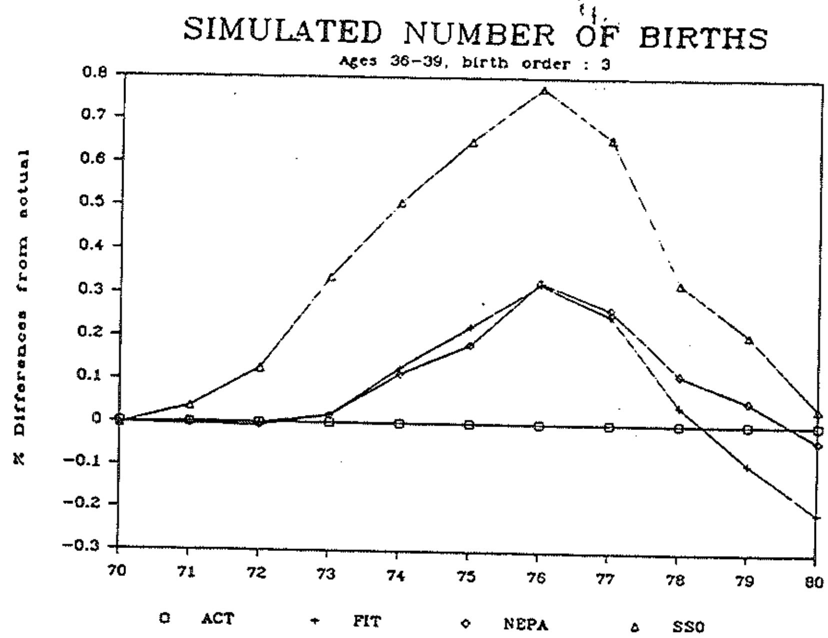


FIGURE 10: Best component age bands, third and fourth births



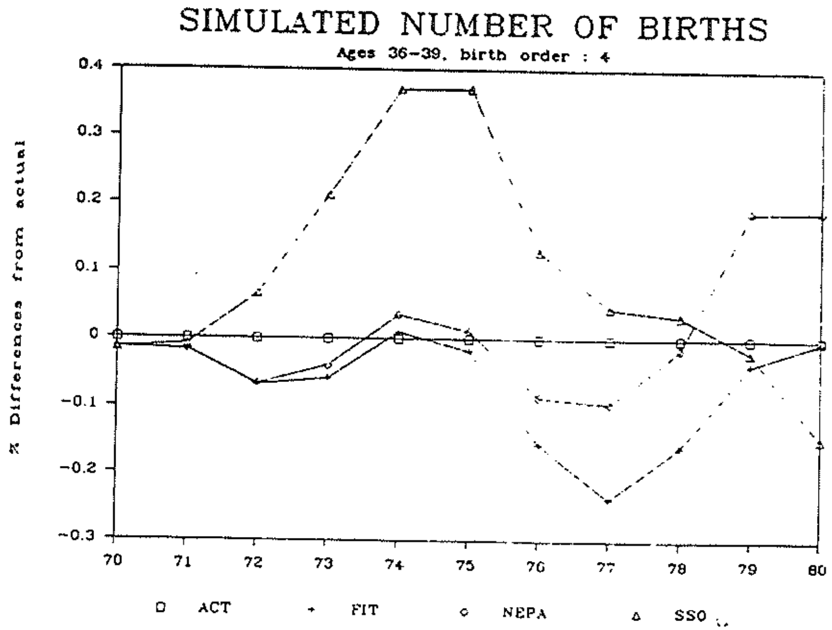
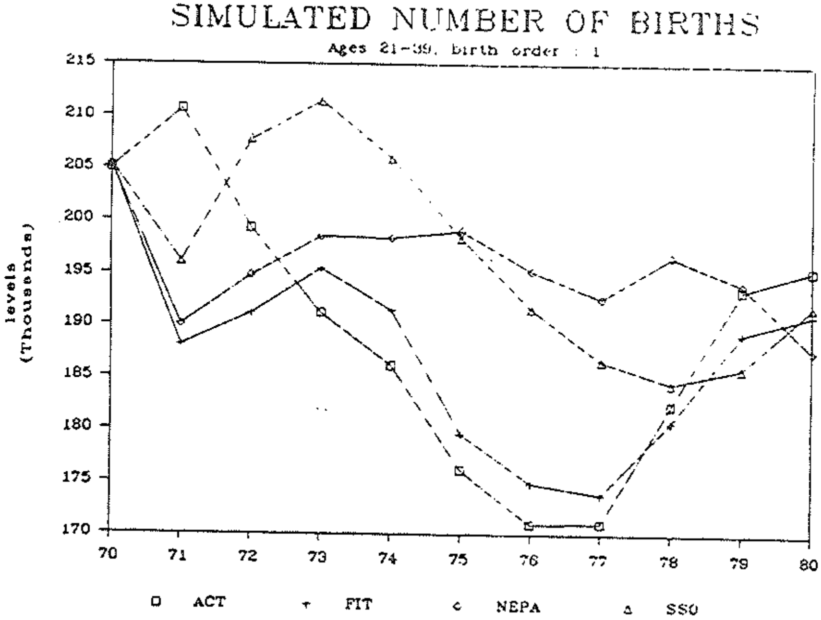


FIGURE 11: First and second births



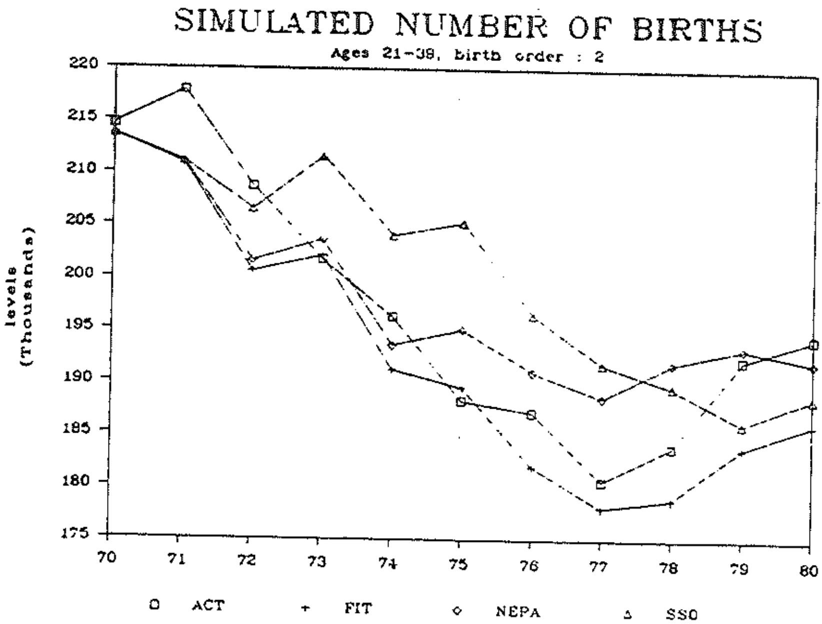
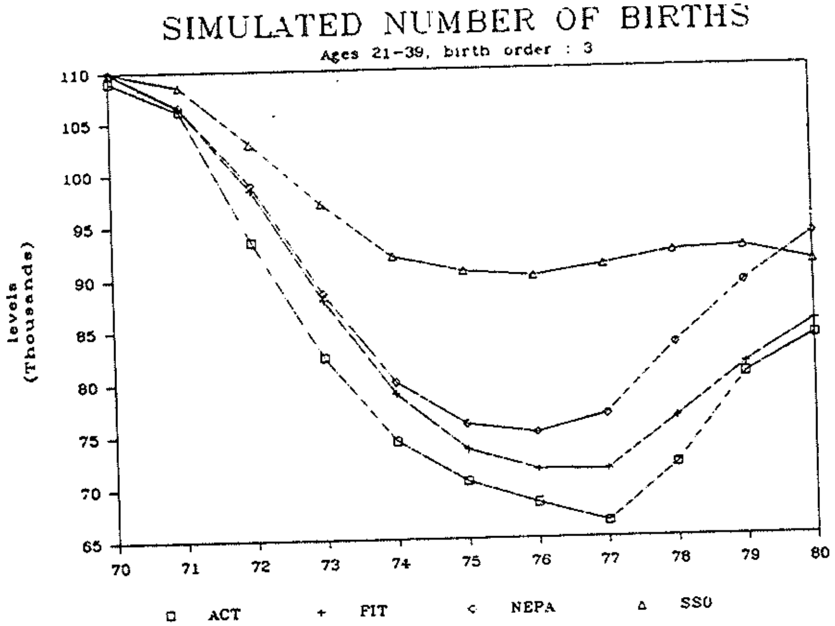


FIGURE 12: Third and fourth births



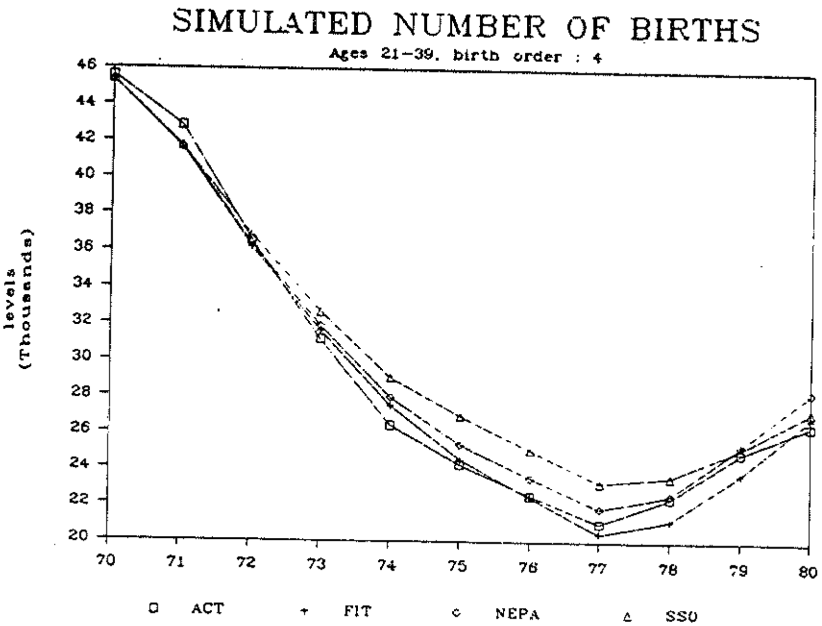
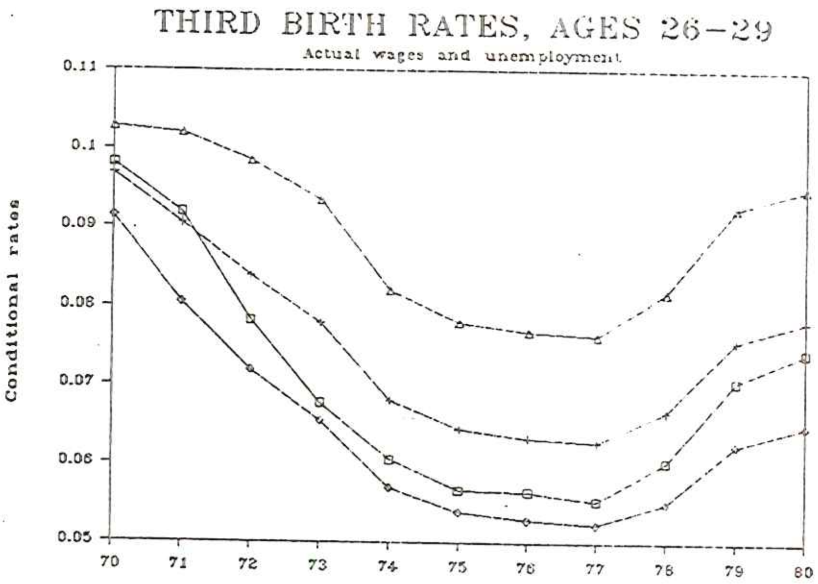
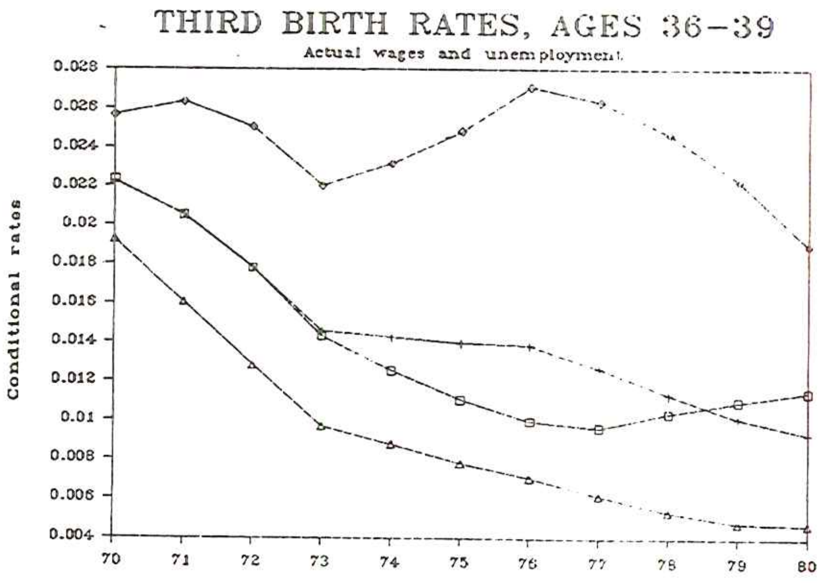


FIGURE 13: The Effect of Labour force attachment





actual □ + fit : K ◇ fit : 0.9 K △ fit : 1.1 K