# MULTILEVEL MULTIPROCESS MODELLING OF PARTNERSHIP AND CHILDBEARING EVENT HISTORIES

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## ABSTRACT

We describe a general framework for the analysis of correlated event histories, with an application to a study of partnership transitions and fertility among a cohort of British women. A multilevel multistate competing risks model is used to examine the relationship between prior fertility outcomes (the presence and characteristics of children) and the dissolution of marital and nonmarital unions and movements from cohabitation to marriage. Using a simultaneous equations model these partnership transitions are modelled jointly with fertility, allowing for correlation between the unobserved woman-level characteristics that affect each process. The analysis is based on the partnership and birth histories collected for the 1958 birth cohort between the ages of 16 and 42.

KEY WORDS: Event history analysis, Multilevel modelling, Multiprocess modelling, Simultaneous equation modelling.

## RÉSUMÉ

Nous décrivons un cadre général pour l'analyse de l’historique d'événements corrélées, appliqué à une étude sur la transition de partenaires et la fertilité d’une cohorte de femmes britanniques. Un modèle de concurrence de risque multi-états multi-niveaux est utilisé pour analyser la relation entre les résultats précédents de la fertilité (présence d’enfants et leurs caractéristiques) et la dissolution de l’union maritale ou non maritale ainsi que la transition de la cohabitation au mariage. Ces transitions d'union sont modélisées conjointement avec la fertilité en utilisant un modèle d'équations simultanées tenant en compte la corrélation entre les caractéristiques non observées au niveau de la femme affectant chacun des processus. L’analyse est basée sur l’historique des partenaires et des naissances recueilli pour la cohorte des naissances de 1958 entre les âges de 16 et 42 ans.

MOTS CLÉS : Analyse d’historique d’événements; modélisation multi-niveaux; modélisation multi-processus; modélisation par équations simultanées.

## 1. INTRODUCTION

The outcomes of marital and non-marital partnerships and childbearing within those partnerships are two related dynamic processes. The decision to end a partnership, or to move from cohabitation to marriage, is likely to be jointly determined with the decision to have a child with that partner. In other words, there may be factors, both observed and unobserved, which drive both processes. While previous research has examined the effects of the presence of children on partnership stability, few studies allow for the possibility that children are prior outcomes of a potentially related process. If decisions about partnerships and childbearing are jointly determined, the unobserved components of the models for each process will be correlated. Therefore indicators of the presence of children will not be independent of the residuals in the model for partnership transitions, and estimates of their effects on partnership outcomes will be biased.

In this paper, we examine the effect of the presence and age of children on partnership outcomes using a multiprocess model (Lillard 1993), which allows for correlation between the unmeasured individual-specific determinants of partnership durations and fertility. A multilevel model is used to allow for correlation between the durations of multiple partnerships, and of intervals between children, for the same individual. Repeated events lead to a two level hierarchical structure, with events nested within individuals.

## 2. METHODOLOGY

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The multiprocess model is a system of simultaneous equations for partnership transitions and childbearing. Simultaneity of the two processes comes from allowing the hazard of a partnership transition at time $t$ to depend on prior outcomes of the childbearing process (the number and age of children born *before* time $t$), and allowing for correlation between unobservables affecting each process. We consider a total of three partnership transitions: marriage to separation, cohabitation to separation, and cohabitation to marriage. The hazards of these transitions are modelled jointly with the hazard of a conception, again distinguishing between marital and non-marital partnerships. Each equation defines a discrete-time hazards model. A discrete-time formulation has two main advantages. First, as with many retrospectively collected event history data, the dates of events are reported in months. It is therefore natural to specify a model that assumes measurement in discrete rather than continuous time. Second, after restructuring the data, standard multilevel methods for analysing discrete response data may be used (Steele et al., 1996). Thus complex event history models, such as the one described below, may be fitted using existing estimation procedures and software.

### 2.1 Model for Partnership Transitions

*Marriage*

A partnership is defined as a continuous period of at least one month spent living with the same partner. The unit of analysis is a partnership episode which is defined as a continuous period of time spent in the same partnership state, marriage or (unmarried) cohabitation, with the same partner.

We denote by $h_{ij}^{PM}(t)$ the hazard of a marital separation during time interval $t$ of episode $i$ for individual $j$. A multilevel discrete-time event history model for marital separations may be written (omitting subscripts) as:

$$\operatorname{logit} h^{PM}(t) = \alpha_0^M D^{PM}(t) + \alpha_1^M F(t) + \alpha_2^M X^{PM}(t) + u^{PM} . \qquad (1)$$

$\alpha_0^M D^{PM}(t)$ is the baseline log-hazard which is a function of marriage duration at time $t$ or, for marriages immediately preceded by a period of cohabitation, partnership duration. Possible choices for the baseline log-hazard include a step function, where the duration is treated as a categorical variable, or a polynomial function. The potentially endogenous time-varying outcomes of the fertility process, which may affect both future partnership transitions and fertility, are denoted by $F(t)$, with coefficient vector $\alpha_1^M$. Other covariates which affect marital dissolution are represented by $X^{PM}(t)$. Unobserved time-invariant individual-specific factors are represented by normally distributed random effects $u^{PM}$.

In order to estimate (1) each marriage duration, $D_{ij}^{PM}$, is converted to a sequence of $D_{ij}^{PM}$ binary responses, $y_{ij}^{PM}(t)$. For $t$=1, . . ., $D_{ij}^{PM} - 1$, $y_{ij}^{PM}(t)$=0; and for $t$=$D_{ij}^{PM}$, $y_{ij}^{PM}(t)$=1 if separation occurs at $D_{ij}^{PM}$ and $y_{ij}^{PM}(t)$=0 otherwise (right-censored durations). As start and end dates of episodes were recorded to the nearest month, it is possible to have a binary response for each month. However, using discrete time intervals of one month leads to a very large dataset. We therefore grouped partnership durations (and birth intervals) into six-month intervals, with each observation weighted by the number of months for which an individual was 'at risk' of having an event.

*Cohabitation*

We consider two transitions from the cohabitation state: separation, and marriage to the same partner. Denote by $h_{ij}^{PC(r)}(t)$ the hazard of a transition of type $r$ from cohabitation, in time interval $t$ of episode $i$ for individual $j$, where $r$=0 (no transition), 1 (separation), or 2 (marriage). Transitions from cohabitation may be modelled using a multilevel discrete-time competing risks model (Steele et al., 1996):

$$\log\left[\frac{h^{PC(r)}(t)}{h^{PC(0)}(t)}\right] = \alpha_0^{C(r)} D^{PC(r)}(t) + \alpha_1^{C(r)} F(t) + \alpha_2^{C(r)} X^{PC(r)}(t) + u^{PC(r)}, \quad r = 1,2 \qquad (2)$$

where $\alpha_0^{C(r)} D^{PC(r)}(t)$ is a function of cohabitation duration at time *t*, $X^{PC(r)}(t)$ are covariates that affect the hazard of a transition of type *r* from cohabitation, and $u^{PC(r)}$ are individual and transition-specific random effects.

To estimate (2) each cohabitation duration, $D_{ij}^{PC}$, is converted to a sequence of $D_{ij}^{PC}$ multinomial responses, $y_{ij}^{PC}(t)$. The response at time *t* is coded 0 if still cohabiting, 1 if separation occurs, and 2 if marriage to the same partner occurs.

Equations (1) and (2) define a multilevel multistate model (Steele et al., 2004), where in the present case the states are marriage and cohabitation. To allow for unobserved individual-level characteristics that affect each type of transition, the random effects may be correlated across transitions with covariance $\Omega_u^P$. Simultaneous estimation of (1) and (2) is achieved by pooling all episodes and defining indicator variables for marriage and cohabitation. These indicators are interacted with the explanatory variables to allow for marriage and cohabitation specific effects of partnership duration, fertility outcomes and background characteristics. The coefficients of the indicators themselves are allowed to vary randomly across women to produce the state-specific random effects.

### 2.2 Model for Childbearing within Partnerships

Denote by $h_{ij}^{FM}(t)$ the hazard of a conception leading to a live birth within marriage during time interval *t* in partnership episode *i* for individual *j*. We denote by $h_{ij}^{FC}(t)$ the hazard of a conception within a cohabiting partnership. The model for childbearing consists of separate equations for marriage and cohabitation, which are estimated simultaneously. Both equations include as covariates prior outcomes of the childbearing process, $F(t)$, as well as background characteristics

*Marriage*

A multilevel event history model for the waiting time to conception within marriage may be written (omitting subscripts):

$$\text{logit}\, h^{FM}(t) = \beta_0^M D^{FM}(t) + \beta_1^M F(t) + \beta_2^M X^{FM}(t) + u^{FM} \qquad (3)$$

where $\beta_0^M D^{FM}(t)$ is a function of the partnership duration, $X^{FM}(t)$ are covariates affecting the fertility process, and $u^{FM}$ is an individual-level random effect.

*Cohabitation*

The model for conceptions within cohabitation is written:

$$\text{logit}\, h^{FC}(t) = \beta_0^C D^{FC}(t) + \beta_1^C F(t) + \beta_2^C X^{FC}(t) + u^{FC} \qquad (4)$$

where $X^{FC}(t)$ are covariates and $u^{FC}$ is an individual-level random effect, which may be correlated with $u^{FM}$ with covariance $\Omega_u^F$.

### 2.3 Estimation

Equations (1), (2), (3) and (4) define a multiprocess model. These equations must be estimated simultaneously as there may be non-zero correlations between the woman-specific random effects across equations. Specifically we assume that

$u = (u^{PM}, u^{PC(1)}, u^{PC(2)}, u^{FM}, u^{FC}) \sim N_5(\mathbf{0}, \Omega_u)$. Correlated random effects would arise if the unobserved characteristics that influence the timing of partnership transitions are correlated with those that affect childbearing within partnerships. Non-zero correlations between elements of $u^P = (u^{PM}, u^{PC(1)}, u^{PC(2)})$ and of $u^F = (u^{FM}, u^{FC})$ would suggest that $F(t)$, the number and/or age of children from the current or a previous partnership, is endogenous with respect to partnership transitions.

The discrete-time multiprocess event history model can be framed as a multilevel bivariate discrete response model where for each time interval *t* of a partnership there are two responses: 1) a binary or multinomial response for the partnership status, and 2) a binary response indicating the occurrence of a birth. The model may be estimated using existing methods for mixtures of binary and multinomial responses (Steele et al. 2004) after defining indicators for the partnership and fertility responses and interacting these with the duration variables and covariates. The results presented in this paper were obtained using Monte Carlo Markov Chain (MCMC) estimation, as implemented in *MLwiN* (Rasbash et al. 2004).

## 3. DATA

The analysis uses data from female respondents in the National Child Development Study (NCDS), a prospective longitudinal study of all those living in Great Britain who were born in a single week in March 1958 (Shepherd 1997). Retrospective partnership and birth histories were collected in 1981, 1991 and 2000, when the respondents were age 23, 33 and 42. One task of the current study was to link data collected at each age to form continuous partnership and birth histories from ages 16 to 42.

The explanatory variables of major interest are outcomes of the fertility process. Respondents were asked to identify the father of each child and for the date that each child left home. Thus it was possible to create time-varying counts of the number of children living with a woman, distinguishing between preschool and older children, and between children born to the current partner at time *t* and those fathered by a previous partner or a non-coresident partner. Other covariates include age at the start of the partnership, variables relating to previous partnerships, the number of years of post-compulsory education (time-varying), father's social class and the experience of parental separation during childhood.

The analysis sample contains 5142 women who had partnered before age 33; these women contribute 7032 partnerships and 9137 partnership episodes.

## 4. RESULTS

### 4.1 Correlations between Random Effects

The estimated random effects covariance matrix obtained from the multiprocess model is shown in Table 1. There is substantial unobserved heterogeneity in the hazards of all partnership transitions and in the hazards of conceptions within partnerships. Of most interest, however, are the covariance terms, several of which differ significantly from zero. Among partnership transitions, for example, the random effect for marital separation is positively correlated with the random effect for separation from cohabitation; this suggests that women with above average propensities of marital separation ($u^{PM}$>0) will tend also to have above average propensities to separate from a non-marital partnership ($u^{PC(1)}$>0).

Across processes, the random effects for marital separation and conception intervals within marriage are negatively correlated. Women with below average risks of separation, i.e. long marriages, have an above average risk of having a child with a husband. A strong positive correlation is found between the unobserved woman-specific factors affecting the hazard of converting a cohabitating partnership into marriage and those affecting the hazard of a birth within cohabitation. A possible interpretation of this correlation is that women who view cohabitation as a precursor to a more formal marital partnership (and therefore have a high probability of marrying) are likely to have a child while cohabiting, in anticipation of marriage. However, the significant positive correlation between the random effects for marital separation and births within cohabitation suggests that women with a high chance of having a child during cohabitation tend to have a high risk of separation should they marry.

### 4.2 Effects of Prior Fertility Outcomes on Partnership Transitions

Table 2 shows estimates from two model specifications, controlling for the effects of the other covariates mentioned earlier. The first model is a single process model, where the random effects across processes are assumed to be uncorrelated. This model assumes that prior fertility outcomes are exogenous with respect to partnership transitions. The second model considered is a multiprocess model in which the correlations between $u^P$ and $u^F$ are estimated freely. A correlation that is significantly different from zero provides evidence that prior fertility outcomes are endogenous, in which case the estimated effects from the single process model will be biased.

For illustration, we present only the effects of having preschool age children fathered by the current partner. The results from both models imply that the presence of young children reduces the risk of marital separation. The effects are slightly weaker for the multiprocess model, which can be explained by the negative correlation between the random effects for marital separation and marital fertility (Table 1). The strong negative effect obtained using a single process model is partly due to selection; women with a low risk of separation are more likely to have children within marriage. These women lower the risk of separation for women with marital children, leading to an overstatement of the negative effect of having children.

Having young children also reduces the risk of separation for a cohabiting couple. Since the random effect for separation from cohabitation is not significantly correlated with either of the random effects for fertility, we do not have sufficient evidence to reject the single process model in favour of the multiprocess model.

Based on the single process model, we would conclude that cohabiting couples who have had children together are not significantly more or less likely to marry than those who have not. However, when we move to a multiprocess model the negative effect of having one child becomes stronger and attains significance at the 5% level. This change in the estimates is due to the positive correlation between the random effects for the transition from cohabitation to marriage and births within cohabitation. On average, women with a high propensity to marry a cohabiting partner have a high propensity to have a child during cohabitation. If this form of selection is ignored, the estimated odds of marriage for women who have had children with their current (cohabiting) partner will be inflated, leading to the erroneous conclusion that having young children is not associated with marriage.

**Table 1 - Estimated random effects covariance matrix from the multiprocess model**

| | Conception in cohabitation | Conception in marriage | Marital separation | Cohabitation separation | Cohabitation to marriage |
|---|---|---|---|---|---|
| Conception in cohabitation | 0.296*<br>(0.212, 0.431) | | | | |
| Conception in marriage | -0.018<br>(-0.041, 0.001)<br>**-0.143** | 0.050*<br>(0.041, 0.062) | | | |
| Marital separation | 0.246*<br>(0.088, 0.417)<br>**0.377** | -0.075*<br>(-0.130, -0.030)<br>**-0.278** | 1.433*<br>(0.975, 1.884) | | |
| Cohabitation separation | 0.081<br>(-0.057, 0.206)<br>**0.187** | -0.026<br>(-0.059, 0.009)<br>**-0.145** | 0.497*<br>(0.210, 0.741)<br>**0.520** | 0.652*<br>(0.424, 0.928) | |
| Cohabitation to marriage | 0.214*<br>(0.130, 0.319)<br>**0.591** | -0.019<br>(-0.047, 0.007)<br>**-0.129** | 0.237*<br>(0.051, 0.428)<br>**0.296** | 0.095<br>(-0.072, 0.263)<br>**0.178** | 0.444*<br>(0.301, 0.602) |

*Note*: The values in each cell are the point estimate (the mean of the MCMC samples) and the 95% interval estimate (the 2.5% and 97.5% point of the distribution). In off-diagonal cells an estimate of the correlation (the mean of the correlation estimates across samples) is shown in bold. The results are based on 30,000 MCMC samples, with a burn-in of 5,000.

*Indicates that the 95% interval estimate does not contain zero.

**Table 2 - Estimated effects of preschool children with the current partner on partnership transitions**

| *Variables* | *Single process model* | | *Multiprocess model* | |
|---|---|---|---|---|
| | *Coefficient* | *(SE)* | *Coefficient* | *( SE)* |
| ***Marital separation*** | | | | |
| No. children (ref.=none) | | | | |
| 1 | -0.525* | (0.067) | -0.510* | (0.067) |
| 2+ | -0.878* | (0.103) | -0.837* | (0.104) |
| ***Separation from cohabitation*** | | | | |
| No. children | | | | |
| 1 | -0.280* | (0.116) | -0.299* | (0.119) |
| 2+ | -0.739* | (0.258) | -0.792* | (0.265) |
| ***Cohabitation to marriage*** | | | | |
| No. children | | | | |
| 1 | -0.147 | (0.081) | -0.230* | (0.084) |
| 2+ | -0.073 | (0.158) | -0.245 | (0.162) |

*Indicates that the 95% interval estimate does not contain zero.

## 5. CONCLUSIONS

We have proposed a multiprocess model for the analysis of correlated event histories. By modelling jointly the processes of marital dissolution, the outcomes of cohabitation and childbearing we allow for endogeneity of the presence of children born within partnerships. While adopting a multiprocess approach leads to little change in the substantive conclusions about the effects of prior fertility outcomes on partnership dissolution, a negative effect of the presence of young children on the transition from cohabitation to marriage emerges. In addition, the multiprocess model reveals a number of interesting findings regarding correlations between the unobserved factors influencing the different processes. For example, a negative residual correlation between the hazards of marital dissolution and of a marital birth suggests that women with a high risk of dissolution tend to delay or limit childbearing within marriage.

Future research under the current project will explore partnership transitions and fertility for women from the 1970 British Cohort Study (BCS70). The experiences of this younger cohort will be compared with those of the 1958 birth cohort for ages 16-30. Questions for further research include whether the effects of the presence of children on partnership dissolution and the movement from cohabitation to marriage have changed as single parenthood and non-marital births become increasingly common.

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