Female Employment and Timing of Births Decisions: a Multiple State Transition Model. *

Hans Bloemen and Adriaan Kalwij **

March 1996, Tilburg University
(first draft: january 1994)

abstract

In this paper we estimate a multiple state transition model, describing transitions into maternity and labor market transitions for women. Each state is characterized by two components: the labor market state and the maternity state. This enables us to investigate to what extent transition intensities into maternity differ for women in different labor market states, and transition intensities on the labor market differ for women in different maternity states. We disentangle the effects of socio-economic variables on the timing of births and on labor market transitions.

We find that the transition intensities into maternity are significantly higher for non-employed women than for employed women, and transition intensities into employment are significantly higher for women with no children than for women with children. Lower educated non-employed women have a higher transition probability into maternity and lower transition probability into employment than higher educated non-employed women. The effects of schooling, as a proxy for expected wages, on the transition intensities into maternity are small compared to the effects on the transition intensities into employment.

* We would like to thank Siv Gustafsson, Guido Imbens, Arie Kapteyn, Tony Lancaster and Arthur van Soest for valuable comments.

** Mailing Address: Tilburg University, CentER for Economic Research, P.O.BOX 90153, 5000 LE Tilburg, The Netherlands. E-mail: A.KALWIJ@KUB.NL

1. Introduction

In this paper we investigate the outcomes of the fertility and employment decisions of women in the Netherlands. We use a model where the employment and fertility processes are assumed to be interrelated. On the one hand, the timing of births affects the employment decision of a woman. A woman has to decide how much time to devote to her children and this restricts the time available to participate in the labor force. On the other hand, labor market opportunities affect the timing of births. Higher wages delay the time to conception of the first child, see for instance Heckman and Walker (1990). One explanation for this is that there is considerable loss in human capital during the time-period of raising a child. Therefore reentering employment, for instance, after all children left the parental home becomes difficult and takes place at a considerably lower wage rate than the wage rate received before leaving employment.

Conventionally, empirical studies investigating the interrelation between life-cycle fertility and labor supply on a household level use a static framework, e.g. Willis (1973), Siegers (1985) and Cigno (1994)[1]. The central finding in these studies is that the labor force participation decision and the demand for children are interrelated. This static approach ignores any intertemporal effects of fertility decisions. And this is especially important when investigating the interrelation between the fertility and labor supply processes, as it is clear that fertility decisions cannot be reversed and will have a significant effect on future labor market opportunities.

During the last decade the focus of econometric analyses of fertility shifted from the study of completed fertility to the study of the timing and spacing of births over the life-cycle. This line of research started of with the paper by Newman and McCulloch (1984). The literature on fertility dynamics provides sufficient evidence that female labor force participation and wages have a significant effect on the timing of births. Heckman, Hotz and Walker (1985) find that for women participating in the labor force, the expected time until first child-birth is higher than for non-participants. The central finding in Heckman and Walker (1990) is that higher wages of working women delay their times to conception and reduces the total number of conceptions. These findings are in line with earlier work of Newman and McCulloch (1984). The empirical studies of fertility dynamics assume an exogenous labor supply process. Wages or labor market status are assumed to be exogenous explanatory variables. The (expected) wage, which is so strongly related to the timing of births, is an important determinant of the employment decision, and is, moreover,

[1] The econometric framework is a simultaneous equations model. The interrelation between the number of children (interpreted as the demand for children) and female labor force participation is investigated by testing parameter restrictions.

related to job tenure. The employment decision depends in turn on the expected wage and the fertility decision. Therefore one can argue that birth and employment processes are interrelated. We are aware of only one study, a working paper by Walker (1995), that explicitly models the interrelation between birth and employment processes. He finds that higher wages for working women delay their time to conception of the first child. More importantly, this result holds for women in the state of employment as well as for the state of non-employment. His results imply that explicitly modelling the employment process does not alter the main findings concerning the wage effects on the timing and spacing of births. Therefore the question remains to what extent the timing of births and labor market transitions are interrelated. A central finding in all empirical studies concerning the timing and spacing of births is that the effect of (expected) wages or labor force participation are strongest on the timing of conception of the first child.

The main question to be answered in this paper is to what extent transition intensities into maternity differ for women in different labor market states, and transition intensities on the labor market differ for women in different maternity states. In our attempt to investigate these issues we do not estimate a tightly specified structural model but estimate a reduced-form model. The econometric framework we use is a multiple state transition model. This framework is capable of disentangling the effects socio-economic variables on the timing of births and transitions between employment and non-employment. Because of heterogeneity across women in preferences and ability we control for both observed and unobserved heterogeneity.

Our main findings are the following. The transition intensities into maternity are significantly higher for non-employed women than for employed women. The transition intensities into employment are significantly higher for women with no children than for women with children, and the transition intensities into non-employment are significantly higher for women with children than for women with no children. Lower educated non-employed women have a higher transition probability into maternity and lower transition probability into employment than higher educated non-employed women. Higher educated women in employment have a higher transition probability into maternity while staying employed. The effects of schooling, as a proxy for expected wages, on the transition intensities into maternity are small compared to the effects on the transition intensities into employment. Women with a higher educated partner have a higher transition intensity into maternity than women with a lower educated partner.

The outline of the paper is as follows. Section 2 describes the model specification. Next, section 3 describes the data used for the empirical analysis. Section 4 discusses the estimation results and investigates to what extent transition intensities into maternity differ for women in different labor market states, and transition intensities on the labor market differ for women in different maternity states. Section 5 concludes.

2. Model specification

2.1 Transition Possibilities

The employment decision is whether or not to be employed. The labor market states are *employed* (E) and *non-employed* (U)[2]. We do not distinguish between full and part-time work. The fertility decision is the timing of conception of the first child. The timing of subsequent births or birth spacing issues are not investigated. The fertility states are *no pregnancy and no children in the household* (N) and *pregnancy and/or children in the household* (C). State C is assumed to be an absorbing state. We combine the two states in each of the two processes. This results in four different states, each containing two components: (E,C), (E,N), (U,C) and (U,N). The first component is the labor market state and the second component is the maternity state.

In the model the number of transitions between the four states (U,N), (E,N), (E,C) and (U,C) is restricted. As discussed above, a transition from C to N is, by assumption, not possible. Furthermore, in continuous time two events occur at exactly the same moment in time with zero probability. Therefore transitions from (U,N) to (E,C) and from (E,N) to (U,C) have a zero transition intensity. To summarize, we have 6 transition possibilities with positive intensities (table 2).

Many women conceive while being employed and leave employment just before childbirth. Disregarding pregnancy would make it appear as if these women scheduled childbirth while being non-employed. Therefore pregnancy has to be taken into account when investigating the interrelation between the fertility and employment processes. Marital and cohabitation decisions are also considered to be interrelated with the fertility and employment decisions, e.g. Becker (1981). We are primarily interested in the interrelation between the fertility and employment decisions. For this reason we assume that education, marital and cohabitation decisions are exogenous. The behavior of all other members of the household is assumed to be exogenous with respect to the decisions taken by the woman in the household.

< table 2 >

[2] Employed is defined as having a job and receiving a wage. Non-employed is defined as being out of the labor market (non-participating) or being unemployed. It is possible that a woman is employed, receives a wage and works zero hours because she is on maternity leave.

2.2 The Econometric Framework: a Multiple State Transition Model

We have four different states and order them in the following (arbitrary) way: (U,N), (E,N), (E,C) and (U,C). The employment and fertility decisions are taken in continuous time. The woman can, in principle, decide to be employed or to have a child at any point in time. Of course, the timing of births are restricted to a woman's fertile period. We only observe the outcomes of the decision processes. Uncertainty about, for instance, the availability of jobs and fertility rates is captured in the transition probabilities. The transition probabilities are assumed to depend on the current state, elapsed duration and some exogenous covariates. A detailed description of the derivation of the survivor and the density functions necessary to build the multiple state transition model can be found in Flinn and Heckman (1983) or Lancaster (1990). We restrict the discussion to those parts necessary to define the contributions to the likelihood function from which we can identify all parameters of interest.

First we need to introduce some notation. Let k and l denote respectively the source state and destination state where k,l ε { (U,N), (E,N), (E,C), (U,C) }. The so called transition intensity of a departure to state l in a short interval (t,t+*dt*), given survival to t in source state k, some exogenous covariates Z and the unknown parameter vector θ, is denoted by $h_{kl}(t|Z;\theta)$. The hazard rate, the intensity of leaving state k, is defined as the sum of transition intensities over the destination states: $h_k(t|Z;\theta) = \Sigma_{l\neq k} h_{kl}(t|Z;\theta)$. $H_k(t|Z;\theta)$ is the corresponding integrated hazard. We use the following functional form of the transition intensity:

$$h_{kl}(t|Z;\theta) = \exp\{\alpha_{0,kl}\ln t + \alpha_{1,kl}(\ln t)^2 + X^T\beta_{kl} + \gamma_{kl}\nu\}$$

where θ denotes the parameters of interest and includes $(\alpha_{0,kl},\alpha_{1,kl},ß_{kl},\gamma_{kl})^T$ for all possible (k,l). $Z=(X,\nu)^T$ where X is a vector of observable characteristics and ν an unobserved individual specific characteristic. One can think of ν as being the taste for working or having children. This differs across women and influences both the employment and fertility decisions. The baseline hazard allows for a non-monotone relation between the transition intensity and elapsed duration, t [3].

Childbirth can take place at any moment in time and also a job can be accepted at any point in time. However, jobs usually start at the beginning of the month and also the birth of a child is reported, in our survey, on a monthly basis. In the empirical analysis we have to take the discrete nature of the data into account. This is especially important when investigating the interre-

[3] To be more precise, the transition intensity is at a minimum or maximum level when $\ln t = -\alpha_0/2\alpha_1$. This level corresponds to a minimum if $\alpha_1>0$ or to a maximum if $\alpha_1<0$. If $\alpha_1=0$ then the transition intensity is a monotonically increasing or decreasing function in t.

lation between two continuous processes. If we observe a transition at time t we know that the actual transition occurred within the time interval (t-1,t]. Therefore the contribution to the likelihood function of a transition from state k to state l within the interval (t-1,t] is

$$P_{k,l}(t|Z;\theta) = \int_{t-1}^{t} \exp\{-H_k(s|Z;\theta)\}\ h_{k,l}(s|Z;\theta)\ ds \quad .$$

Not all spells observed are completed spells. For these incomplete (right censored) observations we do not know the destination state. The contribution to the likelihood function for these spells is of course equal to the value of the survivor function:

$$P_k(t|Z;\theta) = \exp\{-H_k(t|Z;\theta)\} \quad .$$

The observation period starts at the time of schooling completion. A woman can experience one or more spells during the observation period. S_i denotes the number of spells. The density function of the unobserved heterogeneity, ν, is g(υ). Collecting all of these ingredients we can write down the contribution to the likelihood of a woman, indexed by i, with a sequence of spells { $T_{i1}=t_{i1}$, $T_{i2}=t_{i2}$,..,$T_{iS}=t_{iS}$ } and characteristics X_i and υ_i:

$$\mathcal{L}_i(\theta|t_{i1},..,t_{iS_i},X_i) = \int_{-\infty}^{\infty} [\Pi_{s=1}^{S_i-1} P_{kl}(t_{is}|X_i,\upsilon_i;\theta)]\ P_k(t_{is}|X_i,\upsilon_i;\theta) g(\upsilon_i)\ d\upsilon_i \quad ,$$

where we integrate over all possible values of υ_i. The S_i^{th} spell is an incomplete spell and all preceding (S_i-1) spells are completed. The log-likelihood for the complete sample of N women is defined as:

$$\mathcal{L}(\theta|t,X) = \sum_{i=1}^{N} \ln \mathcal{L}_i(\theta|t_{i1},..,t_{iS_i},X_i) \quad .$$

We can use a Maximum Likelihood Estimator (MLE) to get estimates for the parameters of interest (θ). This requires a full specification of the density function g(υ). An alternative estimator is the Non-Parametric Maximum likelihood Estimator (NPMLE) of Heckman and Singer (1982, 1984). This estimation procedure does not require a full specification of the density function g(υ). In our empirical analyses in section 4 we employ both estimators.

3. The SSCW Data

For our empirical analyses we use the so called SSCW data[4]. All households are interviewed in the last quarter of 1992. The questionnaire is of a retrospective nature and the sample is assumed to be representative of the Dutch population. The data contain information on both the complete fertility and labor market history of all members of the household. All dates are reported on a monthly basis. There are about 1900 households in the complete sample and the questions are in principle asked to each member of the household. We only consider the responses of the head of household and the partner.

A spell is defined as being in one of the four states we described in the previous section. The start of the spell is when a woman enters a state and the end of the spell is when she transits into another state. The time spent in a spell is measured in months (DURATION). The years of schooling are the actual years the woman spent in daytime education (SCHOOLING). A male partner is defined as being the husband or cohabiting partner. The actual years of daytime education of the male partner is observed in case a male partner is present in the household at the time of interview (SCHOOLING PARTNER)[5]. Note that the male partner at the time of interview is not necessarily the male partner at the time of childbirth. It is possible that there is no partner present in the household at the time of interview but we do know the woman has been married at least once during the observation period. For instance, a divorced woman who has no partner at the time of interview. For these spells we do not observe SCHOOLING PARTNER. These spells are excluded from our sample in case the woman married before or during the spell[6]. Pregnancies at the time of interview and the expected time to delivery are explicitly asked for in the questionnaire. This is especially important given that we investigate the time to conception of the first child. The date of birth of the first child is observed and we assume the date of conception of the first child to be nine months before the date of birth of the first child. We include the age at the beginning of a spell (AGE AT START OF SPELL) to control for age effects. We select women who are under 65 at the time of interview and completed day-time schooling at the time of

---

[4] Stichting Sociale Culturele Wetenschappen. Data collection has been conducted by Stichting Telepanel. We wish to thank ESR (NWO) for making these data available to us.

[5] In the empirical analysis, we set SCHOOLING PARTNER equal to 0 in case the woman did not marry or cohabit during the observation period or in case the date of marriage is after the date of the relevant spell.

[6] We have 173 of these spells. One can argue that this causes a sample selection bias. However, when we included these spells and necessarily put SCHOOLING PARTNER equal to 0, this did not change the main results of this paper.

interview[7]. The start of the first spell is at the time of schooling completion. We are left with a sample of 709 women. In total we observe 1964 complete or incomplete spells. Table 3.1 reports the sample statistics of the relevant variables. Table 3.2 reports the number of observations for each possible transition. We only observe the destination state in case the spell is completed. There are 674 incomplete spells, i.e. right-censored observations. A transition from (U,N) to (E,C) does not occur and we observe 6 transitions from (E,N) to (U,C). We have only 66 transition from (U,C) to (E,C) and for most women (U,C) is a right-censored spell at the time of interview.

In the figures 3.1 to 3.3 we present Kaplan-Meier estimates of the survival probabilities for each possible transition. Figures 3.1 shows that the survival probability of a non-employed woman declines much faster in the situation where there are no-children in the household (state (U,N)), compared to the situation where there are children in the household (state (U,C)). Figure 3.2 shows that the survival probability in the state of no children declines in the first 7 years much faster in the situation of non-employment (state (U,N)), compared to the situation of employment (state (E,N)). As discussed in the introduction, in the literature the difference between these two curves is considered to be a wage effect. Figure 3.3 shows a fast decline in the survival probability when the woman is in state (E,C). Less than 25% of the women are still employed after a duration of 9 months. In the next section we investigate whether or not these differences between transition intensities can be explained by differences in characteristics across women, by state dependency, or both.

< Figures 3.1, 3.2 and 3.3 >

4. Empirical Results

One can argue that the difference between two transition intensities, as shown in the figures 3.1 to 3.3, are simply caused by the fact that these two groups of women are different with respect to their characteristics, a spurious differential[8]. Therefore, in section 4.1, we control for both observed and unobserved heterogeneity. In section 4.2 we investigate, after having controlled for heterogeneity, to what extent transition intensities into maternity differ for women in different

[7] When we excluded women who did not marry or cohabit at least once during the observation period, this did not change the main results of this paper.

[8] In case we observe that two transition intensities are not significantly different, this can also be the result of excluding characteristics that have, for instance, opposite effects on one of the transition intensities.

labor market states, and transition intensities on the labor market differ for women in different maternity states. Furthermore, we calculate transition probabilities for a representative woman for the different transitions in order to make the most important findings more clear.[9] Hereby we pay special attention to the effects of schooling on the transition probabilities.

4.1 Estimation of the Multiple State Transition Model

Duration dependency is, for instance, caused by job tenure when being employed, a loss in human capital when being unemployed, or a biological time-constraint on conceiving children when being childless. As discussed in section 2.1, we include a flexible function of elapsed duration to control for duration dependency. We include the years of schooling together with job tenure as a proxy for the expected wage of the woman. In case a male partner is present in the household we include the years of schooling of the partner as a proxy for his wage. A woman may value the options of working or having a child differently at different ages. For this reason we include the age at the beginning of a spell. Dummy variables for birth-cohorts are included to pick up any socio-economic changes in society. For instance, for women born in earlier birth-cohorts it was in general less accepted that they kept on working after getting married. We explicitly model unobserved differences across women in preferences and ability (unobserved heterogeneity). We assume that unobserved heterogeneity is uncorrelated with the choice whether or not to have a partner and schooling decisions made earlier in life[10]. The multiple state transition model, as formulated in section 2.1, is estimated with three different stochastic specifications for unobserved heterogeneity. Firstly we choose the often used gamma distribution for $\exp(\nu)$, secondly a normal density function and thirdly we approximate the distribution function of unobservables, $g(\upsilon)$, with a finite mixture distribution. This latter method is known as the Heckman and Singer method, Heckman and Singer (1982, 1984). The main results of the paper seem to be robust with respect to the choice of $g(\nu)$. The Heckman and Singer method imposes the least structure on the model. For this reason the estimation results reported in table 4 are the ones based on the Heckman and Singer (1982) method. A discussion on the performance of this method can be found in Huh and

[9] We use the parameter estimates as reported in table 4. We consider a representative woman with average characteristics as reported in table 3.1.

[10] In the case that unobserved heterogeneity is correlated with the schooling decisions made earlier in life (and therefore with the starting time of our observation period) we have to take initial conditions into account.

Sickles (1994). A variety of starting values are used to guard against failure to locate a global optimum.

In table 4 we see that schooling has a large and positive impact on the transition from non-employment into employment in both maternity states. Possible explanations for this are that higher educated women have better labor market perspectives or can earn higher wages. Schooling has a negative impact on the transition into maternity in the situation of non-employment and a positive impact on the transition into maternity in the situation of employment. The effect of schooling on the transitions into maternity are relatively small compared to the effects on the transitions into employment. Schooling of the partner has a significantly positive effect on the transition into maternity. This finding is in line with earlier findings in Heckman and Walker (1990). This effect is relatively larger in the case of non-employment compared to the case of employment. The maximum transition intensity into maternity occurs after about 8 years when a woman is employed. After this period, the transition intensity into maternity goes to zero. Once a woman conceived a child, the transition intensity into employment is at a maximum after about 13 months. Another interesting result is the positive duration dependence from (U,N) to (E,N) until the 4^{th} month. We included a set of dummy variables for each birth-cohort as defined in section 3. The null-hypothesis that all parameters of the birth-cohorts are equal to zero is not rejected[11]. There are no significant birth-cohort effects. In line with the results of Newman and McCulloch (1984) and Heckman, Hotz and Walker (1985), we find that unobserved heterogeneity is empirically important in explaining fertility decisions[12]. However, ignoring unobserved heterogeneity has a relatively small effect on the parameters of interest.

4.2 The effects of labor market states on the transition into maternity and the effects of maternity states on the transitions on the labor market.

Firstly we investigate to what extent the transition intensities on the labor market are different for women in different maternity states. Figure 4.1 shows the transition probability into non-employment for both maternity states (N and C). We see a large increase in the transition probability into non-employment up to the 7^{th} month in case the woman is presumably pregnant (from (E,C) to (U,C)). Based on the results reported in table 4 we test the null-hypothesis that the transition

[11] The Wald test-statistic is equal to 36.4 (30 degrees of freedom, $\chi_{0.95}^2(30)=43.8$).

[12] We test the null-hypothesis $\gamma\upsilon=0$. The Wald test-statistic is equal to 242 (10 degrees of freedom, $\chi_{0.95}^2(10)=18.3$).

intensities into non-employment for both maternity states are equal[13]. This null-hypothesis is rejected[14]. Figure 4.2 shows the transition probabilities into employment for both maternity states. The transition probability into employment in case there is a child present in the household decreases very fast and remains almost constant after, approximately, 1 year. One possible explanation for this is that most women who plan to return to employment after childbirth do this as soon as possible. The null-hypothesis that the transition intensities into employment for both maternity states are equal is rejected[15]. From these results we infer that the presence of children has a significant effect on the transition intensities on the labor market.

Next, we investigate to what extent transition intensities into maternity are different for women in different labor market states and how schooling effects the transition probabilities into maternity and into employment. Figure 4.3 shows the transition probability into maternity for both labor market states. The transition probability into maternity is considerably higher for non-employed women within, approximately, the first 9 years compared to employed women. After 9 years, employed women have a relatively higher probability of a transition into maternity compared to non-employed women. This shows that employed women schedule childbirth later in time compared to non-employed women. The null-hypothesis that the transition intensities into maternity for both labor market states are equal is rejected[16]. From these results we infer that labor market states have a significant effect on the transition intensity into maternity. We calculate for three levels of schooling the transition probability into maternity for both employed and non-employed women. Figure 4.4 shows that for all levels of schooling the transition probability into maternity is considerably higher for non-employed women within, approximately, the first 7 years compared to employed women. The fact that within the first 4 years for lower educated non-employed women the transition probability into maternity is higher compared to the transition probability for higher educated non-employed women, is explained by the fact that higher educated women have relatively higher transition probabilities into employment compared to lower educated

[13] Testing the differences between the estimated parameters of two transition intensities (jointly) is equivalent with testing the differences between the two transition intensities once controlled for the difference in characteristics between the two subsamples. More formally, testing H_0: $h_{kl}(t|Z;\theta_{kl}) = h_{mn}(t|Z;\theta_{mn})$ is equivalent to testing H_0: $h_{kl}(t|Z;\theta_{kl})/h_{mn}(t|Z;\theta_{mn})=1$. This latter expression can be written as $Z^T_{kl}(\theta_{kl}-\theta_{mn})+(Z_{kl}-Z_{mn})^T\theta_{mn}=0$ where Z_{kl} (Z_{mn}) is the average of the characteristics of the women who make a transition from k to l (m to n) and θ_{kl} (θ_{mn}) is the corresponding parameter vector. In this notation Z_{kl} (Z_{mn}) includes elapsed duration. The decomposition of the hypothesis shows that the second term at the left hand side causes a spurious differential between the two transition intensities because of a difference in average characteristics.

[14] The Wald-statistic is equal to 64 (12 degrees of freedom, $\chi_{0.95}^2(12) = 21$).

[15] The Wald-statistic is equal to 81 (12 degrees of freedom, $\chi_{0.95}^2(12) = 21$).

[16] The Wald-statistic is equal to 115 (12 degrees of freedom, $\chi_{0.95}^2(12) = 21$).

women. This is shown in figure 4.5. Once a woman transits from (U,N) to (E,N) she can no longer transit from (U,N) to (U,C). So the direct effect of schooling on the transition probability into maternity can be explained by differences in labor market perspectives across women with different levels of schooling. This implies that there is also an indirect effect of schooling (via the employment probabilities) on the transition into maternity for non-employed women.

5. Conclusions

In this paper we utilized a multiple state transition model to describe transitions into maternity and labor market transitions for women. Each state was characterized by two components: the labor market state and the maternity state. This econometric framework enabled us to disentangle the effects of socio-economic variables on the timing of conception of the first child and on labor market transitions. Furthermore, this model made it possible to investigate to what extent transition intensities into maternity differ for women in different labor market states, and transition intensities on the labor market differ for women in different maternity states.

We provided empirical evidence that the presence of children has a significant effect on the transition intensities on the labor market and that the labor market states have a significant effect on the transition intensity into maternity. Although this may seem like a trivial outcome, empirical evidence on this has been scarce. We found that higher educated women have a higher transition probability into employment than lower educated women. Once a woman is employed this reduces the transition probability into maternity considerably compared to being non-employed. This is a possible explanation for the central finding in most empirical studies, as discussed in the introduction, that higher expected wages decrease the transition probability into maternity. Furthermore, we found that higher educated women have a lower transition probability into maternity when they are non-employed and a higher transition probability into maternity when they are employed. Being able to disentangle the direct effects of schooling on the transitions on the labor market and on the transition into maternity shows the advantage of using a multiple state transition model.

References

Becker, G.S. (1981): *"A treatise on the family"*, Harvard University Press, enlarged edition 1991.

Cigno, A. (1991): *"Economics of the family"*, Oxford University Press, 1994 edition.

Flinn, C.J. and J.J. Heckman (1983): "The likelihood function for the multiple state multiepisode model". In Models for the Analysis of Labor Force Dynamics, *Advances in Econometrics*, vol.3, ed. R. Bassmann & G. Rhodes, Greenwich, Conn.: JAI Press.

Heckman, J.J., Hotz, V.J. and J.R. Walker (1985): "New evidence on the timing and spacing of births", *American Economic Review*, 75, 179-184.

Heckman, J.J., and B. Singer (1982): "Population heterogeneity in demographic models". In: *Multidimensional Mathematical Demography*, ed. K.C. Land & A. Rogers, New York: Academic Press, 567-599.

Heckman, J.J., and B. Singer (1984): "A method for minimizing the impact of distributional assumptions in econometric models for duration data", *Econometrica*, 52, 2:271-320.

Heckman, J.J. and J.R. Walker (1990): "The relationship between wages and income and the timing and spacing of births: evidence from swedish longitudinal data", *Econometrica*, 58, 1411-1441.

Huh, K., and R.C. Sickles (1994): "Estimation of the duration model by nonparametric maximum likelihood, maximum penalized likelihood, and probability simulators", *The Review of Economics and Statistics*, 4, 683-694.

Lancaster, T. (1990): *"The econometric analysis of transition data"*, Cambridge University Press.

Newman, J.L. and C.E. McCulloch (1984): "A hazard rate approach to the timing of births", *Econometrica*, 52, 939-961.

Siegers, J.J. (1985): *"Arbeidsaanbod en kindertal: een micro-economische analyse"*, Ph.D. dissertation, University of Groningen.

Walker, J.R. (1995): "Parental Benefits and Employment and Fertility Dynamics", working paper, University of Wisconsin.

Willis, R.J. (1973): "A new approach to the economic theory of fertility behavior", *Journal of political Economy*, march/april, Part 2, S14-S64.

TABLES & FIGURES :

Table 2: the transition possibilities. The transition intensities are denoted by $h_{kl}(t|X;\theta)$, with k,l ε { (U,N),(E,N),(E,C),(U,C) }, t denotes the duration, Z are exogenous covariates and θ is a vector with unknown parameters (see section 2.2).

TRANSITION INTENSITY		DESTINATION STATE (U,N)	(E,N)	(E,C)	(U,C)
STATE OF DEPAR-TURE	(U,N)	-	$h_{(U,N),(E,N)}(t\|Z;\theta)$	0	$h_{(U,N),(U,C)}(t\|Z;\theta)$
	(E,N)	$h_{(E,N),(U,N)}(t\|Z;\theta)$	-	$h_{(E,N),(E,C)}(t\|Z;\theta)$	0
	(E,C)	0	0	-	$h_{(E,C),(U,C)}(t\|Z;\theta)$
	(U,C)	0	0	$h_{(U,C),(E,C)}(t\|Z;\theta)$	-

* U: non-employment, E: employment, N: no pregnancy and no children, C: pregnancy and/or children.

Table 3.1: sample statistics (709 women, 1964 spells).

VARIABLE		# obs	mean	std.dev.	min	max
	STATE		(median)			
DURATION[1)]	(U,N)	507	45 (23)	50	1	265
	(E,N)	501	67 (59)	53	1	555
	(E,C)	216	29 (10)	52	1	326
	(U,C)	66	97 (83)	83	1	322
AGE[2)]		709	41	11	22	65
SCHOOLING[3)]		709	12.8	3.7	0	40
SCHOOLING PARTNER[3)]		608	13.4	4.3	0	35
AGE AT BEGINNING OF THE SPELL		1964	22	6.1	6	61
BIRTH-COHORT DUMMY VARIABLES	'37 -'45	709	0.23	0.42	0	1
	'46 -'50	709	0.15	0.36	0	1
	'51 -'54	709	0.15	0.36	0	1
	'55 -'58	709	0.15	0.35	0	1
	'59 -'68	709	0.17	0.37	0	1
	'68 ->	709	0.16	0.37	0	1

Source: SSCW-telepanel.
1) in months, incomplete spells are excluded.
2) age of the respondent at time of interview.
3) measured in years.

Table 3.2: number of observations per possible transition, last column are right censored observations.

	destination state				
source state	(U,N)	(E,N)	(E,C)	(U,C)	not observed
(U,N)	-	268	-	239	72
(E,N)	236	-	259	6	95
(E,C)	-	-	-	216	101
(U,C)	-	-	66	-	406

Source: SSCW-telepanel.
* U: non-employment, E: employment, N: no pregnancy and no children, C: pregnancy and/or children.

Figure 3.1: Kaplan-Meier Survival curves in the cases of a transition from (U,N) to (E,N) and a transition from (U,C) to (E,C).

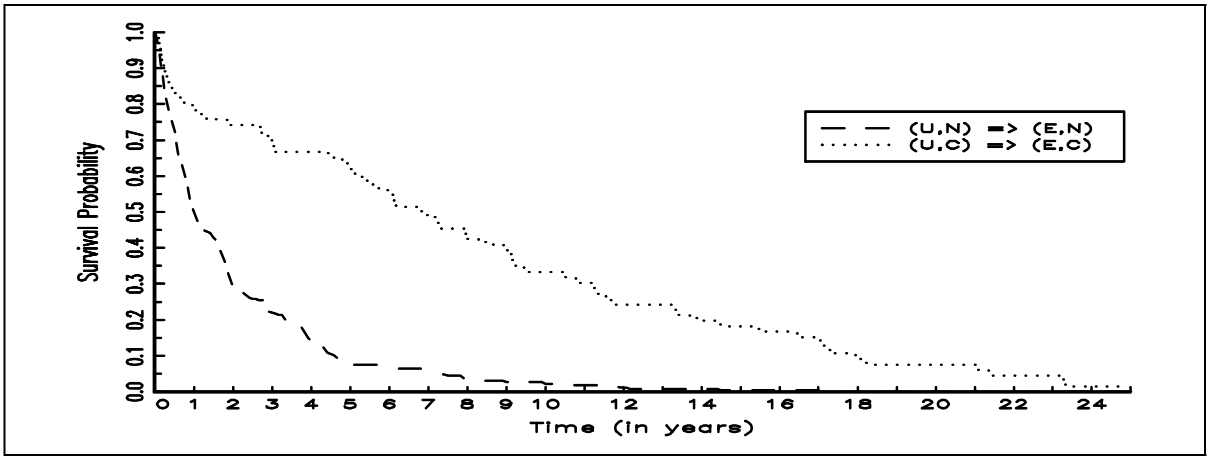

Figure 3.2: Kaplan-Meier Survival curves in the cases of a transition from (U,N) to (U,C) and a transition from (E,N) to (E,C).

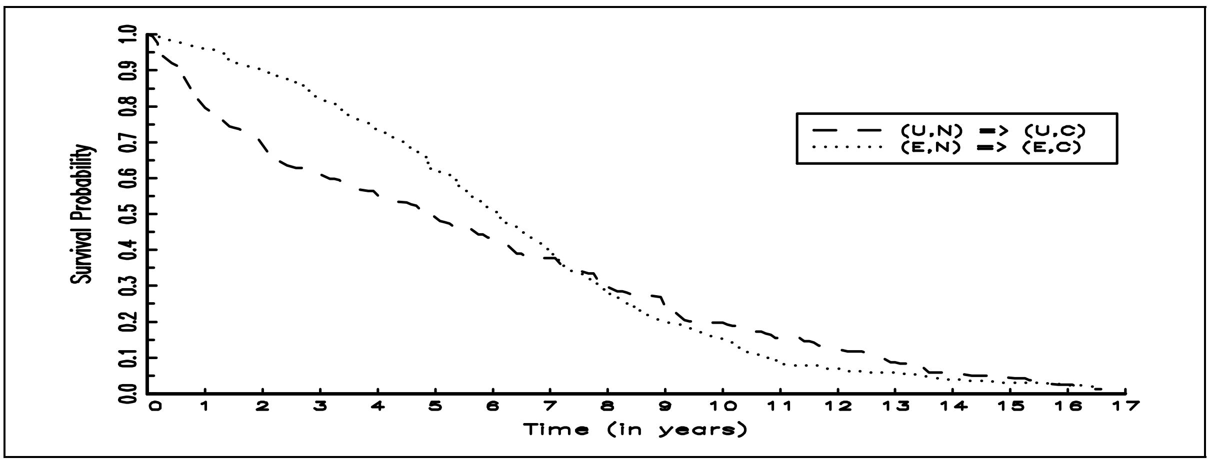

Figure 3.3: Kaplan-Meier Survival curves in the cases of a transition from (E,N) to (U,N) and a transition from (E,C) to (U,C).

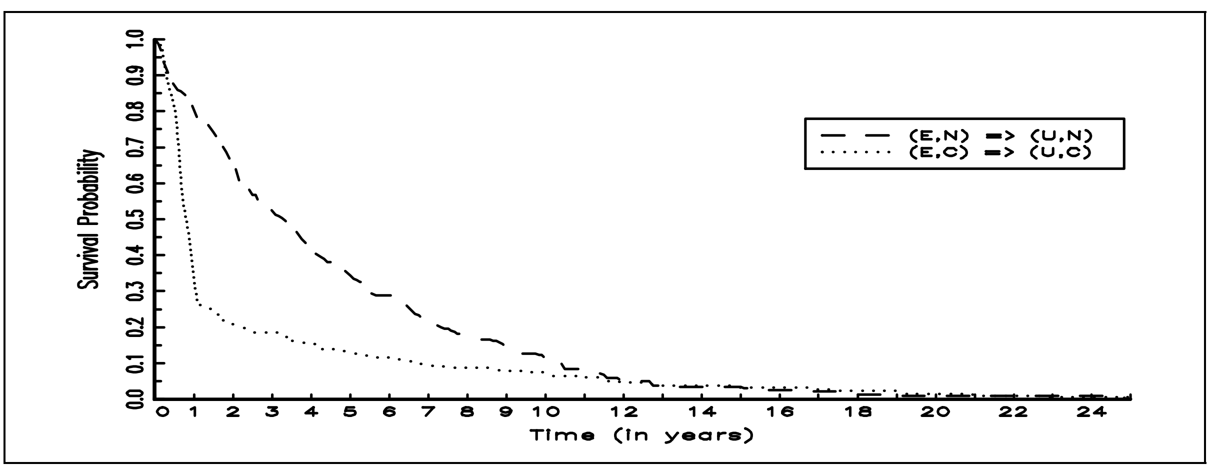

Table 4: estimation results of the multiple state transition model using the Heckman and Singer method to control for unobserved heterogeneity. Standard errors are in parentheses.

log-likelihood = -7408		*Transitions*					
covariates		(U,N) => (E,N)	(U,N) => (U,C)	(E,N) => (U,N)	(E,N) => (E,C)	(E,C) => (U,C)	(U,C) => (E,C)
ln(duration/12)		-0.52 (0.06)	0.28 (0.10)	-0.07 (0.07)	1.33 (0.17)	0.08 (0.12)	-0.28 (0.15)
$(\ln(duration/12))^2$		-0.23 (0.04)	0.05 (0.05)	-0.07 (0.04)	-0.32 (0.06)	-0.36 (0.05)	0.05 (0.08)
intercept		-2.28 (0.43)	-5.19 (0.56)	-3.21 (0.55)	-5.23 (0.55)	2.41 (0.70)	-7.19 (1.23)
schooling /10		1.40 (0.33)	-0.73 (0.30)	0.13 (0.26)	0.43 (0.22)	-0.45 (0.35)	1.80 (0.48)
schooling partner /10		-0.18 (0.12)	0.77 (0.19)	-0.17 (0.11)	0.29 (0.10)	0.06 (0.28)	0.11 (0.33)
age start of spell /10		-0.81 (0.24)	1.63 (0.20)	0.55 (0.25)	-0.05 (0.22)	-1.70 (0.21)	-0.09 (0.40)
birth - cohorts	'28 - '42	-	-	-	-	-	-
	'43 - '48	0.23 (0.25)	-0.05 (0.26)	0.03 (0.26)	0.35 (0.24)	-0.25 (0.30)	0.34 (0.42)
	'49 - '53	0.18 (0.23)	-0.65 (0.31)	-0.24 (0.25)	0.46 (0.22)	-0.50 (0.34)	0.47 (0.45)
	'54 - '57	0.02 (0.27)	-0.45 (0.28)	-0.30 (0.27)	0.35 (0.25)	-0.24 (0.36)	0.07 (0.53)
	'58 - '62	0.32 (0.26)	-0.39 (0.27)	-0.03 (0.26)	0.07 (0.26)	-0.48 (0.41)	0.27 (0.60)
	'63 - '71	0.37 (0.26)	-0.84 (0.36)	0.35 (0.27)	0.06 (0.31)	-0.12 (0.48)	0.60 (0.68)
unobserved heterogeneity (γ)		-0.98 (0.66)	-2.89 (2.05)	-0.57 (0.46)	0.59 (0.35)	2.22 (1.32)	0.68 (0.39)

* U: non-employment, E: employment, N: no pregnancy and no children, C: pregnancy and/or children.

** Three support points: υ_1=0 (-) with π_1=0.51, υ_2=0.19 (0.49) with π_2=0.08, and υ_3=1.34 (0.81) with π_3=0.41.

Figure 4.1: the transition probability into non-employment within 1 month, conditional on survival to time t. The time (duration) is measured in years.

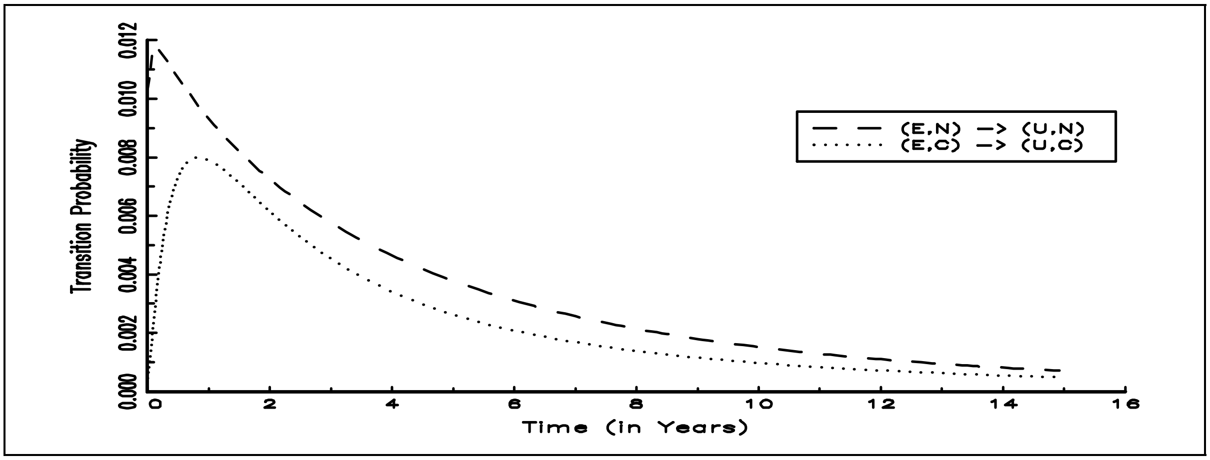

Figure 4.2: the transition probability into employment within 1 month, conditional on survival to time t. The time (duration) is measured in years.

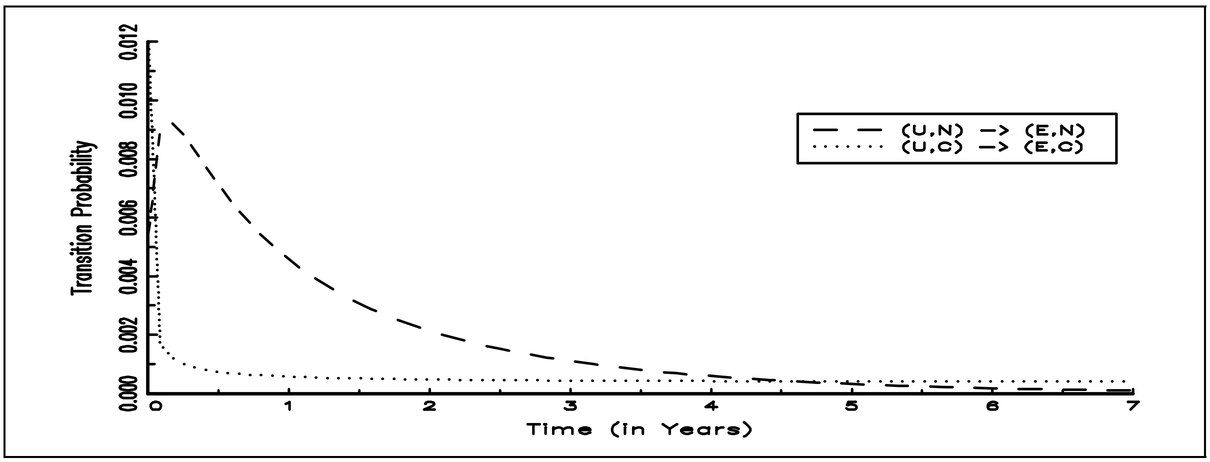

Figure 4.3: the transition probability into maternity within 1 month, conditional on survival to time t. The time (duration) is measured in years.

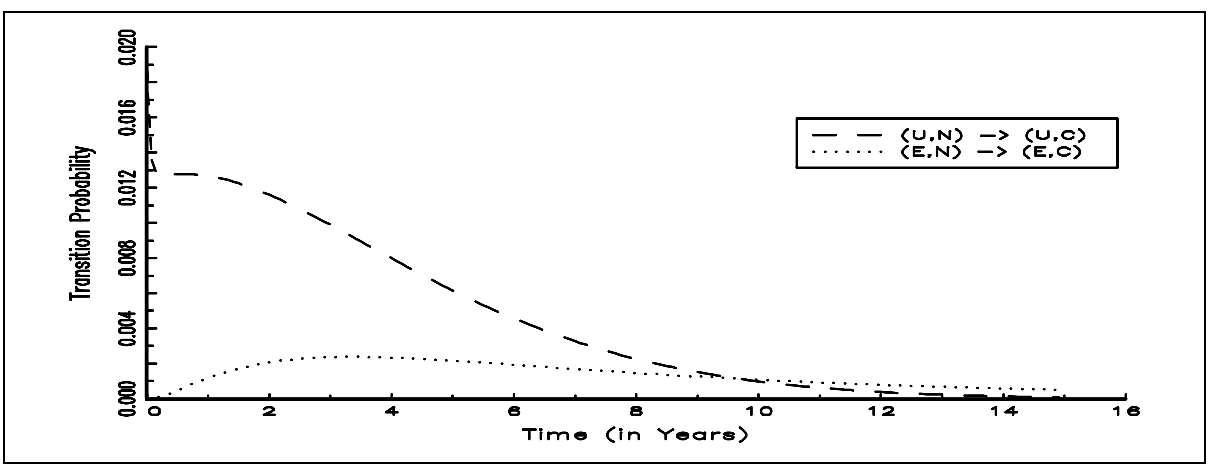

Figure 4.4: the transition probability into maternity within 1 month, conditional on survival to time t. Both in the situation of non-employment (a transition from (U,N) to (U,C)) and in the situation of employment (a transition from (E,N) to (E,C)). The time (duration) is measured in years. We consider 6, 12 and 18 years of schooling.

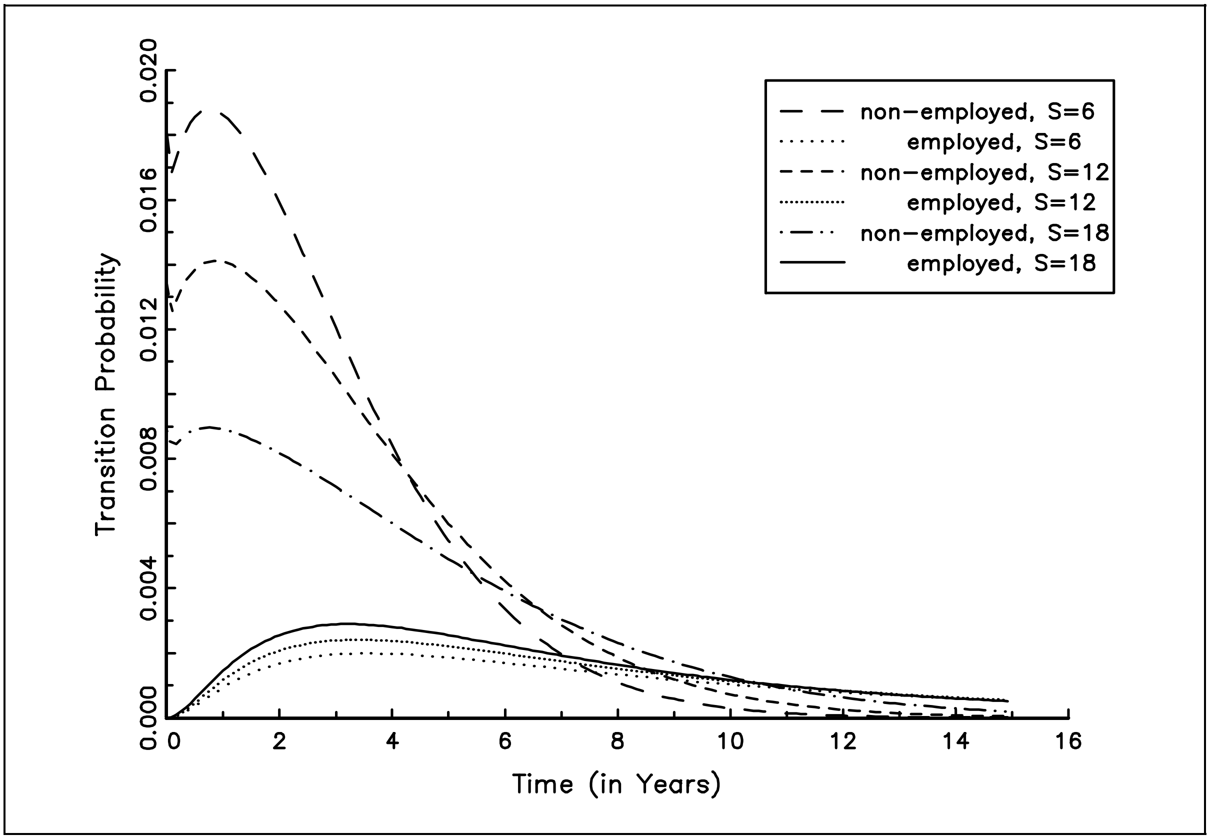

Figure 4.5: the transition probability into employment within 1 month, conditional on survival to time t. This in the situation of non-employment and no children (state (U,N)). The time (duration) is measured in years. We consider 6, 12 and 18 years of schooling.