

A CAUSAL APPROACH TO INTERRELATED FAMILY EVENTS

Hans-Peter Blossfeld¹, Melinda Mills²

ABSTRACT

An important advance initiated by event history research is the use of interdependent processes as explaining factors in transition rate models. Interdependent processes are described first, followed by two event history perspectives: the 'system' and 'causal' approach. The authors assert that the latter is more analytically appropriate as it provides many straightforward solutions (e.g., simultaneity, cause-effect lags). Based on comparative applications in West and East Germany, Canada, Latvia, and the Netherlands, the value of the causal approach is demonstrated by analyzing two highly interdependent processes: entry into marriage (for individuals in a consensual union) and first pregnancy/childbirth. Both statistical and theoretical explanations emphasize the need for conceptual reasoning.

KEY WORDS: Interdependent processes; Causal analysis; Event history analysis; Fertility; Nuptuality; Cross-national comparisons.

1. INTRODUCTION

The study of parallel or interdependent processes as explaining factors in transition rate models is one of the most important advances in life course and event history research (Willekens, 1991; Courgeau and Lelièvre, 1992; Blossfeld and Rohwer, 1995/2001). The purpose of this paper is to demonstrate the usefulness of a causal approach to interdependent family events based on cross-national empirical investigations from five countries. We first describe parallel processes and time-dependent covariates, the latter of which are often used to include the sample path of parallel processes in transition rate models. The widely used 'system' and 'causal' approach are contrasted, with the latter proposed as a more appropriate method from an analytical point of view and that it provides straightforward solutions to simultaneity problems, time lags and varying temporal shapes of effects. Based on separate applications in West and East Germany, Canada, Latvia, and the Netherlands, the usefulness of the causal approach is demonstrated by analyzing two highly interdependent family processes: entry into marriage (for individuals in a consensual union) as the dependent process and first pregnancy/childbirth as the explaining one. After potential statistical reasons for the time-dependent effects are described, we move to more substantive explanations, including the importance of actors, probabilistic causal relations, preferences and negotiation, observed and unobserved decisions and the problem of conditioning on future events.

2. PARALLEL AND INTERDEPENDENT PROCESSES

Parallel or interdependent processes can operate at a variety of different levels. There may be parallel processes at the level of:

- (1) *different domains* of an individual's life. For instance, one may ask how upward and downward moves in an individual's job career influences her/his family trajectory (e.g., Blossfeld and Huinink, 1991).
- (2) *individuals interacting with each other*, termed 'interdependent or linked lives' (Elder, 1987). One might study the effect of the career of the husband on his wife's labour force participation (Blossfeld and Drobnič, 2002) or how the death or migration of the head of the household impacts other family members (Courgeau and Lelièvre, 1992).

¹Otto-Friedrich University Bamberg, Faculty of Social and Economic Sciences, P.O. Box 1549, D-96045 Bamberg, Germany, (e-mail: hans-peter.blossfeld@sowi.uni-bamberg.de)

²Free University Amsterdam (VU), Department of Research Methodology, Faculty of Social Sciences, de Boelelaan 1081c, 1081HV Amsterdam, The Netherlands (e-mail: mc.mills@scw.vu.nl)

- (3) *intermediate*, such as how the changing household structure determines women's labour force participation.
- (4) *macro*, where the researcher may be interested, for instance, in the effect of changes in the business cycle on family formation (e.g., Blossfeld and Huinink, 1991).
- (5) *any combination* of the aforementioned processes of type 1 to 4. For example, in life course studies, cohort and period effects, in addition to time-dependent covariates at different levels must be included simultaneously (Blossfeld, 1986; Mayer and Huinink, 1990). Such an analysis combines processes at the individual level (life course change) with two kinds of processes at the macro level: (1) variations in structural conditions across successive (birth, marriage, etc.) cohorts; and, (2) changes in particular historical conditions affecting all cohorts in the same way.

In event history analysis, time-dependent covariates are often used to include the sample path of parallel processes in transition rate models. In the literature, however, only two types of time-dependent covariates have been described as not being subject to reverse causation (see for e.g., Kalbfleisch and Prentice, 1980; Tuma and Hannan, 1984; Blossfeld, Hamerle and Mayer, 1989; Yamaguchi, 1991; Courgeau and Lelièvre, 1992). The first are *defined* time-dependent covariates whose total time path (or functional form of change over time) is determined in advance in the same way for all subjects under study. For example, process time like age or duration in a state (e.g., duration of marriage in divorce studies), is a defined time-dependent covariate because its values are predetermined for all subjects. It is the predefined onset of the process when the individual becomes 'at risk' in the event history model. Thus, by definition, the values of these time-dependent covariates cannot be affected by the dependent process under study. The second type are *ancillary* time-dependent covariates whose time path is the output of a stochastic process that is external to the units under study. Again, by definition, the values of these time-dependent covariates are not influenced by the dependent process itself. Examples of time-dependent covariates that are approximately external in the analysis of individual life courses are variables that reflect changes at the macro level of society (unemployment rates, occupational structure, etc.) or the population level (composition of the population in terms of age, sex, race, etc.), provided that the contribution of each unit is small and does not really affect the structure in the population (Yamaguchi, 1991).

In contrast to defined or ancillary time-dependent covariates are *internal* time-dependent covariates, which are often referred to as being problematic for causal analysis in event history models (e.g., Kalbfleisch and Prentice, 1980; Tuma and Hannan, 1984; Blossfeld, Hamerle, and Mayer, 1989; Yamaguchi, 1991; Courgeau and Lelièvre, 1992). An internal time-dependent covariate $Y_{B;t}$ describes a stochastic process, considered in a causal model as being the cause, that in turn is affected by another stochastic process $Y_{A;t}$, considered in the causal model as being the effect. Thus, there are direct effects in which the processes autonomously affect each other ($Y_{B;t}$ affects $Y_{A;t}$ and $Y_{A;t}$ affects $Y_{B;t}$), and there are 'feedback' effects, in which these processes are affected by themselves via the respective other processes ($Y_{B;t}$ affects $Y_{B;t}$ via $Y_{A;t}$ and $Y_{A;t}$ affects $Y_{A;t}$ via $Y_{B;t}$). In other words, such processes are interdependent and form what has been called a dynamic system (Tuma and Hannan, 1984). Interdependence is typical at the individual level for processes in different domains of life and at the level of a few individuals interacting with each other (e.g., career trajectories of partners) (see Blossfeld and Drobnič, 2002). For example, the empirical literature suggests that the employment trajectory of an individual is influenced by his/her marital history and marital history is dependent on the employment trajectory. In the literature, there are two central approaches to modelling parallel processes, what we term here as the 'system approach' and the 'causal approach,' with the former often used to deal with such dynamic systems.

2.1 Interdependent processes: The system approach

The system approach in the analysis of interdependent processes (Tuma and Hannan, 1984; Courgeau and Lelièvre, 1992) defines change in the system of interdependent processes as a new 'dependent variable.' Thus, instead of analyzing one of the interdependent processes with respect to its dependence on the respective others, the focus is on the modelling of a system of state variables. In other words, the interdependence between the various processes is taken into account only implicitly.

Suppose that there are J interrelated qualitative time-dependent variables (i.e., processes): $Y_{A;t}, Y_{B;t}, Y_{C;t}, \dots, Y_{J;t}$. A new time-dependent variable (process) Y_t , representing the system of these J variables, is then defined by associating each discrete state of the ordered J -tuple with a particular discrete state of Y_t . As shown by Tuma and Hannan (1984), as long as change in the entire system only depends on the various states of the J qualitative

variables and on exogenous variables, this model is identical to modelling change in a single qualitative variable. Thus, the idea of this approach is to simply define a new joint state space, based on the various states spaces of the coupled qualitative processes, and then to proceed as in the case of a single dependent process.

Although the system approach provides interesting insights into the behaviour of the dynamic system as a whole, it has several disadvantages. First, from a causal analytical point of view, the approach presented by Courgeau and Lelièvre (1992) does not provide direct estimates of effects of coupled processes on the process under study. In other words, when using the system approach, one normally does not know to what extent one or more of other coupled processes affect the process of interest, controlling for other exogenous variables and the history of the dependent process. Since the effects can only be identified in simple models via a comparison of the constant terms of hazard rate equations, it is only possible to compare transition rates for general models without covariates (see Courgeau and Lelièvre, 1992; Blossfeld and Rohwer, 1995/2001). Second, in particular a mixture of qualitative and quantitative processes, in which the transition rate of a qualitative process depends on the levels of one or more metric variables, turns out to be a problem in this approach. Tuma and Hannan (1984) suggest that in these situations it is not very useful. Third, this approach is also unable to handle interdependencies between coupled processes occurring in specific phases of the process (e.g., processes might be interdependent only in specific phases of the life course) or interdependencies that are dynamic over time (e.g., an interdependence might be reversed in later life phases, see Courgeau and Lelièvre, 1992), what Tuma and Hannan (1984) term ‘cross-state dependence.’ Finally, the number of origin and destination states of the combined process Y_t , representing the system of J variables, may lead to practical problems. Even when the number of variables and their distinct values is small, the state space of the system is large. Therefore, in light of rising parameters, the event history data sets must contain a great number of events, even if only the most general models of change (i.e., models without covariates) are to be estimated. Considering these limitations, we therefore suggest a different perspective in modelling dynamic systems, which we call the ‘causal approach.’

2.2 Interdependent processes: The causal approach

The underlying idea of the causal approach for analyzing interdependent processes can be outlined as follows (Blossfeld and Rohwer, 1995/2001). Based on theoretical reasons, the researcher focuses on one of the interdependent processes and considers it as the dependent one. The future changes of this process are linked to the present state and history of the entire dynamic system as well as to other exogenous variables (see Blossfeld, 1986; Blossfeld and Huinink, 1991). Thus, in this approach the variable Y_t , representing the system of joint processes at time t , is not used as a multivariate dependent variable. Instead, the history and the present state of the system are seen as a condition for change in (any) one of its processes. The question of how to give a more precise formulation for the causal approach remains. The following ideas may be helpful.

Causes and time-dependent covariates. In an influential paper, Holland (1986) developed the idea that causal statements imply counterfactual reasoning: If the cause had been different, there would have been another outcome, at least with a certain probability. However, the consequences of conditions that could be different from their actual state are obviously not empirically observable. This means that it is simply impossible to observe the effect that would have happened on the same unit of analysis, if it were exposed to another condition at the same time.

To find an empirical approach to examine longitudinal causal relations, Blossfeld and Rohwer (1995/2001) suggested the examination of conditions which actually do change in time. These changes are characterized as events or transitions. More formally, an event is specified as a change in a variable, and this change must happen at a specific point in time. The most obvious empirical representation of causes is therefore in terms of quantitative or qualitative variables that can change their states over time which links very naturally to the concept of time-dependent covariates. The role of a time-dependent covariate in this approach is to indicate that a (qualitative or metric) causal factor has changed its state at a specific time and that the unit under study is exposed to another causal condition. From this point of view, it seems somewhat misleading to regard simply processes as causes. Rather, only events, or changes in state space can sensibly be viewed as possible causes.

Time and causal effects. Consequently, we do not suggest that process $Y_{A;t}$ is a cause of process $Y_{B;t}$, but that a change in $Y_{A;t}$ could be a cause (or provide a new condition) of a change in $Y_{B;t}$. Or, more formally: $\Delta Y_{A;t} \rightarrow \Delta Y_{B;t'}$, $t < t'$, meaning that a change in variable $Y_{A;t}$ at time t is a cause of a change in variable $Y_{B;t'}$ at a later point in time,

t' . It is not implied that $Y_{A:t}$ is the only cause which might affect $Y_{B:t'}$. We speak of causal conditions to stress that there might be, and normally is, a quite complex set of causes (see Marini and Singer, 1988). Thus, if causal statements are studied empirically, they must intrinsically be related to time, which relates to three important aspects.

First, to speak of a change in variables necessarily implies reference to a *time axis* which is at least two points in time to observe that a variable has changed its value at a specific point in time (or at least approximately). Therefore, we use the symbols to refer to changes in the values of the time-dependent variable $\Delta Y_{A:t}$ and the state variable $\Delta Y_{B:t'}$ at time t . This leads to the important point that causal statements relate changes in two (or more) variables.

Second, we must consider *time ordering*, *time intervals* and *apparent simultaneity*. Time ordering assumes that cause must precede the effect in time: $t < t'$, in the formal representation given above, an assumption which is generally accepted (Eells, 1991: Ch. 5). As an implication, there must be a temporal interval between the change in the variable representing a cause and the corresponding effect (Kelly and McGrath, 1988). The finite time interval may be very short or very long, but can never be zero or infinity (Kelly and McGrath, 1988). In other words, there can never be simultaneity of cause and its effect. In this respect, our causal approach to the analysis of interdependent systems significantly differs from the approach by Lillard (1993), Lillard and Waite (1993), Lillard, Brien and Waite (1995), and Brien, Lillard and Waite (1999), who estimate the hazard rate of a dependent process as a function of: (1) the actual current state of an independent process as well as, (2) on its simultaneous (unobserved) hazard rate.

Some effects take place almost instantaneously. However, some effects may occur in a time interval that requires small time units (e.g., microseconds) or are too small to be measured by any given methods, so that cause and effect seem to occur at the same point in time. Apparent simultaneity is often the case where temporal intervals are relatively crude such as, for example, yearly data. For these parallel processes, the events 'first marriage' and 'first childbirth' may be functionally interdependent, but whether these two events are observed simultaneously or successively depends on the degree of temporal refinement of the scale used in making the observations. Other effects need a long time until they start to occur. Marini and Singer (1988), for example, discuss the gap between mental causal priority and observed temporal sequences of behaviour. Thus, there is a delay or lag between cause and effect that must be specified in an appropriate causal analysis. Unfortunately, in most of the current demographic theories and interpretations of research findings, this interval is left unspecified.

This leads to the third point regarding the *temporal shapes of the unfolding effect*, which suggests that there might be different shapes of how the causal effect Y_t , unfolds over time. While the problem of time-lags is widely recognized in the demographic and social science literature, almost no attention has been given to the temporal shapes of effects (Kelly and McGrath, 1988). Researchers often seem to either ignore or be ignorant about the fact that causal effects could be highly time-dependent as well. For instance, there may be an immediate impact of change that is then maintained. Or, the effect could occur with a lengthy time-lag and then become time-invariant. The effect could start almost immediately and then gradually increase or there may be an almost all-at-once increase which reaches a maximum after some time and then decreases. Finally, there could exist a cyclical effect pattern over time. We cannot rely on the assumption of eternal, time-less laws but have to recognize that the causal mechanisms may change during the development of social processes.

The principle of conditional independence. We consider here only interdependent processes that are not just an expression of another underlying process so that it is meaningful to assess the properties of the two processes without regarding the underlying one. This means, for instance, that what happens next to $Y_{A:t}$ should not be directly related to what happens to $Y_{B:t}$, at the same point in time, and vice versa. This condition, which we call 'local autonomy' (see Pötter and Blossfeld, 2001), can be formulated in terms of the uncorrelatedness of the prediction errors of both processes, $Y_{A:t}$ and $Y_{B:t}$, and excludes stochastic processes that are functionally related.

Combining the ideas to this point, a causal view of parallel and interdependent processes becomes easy, at least in principle. Given two parallel processes, $Y_{A:t}$ and $Y_{B:t}$, a change in $Y_{A:t}$ at any (specific) point in time t' may depend on the history of both processes up to, but not including t' . Or stated in another way: what happens with $Y_{A:t}$ at any point in time t' is conditionally independent of what happens with $Y_{B:t}$ at t' , conditional on the history of the joint process $Y_t = (Y_{A:t}, Y_{B:t})$ up to, but not including, t' . Of course, the same reasoning can be applied if one focuses on

$Y_{A:t}$ instead of $Y_{B:t}$ as the ‘dependent variable.’ This is the principle of conditional independence for parallel and interdependent processes.

The same idea can be developed more formally. Beginning with a transition rate model for the joint process, $Y_t = (Y_{A:t}, Y_{B:t})$ and assuming the principle of conditional independence, the likelihood for this model can be factorized into a product of the likelihoods for two separate models: a transition rate model for $Y_{A:t}$ which is dependent on $Y_{B:t}$ as a time-dependent covariate, and a transition rate model for $Y_{B:t}$ which is dependent on $Y_{A:t}$ as a time-dependent covariate. Estimating the effects of time-dependent (qualitative and metric) processes on the transition rate can be easily achieved by applying the method of episode-splitting (Blossfeld, Hamerle, and Mayer, 1989; Blossfeld and Rohwer, 1995/2001, for a detailed explanation in relation to this analysis see Mills, 2000).

This result has an important implications for the modelling of event histories. From a technical point of view there is no need to distinguish between defined, ancillary, and internal covariates because all of these time-dependent covariate types can be treated equally in the estimation procedure. A distinction between defined and ancillary covariates on the one hand and internal covariates on the other is however sensible from a theoretical perspective, because only in the case of internal covariates does it make sense to examine whether parallel processes are independent, whether one of the parallel processes is endogenous and the other ones are exogenous, or whether parallel processes form an interdependent system (i.e., they are all endogenous). We will now present a series of empirical applications that illustrate the viability of the causal approach.

3. APPLICATION EXAMPLES

In order to demonstrate the utility of the causal approach to interdependent processes, we report the results of three cross-national comparative studies about the effect of first pregnancy/first birth on entry into first marriage for couples living in consensual unions. The earliest investigation was conducted by Blossfeld, Manting and Rohwer (1993), followed by Blossfeld, Klijzing, Pohl and Rohwer (1996; 1999) and finally, Mills and Trovato (2001).

The basic research problem underpinning these studies can be defined as follows. Historically, marriage has preceded the birth of a child in many countries. However, in the last two decades, the link between marriage and childbirth has become more complex, a phenomena that has occurred in conjunction with a rapid rise in consensual unions. The three studies explored this relationship by examining how the experience of a pregnancy within a consensual union conditioned the likelihood of transition to a formal marriage with the same partner. In the later investigations, the process was modelled as explicitly time-dependent, with entry into first marriage as the dependent and first pregnancy/childbirth as the explaining process. The theoretical framework used by the authors to guide a substantive explanation of the time-dependent process was the rational actor model, which proposes that norm-guided and rational self-centered behaviour co-exist.

3.1 The Blossfeld-Manting-Rohwer Study

The purpose of the earlier study by Blossfeld, Manting, and Rohwer (1993) was to gain insight into the process of how consensual unions were transformed into marriages in the former West Germany and the Netherlands. It focussed on the effect of fertility on the rate of entry into marriage, controlling for other important covariates in a transition rate model. Nationally representative longitudinal data were used: the German Socioeconomic Panel (West Germany) and the Fertility Survey (Netherlands) were applied. Both data sets provide information about the dynamics of consensual unions in the 1980s. Attention was limited to cohorts born between 1950-1969 that started a consensual union between 1984-1989 (West Germany) and 1980-1988 (Netherlands).

Recall that a change in the marriage process at any point in time during a consensual union may depend on the history of both processes up to, but not including t' .³ Thus, a change in the marriage process at time t' is conditionally independent of what happens with the fertility process at t' , conditional on the history of the joint

³ We are viewing each of these two processes as having various states in their histories. For example, the partnership process could consist of the states of never married, consensual union, married and the pregnancy/birth process may consist of the states of not pregnant, pregnant and first child.

process up to, but not including t' . The likelihood for the joint process of first marriage and birth can therefore be factorized into a product of the likelihoods for two separate transition rate models for: (1) first pregnancy/first birth, dependent on first marriage as a time-dependent covariate; and, (2) first marriage, dependent on first pregnancy/first birth as a time-dependent covariate.

We will discuss only the fertility effects of one transition model from this study, which utilized a piecewise constant exponential model to estimate transitions from consensual unions to both marriage and dissolution (results not shown here, see Blossfeld et al., 1993). The change in the fertility process was included as a series of time-dependent dummy variables with the states: 'not pregnant,' 'pregnant,' 'first childbirth,' and '6 months after birth.' The effects of the fertility variables on the marriage rate were significant for both countries and worked in the same direction. As long as women were not pregnant, they observed a significant and comparatively low rate of entry into marriage. But, as soon as a woman became pregnant in both countries (and in West Germany also around the time when the woman gets her child), the rate of entry into marriage increased strongly. If the couple did not get married within six months after the child was born, the rate of entry into marriage again dropped to a comparatively low level in West Germany. In the Netherlands, this level is even below the 'not pregnant' level (see Manting, 1994).

3.2 The Blossfeld-Klijzing-Pohl-Rohwer Study

About a year after this comparative study was conducted, Blossfeld et al. (1996; 1999) wanted to examine whether these results could be replicated with new data from the German Fertility and Family Survey. These data were collected retrospectively from respondents aged 20-39 years in West and East Germany in 1992. They started with a simple model of the process of entry into first marriage for couples living in consensual unions using only one time-dependent dummy variable for the event of first birth. However, the effect of this covariate was - surprisingly - not significant. What happened to the fertility effect? After much theoretical discussion, a hypothesis was put forward that could explain the seemingly contradictory results of the estimated models: the effect of changes in fertility on entry into marriage *must be strongly time-dependent in a very specific way*. According to the first study, the rate is low as long as women are not pregnant, then starts to rise at some time shortly after conception, increases during pregnancy to a maximum and finally drops again a few months after birth has taken place. Thus, when a time-dependent covariate was switched at the time of childbirth, a period with a low marriage rate up to the time of discovery of conception and a period with a high marriage rate during pregnancy was confounded and compared with a relatively low rate after the birth had taken place. Thus, the aggregated average tendency to marry before the child is born could equal the aggregate average tendency to marry after the child is born, therefore making the estimated coefficient of the time-dependent covariate 'childbirth' not significantly different from zero.

To deal with this problem, a series of 14 time-dependent pregnancy/birth binary variables were created using information from the reported date of first birth (see Table 1). These variables were grouped into categories ranging from 'marriage before the month of pregnancy,' 'month of the pregnancy,' 'one month since pregnancy,' and so on, to 'more than seven months after birth'. To be clear, since no information on the timing of pregnancy and only on the timing of successful births was available, we were looking backward in time from the first birth and thus estimated the date of pregnancy as nine months before the date of birth. As we discuss in greater detail shortly, this presents two potential problems: neglecting abortions and miscarriages, and conditioning past on future events.

3.3 The Mills-Trovato Study

Building on the previous two studies, Mills and Trovato (2001) wanted to see if the findings would hold in other diverse contexts such as North America or Eastern Europe or a more recent time period within Western Europe. For this reason, we selected Canada and Latvia and more recent data from the Netherlands. Replication using diverse contexts provides a harsher and more useful validation than statistical testing of many models on only one data set. Normally, there is less chance of an artifact, more kinds of variation can be explored, and alternative explanations can be ruled out (Freedman, 1991). A further impetus for this study centered on the fact that consensual unions and non-marital births in Eastern Europe and the Baltic States have skyrocketed since the 1980s (Katus, 1992). Yet, these countries are rarely included in comparative analyses. Similarly, we questioned whether this type of behaviour would still hold in the North American context in a country such as Canada. Using data from the Fertility and Family Surveys (FFS) for Canada (1995) (see Appendix), Latvia (1995) and the Netherlands (1993), we selected a comparative sample of women born between 1950 and 1969.

Table 1 summarizes the results of the partial likelihood estimates from the Cox models for the transition from consensual union to marriage for the final model from the Blossfeld et al. (1999) and Mills and Trovato (2001) studies. Figure 1 plots the final partial likelihood estimates (coefficients) for the time-dependent pregnancy/birth process variable. Overall, the findings suggest a high degree of uniformity, though the levels and significance of effects tend to vary slightly across countries. Notwithstanding these similarities, we acknowledge that the Canadian and East German case shows a few unexpected effects on the transition rate. In Canada, the likelihood appears to drop earlier, at approximately three months before birth, with fluctuations after that point. We attribute this largely to methodological factors since some of the monthly data had to be partially estimated (see Appendix). In East Germany, there is large drop one month before birth as opposed to the month of birth. Difference in the significance level of results by country (especially Canada and East Germany) may also be related to smaller sample sizes and less events. The theoretical reasons behind the generally comparable effects that we observe across the five areas are central to understanding these investigations.

4. SUBSTANTIVE EXPLANATIONS

We previously speculated about these time-dependent fertility effects in *statistical* terms, which does not, however, explain why we should expect these effects in *substantive* terms at all. How can this effect found across a variety of countries be explained? Before we give a more detailed answer to this question, some more general remarks about actors and probabilistic causal relations are in order.

4.1 Actors, Probabilistic Causal Relations and the Hazard Rate

There is a general consensus that demographic phenomena are always directly or indirectly based on actions of individuals. We do not deal with associations among variables per se, but with variables that are associated via acting people (see Blossfeld and Rowher, 1995/2001; Blossfeld and Prein, 1998). There are at least three consequences for explanations of causal relations. First, if individuals relate causes and effects through actions, then explanation of demographic processes should be related to *individuals*. This is why life history data on individuals, and not aggregated longitudinal data, provide the most appropriate empirical evidence for hypotheses about change. Second, explaining or understanding of demographic processes requires: (1) a *time-related* specification of structural constraints which cut down the set of abstractly possible courses of action to a vastly smaller subset of feasible actions; and, (2) a *mechanism* that singles out which of the feasible courses of action shall be realized (see Elster, 1979). Because this is done by individuals, this mechanism must rest on the beliefs, expectations, and motivations of the agents. Third, since individuals are the actors, causal inference must also take into account their *free will*.

This introduces an essential element of indeterminacy into causal inferences. Hence, in demography we can only reasonably account for and model the generality but not the determinacy of behaviour. The aim of substantive (and statistical) models must therefore be to capture common elements in the behaviour of people, or patterns of action that recur in many cases (Goldthorpe, 1998; 2000). This theoretical model must not seek to explain the behaviour of single individuals, but the behaviour of aggregate entities such as groups. As Stinchcombe (1968) has shown, the behaviour of large aggregates can be reasonably well comprehended, even when the individual components of the aggregate are poorly understood. Given this macro-level focus, small idiosyncratic deviations from the postulated model are not damaging (Hedström, 1995). The consequence, however, is that in demographic applications, randomness has to enter as a defining characteristic of causal models.

We can only hope to make sensible causal statements about how a given or (hypothesized) change in variable $Y_{A;t}$ (e.g., pregnancy/birth) in the past affects the probability of a change in variable $Y_{B;t'}$ (e.g., marriage) in the future. Correspondingly, the basic causal relation becomes: $\Delta Y_{A;t} \rightarrow \Delta \Pr(\Delta Y_{B;t'})$, $t < t'$. In other words, a change in the time-dependent covariate $Y_{A;t}$ will change the probability that the dependent variable $Y_{B;t'}$ will change in the future ($t < t'$). In demography, this interpretation seems more appropriate than the traditional deterministic approach. The essential difference is not that our knowledge about causes is insufficient allowing only probabilistic statements, but that the causal effect to be explained is a probability. Thus, probability in this context is not just a technical term anymore, but is considered a theoretical one: it is the propensity of social agents to change their behaviour intentionally.

Using event history data and hazard rate models, the causal reasoning underlying our approach can therefore be restated in a somewhat more precise form as: $\Delta Y_{A;t} \rightarrow \Delta r(t'), t < t'$. As a causal effect, the changes in covariates $Y_{A;t}$ in the past may lead to changes in the transition rate $r(t')$ in the future, which in turn describes the propensity that the actors under study will change their course of action. This causal interpretation requires that we take the temporal order in which structural constraints evolve and the actors' beliefs and motivations seriously.

4.2 Diffuse Marriage Preferences and the Negotiation Process

With regard to the marriage decision, it seems important to distinguish two completely different situations at the time of the discovery of the pregnancy: (1) the preferences of the partners to marry are vague and diffuse; and, (2) the couple has already reached a decision to marry or not to marry in the case of child. In the first instance, the occurrence of a pregnancy may initiate a process of preference formation and persuasion. *Formation* means that initially rather vague preferences with regard to marriage are formed, resulting in more clear-cut preferences in a step-wise negotiation process. *Persuasion* means that an individual is led by a sequence of short-term improvements into preferring marriage over non-marriage, even if he or she has initially vaguely preferred non-marriage over marriage. In such cases the discovery of a pregnancy engenders a time-structured process of change in preferences. On the one hand, the opportunity to legalize the birth of the child tends to decrease with the duration of pregnancy. At the same time, the likelihood of possible medical complications connected with the pregnancy and the visibility of pregnancy to others increases.

With these factors in mind, the optimal time for marriage is at a relatively early pregnancy phase. On the other hand, the optimum in the sense of a safe, well thought-out decision based on a negotiation process between the partners, is often at a relatively later phase of the pregnancy. Thus, there is constant tension between these opposing forces that may often (but not necessarily) be connected to a considerable shift in preferences with regard to marriage. Based on these contradictory forces, one would expect that the rate of entry into marriage after the discovery of pregnancy at first increases with the duration of pregnancy and then, after reaching some maximum, decreases again as the time of birth comes closer. Shortly before and after the birth, one would expect a very low marriage rate. Finally, after the birth has already taken place out of wedlock, the decision of whether or not to marry has a different quality. The child is then already 'illegitimate', and the time pressure to marry has disappeared, thus resulting in a relatively low marriage rate after some time since the birth of the child.

Figure 1: Comparison of Partial Likelihood Estimates (Coefficients) of the Transition from Consensual Union to Marriage, West and East Germany, Canada, Latvia, The Netherlands

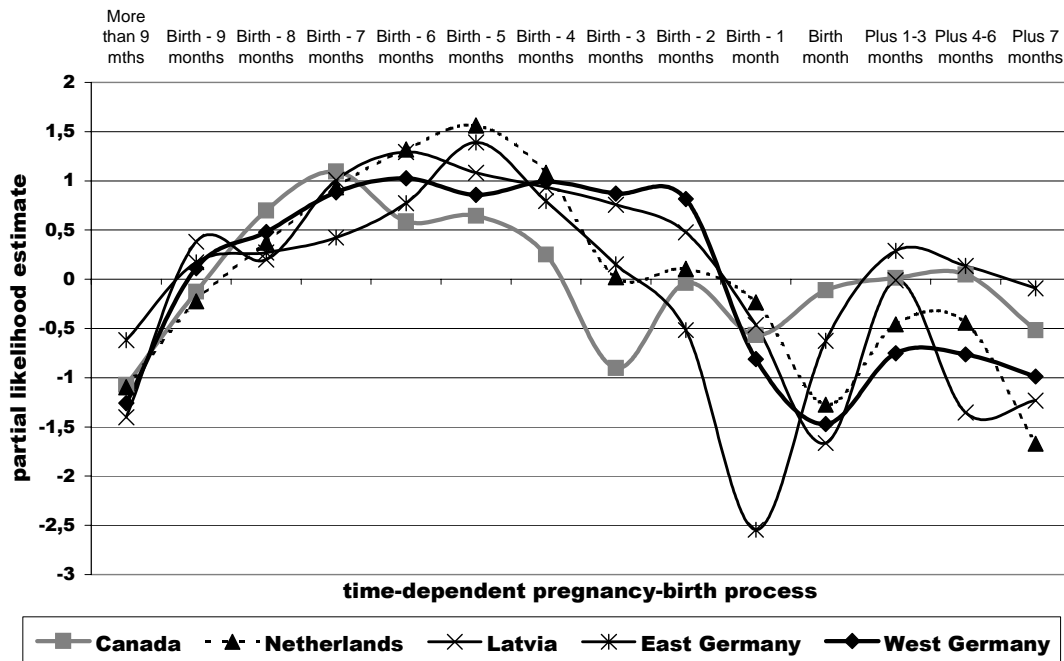


Table 1: Partial Likelihood Estimates of the Transition from Consensual Union to Marriage (Final Model), West and East Germany, Canada, Latvia, The Netherlands

Covariates	Final model results by country				
	West Germany	East Germany	Canada	Latvia	the Netherlands
Pregnancy/birth process (1)					
[time before pregnancy]	-1.2595	-0.6179	-1.0768	-1.3918	-1.0909
month of pregnancy	0.1131	0.1729	-0.1157	0.3822	-0.2217
1 month since pregnancy	0.4783	0.2715	0.7107	0.2009	0.3769
2 months since pregnancy	0.8837*	0.4225	1.0851*	1.0109*	0.9374*
3 months since pregnancy	1.0260*	0.7723*	0.5849	1.2959*	1.3229*
4 months since pregnancy	0.8578*	1.3903*	0.6563	1.0817*	1.5587*
5 months since pregnancy	0.9905*	0.7938*	0.2480	0.9328*	1.0743*
6 months since pregnancy	0.8701*	0.1510	-0.8948	0.7525*	0.0227
7 months since pregnancy	0.8158*	-0.5166	-0.0365	0.4793	0.1028
8 months since pregnancy	-0.8121*	-2.5449*	-0.5693	-0.4727	-0.2350
Month of birth	-1.4709	-0.6254	-0.1115	-1.6669	-1.2711
1-3 months after birth	-0.7513	0.2875	0.0096	-0.0136	-0.4595
4-6 months after birth	-0.7638	0.1351	0.0363	-1.3576*	-0.4404
More than 7 months after birth	-0.9877*	-0.0921	-0.5263*	-1.2336*	-1.6771*
Birth cohort (2)					
1965-69	-0.3094	-0.6001*	-0.4341*	-1.3096*	-2.2829*
1960-64	-0.1700	-0.0536	-0.3589*	-0.8563*	-1.4258*
1955-59	-0.1486	0.0920	-0.4324*	-0.6154	-0.8228*
[1950-54]	0.0	0.0	0.0	0.0	0.0
Historical period					
[Before 1974]	0.0	0.0	0.0	0.0	0.0
1974-83	0.0882	0.3521	-0.3027	0.0010	-0.2488
After 1983	-0.1554	0.0363	-0.2905	-0.3164	-1.7642*
Highest education level					
Low	0.1722*	-0.0189	0.1563	-0.0164	0.2490*
[Medium]	0.0	0.0	0.0	0.0	0.0
High	-0.0354	0.0941	-0.1092	-0.0763	-0.1962*
Educational enrollment					
In school	-0.3575*	0.0061	-0.3187	0.2700	-0.1856
[Out of school]	0.0	0.0	0.0	0.0	0.0

* = significant at the 0.05 level. Results are shown for the final model. (1) First covariate coded as centered effects, all others as cornered effects. Reference groups denoted by brackets. (2) Birth cohorts for West and East Germany are represented by 1968-72, 1963-67, 1958-62 and 1953-57. Source: Blossfeld et al. (1999) for West and East Germany and Mills and Trovato (2001) for Canada, Latvia and the Netherlands. Both the pregnancy/birth and educational enrollment variables are time-dependent.

Table 1 and Figure 1 illustrate that after controlling for several important covariates, women do indeed seem to follow this pattern with respect to the rate of entry into marriage: the marriage rate is very low before pregnancy across all countries; it generally increases strongly up to about 5 months before birth, then falls deeply around the time of birth, and is finally at a relatively low level more than 7 months after the birth. Therefore, our interpretation of the time-dependence in Table 1 is derived from a theoretically supposed underlying negotiation process with the time-dependent dummy-variables serving as proxies for a theoretically important process that is hard (or even impossible) to measure.

4.3 Unobserved Marriage Decisions and the Observed Rate of Entry into Marriage

Of course, one could also argue that many couples have already reached a decision to marry or not to marry in the case of a child at the time of the discovery of the pregnancy. Thus, couples are in fact extremely *heterogeneous* with regard to their baseline rate to enter into marriage when the pregnancy is observed. Consider the example where the

consensual union population consists of two groups - one with a constantly low marriage rate and the other with an increasing rate as pregnancy progresses. This neglected heterogeneity would result in a bell-shaped marriage rate. This is due to the fact that when pregnancy progresses, the composition of the unmarried couples shifts towards couples being 'less' or 'not' ready for marriage which, at first, increases and then decreases the observed effect pattern. Thus, if we do not know whether the couples have already reached a decision to marry in the case of a child at the time of pregnancy, we are unable to say whether the effects of the dummy variables must be considered as proxies for the formation of couples' decisions during pregnancy, or for the heterogeneity of couples' marriage decisions at the beginning of pregnancy. Obviously, in reality both interpretations may be valid. The important conclusion is, however, that the discovery of a pregnancy leads to a changing marriage rate for most couples.

4.4 Abortion, Miscarriage and the Problem of Conditioning on Future Events

Another methodological problem is that we have not considered abortion and miscarriage. Couples can avoid the birth of children (and therefore marriage) by abortion, and they can marry, but then experience a miscarriage. Both of groups present a problem for our causal analysis because we do not have any information about abortion and miscarriages and have constructed the fertility variables on the basis of successful births. In other words, there is the danger that we have committed one of the most serious methodological errors in causal analysis: we have conditioned past events on future events, reversing the temporal order of cause and effect. As long as conditions are random and concern only a small proportion of couples, as is the case with miscarriages, this objection is not exceedingly important. We get biased estimates only if specific couples sort themselves out by choice in greater numbers, as is probably the case with abortion. In particular, we overestimate the size of the pregnancy/birth effect because we systematically underrepresent pregnant couples that would not have wanted to marry because of a child in our 'risk set of pregnant couples' effect (i.e., if we overestimate, then the effect is negative on the rate which gives a downward bias). In former East Germany and Latvia, abortion was easier and more socially accepted than in the other countries. In Latvia, abortion is a widespread method of fertility control with 111 terminated pregnancies per 100 live births and stillbirths in 1991 (Government of Latvia, 1999: 125).

5. SUMMARY AND CONCLUDING REMARKS

The aim of this paper was to demonstrate the viability of the causal approach to interdependent systems using cross-national empirical investigations of interrelated family events. The story these studies tell is persuasive. In substantive terms, the investigations confirm the existence of a highly time-dependent process between pregnancy and marriage for individuals in consensual unions across five different national contexts. In particular, it shows that the force of an empirical analysis results from the clarity of the prior conceptual reasoning and the bringing together of seemingly contradictory evidence. All studies have been instructive in methodological terms because:

- (1) they *analyzed two highly interdependent processes* from a causal point of view,
- (2) the interdependence occurs mainly in a very *specific phase of individuals' lives* (i.e., family formation),
- (3) the relationship between cause and its effect involves *time lags* (e.g., time until detection of pregnancy); and,
- (4) the unfolding *effect is highly dynamic over time*.

These applications illustrate the substantive importance and methodological pitfalls of the identification of time-dependent causes and their time-dependent effect patterns. A central contribution is that we have been able to demonstrate that one process is influencing or causing a change in the other – even if they are interdependent. In cross-sectional data, we often have interdependent systems with feedback mechanisms, but are unable to discern how one process influences the other. We witness associations that describe what has happened, but cannot separate the effect. Associations are quite different from causal statements designed to say something about how events are produced or conditioned by other events. With the event history approach, however, it becomes possible to separate correlation and causation (Blossfeld and Rohwer, 1995/2001).

One shortcoming is that our applications are only based on observed behaviour. It could happen that a couple first decides to marry, the woman becomes pregnant, and then the couple marries. In this case, we would observe pregnancy occurring before marriage and assume that it increases the likelihood of marriage. Yet, the time order is

exactly the other way around. Courgeau and Lelièvre (1992) have introduced the notion of ‘fuzzy time’ to represent this time span between decisions and behaviour. Since the time between decisions and behaviour is probably not random and differs per couple, examining observed behaviour could lead to false conclusions. This does not alter the key temporal issues embedded within the causal logic. However, we must admit that using the time order of behavioural events without taking into account the timing of decisions could lead to serious misspecification. Thus, for studies aiming to model the relationship between attitudes and behaviour over time, panel observations of attitudinal states and retrospective information on behavioural events appear to be a very desirable design.

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APPENDIX

The 1995 FFS data for Canada is derived from Statistics Canada’s 1995 General Social Survey. Since Statistics Canada does not release the month of event to external researchers for confidentiality reasons, but does allow analysis of events to each tenth of the year (i.e., age plus one decimal point), Mills (2000) translated these values to a 12-month scale by estimating a random (uniform distribution) variable of age plus 3 decimal points, followed by a conversion scale to transform it into monthly data.

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