**Changing Paradigm in Demography**

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*Population: An English Selection*, Vol. 9 (1997), 1-10.

Stable URL:
http://links.jstor.org/sici?sici=1169-1018%281997%292%3A9%3C1%3ACPID%3E2.0.CO%3B2-V

*Population: An English Selection* is currently published by Institut National d'Études Démographiques.

# CHANGING PARADIGM IN DEMOGRAPHY*

Daniel COURGEAU** *and* Éva LELIÈVRE** *react in this article to the attempt made by Chantal Blayo (*Population, *6, 1995) to reformulate event history methodology in the classic terms of demographic analysis.*

*They show how the restrictive conditions required for demographic analysis are no longer needed and can be overcome by the use of more sophisticated methodology.*

*They present the transition to a new paradigm for demography which accompanies the move to individual life event history analysis.*

Event history analysis was born from the need to set in a solid theoretical framework the study of the events that occur along the life-course. The amount of survey data made available in recent years opened up paths of research that had been suggested by L. Henry (1959, 1972) and R. Pressat (1966), but could not be explored at the time because the source materials (principally registration data) were inadequate: namely, the analysis of population heterogeneity and of the interactions between demographic phenomena (Courgeau and Lelièvre, 1989, pp. 1-6).

One may wonder whether it is possible to explore these fields under the « condition of homogeneity » that is the postulate on which C. Blayo (1995) bases demographic analysis and which she wants to extend to the statistical analysis of event histories. We propose to prove that this is not the case, and that a new paradigm has become necessary for the analysis of event history data. A paradigm defines the norm of what is legitimate activity within the scientific field it governs. By nature, it therefore resists any precise definition, but it can be delimited by general principles.

This transition to a new paradigm has more easily been achieved in the Anglo-Saxon countries, where demographers have a solid grounding in statistics, as R.D. Lee (1995) reminded us during INED's 50th Anniversary conference. In France, it has met with more resistance, the latest example of which is expressed by C. Blayo.

Event history analysis is based on the seminal works of Cox (1972) and Aalen (1978) among others. In turn, these developments stemmed from

* The authors wish to thank France Guérin-Pace, Denise Pumain and Laurent Toulemon of INED for their comments and advice on a preliminary version of this paper. But they acknowledge full responsibility for their remarks.

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the works of probability theorists, in the majority French, who constructed theories on martingales (Dellacherie and Meyer, 1980), stochastic integrals (Dellacherie, 1980) and counting processes (Brémaud and Jacod, 1977). Demographers who use event history analysis are not required to be familiar with all of this complex corpus. They do, however, need to make the effort to grasp the basic steps of the approach, which we propose to recall in brief. But first, let us examine the hypotheses underlying the classic analysis.

## I. – The analysis of phenomena in their 'pure state'

The paradigm of the analysis of phenomena in their 'pure state' rests on the following postulate: the demographer can only study the occurrence of an event, and of that event alone, in a sub-population "that maintains all its characteristics, and the same characteristics, as long as the phenomenon continues to express itself"[1]. The application of this postulate should ensure a demography that is consistent and can explore all the phenomena within its scope.

As a result, the focus of investigation is not a set of individual life-courses, but a sub-population into which, and out of which, some individuals move. It is within this sub-population, which is considered to remain homogeneous over time, that the intensity and the timing of a phenomenon are calculated. This approach amounts to denying that individual life-courses can be specific in any way, and considers only the occurrence of an event in a sub-population which remains globally identical across time because it is made up of units that are interchangeable[2].

Further, for this population to remain homogeneous, it must be assumed that those who move into it have immediately the same characteristics and adopt the same behaviour as those already in it, while those who move out adopt at once the behaviour of the new sub-population into which they move and wipe from their memories all traces of their past. This amounts to making a Markovian assumption: the present state is independent of the past history of the individuals. Again, such a stand is unrealistic, since undeniably people's past influences their future behaviour.

Let us now examine the processes that govern these moves into and out of the population. The interfering events which, like mortality and emigration, prevent some individuals from experiencing the studied phenomenon, and the competing events which, like unmarried cohabitation, are in competition with marriage (the terms are considered by C. Blayo as being

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[1] C. Blayo (1995), p. 1504.

[2] Absurdly, we note that in order to maintain homogeneity throughout the period when the phenomenon is at work, a sub-population of a single individual could not consist of the same individual from beginning to end. This individual should be replaced by a succession of others in order to maintain "all its characteristics and the same characteristics" in this sub-population.

"strictly synonymous"[3]) must be independent of the studied phenomenon; otherwise, an obvious selection bias removes from the population at risk some individuals having specific characteristics, and introduces others who will modify the group's composition.

Since many demographic events occur within a short span of the life-course, they are competing with one another. To study one of these events in this framework leads either to considering that it is independent of the others, thus denying any potential interactions, or to abandoning an analysis that does not seem feasible.

Moreover, since the classic paradigm only permits the study of one single event, it becomes impossible to study losses from observation due to the occurrence of a competing event. All cause-specific mortality studies are thus barred, since it is obvious that eradicating one cause of mortality will affect the probabilities of dying from other causes, in a way that is practically impossible to forecast while the first cause continues to exist. In the same way, it is impossible to study moves out of the state of celibacy by unmarried cohabitation or by marriage, because the two cannot be assumed to be independent. Finally, it is "for the same reason that the study should not be conducted on a population which can be entered through several different events"[4]. That adds up to a great many cases where the postulate bars all analysis.

Demographic analysis is thus reduced to the analysis of a single event. It must now eliminate the effect of the interfering events, to "isolate the events in their pure state"[5].

L. Henry (1972, pp. 76-80), in an analysis of first marriages occurring within a country, identified two interfering phenomena: mortality and international migration. To calculate the first marriage probabilities for France, he supposed that the behaviour of individuals having experienced one of the events was, or would have been, the same as those who had not.

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[3] C. Blayo (1995) p. 1503: "Interfering event, competing event, concurrent event, are strictly synonymous for the analyst when the event under study is correctly defined. Thus, the « marriage of a single person » prevents the occurrence of the « death of a single person »; this does not mean that the person who marries will not die later, but he or she will not die as a single person. When a previously unpartnered person enters a cohabiting union, that prevents a direct marriage, that is, marriage of a previously unpartnered person, but does not prevent marriage in general – only it will not be a direct marriage."

[4] *Idem.*, p. 1507: "Experience proves that the *duration* since the event which is necessarily and immediately prior to the event studied is an important factor of heterogeneity: the probability of dying or of migrating varies with age, that of having a first child or divorcing varies with duration of marriage... That is why it is preferable to study a phenomenon in a cohort of individuals having experienced the prior event during the same period. It is also why the study should not be conducted on a population which can be entered through several different events (except in the case of different modalities of a same event, and when the probabilities of experiencing the studied event and the interfering events do not depend on the mode of occurrence of the « entry » event").

[5] *Idem*, p. 1504: "Whatever the objective, whether primary (the analysis of phenomena *per se*) or secondary (the analysis of the structures generated by the phenomena), whether to understand, to forecast or to compare, only the approach that consists in isolating the phenomena in their pure state makes it possible to attribute to each phenomenon the weight of its influence on the number of events observed and, thence, on the resulting structures."

Yet it is difficult to consider that the whole of the French population is homogeneous. That is why C. Blayo[6] takes the example of a more specific and certainly more homogeneous population: the "male rural population" in which "first marriages of rural men" are studied. In this case, another process is at work: the departure of single men from the countryside, which at the peak marrying ages concerns many more individuals than does either mortality or international migration. Furthermore, it is highly improbable that these men will have the same marriage behaviour as those remaining in the countryside. Farmers, for instance, whose marriage behaviour is very different from that of farm labourers, also have very different risks of leaving the countryside. The marriage probabilities estimated on a sub-population of sedentary rurals are consequently worthless given that the condition of homogeneity (dixit C. Blayo) is not verified.

The recommended approach is, therefore, to divide this sub-population into an ever- growing number of sub-sub-populations, in an attempt to ensure homogeneity. Rapidly, the size of each group becomes so small as to rule out all analysis. What is more, one can never be sure of having taken into account every factor of heterogeneity, and that is not inconsequential, as C. Blayo herself states[7]. There will always be some unobserved heterogeneity, whose effect on the probabilities will be totally unknown – which is not the case with event history analysis, as we shall see.

In conclusion, the postulate set down by C. Blayo, when applied rigorously to concrete demographic issues, amounts to denying all possibility of longitudinal analysis of an event. Indeed, it calls for such fine-level breakdowns that the calculations lose all significance. It is also so restrictive as regards the events that can be studied that it bars whole sectors of demographic analysis (analysis of competing events, of interactions between events, of events occurring in a population which can be moved into or out of through several different events). Under such conditions, is it not time to take a fresh look at this paradigm, and propose a new one, which allows event history analysis?

## II. – What is event history analysis?

The investigations no longer focus on homogeneous sub-populations, but on a series of individual life-courses involving a succession of different states. The unit to be analysed is no longer the event but the individual

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[6] *Idem*, p. 1502.

[7] *Idem*, p. 1508: "It is necessary to distinguish between heterogeneity that is at the origin of an association between the risks, in which case the study is not possible, and heterogeneity that is accompanied by no statistical correlation between the two types of events; in this case, the analysis loses none of its rigour. What does it matter, then, if some unobserved heterogeneity remains, if it has no impact on the probability of experiencing the interfering event. What does it matter, even, if some selective heterogeneity subsists, if the intensity of the interfering phenomenon is low or if its timing is early in the case of entries and diluted over time in the case of exits."

event history, considered as a complex stochastic process (Courgeau and Lelièvre, 1989, p. 2).

In this case, the paradigm can be approached by the following hypothesis: throughout his or her life, an individual follows a complex life-course, which depends at any moment on the past history and on the information acquired previously.

This change of view leads us to reformulate event history analysis in terms of process analysis, the fundamental concepts of which are now well established (Anderson *et al.*, 1993, pp. 45-120).

The first principle is that we follow a group of individuals over time. The most frequent way for an individual to 'escape' the group is by loss from observation at the date of the survey or, in the case of population registers, of the study (this is termed right-censoring). Insofar as these dates have no reason to be associated in any way with the individual's life, the condition of independence is fully verified: the observation is said to be non-informative and various methods allow for these losses from observation in the estimation of hazard rates (Courgeau and Lelièvre, 1989, pp. 52-61).

Selection bias can be a problem, on the other hand, particularly with retrospective surveys, since only persons who are alive and present at time of survey can be interviewed. In this case, it is often necessary to assume that losses from observation are not selective, unless population register data permit adjustment for emigration (Hoem, 1985). Such selection bias is limited, however, if the studied event does not occur in an elderly population or one that is specially concerned by emigration.

It is possible to work on sub-populations of persons having experienced the same initial event, entry into the farming population, for instance[8]. If these individuals experience an 'interfering event' (exit from the farming population), they are not – in the case of event history analysis – lost from observation, but their behaviour in respect of the studied process, here marriage, may be modified. This can be tested by comparing their behaviour to that of farmers of the same age, or to individuals who have never been farmers. The results can indicate a selection effect or, on the contrary, an adaptation of behaviour (Courgeau and Lelièvre, 1986; Courgeau, 1987).

Unlike C. Blayo[9], we consider it is important to distinguish interfering events from competing events. As we have seen, an interfering phenomenon, which we prefer to term 'interactive phenomenon', modifies the

[8] *Idem*, p. 1502: "It is possible to define as many sub-populations as there are individual characteristics and combinations of these characteristics, but for an unbiased measure of the intensity of exits from a sub-population, the latter must meet a number of conditions. The choice of the populations within which the analysis is conducted is essential, as we shall see.

There are, in general, as many modes of entry into a sub-population as there are acquired characteristics in that sub-population, as well as the arrival in the territory of individuals who have acquired these characteristics previously, and there are as many modes of exit from this sub-population as there are characteristics that are susceptible of being lost, to which are added the individual's death or departure from the territory."

[9] Cf. footnote 3.

probabilities that the studied event will occur. Competing phenomena are different modalities of an event that has the same final outcome: cause-specific mortality, union formation by marriage or by cohabitation, etc. We have presented in detail elsewhere how such cases can be addressed by event history analysis (Courgeau and Lelièvre, 1994). We note here simply that it is not possible to answer questions such as: what would the marriage probabilities be in the absence of cohabitation? Questions of this kind are beyond the scope of the statistics with which we are working, and the answers that some social scientists put forward should be viewed with extreme caution.

We are thus able to explore how an event of a family, economic or other nature experienced by an individual will change the probability of other events happening to him or her. We can, for instance, try to identify how a marriage can influence a professional career, spatial mobility and other occurrences, such as the birth of a child or a break with original family ties.

This is what we term the analysis of interactions between demographic phenomena, which has its place in the study of event histories (Courgeau and Lelièvre, 1989, pp. 29-106).

This analysis supposes that the initial population is homogeneous in respect of the process being studied: that is, that at the beginning of the analysis, the individuals are in the same state vis-à-vis the process. But the population becomes increasingly heterogeneous over time, as it experiences the different interactive events. This hypothesis should be tested in a first stage of the analysis, to identify the interactions between phenomena, and it must necessarily be lifted in a second stage. Indeed, there is no reason why the individuals in a population should be identical, and the regressions used in the second stage of the analysis provide the means of exploring their initial heterogeneity as well as that which is introduced over time.

To understand an individual's behaviour, it is obviously necessary to take into account his or her social origins and past history. In this case we are supposing that behaviour patterns are not innate but rather that they can change over an individual's lifetime as a result of what has been experienced and acquired with time. Thus, two individuals from the same social background, but who have taken entirely different paths in life, can have attitudes to marriage, forming a family, career, etc. that diverge increasingly as time goes on.

We thus arrive at a method of analysis of population heterogeneity which uses a dynamic rather than a static approach. Regression analysis, which was already more efficient than the methods of breakdown and standardization used in classic cross-sectional analysis, has been extended to the study of complex dynamic processes. This was the work of statisticians (Cox, 1972; Aalen, 1978) and, during the 1980s, research in France and elsewhere proved that it was particularly suitable for the study of demo-

graphic phenomena (Menken and Trussell, 1981; Courgeau, 1982; Hoem, 1982; Hobcraft and Murphy, 1986, for instance). The tools required for such analysis are presently available, in their simplest form, as commercial softwares: SAS, SPSS, TDA, STATA and so on (Lelièvre and Bringé, 1998). But now that the statistical foundations of the method have been firmly laid, models capable of handling increasingly complex situations are constantly being developed.

These methods of analysis, which use the recent developments in likelihood theory, cannot be discussed here at any length. For a detailed statistical description, we refer the reader to Andersen *et al.* (1993), for a more economic approach to Droesbeke *et al.* (1989), and for a more demographic presentation to Courgeau and Lelièvre (1989, pp. 109-193). We note simply that with these methods, characteristics that are time-invariant (such as parents' social origins) and others that may vary over time (labour status, for instance) can be handled very flexibly. The characteristics may be qualitative or quantitative, and personal to the individual or shared by the group the individual belongs to or by a wider sub-population. This opens the door to 'multi-level' analyses (Courgeau, 1994).

Such methods make it possible, therefore, to introduce simultaneously the interactions between phenomena and the heterogeneity observed in the study populations, from retrospective survey and population register data. It is important, however, to wonder what effects unobserved heterogeneity may have on the findings. In contradiction with what Blayo presumes[10], J. Bretagnolle and C. Huber-Carol (1985) have demonstrated an impact of unobserved heterogeneity, independent of the characteristics observed, on the results. If this unobserved heterogeneity reduces the absolute value of the parameters representing the effect of the observed characteristics, it does not change their sign. One can thus conclude that, when the observed characteristics have a significant effect, this will not be modified by unobserved heterogeneity; but when they have a non-significant effect, introducing unobserved heterogeneity could in some cases make it significant.

## Conclusions

The initial paradigm posed by C. Blayo only allows the analysis of phenomena that are isolated in their pure state and results in neglecting the study of multiple events, interactive and competing alike. A demographer who follows this paradigm religiously cannot study, say, union formation by cohabitation, since marriage, the interfering event, can obviously not be considered independent in this case. Furthermore, by refusing regression analysis of the effects of the different characteristics on individual behaviours, this paradigm leads to breaking down the study population into an ever-increasing number of more "homogenous" populations, which rapidly become too small to be of interest. In Blayo's own words: "the number

[10] Cf. footnote 7.

of observations is a brake on repeated subdivisions"[11]. Ignorance of the variance of the estimates, which C. Blayo never indicates, creates complete uncertainty about the validity of the timing and intensity thus estimated. We add – in disagreement with C. Blayo[12] – that unobserved heterogeneity, even when it is independent of the characteristics observed, affects the intensity of the phenomenon under study. Finally, her more direct criticisms against event history analysis[13] are not supported by any statistical evidence.

In considering an individual's life not as a series of moves into different sub-populations, where each entry into a new population rubs out all traces of the past, but instead as an evolving life-course, our paradigm permits a much more accurate analysis of individual event histories. First, the individual is lost from observation at the time of the survey or study, which avoids many problems of dependence between interactive and studied events. Several forms of loss from observation can, moreover, be considered (Anderson *et al.*, pp. 135-168).

Second, the simultaneous analysis of interactions between events and of population heterogeneity avoids the successive breakdowns which quickly paralyse any explorations. A great many individual characteristics can be introduced together and their effects be measured, and the role of unobserved heterogeneity can also be studied. Naturally, many different models can be used, and it is important to test whether the selected model is the most satisfactory one for revealing the dependencies investigated. Furthermore, a precise statistical estimation of the effects of heterogeneity and of their variance and covariance permits many tests on these dependencies.

Thus, event history analysis opens up a path of research into human behaviour that is much wider and richer than classic demographic analysis. Begun over fifteen years ago, it is founded on a paradigm and on mathematical and statistical theories that are very solid and that guarantee its validity. Much work remains ahead before we can handle all the complexities of human behaviour and of the societies in which we live. But now, instead of being stifled by restrictions and rapidly unable to take an analysis any further, we are invited to push ahead and explore questions that are increasingly targeted, knowing that these methods will help us to answer them.

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[11] *Idem*, p. 1516.
[12] Cf. footnote 7.
[13] *Idem* pp. 1513-16.

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COURGEAU (Daniel), LELIÈVRE (Éva).– **Changing paradigm in demography**

The classical paradigm in demography states than only one demographic process can be studied at a time. This process develops in a homogeneous population whose characteristics remain unchanged. Such a conceptual stand forbids the study of multiple processes, interactive or competing and necessitates the decomposition of the initial population into an ever increasing number of homogeneous sub-groups. As the size of each sub-population gets smaller, it fast becomes impossible to conduct a valid analysis.

A change of paradigm is therefore inevitable to conduct a study of interacting processes and an exploration of the heterogeneity of a population. This new approach deals with individual life courses in a greater complexity: each new development being dependent on the past experience and the information available to individuals. This new paradigm has opened the way to life event history analysis, in place for already 15 years.

COURGEAU (Daniel), LELIÈVRE (Éva).– **Changement de paradigme en démographie**

Le paradigme selon lequel le démographe ne peut étudier que l'arrivée d'un événement, et d'un seul, dans une population qui conserve les mêmes caractères tant que le phénomène se manifeste, revient à interdire l'étude des événements multiples, tant interactifs que compétitifs. Cela conduit à décomposer la population étudiée en un nombre toujours croissant de sous-populations dont la taille devient rapidement trop faible pour réaliser une analyse valide. Il est, dès lors, nécessaire de changer ce paradigme pour pouvoir réaliser une analyse simultanée des interactions entre événements et de l'hétérogénéité de la population.

Le nouveau paradigme va envisager les trajectoires individuelles dans une plus grande complexité : chacune dépendant, à chaque moment, des expériences antérieures et des informations dont disposent les individus sur le monde qui les entoure. Ce changement de perspective ouvre la voie à l'analyse des biographies, développée maintenant depuis plus de 15 ans.

COURGEAU (Daniel), LELIÈVRE (Éva).– **Cambio de paradigma en demografía**

El paradigma según el cual el demógrafo puede estudiar la ocurrencia de un único acontecimiento a la vez, en una población que mantiene una mismas características constantes mientras el fenómeno se manifiesta, no permite el estudio de acontecimientos múltiples, interactivos o competitivos, y obliga a descomponer la población estudiada en un número creciente de subpoblaciones el tamaño de las cuales es a menudo demasiado reducido para realizar análisis válidos. Por consiguiente, es necesario hallar un paradigma que permita realizar un análisis simultaneo de las interacciones entre fenómenos y de la heterogeneidad de la población.

El nuevo paradigma examinará las trayectorias individuales desde una perspectiva más compleja : cada trayectoria dependerá, en cada momento, de las experiencias anteriores y de las informaciones de las que los individuos disponen sobre su contexto. Este cambio de perspectiva da paso al análisis biográfico, que se viene desarrollando desde hace más de 15 años.