IMPACT OF RESPONSE ERRORS ON EVENT HISTORY ANALYSIS

In the preceding article[1], disparities between the family and migration histories reconstituted from different sources have been revealed. These disparities have two causes: events were omitted, or were misdated. The greatest disparities concern information on residential mobility. The retrospective survey data gave more complete residential histories than the Belgian population register, which does not cover moves outside Belgium. But the moves were more accurately dated in the population register, although the date recorded is that of registration, not of the actual move. The survey data were in all cases more complete and accurate when it was the wife who was interviewed than when it was the husband, and joint interviewing further improved the results. In all, we have four sets which can be compared to reveal the errors one can expect to find when using retrospective life history data. However, such surveys are not conducted to collect simple statistical data like those presented in the preceding article, but to delve further into the complexities of life histories. It was thus of interest to investigate the impact of these errors on analyses of a more elaborate nature.

Over the last ten years, a variety of methods have been developed to analyse life history data (see Courgeau and Lelièvre, 1989). Their aim is to study interaction between events in the lives of individuals, while untangling the problems of heterogeneity in the populations observed. We wondered whether the effect of misdating on complex analyses of this kind might not be so great as to invalidate their results.

This survey provides the opportunity to undertake the same analyses on four separate data sets, the responses of husbands and wives interviewed individually, then jointly as couples, and finally the data from the Belgian

[1] M. Poulain, B. Riandey and J.-M. Firdion in the present issue.

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population register. Comparison of the results is facilitated by these new methodologies. They permit us to estimate not only the effect of different variables on transition intensities from one state to another, but also their variance and covariance. We can then test whether the results of the four data sets diverge, and to what extent.

We will use non-parametric, parametric and semi-parametric methods of analysis and examine how the results are affected by misdating. First, we will use the non-parametric approach to analyse duration of residence in each home occupied since marriage. This will at the same time show that a Gompertz model is well suited to handling such data. We will then take these results, in which effect of duration is taken into account parametrically, and introduce various characteristics of the individuals at beginning of residence. This will permit us to demonstrate differences in the analyses depending on data set.

Finally, we will use a semi-parametric method to analyse interaction between the couple's first move and the birth of their first child (in marriage). We will introduce several characteristics of wife into the model, again to explore differences produced by the different sources.

We will thus have tested, in a variety of situations, the effects of using erroneous life history data on different methods of demographic analysis.

I. – Analysis of mobility after marriage

We consider all moves occurring since marriage. Survey data were collected on duration of residence in each home, measured in months since last move. However, we eliminated durations under six months, as being temporary stays which would be more easily forgotten. They were few in number, and negligible for migration analysis.

For some durations, the interval is 'open', in that observation (time of survey) occurs before the next (or first) move. These data are right-censored and this must be allowed for in estimating the instantaneous rates of migration (see Courgeau and Lelièvre, 1989, pp. 44-57).

We have 1,262 durations of residence reported by husbands, 1,312 by wives, 1,316 by the couples together and 1,193 as derived from the population registers. The lower number for the latter is in part due to international migration and the fact that some moves were not registered. The figures are slightly different from those in the preceding article, because we have eliminated durations under six months.

To estimate the instantaneous rates of migration, we supposed they were constant for a year of observation, and only changed from one year to the next. Let us suppose that, during the k^{th} month of the j^{th} year, the number of moves is m_k and the number of non-movers leaving observation is c_k. If P_j is the population of non-movers still present at end of year j, we can estimate the instantaneous rate of migration h_j by:

$$\hat{h}_j = \frac{\sum_{k=1}^{12} m_k}{P_j + \sum_{k=1}^{12} \frac{2k-1}{24} (m_k + c_k)} \qquad (1)$$

which represents the total number of moves observed in year j divided by the total number of person-years in the risk set (Cox and Oakes, 1984, pp. 53-54).

Figures 1 and 2 show the natural logarithm of these instantaneous rates for durations from 1 to 19 years. We see that the curves are not identical, because of dating discrepancies in the information collected from men, women, couples or the population register. But although different, the curves seem to intertwine perfectly: each one is in turn above, below or in between the others. They might all four belong to the same distribution, the fluctuations being merely the result of low numbers.

This assumption can be tested by comparing differences between the moves actually observed in each group and the theoretical ones corresponding to the number of movers we would observe supposing identical behaviour in all groups (Courgeau and Lelièvre, 1989, pp. 65-66). Taking the 19 years of observation simultaneously, we obtain a chi-square statistic with three degrees of freedom equal to:

$$\chi_3^2 = 1.045$$

which does not contradict the assumption.

Further, we see that straight lines can be fitted to these curves. This justifies the use of a Gompertz model for the parametric analysis below. We can write:

$$\log (h(t)) = \log (\lambda\rho) + \rho t \qquad (2)$$

where ρ and λ are parameters to be estimated, and t the duration of residence considered.

There appear to be more variations around the model at higher durations: the instantaneous mobility rates have much broader confidence intervals than at lower durations. We give in Table 1 the logarithms of these rates and their standard deviations, which confirm that they have confidence intervals greater than the fluctuations observed in Figures 1 and 2.

We will now explore whether certain variables influence duration of residence, and whether measurement of this influence is affected by the data set used.

We introduce duration between marriage and beginning of residence considered (under a year, from one to four years, from five to nine years; the control group consists of cases of residence starting ten years or more

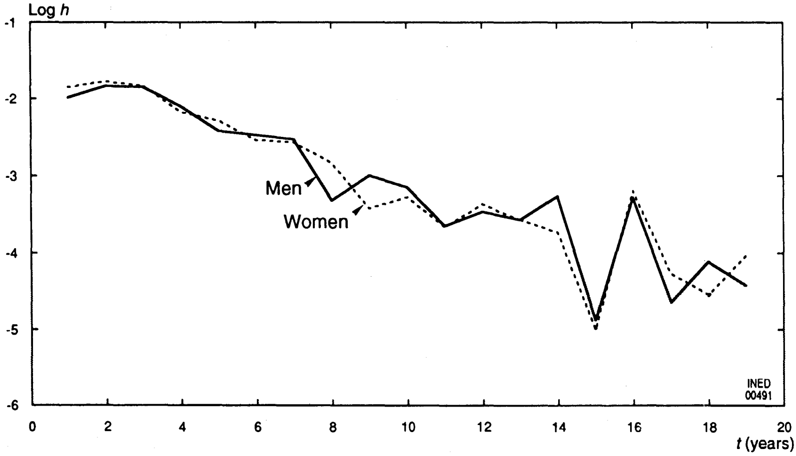

Figure 1. – Natural logarithm of instantaneous rates of migration estimated for men and women

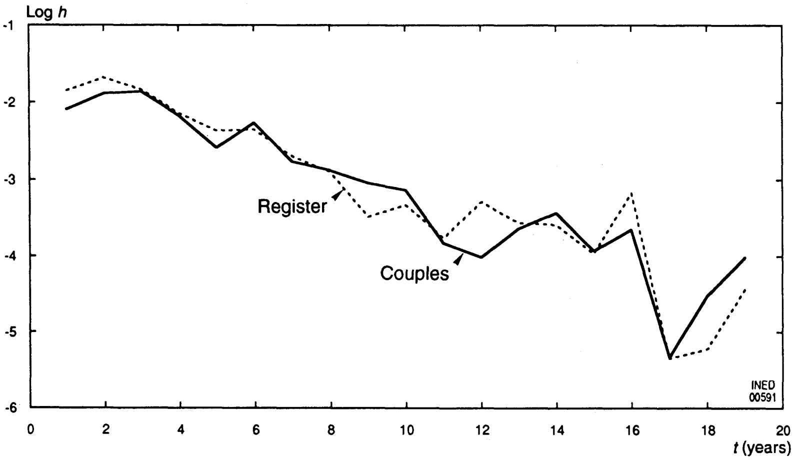

Figure 2. – Natural logarithm of instantaneous rates of migration estimated for couples and from population register

after marriage), and number of children born before beginning of this period of residence. We could not introduce the variable 'departure of the first child', because this concerned only 7 cases. We then introduce tenure status for analysis of the three sets of survey data (this information is not recorded in the population register); the control group is here mostly tenants.

TABLE 1. – NATURAL LOGARITHM OF INSTANTANEOUS MOBILITY RATES AND STANDARD DEVIATIONS, AS ESTIMATED FROM THE SURVEY DATA FOR MEN, WOMEN AND COUPLES AND FROM THE BELGIAN POPULATION REGISTER

Duration (years)	Men		Women		Couples		Poupulation register	
	log *h*	standard deviation	log *h*	Standard deviation	log *h*	Standard deviation	log *h*	Standard deviation
1	–1.982	0.079	–1.844	0.073	–1.848	0.075	–2.093	0.086
2	–1.831	0.079	–1.772	0.077	–1.682	0.074	–1.887	0.082
3	–1.845	0.086	–1.828	0.084	–1.838	0.086	–1.860	0.089
4	–2.097	0.107	–2.174	0.114	–2.139	0.110	–2.172	0.116
5	–2.420	0.136	–2.285	0.124	–2.370	0.130	–2.593	0.146
6	–2.472	0.140	–2.541	0.146	–2.351	0.133	–2.268	0.128
7	–2.528	0.158	–2.565	0.156	–2.701	0.164	–2.767	0.172
8	–3.317	0.229	–2.840	0.186	–2.900	0.193	–2.881	0.193
9	–2.999	0.209	–3.422	0.243	–3.486	0.250	–3.044	0.218
10	–3.150	0.250	–3.275	0.243	–3.328	0.289	–3.168	0.267
11	–3.648	0.316	–3.659	0.374	–3.762	0.333	–3.827	0.354
12	–3.464	0.289	–3.368	0.277	–3.290	0.267	–4.015	0.378
13	–3.566	0.354	–3.566	0.376	–3.562	0.378	–3.639	0.378
14	–3.262	0.302	–3.733	0.353	–3.591	0.333	–3.433	0.333
15	–4.879	0.500	–4.998	0.490	–3.968	0.408	–3.928	0.447
16	–3.279	0.378	–3.197	0.353	–3.175	0.378	–3.652	0.408
17	–4.637	0.705	–4.270	0.564	–5.348	0.966	–5.328	0.975
18	–4.115	0.577	–4.543	0.674	–5.225	0.975	–4.526	0.706
19	–4.425	0.577	–4.036	0.571	–4.436	0.577	–4.015	0.577

We use a parametric model in which duration of residence follows a Gompertz model:

$$h\,(t\,;\ Z,\ \beta) = \exp\,(Z\beta + \rho t) \tag{3}$$

where Z is the vector of observed variables, β a vector of parameters to be estimated, and ρ the effect of duration of residence expressed here in years. The probability of moving for a control group being taken as reference, the effect of a variable is measured by the exponential of the β parameter estimated for this variable. Thus, when this parameter has value + 0.485 for individuals housed by their employer (Table 2), that means that those individuals have a probability of moving 1.62 (= exp (0.485)) times higher than the control group (here, tenants).

Table 2 gives the results of the first model (without tenure status), estimated separately for men, women, couples and population registers(2). All the variables have a similar effect, whatever the data set. Number of children at beginning of residence has no impact on duration, as we observed previously in a French survey (Courgeau, 1985). In contrast, dura-

(2) The parameters were estimated using a Fortran computer programme called RATE written by N. Tuma.

TABLE 2. – RESIDENTIAL MOBILITY ANALYSIS: EFFECT OF TIME SINCE MARRIAGE, DURATION OF RESIDENCE (IN YEARS) AND TENURE STATUS ON PROBABILITY OF MOVING, BY DATA SET (PARAMETER ESTIMATES, WITH STANDARD DEVIATIONS IN BRACKETS)

Variables	Men (1,260 residences)		Women (1,310 residences)		Couples (1,314 residences)		Register (1,189 residences)
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1
Constant	– 2.955***	– 2.322***	– 3.009***	– 2.391***	– 3.062***	– 2.264***	– 3.118***
	(0.174)	(0.193)	(0.179)	(0.193)	(0.183)	(0.192)	(0.187)
Residence starts year of marriage	1.464***	0.438**	1.569***	0.574***	1.642***	0.575***	1.564***
	(0.172)	(0.174)	(0.177)	(0.178)	(0.182)	(0.181)	(0.186)
Residence starts between 1 and 4 years after marriage	1.117***	0.572***	1.198***	0.622***	1.301***	0.750***	1.199***
	(0.160)	(0.160)	(0.157)	(0.158)	(0.161)	(0.161)	(0.166)
Residence starts between 5 and 9 years after marriage	0.641***	0.375**	0.559***	0.286*	0.684***	0.444***	0.707***
	(0.164)	(0.165)	(0.162)	(0.163)	(0.164)	(0.165)	(0.166)
Number of children at start of residence	0.006	– 0.016	0.052	0.042	0.051	0.023	0.033
	(0.040)	(0.039)	(0.042)	(0.041)	(0.042)	(0.042)	(0.044)
Housed by employer		0.485***		0.480***		0.321***	
		(0.091)		(0.090)		(0.078)	
Owner-occupier		– 2.431***		– 2.347***		– 2.538***	
		(0.175)		(0.166)		(0.164)	
Duration of residence	– 0.113***	– 0.056***	– 0.116***	– 0.058***	– 0.119***	– 0.064***	– 0.104**
	(0.0077)	(0.0076)	(0.0076)	(0.0075)	(0.0077)	(0.0075)	(0.0076)

* Result significant at 10% level.
** Result significant at 5% level.
*** Result significant at 1% level.

tion of residence strongly influences the probability of moving, confirming the results obtained by non-parametric analysis, and time between marriage and beginning of residence also has a considerable effect.

Figure 3 shows the parameters estimated for each variable, with a 95% confidence interval. At this level, there is absolutely no distinction between the results obtained from the different sources.

Therefore, in spite of errors in dates of moving into and out of a home, parametric analysis produces results which are very similar, whatever the source: husbands only, wives only, couples or the Belgian population register.

To consider other variables, it is necessary to leave out the population register data. They provide little information on dwellings, and it was important to observe tenure status, since it seemed likely that this would affect the probability of moving. In Table 2, we show the results of a second model which introduces this variable. In Figure 3, we have added parameter estimates for individuals housed by their employer and for owner-occupiers, with a 95% confidence interval.

This new model shows that tenure status has a significant effect on duration of residence, whatever the data set. Compared to tenants, the probability of moving is appreciably higher for people housed by their employer and appreciably lower for owner-occupiers. These results are consistent with those of the Triple Biography (3B) Survey (Courgeau, 1985a). Figure 3 shows that once more the confidence intervals match completely.

The effect of the other variables is limited, but remains similar to the effect when they were considered alone. Number of children has no effect, and the probability of moving increases when the period of residence considered starts less than 10 years after marriage. In the women's data set, the increase between 5 and 9 years only becomes significant at the 10% level. This is essentially due to low numbers of respondents: the coefficient is always positive. In any case, considering the confidence interval, this effect remains the same whatever the data set.

Substantial errors concerning date of move and duration of residence do not, therefore, result in a correspondingly substantial bias when we analyse probabilities of migrating by characteristics of respondent at beginning of residence considered. In most cases, the results were consistent for all the data sets, and the few differences we observed did not modify the principal results of our analysis.

II. – Analysis of the links between birth of first child and first move after marriage

We will now consider a more complex case of interaction between two events, one in family history (first birth after marriage), the other in migration history (first move after marriage). We thus combine errors

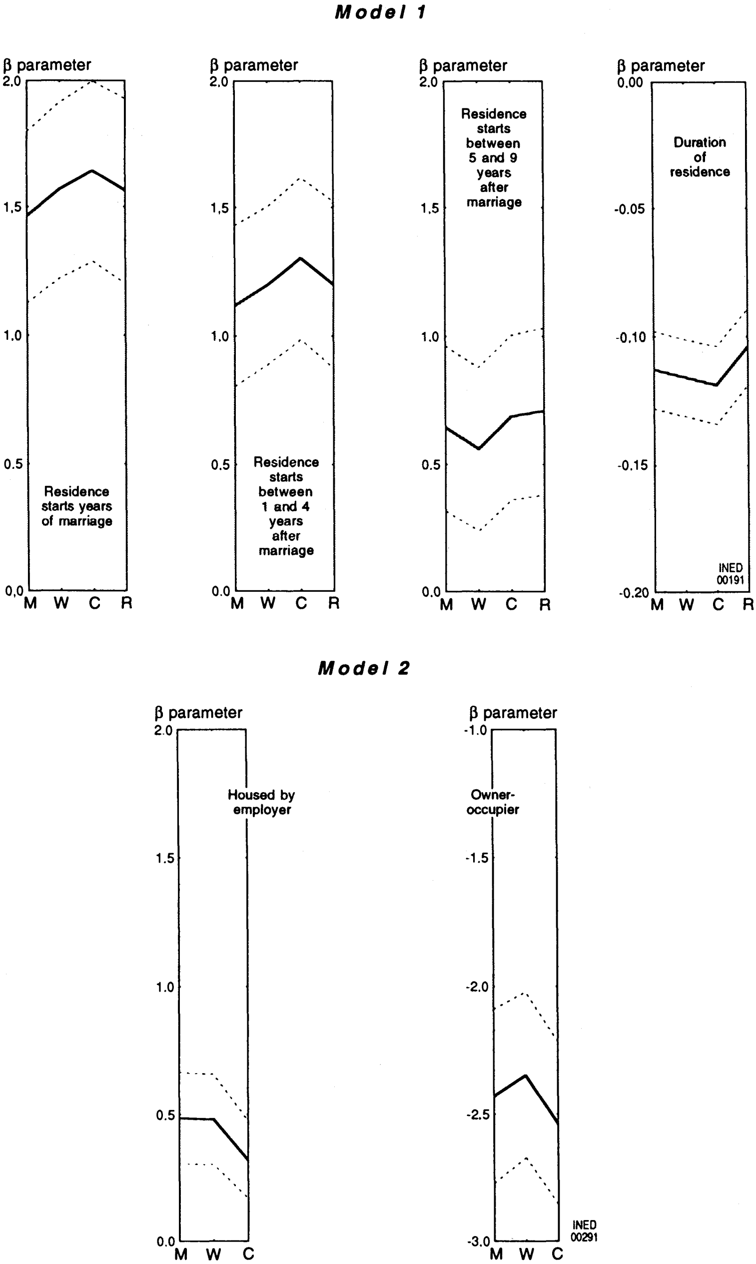

Figure 3. – Parameter estimates and 95% confidence intervals for the variables in Models 1 and 2, Table 2, by data set (M = Men, W = Women, C = Couples, R = Register)

concerning family events (marriage, birth of first child) and those concerning mobility.

This bivariate scheme is presented in Diagram 1.

We suppose here, because of low numbers, that the first birth probability is independent of age at first move after marriage ($h_{12}(t \mid u) = h_{12}(t)$) and that the first migration probability is independent of age at first birth ($h_{21}(t \mid u) = h_{21}(t)$). We also introduce certain characteristics, measured by a vector of observed variables Z or Z', and we use here a semi-parametric model, which is written:

$$h_{.1}(t;\beta,Z) = h_1(t)\exp(Z_1\beta_1 + H(t-u)(\beta_0^1 + Z_1'\beta_1'))$$
$$h_{.2}(t;\beta,Z) = h_2(t)\exp(Z_2\beta_2 + H(t-u)(\beta_0^2 + Z_2'\beta_2')) \qquad (4)$$

where the point represents the possible situations (0, 1 or 2), $\beta_1, \beta_1', \beta_0, \beta_0', \beta_2, \beta_2'$, are parameters to be estimated for the variables before (Z_1 and Z_2) or after (Z_1' and Z_2') the disturbance, $H(x)$ is the Heaviside function (0 if x is negative or 1 if x is null or positive). The parameters are estimated by the method of partial likelihood(3), which then permits the estimation of the non-parametric rates $h_1(t)$ and $h_2(t)$.

We first examine the effect of the first move, considered as a disturbance, on the probability of having a first child. Model 1, Table 3, gives parameter estimates for the different populations, when first moves are introduced alone. In all cases, they are positive and significantly different from zero, at least at the level of 10%, which indicates that the probability

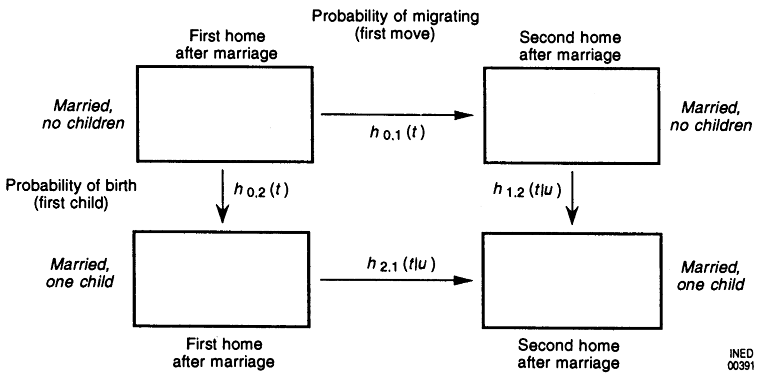

Diagram 1. – Birth of first child and first move after marriage

(3) For further details on this model, see: Courgeau and Lelièvre, 1989, pp. 70-84 and 155-165. We estimated it by using a computer programme called EVACOV written by E. Lelièvre.

TABLE 3. – EFFECT OF FIRST MOVE AND CHARACTERISTICS OF WIFE AT TIME OF MARRIAGE ON PROBABILITY OF FIRST BIRTH (PARAMETER ESTIMATES, WITH STANDARD DEVIATIONS IN BRACKETS)

	Men (434 observations)			Women (443 observations)			Couples (439 observations)			Register (395 observations)		
	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2
Model 1: First move		0.291*** (0.121)			0.268** (0.122)			0.274*** (0.117)			0.191* (0.117)	
Model 2: First move		0.117 (0.368)			0.247 (0.361)			0.208 (0.350)			0.313 (0.367)	
Women married before the age of 20	0.488*** (0.269)		−0.060 (0.534)	0.941*** (0.277)		−0.678* (0.510)	1.013*** (0.282)		−0.747* (0.514)	1.166*** (0.298)		−0.881** (0.521)
Women married at ages 20-21	0.361** (0.218)		0.130 (0.427)	0.445** (0.222)		0.073 (0.415)	0.398** (0.226)		0.078 (0.406)	0.447** (0.241)		0.034 (0.426)
Women married at ages 22-23	0.370** (0.211)		0.374 (0.423)	0.440** (0.218)		0.253 (0.409)	0.430** (0.221)		0.410 (0.399)	0.632*** (0.235)		−0.014 (0.417)
Women married at ages 24-26	0.456** (0.210)		0.107 (0.416)	0.594*** (0.212)		−0.170 (0.413)	0.581*** (0.218)		−0.170 (0.401)	0.720*** (0.233)		−0.354 (0.419)

* Result significant at 10% level.
** Result significant at 5% level.
*** Result significant at 1% level.

TABLE 4. – EFFECT OF FIRST BIRTH AND CHARACTERISTICS AT BEGINNING OF RESIDENCE ON PROBABILITY OF FIRST MOVE (PARAMETER ESTIMATES, WITH STANDARD DEVIATIONS IN BRACKETS)

	Men (434 observations)			Women (443 observations)			Couples (439 observations)			Register (395 observations)		
	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2	Main effect β_1	Effect of migration β_0	Inter-action β_2
Model 1:												
Birth of first child		0.311***			0.214**			0.201*			0.238**	
		(0.128)			(0.129)			(0.131)			(0.143)	
Model 2 :												
Birth of first child		0.365**			0.495***			0.393**			0.443**	
		(0.181)			(0.183)			(0.183)			(0.196)	
Women married before the age of 20	– 0.034		– 0.067	0.530*		– 0.764**	0.429*		– 0.695*	0.600**		– 0.918**
	(0.317)		(0.409)	(0.332)		(0.419)	(0.329)		(0.426)	(0.299)		(0.431)
Women married at ages 20-21	0.000		– 0.178	0.151		– 0.431*	0.026		– 0.250	– 0.009		– 0.160
	(0.211)		(0.274)	(0.215)		(0.272)	(0.204)		(0.268)	(0.213)		(0.283)
Women married at ages 22-23	– 0.135		– 0.020	0.190		– 0.465**	0.099		– 0.334**	0.194		– 0.431**
	(0.209)		(0.265)	(0.207)		(0.262)	(0.199)		(0.258)	(0.201)		(0.270)
Model 3 :												
Birth of first child		–0.246			0.119			–0.347*				
		(0.241)			(0.248)			(0.230)				
Women married before the age of 20	– 0.044		0.025	0.681**		– 0.859**	0.419		– 0.584*			
	(0.317)		(0.410)	(0.335)		(0.423)	(0.331)		(0.430)			
Women married at ages 20-21	0.019		– 0.168	0.241		– 0.433*	0.036		– 0.099			
	(0.215)		(0.275)	(0.218)		(0.275)	(0.210)		(0.270)			
Women married at ages 22-23	– 0.116		0.048	0.236		– 0.508**	0.086		– 0.280			
	(0.210)		(0.267)	(0.208)		(0.263)	(0.199)		(0.259)			
Housed by employer	0.202		0.919***	0.490***		0.656***	– 0.074		1.213***			
	(0.174)		(0.227)	(0.182)		(0.230)	(0.165)		(0.217)			

* Result significant at 10 % level.
** Result significant at 5 % level.
*** Result significant at 1 % level.

of having a first child increases after the first move. The increase is slightly lower for the population register data, but is not significantly different from the other sets.

We now introduce family variables, measured in each of the four data sets. We break the couples down by woman's age at marriage, which is known to influence fertility, as follows: women married before the age of 20, at ages 20-21, 22-23 and 24-26. Women who married after the age of 26 form the control group. The results of this second model are also shown in Table 3.

The parameters estimated before migration are positive in all cases, and differ significantly from zero. But the effect of wife's age at marriage is less clear when the husbands' data are used. For women married before the age of 20, in particular, first birth fertility is observed to be much higher when the information from women, couples and the population register are used. Apparently, men's memories are less reliable concerning how old their wives were when they married them.

This result is confirmed by the fact that, for men, the first move does not modify these effects, whereas with the other three data sets, this event significantly reduces the difference observed for women who married before their 20th birthday: the interaction coefficient is shown to be very slight for men and much more significant in the other data sets (Table 3).

Let us now examine the effect of fertility on mobility. In a first model in Table 4, the birth of the first child is introduced alone. All the parameters are positive and differ significantly from zero, which indicates that the probability of moving increases after the first birth. This result is also consistent with our earlier observations for France (Courgeau, 1985a).

We introduce in a second model the effect of woman's age at marriage, which we have used to study the effect of mobility on fertility. Once more, the results obtained using the husbands' responses differ from the others. Only the variable in model 1 remains significant for men, while the effect of woman's age at marriage does not differ significantly from zero. The results of the other data sets are consistent with one another: before the first birth, the probability of moving is higher for women married after the 20th birthday, but this effect disappears after the first birth; for women married at ages 22-23, mobility is reduced after the first birth.

These results confirm that men had problems recalling how old their wife was when they married. Their memory failure obliterates the effect of this variable on the first move after marriage.

Finally, we introduce tenure status (model 3, Table 4). In all four data sets, being housed by one's employer increases the probability of moving, particularly after the birth of the first child. The effect of woman's age at marriage is the same as in model 2.

Conclusion

The preceding article in this issue revealed considerable error in the retrospective life history data, in particular on migrations. However, the preliminary studies we present here suggest that these data are more reliable than it would seem at first sight.

We have undertaken non-parametric, parametric and semi-parametric analyses of the four sets of data available (survey responses from husbands, wives and the couples together, and data from the Belgian population register).

Non-parametric analysis of durations of residence in the different dwellings occupied since marriage yielded results which merge for the different sources, as our test shows.

Parametric analysis of the same durations of residence, introducing a number of variables at beginning of residence, also yielded results which do not differ significantly, whatever the data set or the variable considered. Misdating of information had no effect on the results of this analysis. The third technique, semi-parametric analysis, investigated interaction between first birth and first move after marriage.

Analysis of first births, with migration playing the role of the disturbance, gave similar results whatever the data set used. But the effect of woman's age at marriage was reduced when the husbands' responses were used. This was even more visible when first moves after marriage were analysed, taking first birth as the disturbance. Inaccuracies in husbands' responses concerning wife's age at marriage made this variable non-significant, while the results obtained from the other three data sets were consistent.

Thus, it was information on one of the variables concerning the spouse, in this case age at marriage, which yielded the least satisfactory results in this semi-parametric analysis of husbands' responses.

This would suggest that family and migration history data should be collected from women, or better still, from couples interviewed jointly. This increased the reliability of the data, and the results became consistent with those of the Belgian population register. Other considerations may, of course, come into play for occupational histories, but these could not be tested here because of lack of information in the population register; other sources must, therefore, be used (Bond *et al.*, 1988). There again, joint interviewing of spouses would no doubt produce the most satisfactory results.

Even if errors in the *dating* of past events are frequent, apparently these do not affect their *logical sequence*, or only very slightly so. This sequence is correctly memorized, and the errors only form a kind of background noise, which does not prevent coherent information from being drawn from all sources. Thus, memory seems to be reliable where the analysis needs it to be. However, it is preferable to collect information directly from the person who has experienced the event, rather than from a third party. Under these conditions, the kind of analysis we have undertaken here can be considered satisfactory. This conclusion naturally does not imply any judgment on the effect memory failure might have on radically different forms of analysis.

Daniel COURGEAU

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