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FAMSIM Austria

ÖIF

This issue of POPNET is published by IIASA in collaboration with the Austrian Institute for Family Studies (ÖIF).

The FAMSIM project has been carried out at the ÖIF by an international research team including Wolfgang Lutz (research director), Douglas Wolf (methodology) and Christian Kramer (software development) with partial funding from the European Commission and the Austrian Ministry of Family Affairs (BMUJF).

The purpose of the FAMSIM project was to demonstrate the feasibility of a microsimulation model based on standardized international data sets through the development of a FAMSIM prototype for Austria. As a next step the model could now be applied to other countries and used for internationally comparative purposes. It also can be expanded to include economic variables and other individual characteristics considered relevant by the users.

FAMSIM Austria is documented in a publication described in the box on page 3, which also discusses the applicability to other countries.

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A prototype dynamic microsimulation model for life course projections and an evaluation and comparison of family policies

There are strong arguments suggesting that we stand at the threshold of a rapid change in the social sciences where increasing computer power not only benefits business and the natural sciences and makes it easier to move a tiny robot on Mars, but may also present a qualitative leap for the analysis and projection of highly complex social behavior.

The main argument lies in the fact that it is now easier to immediately calculate and demonstrate the implications of certain hypotheses or assumed behavioral rules and evaluate their appropriateness under different conditions. This does not contradict the frequently expressed observation that in the social sciences the major bottleneck for analysis and projections has moved from data availability to availability of useful theories. In fact, one could argue that the availability of appropriate computer tools (micro- or macrosimulation) greatly enhances the specification of meaningful and testable hypotheses precisely because competing hypotheses can be compared in terms of the differing results they produce.

Increasing computer power allows qualitatively new approaches in very different fields of the social sciences. In this section an application in the field of microsimulation shall be presented. In the following sections the contributions in the field of probabilistic projections are other examples for this at the macrolevel.

The anticipatory (*ex ante*) evaluation of certain social policies is a promising field for the application of dynamic microsimulation (i.e., where large numbers of individuals are generated on the computer that follow specified behavioral rules and are

An easy-to-use family simulation model.

exposed to a set of assumed transition probabilities, e.g., from married to divorced). Such models make it possible to test a new policy in a virtual world instead of immediately implementing the untested policy in the real world and using the affected individuals as guinea pigs. Such immature policies may cause unnecessary individual hardship, unintended societal side effects as well as confusion, and costs due to necessary corrective measures.

History and Basic Concept

The microsimulation approach was introduced into the social sciences in 1957 when Orcutt (1957) proposed it as a new methodological tool, and it soon found its way into the field of policy planning. The basic concept is that social processes resulting from the interactions of larger numbers of individuals can best be studied by looking at the microunits and modeling their behavior. A great methodological advantage of this approach lies also in the fact that large numbers of presumably relevant individual characteristics can be attached to the individual.

Although Orcutt originally proposed a dynamic microsimulation model where a behavioral model is used to simulate the time path of the individual microunits (Galler, 1997), this turned out to be very time consuming and costly with the computer technology of that time. For this reason most policy applications only used static models in which a given sample of the population was used to estimate the effects of assumed policy measures without accounting for possible reactions to that policy. More recent microsimulation models tend to be dynamic but only a few of them are being used outside academic circles. Moreover, most existing models are very specific for a given country and cannot be transferred to other settings. They also do not tend to be user friendly in such a way that they could be easily operated by other people.

Hence the challenge for FAMSIM was to produce a user friendly and flexible tool that could be used in a large number of countries that have an equally structured empirical basis for the model.

The Family and Fertility Survey (FFS)

The Family and Fertility Survey (FFS) was conducted with comparable core questionnaires in more than 20 industrialized countries. It represents a unique opportunity for the development of a family microsimulation model reaching beyond individual countries. Coordinated by the UN Economic Commission for Europe in Geneva, the FFS is the first attempt since the World Fertility Survey (WFS) to conduct largely standardized fertility surveys in Europe and North America. The WFS interviewed only married women; the FFS includes male and female samples of all marital states in certain age groups. Most importantly for FAMSIM, the FFS takes an explicit event history approach, where parallel biographies are recorded for pregnancies, nonmarital and marital unions as well as education and work. In some countries such as Austria residential histories are also being recorded. Since changes in these histories are closely tied to each other (i.e., having a child and interrupting work) this biographic approach allows a much better causal analysis than traditional cross-sectional survey data.

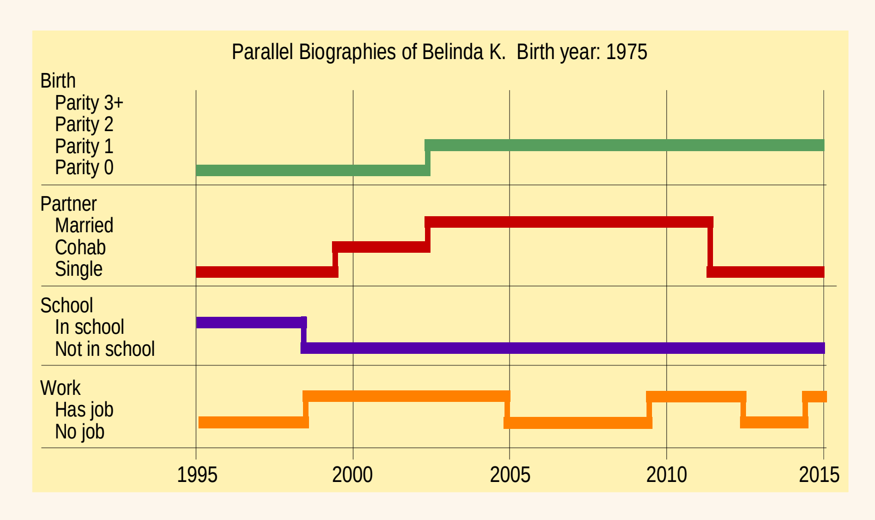

Figure 1. *One sample biography generated by FAMSIM.*

Projecting Three Parallel Biographies

While causal analysis focuses on explaining past events, FAMSIM projects into the future by continuing the individual biographies under certain assumptions. In particular it was decided to create these computer-generated individual biographies (see *Figure 1*) around three pillars: (1) pregnancy and birth histories; (2) union histories (marital or nonmarital co-residence); and (3) educational and work histories.

Table 1 summarizes the structure of the model used in FAMSIM. The rows of this table correspond with possible transitions in the three biographies. The columns indicate which status variables were taken as explanatory factors in the equations determining the individual transition probabilities. The parameters are estimated from the empirical event histories using logistic regressions that also include trend and curvilinear age effects.

Testing Alternative Policies

The simulation equations described above provide future individual biographies under the "business as usual" assumption that can be aggregated for summary indicators of proportions married, average

Table 1. *Life course transitions and their dependence on other state variables.*

	Transition	M	C	BI	P	PD	S	SD	W	WD
1	Not pregnant → month 1 of pregnancy			x	x	x	x	x	x	x
2	No partner → cohabiting partner or → married	x	x	x			x	x	x	x
3	Cohabiting partner → married (to same partner) or → no partner	x	x	x		x	x	x	x	x
4	Married → no partner	x	x	x		x	x	x	x	x
5	Not in school → in school	x	x	x	x	x		x	x	x
6	In school → not in school	x	x	x	x	x		x	x	x
7	Not working → working	x	x	x	x	x	x	x		x
8	Working → not working	x	x	x	x	x	x	x		x

The factors upon which transition probabilities depend are abbreviated as follows: M = month in pregnacy; C = parity (number of live births); BI = birth interval (months); P = partnership status; PD = duration of current partnership; S = schooling status; SD = cumulative amount of schooling; W = work status; and WD = cumulative amount of work. All the listed transitions depend, additionally, on age and calendar time.

number of children, etc. In a way, it is a projection that keeps observed relationships constant and only displays the impacts of structural effects and the estimated trend. The great potential of microsimulation, however, lies in the fact that one can easily "play" with the equations, i.e., assume that certain relationship or transition probabilities change due to external interventions or introduce certain behavioral rules. As described initially this feature makes it a very useful tool for the *ex ante* analysis of alternative policies. The model can then demonstrate the longer term consequences of such behavioral changes and how many people will fall into certain politically relevant categories (e.g., entitled to certain government subsidies) owing to these changes.

Further Developments of FAMSIM

The FAMSIM prototype, developed for Austrian data but with the potential of being applied to all other countries with FFS data or comparable surveys, is still a demographic/ occupation trunk model with many potentials for useful branches. The most obvious and desirable additions are to include income and to link partners. Since much of the discussion around family policies is concerned with financial aspects, a microsimulation model that does not explicitly include income variables will not be able to address these monetary issues. Unfortunately the FFS core questionnaire does not include detailed information on income. Ideally one would have an additional full biography of different types of income (own salary, partner's salary, transfers, etc.) but this is empirically unfeasible. Alternatively, one could use cross-sectional income information from other surveys. The European Community Household Panel (ECHP) is one such source that provides detailed income information for all 15 member countries.

There are two ways of introducing the income variable into FAMSIM. First, by using income only as an attribute of the individual. This is useful for studying the distributional aspect of certain changes, and how many individuals fall under the poverty line or are entitled to income-dependent government benefits. Second, income can be made endogenous and be one of the explanatory variables that drives the demographic/occupational transitions. Since the second aspect raises a large number of problems, both conceptually and empirically, work on FAMSIM-Austria is under way to include at least the first approach using data from the Austrian ECHP.

Another useful expansion would be to directly link partners with all their characteristics. So far having a partner is only an attribute of the individual. Such an expansion would allow the user to model more complex partnership dynamics.

International Application

One of the innovative features of FAMSIM is that it is explicitly designed for application to a larger number of countries, most directly to those with FFS data already available. With some modifications FAMSIM could also be based on other surveys that do include some basic biographic information. The software is very flexible and user friendly; the estimation of the behavioral equations for each country does, however, require some time and intellectual effort.

We hope that by developing the Austrian FAMSIM prototype the threshold for adopting such models to other countries will be significantly lowered. Interested institutions and individuals are welcome to contact us and discuss the issues involved.

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Galler, H.P. 1997. See publication outlined in box below.

The work of this project is documented in a forthcoming publication by the Austrian Institute for Family Studies (ÖIF).

FAMSIM-Austria

A prototype dynamic microsimulation model for the evaluation of family policies and projections based on the European Family and Fertility Survey (FFS).

Editor: Wolfgang Lutz

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Probabilistic Population Projections for Austria

By Wolfgang Lutz (IIASA/Austrian Institute for Family Studies), Sergei Scherbov (University of Groningen), and Alexander Hanika (Austrian Central Statistical Office)

The traditional way of dealing with uncertainty in future population trends has been to produce high and low variants of population projections, in addition to a medium variant. There are two serious problems with this approach. First, traditionally only fertility assumptions have been altered for the variants (which is still the case in the UN projections) while uncertainty in future mortality and migration trends remained unaccounted for. Second, the user is not really told what to make of the variants, whether they are supposed to give the bounds of the uncertainty range or simply represent alternative sample paths. Although the user is often explicitly warned that the variants should not be taken as confidence intervals, this seems to be the only logical interpretation for a user being confronted with a most likely case and a range around it.

Several statistical agencies, including the Austrian Central Statistical Office, have recently solved the first problem by considering alternative scenarios that assume different mortality and migration assumptions in addition to the fertility variants. However, little progress has been made so far on the second issue. This paper demonstrates a feasible way of transforming given expert views on the uncertainty about future fertility, mortality and migration trends into a set of fully probabilistic projections that provide the user with information about the likelihood of alternative future population trends. The methodology for doing so is briefly discussed in the following reprint of a *Nature* article and also in Lutz *et al.* (1996). A sensitivity analysis of some of the assumtions made in the application to Austria, as well as a comparison to alternative methods more heavily based on time series analysis, is given in Lutz and Scherbov (1997). Here only the results can be briefly outlined.

In the case of the Austrian projections, expert opinion on future uncertainty has already been defined through alternative fertility, mortality and migration assumptions for the regular nonprobabilistic projections. For these official projections the Austrian experts defined high, medium and low assumptions for the three components. (The low variant for life expectancy was defined for this study.) Since these assumptions turned out to be symmetric, three normal distributions could be determined. The only additional assumptions required concerned the range of all possible future paths to be covered by the high–low intervals. Further discussions with the Austrian experts resulted in the assumption of 90%

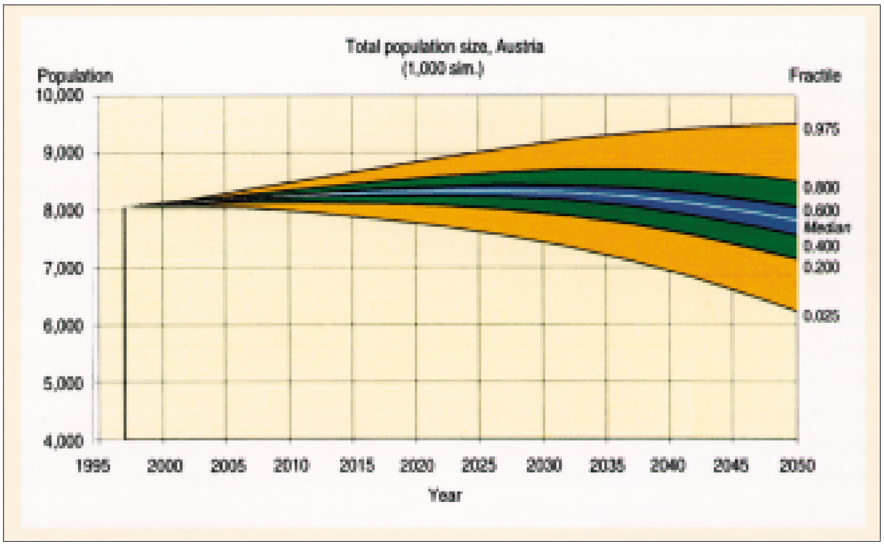

Figure 1. *Median and selected fractiles of the probability distribution of the total population size of Austria.*

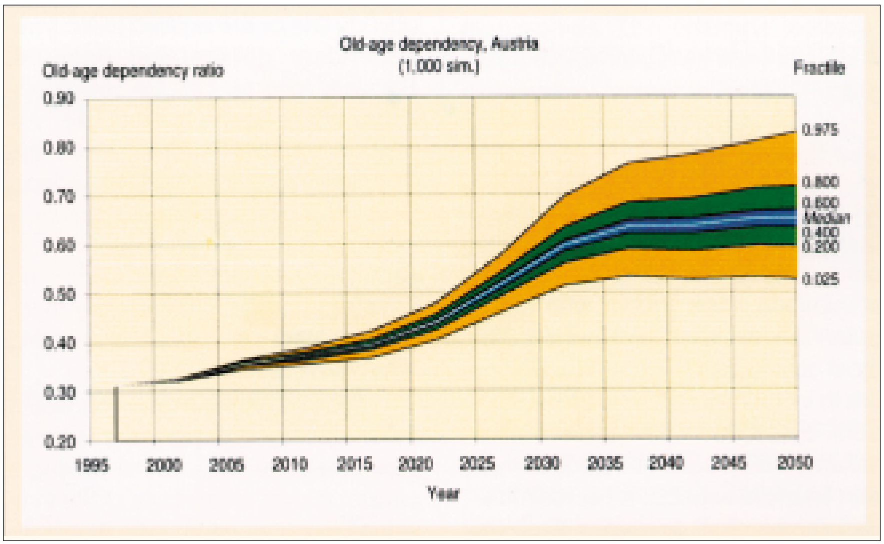

Figure 2. *Median and selected fractiles of the probability distribution of the old-age dependency ratio in Austria.*

between high and low values for fertility and mortality (sensitivity analyses with 85% and 95% show that the system is not very sensitive to slightly different percentages). In the case of migration only two-thirds (67%) was assumed because of the uncertainty about future developments in Eastern Europe. The projections were then performed by independently drawing 1,000 times from the three distributions and combining them into 1,000 cohort component population projections. Selected fractiles of the resulting distributions are shown in *Figures 1–3* and *Table 1*.

In summary, the results show that future trends in old-age dependency ratios are much less uncertain than those of total population size, because much of the future course is already preprogrammed in the present age distribution. The probabilistic age pyramid in *Figure 3* indicates that in 2030 the uncertainty is lowest for the cohorts born between 1955 and 1975 because they will not yet have entered the high mortality ages strongly affected by uncertainty about future old-age mortality. For the cohorts born between 1975 and 1997 the range increases owing to migration uncertainty. Of course, for the cohorts still to be born, fertility uncertainty plays a dominant role.

Such information about the degree of uncertainty by age groups is highly relevant, e.g., for present plans in Austria to change the financing structure of the pension system.

Figure 3. *Selected fractiles of the probability distribution of the Austrian age pyramid in 2030.*

This approach to probabilistic projections presents a direct evolution of the current practice of population projections in most statistical agencies and can build on the existing structures of defining assumptions. We anticipate great potential for other national statistical agencies following the Austrian example of "officially" publishing the probabilistic projections in addition to the conventional ones. This adds significant value for some uses of the projections (wherever a cost function is involved, such as in social security), without conflicting with the current practice of projections.

Table 1. *Fractiles of the probability distribution of the total Austrian population, proportion above age 60 and proportion below age 15.*

	1997	2010	2030	2050
Total Population				
Median	8.08	8.26	8.29	7.73
Inner 20%		8.22–8.30	8.17–8.42	7.47–7.99
Inner 60%		8.13–8.39	7.91–8.70	7.03–8.45
Inner 95%		7.95–8.55	7.37–9.22	6.08–9.52
Proportion above age 60				
Median	0.197	0.231	0.323	0.344
Inner 20%		0.229–0.232	0.318–0.328	0.336–0.353
Inner 60%		0.227–0.235	0.308–0.339	0.320–0.371
Inner 95%		0.221–0.240	0.287–0.362	0.290–0.416
Proportion below age 15				
Median	0.173	0.149	0.134	0.128
Inner 20%		0.148–0.152	0.132–0.138	0.124–0.133
Inner 60%		0.142–0.156	0.122–0.146	0.111–0.144
Inner 95%		0.132–0.165	0.104–0.162	0.088–0.164

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Reprint from *Nature**

Doubling of World Population Unlikely

Wolfgang Lutz, Warren Sanderson & Sergei Scherbov

Most national and international agencies producing population projections avoid addressing explicitly the issue of uncertainty. Typically, they provide either a single projection or a set of low, medium and high variants[1,2], and only very rarely do they give these projections a probabilistic interpretation. Probabilistic population projections have been developed for specific industrialized countries, mostly the United States, and are based largely on time-series analysis[3]. On a global level, time-series analysis is not applicable because there is a lack of appropriate data, and for conceptual reasons such as the structural discontinuity caused by the demographic transition[4-6]. Here we report on a new probabilistic approach that makes use of expert opinion on trends in fertility, mortality and migration, and on the 90 percent uncertainty range of those trends in different parts of the world. We have used simulation techniques to derive probability distributions of population sizes and age structures for 13 regions of the world up to the year 2100. Among other things, we find that there is a probability of two-thirds that the world's population will not double in the twenty-first century.

The probabilistic projections are based on distributions for fertility, mortality and migration in all regions, defined in terms of high or low values assumed to cover 90 per cent of all possible future outcomes. For today's high-fertility countries they are based on an assessment of their current standing in the process of demographic transition towards low fertility[7], together with information about reproductive intentions[8]. These data show that even in sub-Saharan Africa the fertility transition has started, and that it is well advanced in most other developing regions. The high and low assumptions for the years 2030–2035 are total fertility rates (TFR, the number of children per woman) of 4.0 and 2.0 in Africa, central Asia and the Middle East, 3.0 and 1.7 in southern Asia, Pacific Asia and Latin America and 3.0 and 1.5 in Central East Asia (mostly China).

Table 1. *Result of probabilistic projections for 13 world regions.*

	Total population (millions)				Population above age 60 (in %)			
			2050				2050	
Region	1995	Median	2.5%*	97.5%*	1995	Median	2.5%*	97.5%*
Africa								
North Africa	162	439	309	583	5.9	13.3	9.4	19.2
Sub-Saharan Africa	558	1,605	1,085	2,316	4.7	9.2	6.9	12.8
East Asia								
Central East Asia	1,362	1,865	1,351	2,574	9.2	24.9	17.8	34.1
Pacific Asia	447	796	579	1,047	6.8	19.4	14.4	26.5
Pacific OECD countries	147	146	117	182	19.4	39.5	31.5	48.7
West Asia								
Central Asia	54	137	88	206	7.8	15.4	10.2	24.0
Middle East	151	515	380	692	5.4	12.5	9.1	17.3
Southern Asia	1,240	2,368	1,833	2,970	6.7	16.6	13.4	20.8
Europe								
Eastern Europe	122	110	86	141	16.7	34.0	26.7	43.4
Former Soviet Union	238	188	144	241	16.9	34.1	26.3	44.5
Western Europe	447	471	370	584	18.6	35.0	27.5	43.9
Latin America	477	925	707	1,177	7.6	20.4	15.8	26.4
North America	297	403	303	534	16.4	30.2	24.0	38.6

Fertility, mortality and migration are assumed to be independent.

* Columns labelled 2.5% and 97.5% provide data on the lower and upper bounds, respectively, of the 95% confidence interval.

For today's industrialized countries the assumptions are based on a broad survey of possible future societal changes[9]. The United Nations and other institutions have assumed that fertility will eventually recover to replacement level (TFR slightly above 2.0), but there is little support for this view[10,11]. Accordingly, TFR values of 2.1 and 1.3 for Europe and the Pacific members of the Organization for Economic Cooperation and Development (OECD countries) and 2.3 and 1.4 for North America have been assumed for 2030–2035.

Assumptions for mortality were set in terms of increase in life expectancy at birth per decade. Contrary to earlier beliefs, there now is a considerable degree of uncertainty about the future course of mortality. In the industrialized countries this stems from the scientific dispute of whether we are already close to a biologically determined limit to life expectancy[12,13]. Accordingly, increases of 3.0 and 1.0 years have been assumed as the 90 per cent range. In the developing countries the uncertainty is more associated with future trends in AIDS[14] and other infectious diseases and the development of health services[15]. For certain regions possible problems with food supply have also been considered[16,17]. Consequently in such cases the assumed range of mortality improvement is wide, for example +4.0 to -2.0 years per decade in sub-Saharan Africa.

Migration is most difficult to handle because of unreliable data and high volatility[18]. For this study a matrix of constant annual interregional migration flows was assumed with the 90 per cent ranges covering two million to zero migration gains in North

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different parts of the world[21]. Their discussions produced a consensus about ranges in 2030–2035 that they thought would cover 90 per cent of all future paths of TFR, life expectancy at birth, and the interregional migration matrix[22]. Because the resulting distributions of assumed values turned out to be symmetric, normal distributions were fitted to those ranges. For each of the three variables, a single draw from a standard normal distribution determined its relative position within its range of future values at selected dates. The values at intermediate dates were determined by piece-wise linear interpolation. This method has been labelled a random scenario approach to population projection[23]. Experiments with less autocorrelated paths for each variable produced very similar means and medians and minor differences in variances[24].

Beyond 2030–2035, fertility was assumed to reach an average level of between 1.7 and 2.1 children per woman by 2080, with the specific value depending on population density in 2030 (the higher the density, the lower the fertility). The 90 per cent range around that value was set at 1.0 children. The range for life-expectancy increases after 2030–2035 was set to 0–2.0 years per decade. Smooth transitions of assumed future life expectancies at birth into age-specific mortality rates were performed by transforming baseline mortality patterns with the help of relational models[25]. Because separate baseline data were needed for males and females in each region, 26 patterns were used. Age-specific fertility rates were derived from the total fertility rates by using a fixed relative age profile of fertility. We used a fixed relative age profile for migrants to determine age-specific migration rates. The projections were performed in five-year steps on populations in five-year age groups.

An unusual feature of this global projection is the explicit consideration of possible correlations in fertility and mortality between and within regions. Four sets of 1,000 simulations were produced, resulting from a cross-classification of perfectly correlated/uncorrelated fertility and mortality trends across regions and within regions. The regional results presented in *Table 1* are from the set with uncorrelated trends. The global results are based on the merged distribution of all four sets of simulations, which make up 4,000 projections in total.

S. Scherbov, W. Lutz & W. Sanderson (left to right).

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