ÖSTERREICHISCHES INSTITUT FÜR FAMILIENFORSCHUNG
SCHRIFTENREIHE
AUSTRIAN INSTITUTE FOR FAMILY STUDIES

FAMSIM-Austria

Feasibility Study for a Dynamic Microsimulation Model
for Projections and the Evaluation of Family Policies
Based on the European Family and Fertility Survey

Wolfgang Lutz
(Editor)

NR. 5, WIEN, 1997
ISBN 3-901668-12-8

This volume describes the results of a feasibility study for a microsimulation model of family dynamics (FAMSIM) that could be applied to a number of countries utilising the rich data source collected in the context of the Family and Fertility Survey (FFS) in more than 20 industrialised countries. This also involved the development of FAMSIM-Austria, a prototype model based on the Austrian FFS conducted in 1996 by the Austrian Institute for Family Studies.

The nine chapters of this volume focus on:

ISBN 3-901668-12-8

FAMSIM-Austria
Feasibility Study for a Dynamic Microsimulation Model
for Projections and the Evaluation of Family Policies
Based on the European Family and Fertility Survey
Wolfgang Lutz (Editor),

Schriftenreihe des ÖIF Nr. 5, Wien, 1997
ISBN 3-901668-12-8

Eigentümer, Herausgeber und Verleger:
Österreichisches Institut für Familienforschung (ÖIF);
Geschäftsführer: Helmuth Schattovits;
Mit der Herausgabe beauftragt: Wolfgang Lutz,
Michael Mitterauer, Sieglinde Rosenberger;
Alle: Gonzagagasse 19/8, A-1010 Wien
Gestaltung, Layout und Grafik: Edith Vosta, 1050 Wien;
Druck: Melzer, 1070 Wien

Order from:
Österreichisches Institut für Familienforschung;
Gonzagagasse 19/8, A-1010 Wien; Tel.: +43/1/5351454

**Gedruckt mit Förderung des Bundesministeriums für Umwelt, Jugend und Familie
sowie der Bundesländer Burgenland, Niederösterreich, Oberösterreich,
Salzburg, Tirol, Vorarlberg und Wien
und der Österreichischen Lotteriegesellschaften**

**This project has received financial support from the European Commission (DG V)
and the Austrian Ministry for Family Affairs (BMUJF)**

Preface

The Austrian Institute for Family Studies (ÖIF) was founded in 1994, the International Year of the Family, in order to enhance interdisciplinary research on changing family patterns and related issues. It understands itself as an independent, non-profit organisation for interdisciplinary, scientific and application-oriented analysis of familial relationships and structures from the perspective of children, women and men. It applies a multitude of research methods ranging from qualitative to highly quantitative.

In this context, the FAMSIM project described here attempts to introduce a meaningful quantitative tool into the planning and evaluation of family policies, a field still characterised by strong emotions and ideological views. The study convincingly demonstrates the feasibility of a dynamic microsimulation model in this field which is based on the recent Family and Fertility Survey (FFS).

Through its participation in the international FFS project, which in Austria was carried our by the ÖIF in 1996, the institute could not only produce unique new data for Austria but also enhanced the international dimension of its work. FAMSIM which is based on the FFS and applicable to a large number of countries is hoped to further strengthen the international collaboration in this important and timely field of interdisciplinary family studies.

Wolfgang Lutz
Research Director
Austrian Institute for Family Studies

Contents

Chapter 1
Introduction: Purpose of FAMSIM

Wolfgang LUTZ

1.1. Computer, People and the Social Sciences

Computers can be used to do all kinds of things for work or fun. They are becoming an integral part of every day life for a rapidly increasing portion of the population. Yet one of the last things that comes to mind when talking about computer application is that they might be used to study and improve government policies. This, however, is the explicit purpose of FAMSIM.

Computers can also be used to generate new virtual people. Such computer-generated individuals are only partial, inadequate images of real people. They may, nevertheless, be generated in a way that they carry some of the characteristics of real people that we consider decisive in determining their own behavior and their impact on other people. One way of generating virtual people and having them behave according to certain characteristics and rules is dynamic microsimulation. As will be described in this volume, many things can be done with microsimulation.

We always have to be aware of the fact that any model is based on an extreme simplification of the real world. It can easily happen that an important dimension remains unaccounted for and therefore makes the behavior of the model unrealistic. Yet in the absence of any tools better than simplifying models, one can only try to constantly improve the model assumptions and give special attention to deviant behavior and potentially important influences that are not yet included in the model. If the model becomes too complex, on the other hand, there is a real danger that no one will understand what is going on inside the model; it becomes a black box, which for good reasons is not trustworthy.

Despite all the problems, 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, 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 book an application in the field of microsimulation will be presented, but there are other examples at the macro level.

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 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.

1.2. Why Produce A New Microsimulation Model?

The microsimulation model 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 micro units and modeling their behavior. A great methodological advantage of this approach as compared to macrosimulation lies also in the fact that large numbers of presumably relevant individual characteristics can be considered in the analysis.

Although Orcutt originally proposed a dynamic microsimulation model where a behavioral model is used to simulate the time path of the individual micro units (see Chapter 3), 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.

In Austria the idea of trying to produce a family microsimulation model was closely connected with the planning and execution of the Family and Fertility Survey (FFS) in 1995-96 when Austria decided to join the group of more than 20 industrialized countries conducting this standardized survey. When talking to government officials in an attempt to raise the significant funds necessary to conduct the survey, they asked the obvious question: How could this survey help them design more appropriate and more efficient policies?

The survey itself certainly gives important information on how women and men live, their biographies, their views on social and political issues, but it cannot be directly used to predict the consequences of certain political actions. Although the FFS cannot provide such information directly, it provides the kind of biographic data necessary to construct a meaningful model that can then directly address the question. This prototype version of FAMSIM also restricts its scope to younger adult women who are a key focus both of national family policies and the Familiy and Fertility Survey, which presents the empirical basis of FAMSIM. Men and children are therefore treated as attributes of women rather than independent entities. To directly simulate children and men is high on the agenda of future expansion of FAMSIM together with the inclusion of the financial dimension.

The most appropriate model for this kind of question is a dynamic microsimulation model. Hence the FFS and FAMSIM directly complement each other. FAMSIM can also be viewed as a way to continue into the future all of the individual biographies that have been recorded in the FFS but truncated by the interview. But since the future is inherently uncertain, and it is not clear today what social, economic or policy factor will determine behavior in the coming years, FAMSIM will produce alternative scenarios under alternative assumptions. The comparative analysis of the results of the different scenarios will allow the user to evaluate the effect of the alternative assumptions, be they new policies, new social trends, economic crises, etc.

These arguments convinced the Austrian Ministry for Family Affairs not only to sponsor the FFS but also to contribute to the development of a FAMSIM prototype for Austria.

An additional important feature of the proposal to develop a microsimulation model around the FFS was the opportunity to do this for a larger number of countries, since the FFS provides a standardized format. This aspect caught the attention of the European Commission in Brussels, whose mandate in the field of family policies also includes the development of tools that assist national policy makers. The more standardized these tools can be at the European level, the more useful they are and the better they serve European integration. This also opens the possibility for internationally comparative policy evaluations. It may well be that a certain policy or a certain behavioral change has very different consequences on family structures and female employment patterns, e.g., in Finland and Portugal (both countries participated in the FFS). Hence the Directorate General V of the Commission decided to cosponsor FAMSIM-Austria as the development of a prototype model that could then be implemented in other European countries. For this reason the last chapter of this volume will give special emphasis to the transferability of FAMSIM.

The FAMSIM-Austria project was carried out by the Austrian Institute for Family Studies (ÖIF) between July 1996 and July 1997. It began in July 1996 with a workshop at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg Castle (outside Vienna) that brought together international scholars of microsimulation with family researchers and Austrian government officials in charge of family affairs. Following that meeting work on FAMSIM was conducted simultaneously at three levels:

1) analysis of the FFS data and estimation of the behavioral equations, lead by Douglas Wolf;
2) development of a software platform, Micro-Sim, that should be appropriate for flexible FAMSIM applications, by Christian Kramer;
3) international networking through a series of visits to European capitals and discussions of FAMSIM at international scientific meetings.

Finally, in conjunction with the Second European Congress on Family Research in Vienna in June 1997, another international group of experts from a large number of European Union (EU) member countries came together to discuss the prototype version, suggest possible improvements, and consider options for applying FAMSIM to other countries. Several countries expressed serious interest. FAMSIM was also presented with a computer demonstration in the Viennese Hofburg at a meeting of family ministers under the auspices of the Council of Europe in June 1997.

1.3. Structure of the Volume

The work documented in this volume has primarily been a feasibility study for FAMSIM. Hence the volume does not not present final results but rather serves a dual purpose: 1) The research conducted under the project will be documented and communicated to international scholars in the usual way of scientific papers. 2) The potential of microsimulation in the field of family studies shall be presented and thereby possibly solicit its application to other countries. It is written in a way that can hopefully be absorbed by a much larger group of people than the traditional microsimulation community.

The volume begins with a concise review by Kathleen Kiernan of some of the major challenges to family studies and family policies in Europe, which have been at the center of her research interest for many years. She discusses some of the trends that have transformed European family patterns since the 1970s and identifies the problems of combining employment and family life as a key issue for public policies. Based on the increasing diversity in family life she also suggests that parenthood rather than marriage be made the primary policy focus.

Next comes a comprehensive introduction to microsimulation by Heinz Galler, who has been very actively involved in the development of the field since the 1980s. After a survey of the history and the basic concepts of microsimulation, the chapter describes some selected fields of applications in the social sciences, such as the evaluation of the fairness of pension schemes and the analysis of kinship networks in an aging society.

The following chapter by Douglas Wolf discusses some important technical issues in the design and implementation of dynamic microsimulation models. Wolf has been working with microsimulation for many years and recently addressed the issue of kinship networks. Here he discusses several issues relevant for the design of FAMSIM, including the choice of the starting population, rules for the evolution of life histories, "closed" versus "open" populations, and how to deal with different sources of uncertainty.

Chapter 5 was written by a team of researchers from the Austrian Institute for Family Studies (ÖIF). It introduces the data collected under the Austrian Family and Fertility Survey (FFS) which forms the empirical basis for FAMSIM-Austria. After a discussion of the survey design and sampling issues, selected results with respect to the three pillars of FAMSIM are discussed, namely partnership formation and dissolution, birth histories, and education/employment histories. This chapter also attempts to draw attention to some significant interactions between these three parallel biographies.

The following chapter by Douglas Wolf goes a step further by describing how the FFS data have been used to estimate the equations determining the individual transition probabilities in FAMSIM. This has been done on the basis of monthly observations throughout the event histories of all women in the sample. It also describes the estimated parameters and defines the microsimulation algorithm.

Although the original intention of the FAMSIM prototype was to restrict the dimension considered to the three pillars partnership, fertility and education/work, it soon became obvious that some of the potential users (especially politicians) were more interested in the monetary aspects of changing family structures than in the family dynamics itself that form the core of FAMSIM. Since income was not a priority concern of the FFS, some other ways must be found to introduce income variables into FAMSIM in a meaningful way, if the demand for monetary aspects is to be accommodated. Such considerations are summarized in Chapter 7 by Hans-Peter Kohler, an economist with a demographic background.

Chapter 8 gives a short introduction to the software of FAMSIM, which has been designed and implemented by Christian Kramer (a computer scientist working primarily in investment banking) mostly out of academic interest. Since flexibility was the overriding goal of the project, he developed a generic microsimulation toolbox (Micro-Sim) that provides the basic infrastructure for specific applications such as FAMSIM-Austria, but also for other applications. Another feature of the software is its high degree of user-friendliness.

In the concluding chapter, Wolfgang Lutz puts the FAMSIM-Austria project into the international context and discusses the potentials and difficulties involved in applying FAMSIM to other European countries.

References

Orcutt, G. 1957. A new type of socio-economic system. Review of Economics and Statistics 58:773-797.

Chapter 2
Challenges to Family Studies and Family Policies in Europe

Kathleen KIERNAN

2.1. Introduction

In many European countries the family is increasingly featuring in political and policy discussions arising from the developing pattern of family change that has occurred over the last few decades. Amongst these changes in family patterns are major demographic changes that directly influence the relationship between the family and public policy. These demographic changes include: fewer marriages, more cohabitation and more births outside marriage; increases in divorce, remarriage and reconstituted families; an increase in the proportion of lone-parent families; falling birth rates and smaller families; and an aging population. Alongside these demographic developments the other key and long-term trend which is having a fundamental effect on family life and the roles of men and women in society is the marked increase in the level of women's participation in the labor market. In this chapter we examine these demographic and economic developments and consider their implications.

2.2. Family Trends and Issues

2.2.1. Marriage and cohabitation

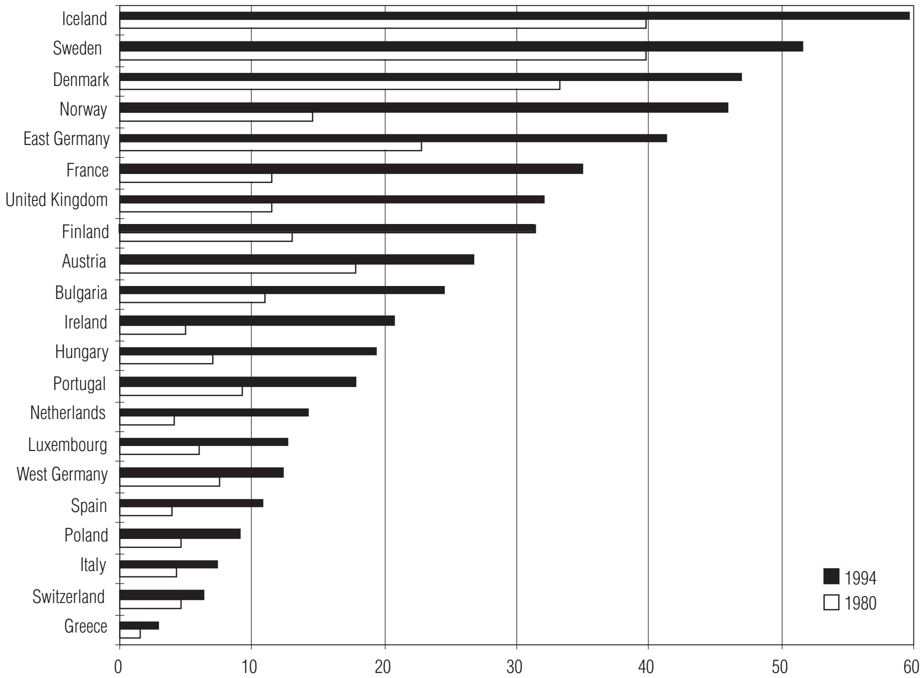
We commence with the formation of unions. Since around the beginning of the 1970s young people in most western European countries have been marrying at increasingly older ages and less of them are marrying, a trend that continues to the present day (see Table 2.1). The sharp falls in marriage rates have been accompanied by a rise in the proportions of young people in cohabiting unions such that in many European countries nowadays it has become almost the norm to cohabit before marrying. But, cohabitation is not the whole story in the decline in marriage rates. Young people are spending longer periods of time as solos than in the recent past, living with their parents, on their own or sharing with others. In fact young people's formal marriage behavior in the 1990s is more reminiscent of the marriage patterns of their grandparents or great-grandparents than of their parents' generation.

Table 2.1: Mean age at first marriage amongst women marrying in 1975 and in 1994. Source: Council of Europe, 1996.

Average age	Countries 1975	Countries 1994
29	-	Denmark, Iceland, Sweden
28	-	Belgium
27	-	Finland, Ireland, Netherlands, Norway, Spain, Switzerland, West Germany
26	-	Austria, East Germany, France, Italy, Luxembourg, United Kingdom
25	Sweden	Greece, Portugal
24	Ireland, Italy, Switzerland	
23	Denmark, Finland, Luxembourg, Portugal, Spain	
22	Austria, West Germany, Greece, Iceland, Netherlands, Poland, United Kingdom	Bulgaria, Czech Republic, Hungary, Poland
21	Belgium, Bulgaria, East Germany	
20	Czechoslovakia, Hungary	

Another major recent feature in family demography, which is likely to be related to developments in cohabitation, has been the increased separation of marriage and childbearing. The rise in extra-marital childbearing that can be seen in Figure 2.1 is probably intimately related to developments in cohabitation. In many northern and western European countries there has been a noticeable increase in the proportions of births outside marriage and in many of these countries extra-marital births are making a significant contribution to the Total Fertility Rate. Currently, there is a good deal of intra-European variation in cohabitation and extra-marital childbearing.

Figure 2.1: Extra-marital births (per 100 births).
Source: Council of Europe, 1996.



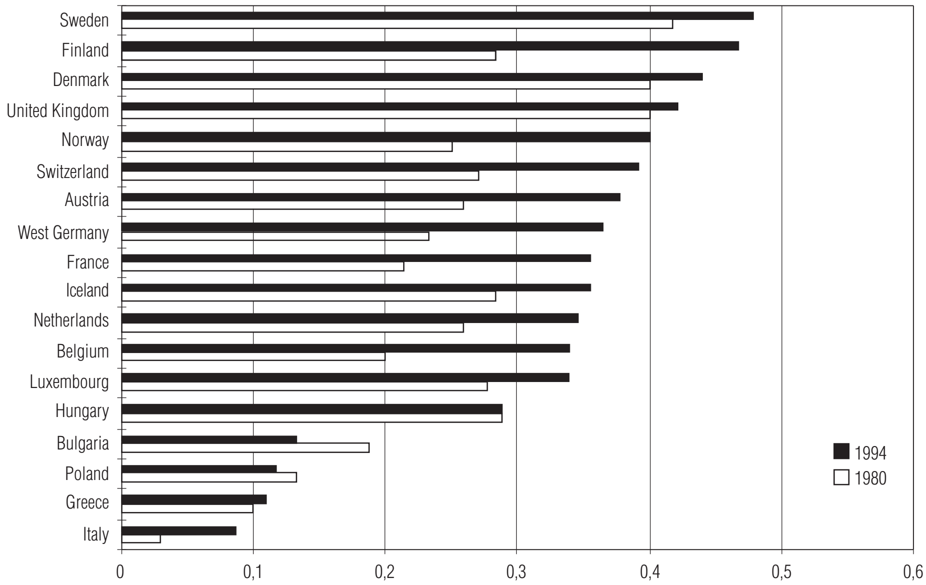
In the future many institutions, both public and private, will need to address the implications of rising levels of cohabitation, particularly if these unions become more long-standing and children are increasingly born and reared within them. The interesting question is how legal institutions will accommodate to the debate that in the simplest terms could be said to have two main points of view? One set argues that the legal distinction between marriage and cohabitation should be maintained as its removal would undermine the position of marriage. Another set would be reluctant to accord cohabitation full recognition on the grounds that it forces upon unmarried couples a legal framework, which by the act of cohabiting they may be trying to avoid. A similar debate raged in Sweden in the early 1970s and is still not fully resolved. Sweden is the country where cohabitation has been most long-standing and is most prevalent, but even here there is a reluctance to accord the same rights to cohabitants and married couples. Generally it would seem that countries with longer experiences of the cohabitation issue have tended to opt for legislative solutions that compensate cohabitants for drawbacks arising from being outside the legal framework, but mainly on an ad hoc basis.

There are also other issues which may be of concern. A major one is to what extent cohabiting unions and marriages are similar and to what extent they are different. How, if at all, do they differ with respect to responsibilities for partners and children, pooling of resources, the division of labor within the household and labor market participation, etc. Evidence is accruing which suggests that there are some differences between marital and cohabiting unions. For example, cohabiting unions are less stable; when these unions break up, fathers of children born outside marriage are less involved with their children on dimensions such as paying child support, visiting their children, and being involved in childrearing decisions than are fathers whose children were born within marriage. The consequences this may have for the children need to be further studied.

2.2.2. Divorce trends

Alongside the increasing separation of marriage and childbearing there has also been, with the rise in divorce, the increasing separation of childbearing and childrearing for at least one of the parents, typically the father. It is still the case that death terminates the majority of European marriages. However, marriages are increasingly being dissolved by divorce at a stage in marriage before death has made any significant inroad and at a stage in the marriage when there are likely to be dependent children. Divorce has increased since the 1970s and the extent of divorce across European countries during the 1990s is illustrated in Figure 2.2. If recent divorce rates were to continue it is estimated that in most countries in Europe the chances of couples divorcing would be around one in three. Sweden, Denmark, and the United Kingdom are highest at around two out of five; some of the southern European countries are lagging behind at one in ten or less. With the rise of cohabitation the issue of the dissolution of unions is becoming more complex as the true number of separations are not captured in official statistics on legal separations or divorce.

Figure 2.2: Total divorce rate. Source: Council of Europe, 1996.



As marriages are tending to break up sooner, as a consequence, more couples are likely to be childless but, amongst couples with children, the children are likely to be younger and thus exposed to spending longer periods of time in lone-parent families. As a consequence of divorce there has been a growth in lone-parent families, the residential separation of fathers from their children, remarried couples, and stepfamilies.

2.2.3. Effects of divorce

Divorce is perhaps one of the most significant social developments of recent decades and one of the major unresolved social issues that brings to the fore fundamental issues about the roles of men and women in society and the care of and support for children. For example, take the case of divorce legislation. Divorce legislation in many countries has been increasingly moving to the "clean break principle" placing greater emphasis on the desirability of the partners being self-sufficient so far as possible after the divorce. However, changes which promote post-divorce financial independence in turn need to reflect back upon arrangements within the marriage, as such changes tend to imply that both spouses should be prudent and maintain their market potential throughout marriage in case divorce should occur. But this is difficult if the couple become parents.

There can be opportunity costs to being born a female, but they are more so to becoming a mother, and whilst some argue that women's disadvantages are structural to society and husbands should not bear the costs in the event of divorce, others have argued that the disadvantages that women face because of having children by their husband, should be perhaps compensated for by him. Moreover, the foregone earnings of mothers who take time out of the labor market to care for their children could be seen as much of a cost of rearing the next generation of citizens as the money that is directly spent on children. The bearing and rearing of children undoubtedly reduces women's economic power which in turn leads to other economic consequences, such as lack of adequate personal pension rights.

The division of pensions or "pension splitting" on divorce or at the point of retirement is increasingly the subject of discussion and debate which arises because typically both spouses have not acquired comparable pension entitlements. The question of what claims, if any, ex-wives should have on a former spouse's occupational pension rights and how and when it should be divided is a major social policy issue.

This in turn raises issues with respect to remarriage or repartnering. Will men who re-marry have adequate resources to support two families, and if this is not possible, which of these families have recourse to state support. The answer has frequently been that the first family tends to have to rely on state support in the absence of other adequate sources of income? However, this is changing in some countries and the emphasis is increasingly being put on the responsibilities of biological fatherhood as opposed to social fatherhood.

2.2.4. Lone-parent families

The "modern European family" used to evoke a picture of a husband and wife and their children living together in one household. Nowadays, a variety of alternative images surround this central picture. One of these is the lone-parent family. Although the prevalence of lone parenthood varies considerably between countries as can be seen in Table 2.2, the proportion of families headed by a lone parent has been increasing. As yet, no western European country has attained the heights of the USA where over 1 in 4 families with children are lone-parent families. Various reports made for the EC (Roll, 1992; Bradshaw et al., 1996) show that the great majority of lone-parent families are headed by a woman (80-90 percent). The largest group of lone parents are those who have experienced a marital breakdown; the next largest group comprise widows, whilst lone mothers who had never been married but not necessarily never partnered were the smallest category. Overall, the majority of lone-parent families emanate from the break-up of either marital or cohabiting partnerships.

Table 2.2: Lone-parent families with at least one child of less than 15 years of age in the EC as percentage of all families with dependent children. Sources: European Commission, 1994; Bradshaw et al., 1996.

Country	1980/1	1990/1
Austria	-	15
Belgium	9	15
Denmark	18	20
Germany	10	15
Greece	4	6
Spain	5	8
Finland (93)	-	16
France	8	11
Ireland	7	11
Italy	7	6
Luxembourg	9	12
Netherlands	8	16
Portugal	12	13
Sweden (90)	-	18
United Kingdom (92)	14	21
United States (91)	-	29

Living in a lone-parent family is not necessarily a permanent arrangement. The broad evidence that we have suggests that over one-half of lone parents leave the lone-parent state within five years: through remarriage, children leaving home or children attaining ages when they are no longer classified as children. This may seem a short time in the lives of adults, but for children five years is a substantial part of childhood. With respect to remarriage, we note that remarriage rates have taken a downturn, after an initial upsurge in the early years following the enactment of more lenient divorce legislation which occurred in most European countries in recent decades. Some of this decline may well be due to post-marital cohabitation becoming more common.

2.2.5. Reconstituted families

Being reared by a lone parent is frequently not a long-term arrangement as a substantial proportion of divorced persons eventually remarry. Men are even more likely than women to remarry and are also more likely to remarry more quickly after a divorce. Divorced men as well as being more likely to remarry are also more likely to cohabit than are divorced women. Remarriages are also at greater risk of dissolving than are first marriages. We do not know whether different types of reconstituted and blended families have greater risks of breaking up but there is some information from the United States which suggests that the risks increase with the complexity of the re-formed families. For example, couples in which only one of the parties has been previously married and where there are no stepchildren have the lowest risk, whilst those marriages where both husband and wife are remarrying and where there are stepchildren have the highest risk.

2.2.6. Children in families

As a consequence of these demographic changes children are increasingly experiencing a variety of family settings as they pass through childhood and adolescence. The implications of these changing circumstances for the welfare and development of children both in the short and the more long term have yet to be fully assessed. If one thinks about a family, there are two main perspectives on divorce, one from the standpoint of the spouses and the other from that of the child. The link between spouses may be severed but the generational link between parents and children continues. With the growth in divorce, more and more children are experiencing the break-up of their parents' marriage, more are spending part of their childhood in lone-parent families (typically a lone-mother family), and these families frequently convert into stepfamilies, formed through cohabitation or remarriage. Information on the differing family circumstances of children tends to be rare. But there can be little doubt that increasingly European children are experiencing a variety of family settings as they move through childhood and adolescence. One might ask what effects if any do these changes have for the lives of these children?

There is a good deal of evidence that children who experience the break-up of their parents' marriage or union are more likely to experience poverty or reduced economic circumstances than children who grow up with both natural parents. The financial exigencies associated with marital breakdown arise from the precarious economic position of lone mothers, with whom most children reside, and the dis-economies of scale associated with the maintenance of two households, when fathers live apart from their children. The low incomes of lone-mother families are due to a combination of factors: low earnings from employment, lack of or low levels of child support from the natural father, meager or inadequate state support.

Parental divorce and its aftermath is a major factor in the collective make-up of the generation of children born since the 1970s in northern European countries (as it was for the generations born since the 1960s in the USA and from whose experiences much of our knowledge on this topic emanates) and is being increasingly experienced by the generation born during the 1980s in many other European countries. Within Europe the demographic, social, psychological and economic determinants and consequences of this development have as yet received little attention.

2.2.7. Becoming a parent

The three major and recent themes in the transition to parenthood in European societies are later entry into parenthood, lower probabilities of parenthood and as discussed above, greater probabilities of having a child outside marriage. Across most European countries in recent decades there has been a movement to later entry into motherhood. Information on becoming a father is rare but we assume that trends have followed the same general direction as that seen for motherhood.

Changing fertility patterns have short and long term effects. Significant shifts to an older age pattern of childbearing has implications for the obstetric and gynecological services as women having their first child in their thirties, other things being equal, require more medical resources. On the other hand, they will have contributed more taxes and national insurance contributions prior to becoming mothers than women who become mothers at a younger age. For the children there are also economic and psychic consequences of having older parents. Fertility patterns are the main engine driving the age distribution of the population, and changes in the timing of childbearing and declines in fertility affect, for example, the planning of hospitals, schools and the housing market.

A later start to parenthood may be driven by both positive and negative impetuses. A later start allows young people to acquire more educational and occupational training as well as higher savings and incomes. Additionally, later marriage and parenthood are associated with lower risks of marital breakdown and later motherhood is also associated with a greater attachment to the labor market, which in the event of divorce may lessen the deprivations that are a frequent accompaniment to divorce. On the other hand, in an era of rising expectations, couples may be postponing having children because raising children is expensive, and many families may feel that they need two employed adults to provide a decent standard of living for themselves and their children. Moreover, women have become increasingly committed to being in the labor market, and leaving the labor force for extended periods has become less popular. Faced with such dilemmas and economic stresses including uncertain job prospects and low incomes, some couples may postpone having children to later than they would ideally wish, have fewer children or none at all.

2.2.8. The aging population

The final important demographic change is the aging population. The major factors contributing to this aging population are the downward trend in the number of births and increasing longevity. Aging populations are likely to affect policies in a number of ways. First, it means an increased proportion of social security resources and expenditure will have to be allocated to ensure an adequate income for the elderly, thereby possibly competing with the amount available for other groups such as children, lone-parent families, the unemployed, etc. Secondly, it raises the whole question of who cares for the elderly, including family support for elderly relatives particularly in the light of the growth in women's labor force participation.

2.3. Employment Trends, Patterns and Issues

Alongside these demographic developments, the other key and long-term trend which is having a fundamental effect on family life and the roles of men and women is the marked increase in the level of women's participation in the labor market. A generation ago the most common pattern of employment amongst women was either to leave employment permanently when they had their first child or to have a break in employment during the childrearing years and then return to paid work. Few women had continuous employment throughout their lives. In contrast, today in the Nordic countries of Denmark, Sweden and Finland as well as in France and Portugal, continuous employment is the most common pattern, whereas, in Germany, the Netherlands and the United Kingdom, a break in employment for children, particularly in the early years of their lives, is the most frequent pattern. In other countries there are noticeable differences according to age: older cohorts of women left employment when they had their children, while the younger cohorts of mothers appear to be moving towards a more continuous pattern. The combination of employment and motherhood is likely to become the normal experience for most European women. Nevertheless, across Europe there continue to be differences in the labor market experiences of men and women which arise from the advent of motherhood.

The growth in women's employment is probably altering the economic arrangements between men and women. Women may increasingly be taking a greater share of the economic support of the household, and men's prime responsibility is likely to have lessened. The proportion of women who depend on men and their degree of dependence may well decline further in the future, as women acquire more education, make more inroads into a wider range of occupations, progress up the occupational and political hierarchies, and take less time out of the labor market to care for young children. Until men and women become financially autonomous, public policies will have to live with the legacy of existing regimes in which marriage both fostered financial dependency but also offered financial protection for women and children.

2.4. Work and Family Life

In recent years the growth in the labor force participation of married women with children, and increasingly young children, a trend that, other things being equal, is unlikely to go into reverse, has reduced the extent to which mothers are available to organize and support the home and care for family members. As a consequence, the tension between family and work may have become more severe. Moreover, such difficulties may be one of the important engines behind the growth in childlessness, delayed childbearing and reductions in fertility levels that have occurred across Europe in recent decades. The psychic costs of combining work and caring for young children may lie behind some illuminating findings from the 1990 Eurobarometer Survey (Kempeneers and Lelievre, 1992). Results from this survey suggest that if women and men in the community at large were given a completely free choice, about 8 out of 10 women and 4 out of 10 men would prefer not to work full-time when their children were under school age.

The modern European family is, and is likely to be increasingly headed by two workers rather than one. Female economic activity rates have increased and are likely to increase further. Today's young women have aspirations in terms of paid work and future employment patterns, which in some countries threaten traditional public policy assumptions about a 'woman's place' and her 'natural role' in relation to home and care. Some of the obvious implications are how to reconcile work and family life.

Family well-being is remarkably dependent on an economy in which families can earn an adequate income from work. Employment is the main source of economic support for families and plays a pivotal role in the lives of both men and women. However, work can also constrain family life by limiting the time available for family tasks and interaction between family members, and conversely the obligations and responsibilities of family life may act as a constraint on labor force participation. Moreover, competing pressures of work and family obligations may make for inefficiencies both in parenting and employment.

Nowadays, most mothers are employed outside the home, a long-term trend that is unlikely to go into reverse or be reversible. Whether a mother continues in paid work or returns to the labor market after time out to care for children partly depends on the balance between the income that employment brings and the financial costs of childcare. The decision of a mother to work also depends on social and psychic costs and benefits related to her own needs, the needs of her children and the needs of the family unit. For a lone mother with no alternative source of income, the financial factor may be of critical importance.

Research on the effects of maternal employment on children has largely examined the impact on children's academic performance and achievements. The findings in relation to this issue tend to be ambiguous, contradictory and weak. There is no robust evidence that maternal employment negatively or positively affects a child's educational achievement. In the USA, where this issue has received more attention, the general consensus among those who maintain that maternal employment affects the child's performance in school is that subgroups of children must be considered separately because employment has different meanings for a child depending on their home environment.

Recognizing that the worlds of work and family are interdependent implies the fostering and development of policies that ease the tensions between the two domains. Such policies are well rehearsed and include: maternity and ideally parental leave; flexible hours of work including part-time employment; more flexibility in family leave to care for sick children and other dependents; affordable quality child-care, including the provision of nursery schools and after-school care; tax concessions and child benefits and allowances. These policies directly and explicitly support families with children and give recognition to some of the costs in rearing the next generation. In the future they will also need to consider the responsibility of employees to care for their aged parents.

2.5. Conclusion

The changing demography of families, an aging population, the rise of dual worker families as well as families with no workers, which is also unfortunately increasing in many European countries, require improvements and amendments to and the coordination of social welfare policies, child-care policies, employment and pension policies that support and develop families in this fast changing social and economic climate. The increased diversity and turnover in family life which largely emanates from partnership changes makes policy built on marriage increasingly problematic and suggests that parenthood rather than marriage may be a better primary policy focus, and that parenthood rather than marriage contracts underpin family relations.

References

Bradshaw, J., S. Kennedy, M. Kilkey, S. Hutton, A. Corden, T. Eardley, H. Holmes, and J. Neale. 1996. Policy and the Employment of Lone Parents in 20 Countries. The EU Report. Social Policy Research Unit, York, U.K.

Council of Europe. 1996. Recent Demographic Developments in Europe: 1996. Council of Europe, Strasbourg, France.

European Commission. 1994. Social Europe 1/94: The European Union and the Family. Office for Official Publications of the European Communities, Luxembourg.

Kempeneers, M. and E. Lelievre. 1992. Employment and the Family. Eurobarometer 34:1990. Study published by the European Commission, Luxembourg.

Roll, J. 1992. Lone Parent Families in the European Community – A Report to the European Commission. Family Policy Studies Centre, London.

Chapter 3
Microsimulation: History and Applications

Heinz P. GALLER

3.1. Historical Background

The introduction of the microsimulation approach into the social sciences can be dated rather precisely. In 1957, Guy Orcutt published an article in the *Review of Economics and Statistics* (Orcutt, 1957) in which he advocated this approach as a new methodological tool. Based on these ideas, the first (dynamic) microsimulation model for the US was developed in the following years at the Urban Institute and was published in 1961 (Orcutt et al., 1961). The core of the model consisted of a demographic module that simulated a sample of individual persons and their marriages. In addition, some relations were developed in order to extend the model to simulate education, labor force participation, consumption, and saving. But these relations have not been included into the simulation runs that were restricted to the demographic processes. The simulations were performed on an IBM 704 computer with a total of eight kilowords of core memory and drum storage, respectively.

Orcutt's basic idea was, that socio-economic processes that result from interactions of a large number of decision-making micro units can be explained best by looking at the micro units and their behavior. He expected to find more stable behavioral relationships on the micro level than can be found in aggregated data that are affected by structural changes when the number or size of the micro units in the population changes, even if the behavior of the individual micro unit does not change. An additional, more methodological, argument in favor of the micro approach was that the precision of empirical estimates depends crucially on the number of (independent) observations that can be used for estimation. If micro units are observed, the number of observations and, as a consequence, the precision of the estimates are increased dramatically as compared to estimates that are based on comparatively few observations on the level of aggregates (Orcutt, 1986). Finally, the micro approach allows for much more detailed hypotheses since, in general, much more structural information is available about micro units, for instance in survey sample data, than can be obtained from more aggregated data sets.

Before being introduced to the social sciences, the concept of microsimulation had been developed in the natural sciences, especially in thermodynamics, in fluid dynamics and in the nuclear sciences. In these fields the dynamics of the macro system result from complex interactions of a large number of micro units or particles. Thus, in order to fully understand the dynamics on the macro level, (simulation) models were developed that derive the behavior of the system from the processes on the micro level of individual particles. Since many problems in the social sciences have a similar structure, it is quite natural to transfer the concept of microsimulation modeling to the social sciences. Most social processes result from the interaction of a large number of individuals in the society and depend strongly on the behavior and on the characteristics of these micro units. Thus, one would expect that these processes can be explained best by modeling the behavior of the micro units.

An additional argument in favor of the micro approach is that in policy planning, many problems depend on detailed structural characteristics of the population and on the dynamics of these structures. Examples are tax-transfer programs, where in general both budgetary and distributional effects of a specific program depend on the structure of the contributors and beneficiaries of the program. The same is true for housing policy, where housing demand depends on the dynamics of family size and composition and of other socio-economic characteristics like family income. In order to get reliable estimates of the effects of a given program, detailed information on the population structure and its dynamics is required.

Since the construction of dynamic microsimulation models, according to the original concept of Orcutt, proved to be rather time consuming and costly, static microsimulation models have been developed as a simplified approach that has become rather popular for applied policy analyses. While in a dynamic approach, a behavioral model is used to simulate the time path of the individual micro units in the sample, in a static model a given sample of the population is used to estimate the effects of changes in institutional regulations or other policy measures. Basically, the impact of different measures is calculated for the individual units in the given sample and then the results for the individual units are aggregated to some output variables. Changes in the population structure are taken into account by simple re-weighting of the sample units or re-scaling of variables like income and expenditures. To some extent attempts are made to take account of second round effects that result from behavioral response of the micro units. But in general, static microsimulation uses comparatively simple model structures to generate estimates of the impact of policy measures. Since changes in the population structure are not modeled explicitly, the application of static microsimulation models is restricted to short-term analyses.

Also within the dynamic approach to microsimulation, a differentiation of models has taken place in response to computational constraints. Besides the dynamic simulation of cross-sectional samples, models have been developed that are restricted to the simulation of a sample of members of a given birth cohort. These models are called cohort models or longitudinal models as compared to cross-sectional microsimulation. Models of the longitudinal type are used to generate a sample of individual biographies that are used for instance for analyses of intertemporal income redistribution by social security systems over the individual life cycle. The advantage of the longitudinal approach is that only a comparatively small sub-sample of the total population must be considered in the simulation. If the same problem is investigated using a cross-sectional approach, the micro units of a large sample must be simulated over a long period but finally only the information on a single cohort is actually used for the analysis. Thus, the cross-sectional approach implies large overhead costs that can be avoided by restricting the simulation to the cohort being considered.

However, if the main interest is on the long-run dynamics of the population structure and its impact, for instance, on the labor market, on housing demand or on the pension systems, dynamic cross-sectional microsimulation models are required. This is, for instance, the case if estimates of the long-run dynamics of total revenue and expenditure of the social insurance system is required. Since computing costs have dropped substantially in the last years, cross-sectional microsimulations of this type can now be generated at much lower costs as compared to fifteen years ago. As a consequence, interest in dynamic cross-sectional microsimulation has gained new momentum with some new models being under construction.

3.2. Basic Concepts

The basic idea of micro-based analyses was developed in the social sciences long before. For instance, it is the starting point of the neo-classical approach to economic theory that tries to explain economic processes in a market economy from the decisions of individual firms and households. However, a general problem of the traditional micro approach is that it is difficult to implement if there is a large number of micro units to be considered. Thus, rather restrictive simplifications had to be adopted to make the approach feasible. A common simplification is the concept of a stylized "representative micro unit" which is supposed to represent the "average behavior" in the population. This approach has proven to be useful for a basic understanding of the processes, but it is not sufficient for quantitatively modeling the specific dynamics of an observable process. In the "real world," the micro units are heterogeneous in the sense of differing characteristics and of behavioral differences that are of great importance for the outcomes being observed. This is especially true if programs depend in a "non-linear" way on the characteristics of the micro units as is typically the case in transfer policy, where entitlements or contributions depend on income and other characteristics in a complex way. Thus, especially for quantitative policy planning, the approach of the "representative unit" is not sufficient, but models are required that enable to capture the effects of a specific population structure and of heterogeneity of the micro units being involved.

The basic innovations of the microsimulation approach as compared to traditional micro-based theory are the sample representation of heterogeneous populations and the application of numerical simulation techniques as a tool for solving a model. In microsimulation models, the population is represented by a data file containing the characteristics of a random sample of micro units. This sample representation avoids the problem of the "curse of dimensionality" that poses a restriction on all models that use some kind of contingency tables to represent the population structure. If an additional characteristic is considered in a contingency table, the number of cells in the table is increased by a factor that is equal to the number of different values the additional characteristic can take. Thus, the number of cells in a table "explodes" even if only a few characteristics are considered at the same time. If only ten characteristics are considered, of which each has ten different values, the total number of cells will exceed the current size of the population of the world. As a consequence, models based on the contingency table approach can only take a few characteristics into account at the same time.

In contrast, in the sample representation of the population, the size of the data file is a linear function of the number of characteristics being recorded in the file. Thus, each micro unit in the sample can be represented by many variables that give detailed information on the characteristics of that unit without making the approach infeasible. Current microsimulation models contain up to more than one hundred different variables for each individual micro unit. This rich information can be used for a rather detailed model structure that uses all structural information that is available to estimate the outcomes that are of interest. The corresponding aggregated outcomes and the structure of the population then are derived from such a sample data file by aggregating the microdata into statistical measures like frequencies, means, quantiles or similar quantities. However, the additional structural detail is obtained at the cost of some sampling errors. While a contingency table can give a precise description of the population structure—if it is derived from a census of the population—estimates from a random sample contain some sampling errors. However, the size of the sampling errors can be controlled by the sample size, and in general a relatively small sample will provide estimates of sufficient precision that can be used for decision making.

Modeling the micro units of a heterogeneous population is in general not feasible using traditional analytical instruments like calculus. However, with the advent of powerful computing technology, models can be solved numerically for a large number of different configurations of variables and parameters. Using numerical simulation techniques, a specific solution of a microanalytic model can be generated for each individual micro unit in a large sample from the population being considered. Thus the effects of heterogeneity of the micro units on the estimates can be taken into account just by applying the model to the different units in the random sample. Typically, in microsimulation models, Monte-Carlo simulation techniques are used that generate the outcomes for the individual micro units in a probabilistic way conditional on the probabilities of the outcomes that are implied by the model. Thus, the outcomes of the simulation for the different micro units can be considered again as a random sample of the outcomes that would be observed in reality as a result of the process being modeled. This enables the generation of sample data conditional on the process being modeled and to infer about the implications of the process from the resulting sample data file. For example, if in the model a change in nuptiality is assumed, the consequences for the structure of families and households, for labor supply and finally for the pension system can be inferred from the sample data that are generated by the model.

A great advantage of the simulation approach is that rather complex model structures can be used that could not be solved analytically. Basically, all types of relations can be used in a simulation model as long as it is possible to code them into a simulation algorithm. This allows for general non-linear relations as well as logical relations or other non-standard model structures. Thus a microsimulation model gives much more flexibility than traditional analytical approaches to modeling. However, this is paid for by a loss of generality of the results since a simulation is always based on a set of specific assumptions about the parameters and the model structure and as a consequence will only allow to infer about the implications of this specific set of assumptions. Thus, in order to explore more general properties of the processes being considered, multiple simulations based on different assumptions must be compared.

The sampling approach and the probabilistic simulation techniques used in microsimulation models generate some random variation in the model results. The main sources are sampling errors and Monte-Carlo variation of the simulation procedure. In general these errors can be considered as random errors. But since rather complex model structures are used in most cases, the distribution of these errors in general cannot be derived analytically. However, statistical techniques like sample-reuse, jackknifing and bootstrapping can be applied in order to estimate the extent of simulation errors (cf. Cohen, 1991). Like sampling errors, the Monte-Carlo variation in the simulation results can be controlled by the choice of the sample size. If a larger sample is chosen, the random variation in the results is reduced approximately proportional to the square root of the sample size (Galler, 1994b). Thus, in principle almost any degree of precision of the estimates can be obtained, however, at the price of additional computing.

3.3. Microsimulation Applications

3.3.1. An overview on microsimulation activities

After the pioneering work of Orcutt, the development of dynamic microsimulation models proceeded slowly for some time due to limitations of the available data bases and of the computing technology. However, with the increasing availability of large microdata sets and the rapid development of computing technology, especially the introduction of microcomputers that made big computing capacities available at much lower costs, the interest in microsimulation methods has increased rapidly in the last decade.

The first static microsimulation models for tax-transfer analyses were the OTA, the TRIM/TRIM2 and the MATH models in the US, that have been in use since the 1970s and have been maintained since that time (cf. Cilke and Wyscarver, 1990; Webb et al., 1990; Beebout, 1986). Today, static microsimulation models have become a standard tool for tax-transfer analysis in most countries, that is used by both government agencies and scientists (cf. OECD, 1988; Brunner and Petersen, 1990; Mot, 1991; Spahn et al., 1992). During the last years, rather comfortable simulation packages have been developed for microcomputers that simulate the impact of changes in taxes or transfers very easily. Examples are the SPSD/M and the STINMOD models that have been developed by Statistics Canada (1988) and NATSEM (1994) in Australia, respectively, and are distributed for use by political decision makers. Another important model in this area is the POLIMOD model that has been developed at the Microsimulation Unit of the University of Cambridge (Redmont et al., 1995).

Due to the more complex structure and the larger costs of development and maintaining, dynamic microsimulation models have not spread as rapidly as the static approach. In the 1960s and early 1970s a number of small, purely demographic models were developed. At the University of Gothenburg, Hyrenius and colleagues constructed a dynamic reproduction model (Hyrenius and Adolfsen, 1964). The POPSIM model was used for the evaluation of family planning programs (Horvitz et al., 1972). Kinship relations in small populations have been simulated by the AMBUSH model (Howell and Lehotay, 1978). Another example is the REPSIM model for studying natality (Ridley and Sheps, 1966). These models were primarily of academic interest and seem to have disappeared in the meantime.

An early attempt to implement a comprehensive dynamic socio-economic microsimulation system, the MASH system, finally proved to be too ambitious given the computing facilities available at that time (Sadowsky, 1977). As a consequence, a simpler, recursive structure and sequential data processing techniques were used for the first operable dynamic microsimulation model that also included economic variables, the DYNASIM model (Orcutt et al., 1976). In the 1970s, the dynamic microsimulation approach started to spread out of the

US. Work on a microsimulation model of the Swedish economy was started by Eliasson (1977). Approximately at the same time, a dynamic model of the household sector was developed in Germany by Hecheltjen (1974). This model formed the basis of a family of microsimulation models at the University of Frankfurt that were used for policy analyses until the unification of Germany in 1989 (cf. Galler, 1994a). A second model was developed in Germany at the University of Darmstadt (cf. Appendino, 1986). A Hungarian version of this model, HCSO, was implemented at the Hungarian Central Statistical Office.

After the first generation of models in the US, Sweden and Germany, an increasing number of dynamic models were developed in different countries during the last ten years. Following the original DYNASIM model, a new version DYNASIM2 was developed in the US (Zedlewsi, 1990). A second dynamic model that focuses on the economic position of the elderly is the PRISM model (Kennell and Sheils, 1990). Currently a new dynamic model, CORSIM, is being developed in the US by Caldwell (1996). In the Netherlands, the NEDYMAS model is used for the analysis of the Dutch social security system (Nelissen, 1994). Besides that, the MIKROPOLIS model, developed at the Dutch Central Planning Bureau by Van Schaaijk, is used for simulations of the earnings structure (cf. Mot, 1991, p. 19). In Great Britain, the UPDATE model is used to update demographic structures between census years for small geographical areas (Clarke and Holm, 1987). Microsimulation models of household dynamics have been constructed for the United Kingdom by Spicer et al. (1992) and for Italy by Egidi and Tomasetti (1988). A cohort model for analyzing income redistribution over the life cycle has been developed by Harding (1993). Currently, the first version of DYNAMOD, a large dynamic cross-sectional microsimulation model for Australia, is being extended for practical policy analyses (cf. Antcliff, 1993).

3.3.2. Example applications of dynamic microsimulation

3.3.2.1. Evaluating the fairness of pension schemes

Analyses of pension schemes have been an important field of application of dynamic microsimulation models. In most countries, both contributions and benefits of the pension system depend on the characteristics of individual biographies in a rather complex way. For instance, in the German public pension system, individual pension benefits are basically proportional to the average ratio of the individual contributions to the average earnings of the contributors in the different years of the life cycle of a person. However, there are several regulations that grant entitlements without corresponding contributions. An example is a claim that is imputed for childrearing or during education. In addition, pension entitlements are transferred between individuals if a marriage dissolves. Thus, the observed individual pension entitlements depend in a complex way on the characteristics of the individual biographies.

Due to such complexities and since different groups are affected differently, the distributional fairness of the pension system cannot be assessed easily. Analyses on an aggregated level are not well suited for this problem, since the distributional effects depend strongly on the individual characteristics and their distribution in the population. An additional problem is, that information on individual biographies is required in order to compare individual contributions to the system and the benefits that are received later on. In principle, such an analysis could be based on biographical data that can be obtained for instance from the files of the pension system. However, since information on both individual contributions and the resulting pensions are required, only information on current pensioners, who have already completed their working biographies, could be used. But these biographies resulted from the economic and social situation during the last decades and will not be representative for the biographies of future pensioners since for instance both marital stability and the situation on the labor market have changed substantially during the last decades.

These difficulties can be circumvented if a dynamic microsimulation model is used to generate individual biographies conditional on a set of assumptions concerning the demographic processes, the labor market and earnings dynamics. In this way, a synthetic sample of individual biographies can be generated with all the structural information that is required to compute individual contributions and individual benefits, and to compare the fairness of the system between different biographies. An example of such an analysis is the work by Wagner (1984), who used the longitudinal version of the dynamic Frankfurt microsimulation model to generate a sample of individual biographies that were consistent with the current economic conditions and with the current regulations of the pension system. This sample can be considered to represent the biographies of a cohort that will be observed in the future given the assumptions of the simulation. Thus, the simulation approach can control the economic and social environment for which the analysis is performed. Similar approaches have been used in other studies of this kind, for instance by Nelissen (1995) in a study of the redistributional effects of the Dutch social security system.

In the dynamic microsimulation model used by Wagner, the biography of an individual is generated starting from birth by simulating all the relevant processes. The individual is aged and mortality is simulated by a Monte-Carlo procedure. Passing through the education system is simulated using conditional transition probabilities. After leaving the education system, labor force participation, occupational mobility and earnings are generated. In parallel, the processes of family formation and eventual divorce and re-marriage are simulated for all units in the sample. Using this information, individual contributions to the pension systems and the resulting entitlements can be calculated conditional on the individual biography. Since the same variables are also available for the spouses of married persons, survivor's benefits can be calculated easily for widows and widowers. Also, the regulations concerning the splitting of pension entitlements can be applied in the case of a divorce, and the resulting individual claims can be assessed.

Based on the contributions and benefits that have been computed for the individuals in the sample, different indicators have been defined by Wagner, that measure the extent of redistribution that takes place in the system. Basically, the ratio of contributions and benefits and its distribution in the sample are considered. A simple measure of this kind is the ratio of the total sum of contributions that have been paid by a socio-demographic group to the total sum of benefits that are received by the same group. This identifies groups in the population who systematically receive more or fewer pension benefits than they have contributed to the system. To some extent, such differences are caused by differing life expectancies but also by systematic differences in the number of years for which contributions have been paid. Wagner finds that in the German pension system a substantial redistribution takes place, from men to women and from individuals with a long working record, to persons who have been working for shorter periods. This also implies some redistribution from low-income earners to the higher income brackets since individuals with a lower income tend to work longer during their life cycle.

Besides such general outcomes, much more detailed results can be obtained by controlling different structural characteristics of the individuals. Since the basic information is available on the level of individuals, different groupings of the sample can be applied in the analysis depending on specific questions. This is a major advantage of the micro approach over the more aggregated models that rest upon a given classification of the population that cannot be changed during the analysis. In contrast, the micro approach even allows using a data-driven approach for the analysis. An example is the use of a multivariate AID-procedure by Wagner (1984, p. 237) that groups the sample into subgroups of individuals with a small variance of the contribution-benefit ratio within the group and a large variation of the ratio between the groups. This allows identification of groups of individuals that are especially favored or disadvantaged in the system. Since the characteristics of such groups are not known in advance, an analysis of this kind cannot be performed with more aggregated models.

3.3.2.2. Kinship networks in an aging society

A question that is of some relevance in the context of social security refers to the extent to which nursing and other services are provided by family members to incapacitated persons. Given the high costs of professional nursing in institutions, and given the preferences of many persons needing help to stay in their homes, nursing by family members is a preferred solution. However, due to the decline in the number of children that has occurred in most European countries in the past, the number of persons who are potential providers of nursing services within a family will be reduced in the future. To the extent that nursing services cannot be provided by family members, substitutes must be provided. Thus, the future extent and structure of kinship networks is of some interest for policy planning in this field.

The future size of a population and its age structure can be assessed comparatively easily by standard demographic models on an aggregated level. However, it is difficult if not impossible to derive the extent and the structure of kinship networks using such models, since the relations between members of the same family cannot be taken into account. Given these problems, the dynamic Frankfurt microsimulation model has been used by Galler (1990) to analyze the future development of kinship networks in (West) Germany and to infer about the demand for professional nursing services.

An analysis of kinship networks can be performed in a simple way using a dynamic microsimulation model if the individual persons are simulated in the context of their families. In principle, the relations to other family members are considered as additional characteristics of the individual that are updated during the simulation process like other attributes. They establish links between the individuals in the simulated sample that can be used to infer about the characteristics of the kinship networks to which the individuals in the sample belong.

In the dynamic Frankfurt microsimulation model, the data record of each individual that is born during the simulation contains the identifier of the mother and the father of the person. These identifiers are stored together with the identifier of the child, date of birth and, when relevant, date of death of the individual into a relational data base. In a similar way pointer variables are stored for marriages and consensual unions giving the identifiers of the partners together with the dates of the start and end of the union. Also, pointers are stored in the data base to identify the household to which an individual belongs in a given year. Using this basic information, the composition of the kinship network of an individual at a given point of time can be reconstructed by joining the information on individuals who are related by these pointers. Since the microsimulation model simulates elementary kinship relations between individuals in the first step, different definitions of kinship networks can be applied during the analysis depending on the specific questions being analyzed.

The simulations performed by Galler were based on the assumption that the demographic behavior observed in the 1980s will remain unchanged until 2050. Given this assumption, the number of close relatives will decrease substantially for the elderly over that period. Especially the portion of persons over 60 years with a living partner, living children or grandchildren will decrease, while the percentage of persons without any close relatives will double from about 10 percent to about 20 percent. In the age bracket over 80 years almost one-third of the population will not have any close relatives at all. This implies a substantial reduction in the potential supply of nursing services by family members since nursing is performed in most cases by the partner or by the children of a person. Thus, one would expect a substantial increase in the demand for professional nursing services over that period.

3.4. Open Problems

Forty years after the seminal article by Orcutt, microsimulation models are well established as instruments for policy analysis. This is especially true for the static microsimulation approach that is used as a standard instrument especially in analyses of tax-transfer policy in many countries. During the last decade, interest in dynamic microsimulation models has become stronger since available computers have become much more powerful at much lower costs. Thus, long-term analyses of structural change and its consequences for policy have become easier to conduct. From this point of view one would expect that a growing number of dynamic models would be developed in the future.

However, some problems remain that have not yet been solved in a convincing way. From a theoretical point of view, a shortcoming of practically all current microsimulation models is that the simulation of different processes for the same individual is based on some ad hoc assumptions of conditional independence given the values of the explanatory variables. In most models, no stochastic dependencies between different processes, like the demographic processes, labor force participation and earnings, are taken into account in addition to the dependencies that are modeled explicitly. However, due to omitted explanatory variables and unobserved heterogeneity in general, one would expect that such dependencies exist. However, if different processes are simulated jointly, the simple structure of the simulation procedure gets lost. Thus, a simulation framework is required that will specify stochastic dependencies between processes in an easy way.

A second problem is that most microsimulation models are specified as partial models of the household or enterprise sector that do not take into account feedback that result from interactions on the markets. There have been several attempts to link microsimulation models with macroeconomic models but none has provided a general solution to the problem. In most cases, only a one-directional linkage has been realized with typically the microsimulation model depending on aggregated variables that are supplied by a macroeconomic model. But in general no feedback from the micro level to the aggregates is taken into account. As a consequence some inconsistencies may occur between the aggregates that are obtained from the microdata and the corresponding values in the macro model. However, such differences in the outcomes on the macro and the micro levels may also be a consequence of imperfections of micro models. In many cases, the aggregated values that are derived from microdata underestimate the true values of the aggregates due to underreporting in the sample data. If this is the case, the results of the microsimulation model should only be used to infer about structural and distributional information, but not for estimating the aggregates.

A last area that needs further development are procedures for deriving measures of the forecasting error of the model that can be used for instance to construct confidence intervals for the estimates. Up to now, only point estimates have been derived from most models, and no information has been supplied on the possible errors in the estimates. However, in order to gain more confidence in simulation models and the results derived from them, such information should be provided as a standard procedure. In principle, estimates of the forecasting errors can be obtained by re-sampling methods like jackknifing and bootstrapping techniques. But a naive application of such methods will increase the computational costs substantially, and more elaborate procedures are required that provide such estimates at reasonable cost.

References

Antcliff, S. 1993. An Introduction to DYNAMOD: A Dynamic Microsimulation Model. DYNAMOD Technical Paper No. 1. National Centre for Social and Economic Modelling, University of Canberra, Australia.

Appendino, J.R. 1986. Entwurf von Modulen des Darmstädter Mikrosimulationsmodells. Ph.D. Thesis. Technical University of Darmstadt, Germany.

Beebout, H. 1986. Evaluating Reagan Administration social program changes: Two applications of MATH. Pages 83-97 in G. Orcutt, J. Merz, and H. Quinke, eds., Microanalytic Simulation Models to Support Social and Financial Policy. North-Holland, Amsterdam.

Brunner, J.K. and H.-G. Petersen, Eds. 1990. Simulation Models in Tax and Transfer Policy. Campus, Frankfurt, Germany.

Caldwell, S. 1996. Health, wealth, pensions and life paths: The CORSIM dynamic microsimulation model. Pages 505-522 in A. Harding, ed. Microsimulation and Public Policy. Elsevier, Amsterdam.

Cilke, J. and R.A. Wyscarver. 1990. The Treasury Individual Income Tax Simulation Model. Office of Tax Analysis, US Department of the Treasury, Washington, D.C.

Clarke, M. and E. Holm. 1987. Microsimulation methods in spatial analysis and planning. Geografiska Annaler 69B:145-164.

Cohen, M.L. 1991. Variance estimation of microsimulation models through sample reuse. Pages 237-254 in C.F. Citro and E.A. Hanushek, eds. Improving Information for Social Policy Decisions – The Uses of Microsimulation Modelling. Volume II. National Academy Press, Washington, D.C.

Egidi, V. and A. Tomasetti. 1988. A Method for Projecting Families. Paper presented at the IIASA Conference on Future Change in Population Age Structure, Sopron, Hungary.

Eliasson, G. 1977. Competition and market processes in a simulation model of the Swedish economy. American Economic Review 67:277-281.

Galler, H.P. 1990. Verwandschaftsnetzwerke im demographischen Wandel – Ergebnisse einer Modellrechnung. Acta Demographica 1990:63-84. Heidelberg, Germany.

Galler, H.P. 1994a. Mikrosimulationsmodelle in der Forschungsstrategie des Sonderforschungsbereichs 3. Pages 369-379 in Richard Hauser, Notburga Ott and Gert Wagner, eds. Mikroanalytische Grundlagen der Gesellschaftspolitik. Volume 2. Akademie Verlag, Berlin.
Galler, H.P. 1994b. Prognoseeigenschaften dynamischer Mikrosimulations-modelle. Pages 428-442 in Richard Hauser, Notburga Ott and Gert Wagner, eds. Mikroanalytische Grundlagen der Gesellschaftspolitik. Volume 2. Akademie Verlag, Berlin.
Harding, A. 1993. Lifetime Income Distribution and Redistribution: Applications of a Dynamic Cohort Microsimulation Model. North-Holland, Amsterdam.
Hecheltjen, P. 1974. Bevölkerungsentwicklung und Erwerbstätigkeit. Westdeutscher Verlag, Opladen, Germany.
Horvitz, D.G., B.V. Giesbrecht, B.V. Shah, and P.A. Lachenbruch. 1972. POPSIM, A Demographic Microsimulation Model. Monograph No. 12. Carolina Population Center, Chapel Hill, USA.
Howell, N. and V.A. Lehotay. 1978. AMBUSH: A computer program for stochastic microsimulation of small human populations. American Anthropologist 80:905-922.
Hyrenius, H. and I. Adolfsen. 1964. A Fertility Simulation Model. Almquist and Wicksell, Stockholm.
Kennell, D.L. and J.F. Sheils. 1990. PRISM: Dynamic simulation of pension and retirement income. Pages 137-172 in G.H. Lewis and R.C. Michel, eds. Microsimulation Techniques for Tax and Transfer Analysis. The Urban Institute Press, Washington, D.C.
Mot, E. 1991. Survey of Microsimulation Models: Inventory and Recommendations. Ministerie van Sociale Zaken en Werksgelegenheid, s'Gravenhage, the Netherlands.
NATSEM. 1994. STIMOD User Guide. National Centre for Social and Economic Modelling, University of Canberra, Australia.
Nelissen, J.H.M. 1994. Income Redistribution and Social Security. An Application of Microsimulation. Chapman and Hall, London.
Nelissen, J.H.M. 1995. Lifetime income redistribution by the old-age state pension in the Netherlands. Journal of Public Economics 58:429-451.
OECD. 1988. A Comparative Study of Personal Income Tax Models. OECD Studies in Taxation. Organization for Economic Cooperation and Development, Paris.
Orcutt, G. 1957. A new type of socio-economic system. Review of Economics and Statistics 58:773-797.
Orcutt, G., M. Greenberger, J. Korbel, and A. Rivlin. 1961. Microanalysis of Socio-Economic Systems: A Simulation Study. Harper and Row, New York.
Orcutt, G., S. Caldwell, H. Wertheimer, S. Franklin, G. Hendricks, G. Peabody, J. Smith, and S. Zedlewski. 1976. Policy Exploration Through Microanalytic Simulation. The Urban Institute, Washington, D.C.
Orcutt, G. 1986. Views on microanalytic simulation modelling. Pages 9-26 in G. Orcutt, J. Merz, and H. Quinke, eds. Microanalytic Simulation Models to Support Social and Financial Policy. North-Holland, Amsterdam.
Redmont, G.H., H. Sutherland, and M. Wilson. 1995. POLIMOD: An Outline. Microsimulation Unit Research Note RN/MU/5. DAE, Cambridge, UK.
Ridley, J.C. and M.C. Sheps. 1966. An analytical simulation model of human reproduction with demographic and biological components. Population Studies 19:297-310.
Sadowsky, G. 1977. MASH: A Computer System for Microanalytic Simulation for Policy Exploration. The Urban Institute, Washington, D.C.

Spahn, P.B., H.P. Galler, H. Kaiser, T. Kassella, and J. Merz. 1992. Mikrosimulation in der Steuerpolitik. Physica-Verlag, Heidelberg, Germany.
Spicer, K., I. Diamond, and M. Ni Bhrolchain. 1992. Into the twenty-first century with British households. International Journal of Forecasting 8:529-539.
Statistics Canada. 1988. SPSD/M Introductionary Manual. Statistics Canada, Ottawa.
Wagner, G. 1984. Umverteilung in der gesetzlichen Rentenversicherung. Campus, Frankfurt, Germany.
Webb, R.L., R.C. Michel, and A.B. Bergsman. 1990. The historical development of the Transfer Income Model (TRIM2). Pages 33-76 in G.H. Lewis and R.C. Michel, eds. Microsimulation Techniques for Tax and Transfer Analysis. The Urban Institute Press, Washington, D.C.
Zedlewski, S.R. 1990. The development of the Dynamic Simulation of Income Model (DYNASIM). Pages 109-136 in G.H. Lewis and R.C. Michel, eds. Microsimulation Techniques for Tax and Transfer Analysis. The Urban Institute Press, Washington, D.C.

Chapter 4
Technical Issues in the Design and Implementation of Dynamic Microsimulation Models

Douglas A. WOLF

This chapter provides a brief overview of selected issues in the design and implementation of dynamic microsimulation models. A recent and excellent paper by Van Imhoff and Post (1997) is the first serious attempt to provide a technical overview of the field of dynamic microsimulation. In its treatment of several of the topics covered in the Van Imhoff and Post paper, the present discussion is intentionally brief. However, the issue of uncertainty and the closely-related issue of interval estimation, which they do not discuss, is given considerable attention here.

4.1. Microsimulation Defined

Microsimulation is a process of making predictions at the individual level, while taking into account probabilistic uncertainty. For example, in some population there may be 100 otherwise identical women among which some births are expected to take place in the coming year. Although one may be prepared to assume that overall, the chances of any one of these women giving birth is 0.10, or 10 percent, there is the uncertainty of which of the women will actually give birth. A microsimulation consists of somehow choosing one of the large number of possible ways in which these chances may be realized. Note that one approach would be to fix the total number of births at 10 (which is the expected number of births) and then somehow randomly choose one of the numerous combinations of 10-out-of-100 women consistent with this expected outcome. Alternatively, one might somehow give each woman, in sequence, a 10-percent chance of giving birth, and thereby randomly choose one of the much larger number of combinations of a random number of births (whose *expected value* is 10) distributed over the 100 women. In either instance, the procedures exhibit two of the key features of microsimulation: outcomes are determined at the individual, or "micro" level; and, the value assigned to any particular individual depends partly on chance factors.

In order to produce the simple microsimulation just described, it is necessary to adopt, as a prior assumption, a numerical value for the expected number of births. More generally, for any outcome to be simulated using probabilistic rules, one must have sufficient knowledge (in the form of assumptions) about the process to be able to make probabilistic assignments. Therefore, another way of depicting microsimulation is r***epeated sampling of individual outcomes from a stochastic process with known probabilistic rules*** (or "with a known probability law"). This illustrates an often overlooked fact about microsimulation: the analyst must know (or be prepared to assume knowledge of) all the key parameters governing, and all interdependencies among, all variables of interest, prior to "running" the model. The microsimulation is simply a means of studying the *implications* of that prior knowledge, in great detail.

Microsimulation, in the context of applied social science and public policy research, can be classified into "static" and "dynamic" microsimulation; the former category tends to be much larger. Static microsimulations tend to produce representations of alternative policy environments, more or less holding the populations to which they pertain constant. This approach is widely used by, or on behalf of, governmental agencies interested in the consequences of alternative tax or transfer policies; a typical example is the "TRIM2" model (Giannarelli, 1992).

Static approaches, as their name suggests, permit comparisons of alternative states of the world, holding time constant (notwithstanding the possibility that the "time" in question may be a date in the future). In contrast, dynamic microsimulations attempt to represent the pathway in time that leads to some future state. In a dynamic microsimulation, a population can change through new births, through deaths, and possibly through migration into or out of the population of interest. Ideally, the simulation, once completed, will allow the user to look forward, or backward, over the lives of the individuals in the population, and reach conclusions about the life-cycle circumstances of individuals in the population. Needless to say, demographic processes are key elements of dynamic microsimulation, and demography is a featured element of most such efforts (see, for example, Orcutt et al., 1976; Nelissen, 1995; Galler, 1989; Harding, 1993; Walker, 1997; Wolfson, 1989; Wolfson et al., 1990). Among these efforts are applications to life-cycle fertility processes (Ridley and Sheps, 1966; Barrett, 1971), the evaluation of family planning programs (Inoue, 1977), and especially to study kinship patterns (Hammel et al., 1981; Ruggles, 1987; Wolf, 1988).

In this chapter the assumed situation is one in which the variables of interest include conventional demographic and economic variables, such as parity, marital or partnership status, family and household composition, labor force status, wages and earnings or other sources of income, and so on. Moreover, the micro units—individuals, families, or households—whose life-cycle dynamics are simulated are viewed as a sample from the population of interest. It should be noted that the latter assumption is not always maintained; for example, in several applications of microsimulation to the study of small, isolated societies, the collection of units studied are treated as a representation of the entire society.

Microsimulation offers several advantages when compared to aggregate-level analyses, or to individual-level analyses that ignore stochastic variability. One such advantage is the ability to produce the full frequency distribution of variables of interest, rather than simply their average value, or other simple summary statistics. Another is the fact that microsimulation can (but is not guaranteed to) simplify the analysis of complex, interactive systems, and the representation of behavioral responses to external influences. Finally, as is emphasized below, it provides a natural and flexible basis for studying randomness, or uncertainty, in the projected quantities of interest.

4.2. Principal Elements of Microsimulation Models

There are two main ingredients needed to carry out microsimulation. The first is, in most cases, a data file that represents the starting, or "jumping off" point from which the population's dynamic behavior will evolve. The second is the set of rules by which these dynamics are governed. For both of these ingredients a great variety of alternative approaches can be taken. A third such main ingredient might be identified, namely the output produced by the simulation. The output can take the form of a new, updated microdata file, and/or a series of summary tables based on the simulated microdata. Only the first two elements, however, are discussed, rather briefly, in this section.

4.2.1. The starting population

The starting population represents the "initial conditions" for a set of dynamic relationships. Since we are dealing with microsimulation the starting population needs to contain information on individual members of the population, and must in addition contain measures of all attributes of interest. So, for example, a data record in the data file representing the starting population might contain, at a minimum, (1) an identifying number or code; (2) a code for the person's sex; (3) a code for the person's age, or date of birth; (4) codes for other attributes of the individual such as race, educational level, and so on; (5) "pointers" to the records of other individuals in the starting population to which the individual is linked, such as by marriage (i.e., the data record of the spouse) or by blood (e.g., the identifying numbers of data records pertaining to this person's children, siblings, or other relatives); and (6) possibly, a numerical factor used to indicate the person's relative weight in the sample.

Typically, the data records contained in the starting population file are abstracted from a household survey, or from census records, or from information contained in a population registry. That is, they represent a sample from an actual population, taken at a well-defined time. In special circumstances, records may be artificially constructed, for example to reproduce the known aggregate characteristics of a tabulated historical population. Conventionally, every person found in the data base is considered a "sample person." This follows most naturally from the situation in which the data from which the data base is derived comes from a survey of households, one in which every person found in every sample household is included in the sample. This might be the case, for example, if the U.S. Current Population Survey, a monthly household survey conducted for the primary purpose of estimating employment and unemployment, were the source of the starting population. Another example would be the use of a random sample of households from a Census enumeration, as was done in the original version of the Urban Institute's DYNASIM model (Orcutt et al., 1976).

An alternative, not often used, is to consider that the starting population data base contains both *sample persons* and *nonsample persons.* The sample persons are the reference persons, that is, those whose presence defines the true sample from the population of interest. Linked to each sample person are one or more nonsample persons, such as a spouse or partner, siblings or parents, or children; this approach is adopted in a model currently under development, the design of which is discussed in Wolf et al. (1995). The former approach, in which every person represented in the data base is a sample person, corresponds most naturally to the use of a "closed" population, while the latter suggests the use of an "open" population (the distinction between closed and open population models is discussed more fully below).

4.2.2. Rules for the evolution of life histories

The lives of the individuals contained in the simulated population evolve in a highly stylized way. The rules or procedures for this evolution may include *random* assignments or *deterministic* assignments, and these assignments may be specified either as mathematical relationships or as logical statements. The precise nature of the relationships used depends, in part, on whether time is treated as continuously varying or advancing in discrete intervals (a topic to which we return below).

The FAMSIM prototype discussed elsewhere in this volume uses both random and deterministic assignments. The FAMSIM model uses a "cobweb" specification, which can be represented as

$$y_{i,j,t+1} \;=\; f_j\,(y_{i1t}\,,\, y_{i2t}\,,\,\dots\,,\, y_{iR,t}\,,\, r_{ijt})\;,$$

for i=1, ... , N individuals and j = 1, ... , R dependent variables. In this model the value of each one of a set of R randomly-assigned dependent variables may depend in some way on the values of all those variables in the current period, plus some random factor rijt. An example would be the rule

$$y_{i,j,t+1} \;=\; 1 \quad \text{if } \operatorname{logit}(y_{i1t}\,,\, y_{i2t}\,,\,\dots\,,\, y_{iRt}\,;\, B_j) < r_{ijt}\;,$$

and

$$y_{i,j,t+1} \quad = \quad 0 \quad \text{if } \mathrm{logit}(y_{i1t}\,,\, y_{i2t}\,,\, \dots\,,\, y_{iRt}\,;\, B_j) \quad r_{ijt}\,,$$

where B is a set of logistic regression coefficients. In this case, rijt is a random number from the uniform distribution, bounded by zero and one. This type of random assignment procedure could be used to assign either "status" variables (for example, an indicator of whether or not someone is working next period) or "transition" variables (for example, an indicator of whether or not an unemployed person *begins* working next period).

A different sort of random assignment rule is

$$y_{i,j,t+1} \quad = \quad f_j(y_{i1t}\,,\, y_{i2t}\,,\, \dots\,,\, y_{iRt}\,;\, B_j) + r_{ijt}\,,$$

where r_{ijt} is, for example, a number randomly drawn from a normal distribution with average value equal to zero and standard deviation equal to a prespecified value. This type of assignment statement is appropriate for continuous variables, such as annual income.

Note that in the "cobweb" model, the specific value assigned to any one of the random dependent variables in the next period does *not* depend on the value of any of the values assigned to *other* random dependent variables in the next period. This greatly simplifies the model, but does so at a cost: it assumes that, conditional on all current (and past) values of all variables in the system, all outcomes in the next period are mutually independent of each other.

As an example of a deterministic assignment, suppose that y_1 is a 0,1 variable indicating that someone is working next period, and that y_2 is a continuous variable that represents the cumulative number of periods of work. Then, given a randomly-assigned value to $y_{i,1,t+1}$, we can calculate, quite simply, $y_{i,2,t+1} = y_{i,2,t} + y_{i,1,t+1}$. No further randomization is necessary.

An important point to be understood is that in a microsimulation, ***every variable is either fully specified in advance, or is endogenous.*** That is, any variable that is to appear, anywhere in the model, must itself either have either a fixed or deterministically-evolving value that is specified in advance, OR must evolve randomly according to a prespecified rule. For example, the age and sex and (if relevant) race of each person in the starting population data file are recorded there. Race and sex are treated as fixed values, while age evolves deterministically. In contrast, education, marital status, number of children, and so on, may be recorded in the starting population but must be regarded as random variables whose values can change over time. It is common, in applied social science research, to use complex regression specifications with numerous explanatory variables, to explain variations in dependent variables of interest. The needs of microsimulation place great restrictions on one's ability to use complex predictive equations of this sort; any variable used to "explain" some other variable must be allowed to evolve, period to period, along with all the other variables in the system. Since most variables commonly used in this type of research are not fixed but variable (and therefore more interesting), it becomes very difficult to achieve a high degree of detail in a microsimulation model, and as a consequence microsimulation models often appear to be quite simple, or incomplete, in comparison to the standards for inferential research on the same variables.

A second important point is that, since parameter values must be known in advance for any random-assignment relationships such as those given above, a substantial amount of data analysis must take place prior to the running of any microsimulation program. The data used to estimate model parameters need not be the same as the data used to create the starting population, and in many if not most cases different data sources are in fact used; it is also common to employ a number of different data sources in parameter estimation. Indeed one of the reasons to do microsimulation is to generate artificial data in which variables otherwise only recorded in different data sets can be "observed" in a single, unified – albeit simulated and therefore artificial – data file.

4.3. Some Model Design Options

4.3.1. Discrete time versus continuous time

The issue of the representation of time in a dynamic microsimulation is partly decided by the nature of data available for the estimation of model parameters. However, regardless of data limitations, it is often most natural to treat the underlying processes that are being modeled as processes that evolve in continuous time. This is, at least, true for most if not all demographic processes, such as birth, death, and changes of marital status, any of which can be observed to occur continuously in time. Real-valued outcomes such as earnings or total income, however, lend themselves more readily to discrete-time measurement. For example, people commonly are prepared to express their incomes in monetary units per year. For reasons of mathematical convenience, we might think of annual income as the integral, over a single time unit, of an income (per year)-generating "intensity" function that is assumed to be constant throughout the time interval, notwithstanding the fact that for many people it is clearly not constant. Problems arise, however, when the income-generating function is modeled as depending on other current circumstances (such as marital status, health status, or eligibility for program benefits) which themselves can change value at arbitrary times. Extraordinarily rich and detailed data are required to permit the estimation of model parameters if the model is specified to permit multiple events at arbitrary times, and instantaneous adjustment of the income-generation function at those same times.

An important distinction is that between the representation of the underlying *process* that is simulated – which, for demographic variables, is best thought of as a continuous-time process – and the way the results are represented in the output file produced by the microsimulation – in other words, what we might call the *accounting scheme* used to represent the process. Thus, the mathematical relationships used to assign simulated values may treat time as continuously evolving, and assign times, or dates, of vital events accordingly, yet record people's statuses at discrete intervals (for example, every January 1, or every July 1). If it is considered adequate to represent the state of the population as of a specified date, every year, then the model – the rules for the dynamics of the process – can be formulated in terms of either transitions, over discrete intervals, from state to state, or alternatively as a model of "levels," that is, of the state occupied at a specified instant. In either case, we would lose the ability to record *events* that occur from one "reporting period" to the next. In many cases, this loss of detail on the occurrence and number of events is not troubling, since a change in status is evidence that at least one event has taken place, and the possibility of multiple events in a one-year period is negligible or completely ruled out. However, in a continuous-time world someone can be "married" at time t and also "married" at time t+1, yet have experienced both divorce and remarriage in a single year. It is because of the need to avoid this sort of ambiguity, or indeterminacy, that it is preferable to represent the underlying process as a continuous-time process (however we choose to tabulate the simulated outcome of the process).

The FAMSIM prototype deals with the problem of continuous versus discrete time by using atypically small time units – months – in a discrete-time representation. The problem of multiple events of a single type is nearly eliminated by the choice of a very small time unit. Importantly, the mathematics by which the process is represented – a series of equations producing the probabilities of each possible transition, month by month – are greatly simplified through the use of this approach.

4.3.2. „Closed" versus "open" population

In a dynamic demographic microsimulation the population can change through the fundamental processes of birth and death. In a "closed" population this is the only way the membership in the population can change. An "open" population, on the other hand, can lose members through emigration from, or immigration to, the geographic area containing the population. A second manifestation of the closed/open distinction is in the formation of unions; it is the latter case that is discussed here.

Disregarding the possibility of same-sex partnerships, in a two-sex microsimulation it is necessary to assign spouses to those simulated to marry. The need to achieve balance and consistency between the simulated union formation outcomes assigned to men and to women has given rise to numerous approaches to, and algorithms for, achieving internal consistency in a closed population model. The reason that this is a problem is that in a closed model all mates must come from within the data file that represents the population.

If, instead, the microsimulation is formulated as an "open" model the problem of internal consistency is automatically solved (although other problems are created; see Van Imhoff and Post, 1997). Among the many arguments put forward by practitioners of microsimulation concerning the relative merits of open versus closed models, one not apparently advanced is the following: since the data base that represents the population is, in almost every instance, a sample from the larger population, then it makes sense to "create" partners from outside the data base, as needed, whenever union formation is simulated to occur. This is, in other words, an argument for the open-population approach, and is one that appeals to the analogy between sample and population: in, say, a longitudinal household survey, new partners of existing sample members almost inevitably are not original sample members (the probability that two members of a randomly selected sample, of typical size, will in the future become partners is vanishingly small).

The same argument can be used to justify a reduced emphasis on achieving complete and flawless balance, or internal consistency: in any finite sample from a large population, pure sampling error or "noise" will ensure that symmetric relationships in the population (e.g., the fact that for every wife there must be a husband) will not be mirrored by perfectly symmetric relationships in the sample (i.e., exactly equal numbers of married women and of married men).

4.4. Uncertainty in Predictions from Microsimulation

In the preceding pages we have presented a brief and selective discussion of issues in the specification of a microsimulation model. Once the model has been estimated, and implemented in a working computer program, new issues arise concerning the types of questions that can be addressed with the model, and the way in which the answers produced by the model are to be expressed. For the remainder of this chapter we discuss a single issue: the representation of uncertainty in the predictions, or forecasts, produced by a microsimulation.

Naturally, an overriding goal of a microsimulation, or of any other type of forecast, is to produce as accurate an estimate of a predicted quantity as is possible; accuracy, as conventionally understood, refers in this case to the distance between the predicted and actual quantity. Random variability is present in microsimulation, and can cause the prediction produced by any one run of the model to depart from the theoretically (and probabilistically) expected value. In most instances the people who have produced working microsimulation programs have taken special efforts to minimize various types of random error, or random fluctuations (see, for example, the discussion of this point in Van Imhoff and Post, 1997). Yet, since error and consequent uncertainty about the true value of any sample statistic, and by extension of any prediction based on sample data, are pervasive, it seems reasonable to exploit the unique power of microsimulation methodology to provide information about the probable degree of error in a forecast. It is, in fact, the presence of random variability – from several sources – that makes microsimulation a potentially useful and powerful vehicle for studying uncertainty in demographic forecasts.

4.4.1. Alternative methodologies for making demographic forecasts

It is often asserted that, at least in the short run, and relative to other phenomena studied by social scientists, population futures are easy to forecast. The underlying parameters governing population dynamics change fairly slowly. Deaths constitute one of the principal forces of population dynamics, and most of the people who will die for many years into the future are already living, and their numbers are generally known with considerable accuracy. Yet, notwithstanding the purported amenability of population characteristics to forecasting, population forecasts are generally quite inaccurate. All types of forecasts must, of course, be treated as erroneous, but there have been documented many instances of troublingly inaccurate "official" population forecasts. Conventional forecasts often consist of a "best guess" projection, accompanied by "high" and "low" variants, suggestive of statistical interval estimation, and implying a bounding of the future path of the population. Yet, as noted by Lee and Tuljapurkar (1994), the "low" and "high" variants of the 1967 U.S. Bureau of the Census population forecasts failed to bound the actual values for virtually the entire forecast period.

The inevitability of forecasting errors has led to a variety of efforts to introduce explicitly probabilistic elements into population forecasting. These efforts include ex-post analysis of forecast errors (e.g., Keyfitz, 1981; Stoto, 1983), and a number of stochastic-parameter models (e.g., Sykes, 1969; Pollard, 1973; Lee and Tuljapurkar, 1994). Virtually all attempts to produce rigorous population forecasts use aggregate data. However, while microsimulation methodology addresses many of the same concerns as do the stochastic parameter models, the approach is fundamentally different: a microsimulation mimics the underlying demographic processes, such as fertility and mortality, as they occur at the **individual** level.

For purposes of this discussion, three fundamental attributes of a projection methodology can be identified, and used to classify alternative approaches. These three attributes are (1) the **level of analysis**, which can be either aggregate or individual; (2) the **characterization of the underlying process**, which can be either deterministic or stochastic; and (3) the **representation of the parameters**, which can be either stochastic or nonstochastic.

The distinction between the aggregate and individual level of analysis requires no explanation. Note merely that the degree of aggregation includes grouping by age as well as within age. The "characterization of the underlying process" refers to the assumption made about outcomes within a cell of the population table, i.e., to persons alike on all recorded attributes. Within such a group, outcomes can be viewed as deterministic. Under this assumption, if n individuals are exposed to a chance *p* of experiencing some event, then *np* events are considered to occur; in other words, the actual outcome is exactly equal to its expected value, and stochastic variability around this expected value is disregarded. Most demographic models, such as the life table and usual cohort-component projection methods, are deterministic in this sense. In contrast, within-cell outcomes can be viewed as stochastic: in this case the actual outcome has a distribution with expectation *np* but a nonzero variance.

Finally, the parameters of a population projection – at a minimum, birth and death rates – can be considered either nonstochastic or stochastic. In any projection it will be necessary to specify future values of birth and death rates, and these are of course inherently unknown. Most projections are based on nonstochastic rates; that is, a series of rates is prespecified, based on extrapolation of a trend, or by fixing rates at a baseline value, or adopting an assumed value based on expert judgement, or on some combination of these and other approaches. In any event, once specified the series is viewed as a set of fixed constants. Alternatively, the sequence of future rates can be viewed as the outcome of a stochastic process. Rather than prespecifying the future rates, we can prespecify the parameters of the stochastic process that generates future rates; this, in turn, implies a probabilistic distribution of future paths of population growth and change, and the analyst's job becomes one of studying and summarizing this distribution of population futures.

Having defined these three dimensions of projection methodology, we can use them to classify several approaches found in the literature into four categories, as follows:

(1) *Aggregate/Deterministic/Nonstochastic.* Most population forecasts, and virtually all "official" national population forecasts, fall into this category. Here, calculations are performed for aggregates, generally one- or five-year age groups, further grouped by sex (and possibly by further attributes such as race); events underlying population change are deterministically calculated; and, the future values of vital rates consist of fixed values, nonstochastically determined. This category includes the projections produced by the U.S. Bureau of the Census (e.g., Day, 1992). The Census Bureau periodically publishes population projections by age, sex, and racial/ethnic origin, and occasionally by state of residence. These projections follow the conventional practice of including, in addition to the principal or central "medium" version, a "high" and a "low" variant. A second major producer of national forecasts in the US is the Social Security Administration's Office of the Chief

Actuary (SSAA). The SSAA's charge includes the routine production of short-range and long-range (75-year) estimates of the actuarial fiscal balance of the Social Security Trust Fund. These projections employ both demographic and economic components, each of which are periodically revised.

(2) *Aggregate/Deterministic/Stochastic.* Most of the theoretical and applied developments in stochastic population models fall into this category: calculations are performed for aggregated cells of a population tabulation, and are deterministically applied. However, the future paths of vital rates are treated as the outcomes of stochastic processes. Some of the relevant theoretical developments can be found in Sykes (1969) and Pollard (1973). However, the most complete such model is that of Lee and Tuljapurkar (1994; hereafter, LT).

LT discuss three potential sources of error or uncertainty in demographic forecasts, including "individual level randomness" (elsewhere, this is called "branching process uncertainty" (Lee, 1996), "data errors", and "changing vital rates." LT dismiss individual level randomness as a "negligible" factor in large populations. They also disregard data errors, emphasizing the contributions to uncertainty about the size and composition of future populations of uncertainty, and about the values of future birth and death rates. LT, like others who have developed the theory of stochastic population projection, develop analytic methods for calculating the moments (that is, the first and second moments) of future population values. These analytic expressions are quite complicated, but can be simplified by resorting to approximations in lieu of "exact" solutions. In order to go beyond moments, Monte Carlo techniques must be used (see also Pollard, 1973).

(3) *Microanalytic/Stochastic/Nonstochastic.* This class of models contains numerous existing large-scale socio-economic microsimulation analyses of national populations (see examples cited near the beginning of this chapter), the key features of which were discussed above. Among the advantages of microsimulation is its capacity to produce disaggregated projections, and to project not only means and moments of projected quantities, but also any other quantile in the frequency distribution of a projected quantity. Microsimulation is also able to deal with extremely complicated state spaces, and to permit both continuous and discrete outcomes. But these advantages simultaneously expose the disadvantages of microsimulation, particularly the heavy demands it imposes on model specification and input parameter estimation. Microsimulation can be used to make projections using very complex models in which there are numerous interacting endogenous dimensions, but models of such complexity are difficult to specify and estimate.

(4) *Microanalytic/Stochastic/Stochastic:* Random-parameter micro-simulation. This class represents a variant of the existing family of established dynamic microsimulation models, one that combines the practice of representing individual-level randomness with randomization over parameters as in the LT Monte Carlo estimates. This approach does not appear to have been

taken so far, although it is advocated in Wolf et al. (1995), and was implemented in a very limited fashion in Wolf and Laditka (1996). Its distinctive feature is the introduction of an additional source of randomness into the projection, in order to more fully represent the uncertainty associated with the method. The several sources of uncertainty that can be dealt with are discussed below.

4.4.2. Sources of uncertainty in population projections

As noted above, a major reason to use microsimulation is its ability to represent several sources of error and uncertainty in projected quantities. "Error," of course, is to be avoided, and many analysts have devoted their energies to minimizing various sorts of errors. The issue here is that some methods (notably the deterministic ones) wrongly assume some classes of error, or sources of uncertainty. Microsimulation is not unique in its capacity to address many of these types of uncertainty; indeed, the desirability of representing uncertainty is the motivation for the development of the stochastic methods of LT and several others.

► ***Errors in the Distribution of Starting Population Characteristics.***

In aggregate projections the starting (or jump-off) population is, inevitably, represented with error. The SSAA's recent projections, for example, begin with estimates of beginning-of-year populations that are extrapolated from mid-year populations, each of which is only an estimate. These estimates are further adjusted for net census undercount, and then have added to them counts of people in several comparatively minor groups using diverse sources such as the Maritime Administration and the State Department (Bell and Kumar, 1996), each of which is undoubtedly subject to errors of various types. The contribution of this class of errors to uncertainty in future population figures has rarely been addressed (Alho, 1992); it is, for example, disregarded by LT.

Microsimulations, which begin with a microdata file representing (virtually always) a sample from the relevant population, are subject to sampling error, a very different source of uncertainty. This source of uncertainty can, in principle, be reduced by increasing the size of the sample from the jump-off population, although in practice this may not be possible. More challenging is the prospect of dealing with the sorts of enumeration errors discussed in the preceding paragraph, by altering the distribution of characteristics in the microdata file used to initiate a microsimulation. To my knowledge this has never been proposed, much less implemented. Microsimulation is well suited to resampling techniques such as the bootstrap, a promising solution to the micro-sampling-error problem. Microsimulations, relying as they do on a microdata file, uniquely confront another class of errors typically found in microdata: missing values. Multiple-imputation approaches to this problem have been proposed (Wolf et al., 1995) but do not appear to have been implemented so far.

▸ *Branching Process Uncertainty.*

LT dismiss individual-level randomness as negligible, appealing to results found in Sykes (1969) and Pollard (1973). Both earlier authors argued that, in large populations, the large numbers of individuals exposed to risk cause standard errors of projected population counts to shrink to inconsequential levels. Both authors reached their conclusions using models in which vital outcomes resulted from binomial trials. That is, in a population cell containing n individuals, each facing a probability q of some event, the number of events that occur follows a binomial distribution with mean nq and variance nq $(1q)$. With large n these binomial probabilities are closely approximated by the normal curve.

Both Sykes and Pollard restricted their attention to only part of the age distribution: Sykes considered only the reproductive years (through age 44), while Pollard's numerical examples use ages 0 through 59. In view of the great interest in population aging, aged dependency ratios, and so on, it is worth reconsidering the relative amount of branching process uncertainty at older ages. Not only are death rates higher at older ages, but cell sizes in a population tabulation become relatively small at the oldest ages. Wolf (1997) shows results from a simple projection of the survivorship of a one-year birth cohort, specifically men 65 years old in 1990. Using the SSAA's mortality rates, Wolf shows that by age 99 the coefficient of variation (a measure of variability relative to the mean) for the projected number of survivors has reached over 14 percent, a substantial amount of variability. While few members of this cohort are projected to survive to this advanced age, very old persons tend to have very large medical and personal-care costs, and therefore variability in their projected numbers has potentially large substantive implications.

▸ *Sampling Variability in the Parameters Used to Project Rates.*

Many population projections use as parameters projected series of birth and death rates that are based on some statistical model fitted to past rates. LT, for example, use a model of age-specific mortality in which two age-specific parameters (a pure age effect and an age-time interaction) and an autoregressive time factor (entailing a drift parameter and a pure noise factor) are used to model a long time series of age-specific death rates, extrapolation of which provides a series for the forecast. Wolf and Laditka (1996) discuss a set of multinomial logit models of transitions between various disability states and death, estimated from individual-level longitudinal data. In both cases, there is some sampling variability present, reflected in the estimated standard errors of the model parameters.

Sampling variability in estimates of the parameters of models of past vital rates implies uncertainty about the point estimates of extrapolated future rates implied by those models. In any projection, whether based on microanalytic or aggregate approaches, this type of uncertainty merits consideration. It has, however, received little attention. A straightforward way of doing so is to randomize over the ex-post distribution of estimated parameters. For example, if maximum-likelihood estimation is used, we can appeal to the asymptotic properties of the estimators, which have a limiting normal distribution whose mean is equal to the estimated parameters and with covariance matrix equal to the inverse Hessian of the likelihood function evaluated at its maximum. This is the approach taken in Wolf and Laditka (1996). Much more challenging is to take account of the "sampling variability" present in expert judgment about the likely path of future fertility and mortality rates. In some judgmental or scenario-based forecasts average annual percentage changes in the TFR or some other summary index are assumed to hold; these assumptions are (like statistically estimated parameters) subject to error which, if quantified, could be taken into account in the projection.

4.5. Summary and Conclusions

This chapter has discussed a number of conceptual, definitional, and procedural issues related to the development of microsimulation models. Although the field has a relatively long history, nearly as long as that of the high-speed electronic computer that made microsimulation possible, the field has produced a diffuse range of concrete applications. The method has in many applications shown its power and its potential for even greater value.

- Microsimulation facilitates the representation of complex multivariate processes; it may be that introducing additional dimensions into the projection models conventionally used would improve their forecast accuracy.
- Microsimulation can represent several sources of forecast uncertainty; individual-level randomness (or, branching process uncertainty) is intrinsic to the method.

At the same time, microsimulation creates as well as solves some problems:

- The very model complexity that microsimulation encourages imposes heavy demands on the specification and estimation of models, including a need for unusually rich data; in this regard, microsimulation compares unfavorably to conventional methods.
- Microsimulation introduces some sources of uncertainty, or forecast error, that do not appear to be present in aggregate models. This includes sampling error (attributable to the use of a [small] microdata file to represent the starting, or jump-off, population; it also includes errors associated with missing values in the microdata file. Yet we must be aware that analogous errors are almost certainly also present (even if in implicit form) in the aggregate approaches conventionally used.

References

Alho, Juha M. 1992. The magnitude of error due to different vital processes in population forecasts. International Journal of Forecasting 8:301-314.

Barrett, J.C. 1971. Use of a fertility simulation model to refine measurement techniques. Demography 8:481-490.

Bell, Felicitie C. and Rizie Kumar. 1996. Social Security Area Population Projections:1996. Actuarial Study No. 110. U.S. Department of Health and Human Services, Social Security Administration, Office of the Actuary, Washington, D.C.

Day, Jennifer Cheeseman. 1992. Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin:1992 to 2050. Current Population Reports, No. P25-1092. U.S. Department of Commerce, Bureau of the Census, Washington, D.C.

Galler, Heinz P. 1989. Policy Evaluation by Microsimulation – The Frankfurt Model. Paper prepared for the 21st General Conference of the International Association for Research in Income and Wealth, Lahnstein, Germany, August 20-26, 1989.

Giannarelli, Linda. 1992. An Analyst's Guide to TRIM2. The Urban Institute, Washington, D.C.

Hammel, E.A., K.W. Wachter, and C.K. McDaniel. 1981. The kin of the aged in A.D. 2000: The chickens come home to roost. Pages 11-39 in Sara B. Kiesler, James N. Morgan, and Valerie K. Oppenheimer, eds. Aging: Social Change. Academic Press, New York.

Harding, A. 1993. Lifetime Income Distribution and Redistribution: Applications of a Microsimulation Model. North-Holland, Amsterdam.

Inoue, Shunichi. 1977. Choice of policy measures to affect fertility: A computer microsimulation study. Population Bulletin of the United Nations 10:14-35.

Keyfitz, N. 1981. The limits of population forecasting. Population and Development Review 7:579-593.

Lee, Ronald. 1996. Probabilistic Approaches to Population Forecasting. Paper presented at the IIASA Task Force Meeting on Rethinking International Population Projections, Laxenburg, Austria, June 6-8, 1996.

Lee, Ronald D. and Shripad Tuljapurkar. 1994. Stochastic population forecasts for the United States: Beyond high, medium, and low. Journal of the American Statistical Association 89:1175-1189.

Nelissen, Jan H.M. 1995. Demographic Projections by Means of Microsimulation: The NEDYMAS Model. Work and Organization Research Centre, Tilburg University, The Netherlands.

Orcutt, Guy, Steven Caldwell, and Richard Wertheimer, II. 1976. Policy Exploration Through Microanalytic Simulation. The Urban Institute, Washington, D.C.

Pollard, J.H. 1973. Mathematical Models for the Growth of Human Populations. Cambridge University Press, Cambridge, U.K.

Ridley, Jeanne Clare and Mindel C. Sheps. 1966. An analytic simulation model of human reproduction with demographic and biological components. Population Studies 19:297-310.

Ruggles, Steven. 1987. Prolonged Connections: The Rise of the Extended Family in Nineteenth-Century England and America. The University of Wisconsin Press, Madison, USA.

Stoto, M. 1983. The accuracy of population projections. Journal of the American Statistical Association 78:13-20.

Sykes, Z.M. 1969. Some stochastic versions of the matrix model for population dynamics. Journal of the American Statistical Association 64:111-130.

Van Imhoff, Evert and Wendy Post. 1997. Microsimulation models for population projection. (Final draft, May.) To appear in a Population special issue on "Nouvelles approches méthodologiques en démographie." Netherlands Interdisciplinary Demographic Institute, the Hague.

Walker, Agnes. 1997. Australia's Ageing Population: How Important are Family Structures? Discussion Paper No. 19. National Centre for Social and Economic Modelling, Faculty of Management, University of Canberra, Australia.

Wolf, Douglas A. 1988. Kinship and family support in aging societies. Pages 305-330 in Economic and Social Implications of Population Aging. United Nations Department of International Economic and Social Affairs, New York.

Wolf, Douglas A. 1997. Microsimulation as a Tool for Population Projection. Paper presented at the annual meetings of the Population Association of America, Washington, D.C., March 27-29, 1997.

Wolf, Douglas A., Jan Ondrich, Kenneth G. Manton, Eric Stallard, Max A. Woodbury, and Larry Corder. 1995. A Model for Simulating Life Histories of the Elderly: Model Design and Implementation Plans. Papers in Microsimulation Series, Paper No. 1. Center for Policy Research, Syracuse University, New York.

Wolf, Douglas A. and Sarah Laditka. 1996. Stochastic Modeling of Active Life and its Expectancy. Paper presented at REVES 9, Rome, December 11-13, 1996.

Wolfson, Michael C. 1989. Divorce, homemaker pensions and lifecycle analysis. Population Research and Policy Review 8:25-54.

Wolfson, Michael C., Geoff Rowe, Jane F. Gentleman, and Monica Tomiak. 1990. Earnings and Death — Effects over a Quarter Century. Research Paper Series, No. 30. Social and Economic Studies Division, Statistics Canada.

Chapter 5
The Family and Fertility Survey (FFS)

Wolfgang LUTZ, Vera NOWAK, Christiane PFEIFFER

5.1. Goals

The main purpose of the FFS Survey in Austria (as in many other countries) was to collect data concerning the current familial living conditions and the biographies of adults aged 20-54 years with particular interest in partnerships, births, work experience, and education. The official statistics (censuses and vital statistics) as well as statistics from the Ministry of Finance and the social insurance administrations provide only limited data about the processes surrounding the formation of family structures. These are not always suitable for a deeper analysis of behavioral changes. The FFS was designed to compliment existing official statistics, opinion polls or qualitative studies and provide for the first time in many countries information on biographical interactions between education, work experience, cohabitation, fertility and living arrangements. The FFS data were collected to form a basis for scientific studies as well as for the evaluation and planning of relevant political measures.

5.2. The European Framework

The FFS is coordinated internationally by the Population Activities Unit (PAU) of the Economic Commission for Europe (UN/ECE). So far 20 countries (including Austria) have taken part in the FFS. Three more European countries (Portugal, Bulgaria and the Czech Republic) are presently in the process of conducting the survey. Table 5.1 gives an overview of samples, period of questioning, and availability of data in the form of a standard recode file.

For cross-country analysis, an international team of experts was selected to coordinate the comparative research of the FFS data. A large number of comparative projects have already been approved and will be conducted over the next few years.

Table 5.1: List of countries participating in the FFS with data available by January 1997.

Country	Sample women	Sample men	Age groups	Time of interview Start	Finish	Standard Recode File Available	Submitted to PAU	Open to public
Austria	4500	1500	20-54	12/95	5/96	yes	yes	no
Belgium	3000	2000	20-40	3/91	9/91	yes	yes	no
Canada	7500	6000	15-54	1/90	3/90	yes	yes	yes
Estonia	5000	-	20-69	1/94	8/94	no	no	no
Finland	4000	2000	22-51	8/89	1/90	yes	yes	yes
France	3000	2000	20-49	3/94	4/94	yes	yes	yes
Germany	6000	4000	20-39	7/92	8/92	yes	yes	yes
Holland	5100	3800	18-42	2/93	3/93	no	no	no
Hungary	4000	2000	18-41	11/92	12/93	yes	yes	yes
Italy	4800	1200	20-49	11/95	2/9	yes	yes	yes
Latvia	2700	1500	18-49	9/95	10/95	yes	yes	yes
Lithuania	3000	2000	18-50	10/94	11/95	yes	yes	yes
New Zealand	3000	-	20-59	10/95	10/95	no	no	no
Norway	5000	2000	20-43	10/88	5/89	yes	yes	yes
Poland	4500	4000	18-49	11/91	12/91	yes	yes	yes
Slovenia	2800	1800	15-45	12/94	12/95	yes	yes	no
Spain	4000	2000	18-49	8/94	12/94	yes	no	no
Sweden	4200	2300	22-44	10/92	5/93	yes	yes	yes
Switzerland	4200	2000	20-49	10/94	5/95	no	no	no
U.S.A.	10500	-	15-44	1/95	10/95	no	no	no

5.3. Questionnaire, Sampling and Interviews in Austria

The internationally recommended questionnaire had a modular form allowing great flexibility for national surveys. The core module used in most countries includes biographies for births, nonmarital and marital unions, education and work. In addition the Austrian Survey emphasized migration biographies, conditions in the parental home, family planning and desired family size, as well as opinions and views on social and political issues that have to do with the family.

The sampling and interviewing in Austria was done by the commercial opinion poll company Integral. The method of entering the data was that of a questionnaire with bar codes (like in the supermarket) where the interviewer used a special pen to scan the bar code for the answer given. This method has the advantages of automatic consistency checking and fewer coding errors without the psychological barrier of having a laptop between the interviewer and the person being interviewed.

A pre-test survey concluded that the questionnaire, which originally required an average 71-minute interview, was too long. After a revision, the official survey began at the beginning of December 1995 and ended in the middle of May 1996.

A total of 4,581 women and 1,539 men, who were considered representative for all of Austria as well as for the different provinces, were interviewed. These included also non-Austrian citizens. In order to have a representative female sample for each province, the provinces were disproportional to their size in the overall sample. The regional sample can be seen in Table 5.2.

Table 5.2: Female and male sample sizes in Austria by province.

Women		Men	
Burgenland	350	Tirol and Vorarlberg	300
Vorarlberg	350	Salzburg and Upper Austria	300
Tirol	450	Carynthia and Styria	300
Carynthia	450	Lower Austria and Burgenland	300
Salzburg	450	Vienna	300
Lower Austria	600		
Upper Austria	600		
Styria	600		
Vienna	700		

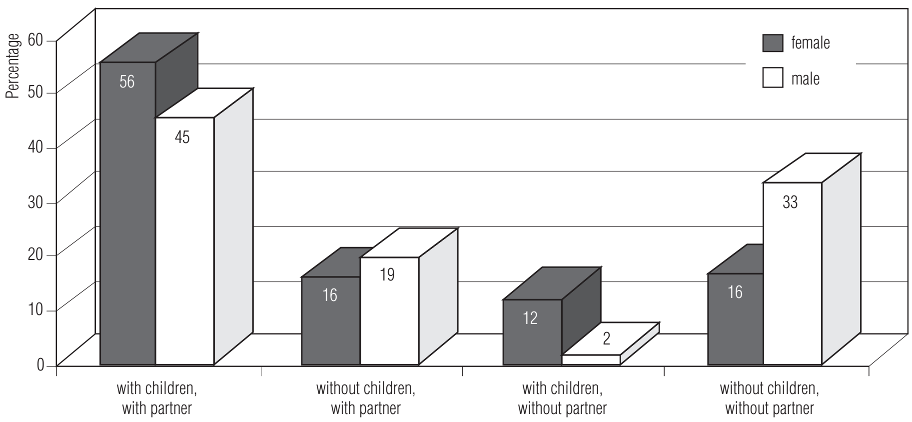
The motivation of the interviewed persons was described by the interviewers as very high, although the average length of interview was 45 minutes and in some extreme cases of persons with very complex histories, even 180 minutes. In general, respondents found it exciting and rewarding to review their biographies in a way they had never done before.

5.4. Family Status at the Time of the Interview

More than half of the interviewed women (56 percent) live together with a partner and children in one household (see Figure 5.1). Approximately 90 percent of these women are married, 7 percent unmarried, and 3 percent divorced or widowed. Of all the interviewed women, 16 percent live with a partner in one household and have no children. From this group, 53 percent are married, whereas every third woman is unmarried. Sixteen percent of the interviewed persons live without children and without a partner; 84 percent of these are unmarried. Of all the interviewed women, 12 percent are single mothers and live with children without a partner. The majority of these women (56 percent) are divorced or widowed, 30 percent are unmarried (this comprises 6.7 percent (divorced) and 3.5 percent (unmarried) of all interviewed women).

Figure 5.1: Percentage of respondents in different living arrangements in Austria. Population aged 20-54. Source: Family and Fertility Survey.

The distribution of family status by age is reflective of the timing of the dif-



ferent phases of the family cycle. In the cohort (age group) 30-39, the portion of women who live together with partner and children comprises over 70 percent; in the oldest cohort (50-54), this portion decreases to 37 percent. This decrease is caused by children leaving their parental household. In the youngest cohort (20-24) every fifth woman lives with a partner and children; but the majority live without children and without a partner, and to a large extent still with the parents (36.5 percent). The portion of single mothers is the highest in the age group 40-45 (18.5 percent) which is almost three times larger than for women in the youngest cohort.

For all age groups, the majority of the women who live with a partner and children are married. The younger the age group, the more often one finds mothers who live in a nonmarital union (20-24: 8.6 percent; 40-44: 0.8 percent). Among the single mothers, with the exception of the youngest age group, divorced women make up the largest portion; 70 percent of all single mothers aged 40-54 are divorced.

The results for men are similar, with two exceptions: the portion of single fathers is only 1.8 percent (single mothers: 12 percent); the portion of men without partner and children in the total sample is 33.4 percent (women: 16.4 percent). This can be explained by the longer period of residence with the parents for young men (see discussion below) and by a higher percentage of single, non-cohabiting men.

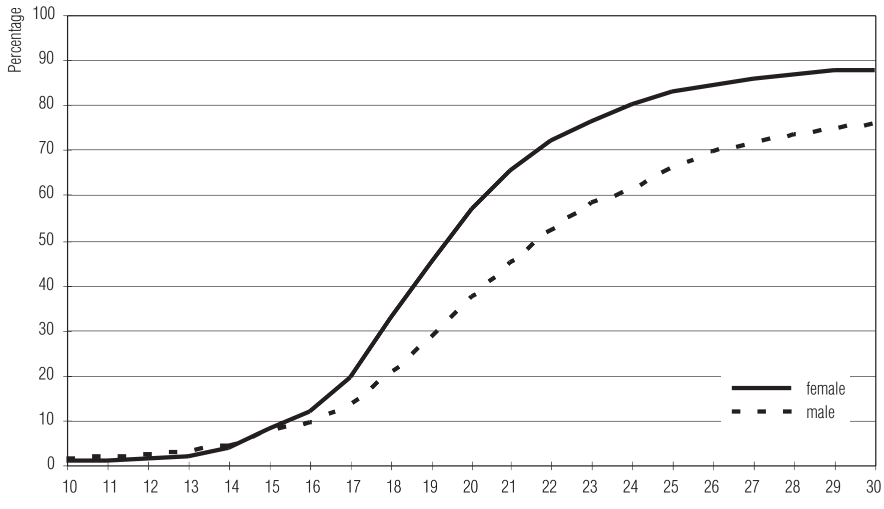
5.5. Leaving the Parental Home

Figure 5.2 shows the cumulative proportions of men and women by the age at which they left the parental home as reconstructed from their life histories. It shows that few young people leave their parents before age 16 and after that age, women generally leave the parental home at higher rates.

The fact that women leave the parental home at younger ages is also reflected in the distribution across cohorts. Of the youngest age group 20-24, 63 percent of all interviewed women live away from their parents, but only 44 percent of all men. For the age group 25-29, this proportion increases to 91 percent for women, while still one-quarter of all men live with parents.

Compared over time, the age of leaving the parental home has been continuously falling over the past decades except for the last few years when a reversal of the trend could be observed.

Figure 5.2: Cumulative distribution of respondents by the age of leaving the parental home in Austria. Population aged 20-54. Source: Family and Fertility Survey.



5.6. Education

Similar to most countries in the world over the last decades, Austria experienced a significant increase in the higher education of women. As indicated in Table 5.3 the mean number of years that women spend in education between the ages 15 and 30 has increased from less than two years for women aged 50-54 at the interview to 3.12 years in the age group 30-34. As indicated by the relatively high standard deviations, educational inequalities did not decline over time.

Table 5.3: Average number of years of education for ages 15 to 30 in Austria.

Age groups	30-34	35-39	40-44	45-49	50-54	Total
Women						
Average	3.12	3.03	2.67	2.25	1.94	2.66
Standard deviation	3.01	3.03	3.08	3.18	2.82	3.06
Men						
Average	4.10	3.55	3.46	4.49	4.03	3.91
Standard deviation	3.45	3.51	3.56	4.35	4.05	3.76

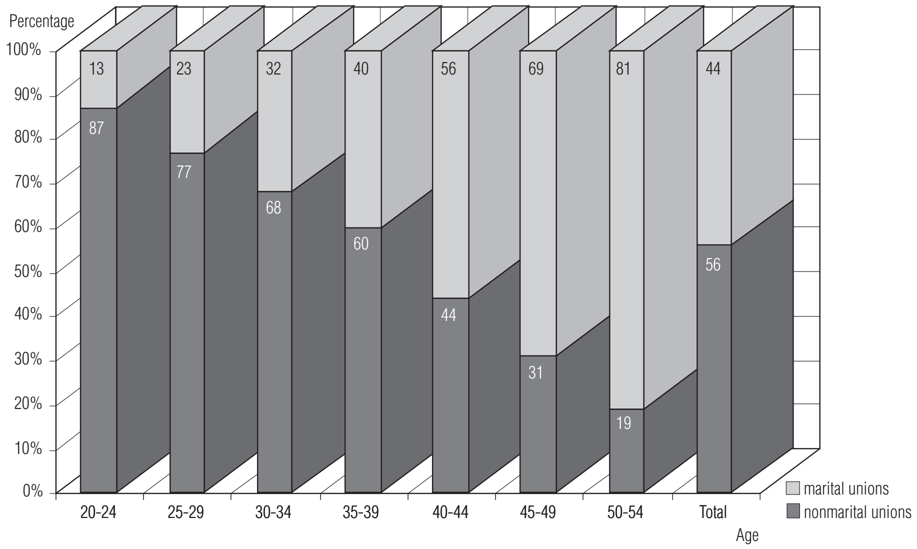
As will be discussed in the subsequent chapters on behavioral equations in FAMSIM, years of education not only affect the living conditions of young adults still in the process of education, but also constitute an important determinant of behavior throughout the rest of a person's life. Such educational effects range from union formation and dissolution to fertility, employment and even life expectancy, which shows great educational differentials.

5.7. Formation of Unions

The FFS defines a union as two people of opposite sex living together as partners in the same household. Unions can be either marital or nonmarital.

The type of first union formed by men and women has changed dramatically over the years. In earlier decades, for a large majority, moving in together for the first time began with marriage. Today, in the youngest cohort, 87 percent of all couples living together live in a nonmarital union. As indicated in Figure 5.3, living together without a marriage certificate has become the standard practice for the younger cohorts, whereas it was still a rare exception three decades ago.

Figure 5.3: Types of unions by age in Austria.
Population aged 20-54. Source: Family and Fertility Survey.



While in the oldest cohort of the FFS (age 50-54), 63 percent of all women had married by age 24 without having lived together with a partner before, only 6 percent of the youngest age group followed such behavior. The change in marriage patterns between these two most extreme cohorts is almost linear. Correspondingly, the portion of first nonmarital unions continually increases.

In summary, three trends are apparent in the formation of first unions:

1) An almost linear decrease in the portion of those who began their first union as a marital union; accordingly the portion of nonmarital unions increases.
2) Up to the cohort aged 30-34, cohabitation was being entered at younger ages.
3) For the youngest cohorts there seems to be a reversal of the trend implying higher ages at the formation of unions. Because the two youngest cohorts remain in their parents' households longer, the portion of marital as well as nonmarital unions decreases for the youngest age groups.

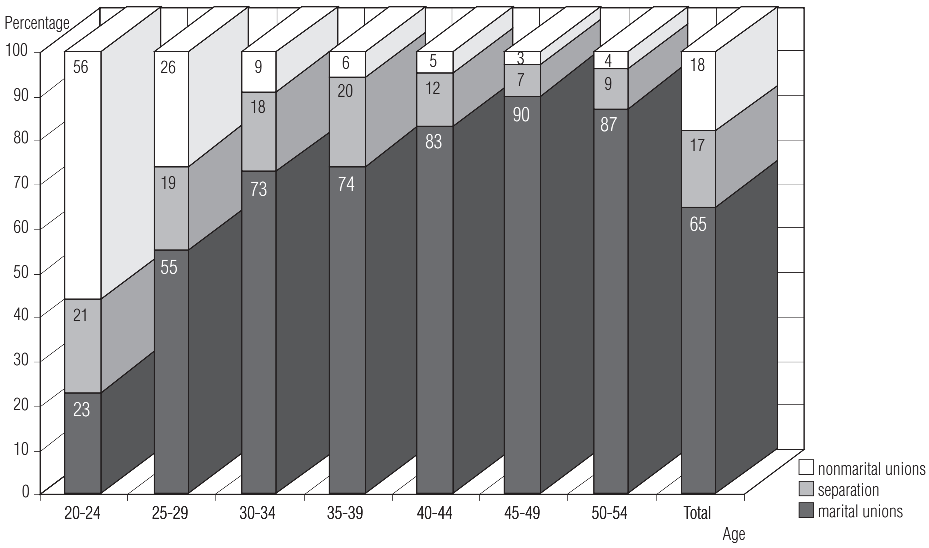
5.8. Changes in Union Status over the Life Course

Figure 5.4 describes the further developments of unions that began as nonmarital unions by age at the time of the interview. Generally this figure confirms the view that in Austria, nonmarital unions are a precursor to a subsequent marriage. For all age groups above age 30, less than 10 percent of all women who started out in a nonmarital union are still living together with the same partner in that form; 70-90 percent of those first nonmarital unions have later been converted into marital unions. The rest ended in separations.

For the youngest two age groups the differences are remarkable. Already at ages 25-29, more than half of all nonmarital unions have been converted into marriages. In the youngest age group, 20-24, the nonmarital unions, which at that age tend to be of very short duration, dominate the picture. Although it cannot be assumed with certainty that the young women living in nonmarital unions today will behave in the same way as women of the preceding cohorts, these data give strong evidence that in Austria, nonmarital unions tend to be largely a precursor to marriage.

At the time of the interview, 21 percent of all first unions for both men and women had ended in dissolution or divorce. The younger the cohort, the larger the proportion of unions that ended in dissolution or divorce at given durations. It is not yet possible to determine whether this indicates a general increase in dissolution probabilities among the younger cohorts, or whether it is only a change of dissolution patterns toward shorter durations.

Figure 5.4: Further development of first nonmarital unions among women in Austria. Population aged 20-54. Source: Family and Fertility Survey.



Of those entering first unions beginning with marriage, 18 percent of the women have been divorced before duration 20. The portion of divorced women is 18 percent in the oldest cohorts and increases in the cohorts 35-39 to a maximum of 24 percent. The risk of dissolution for nonmarital cohabitation is higher than for marital unions. The proportion of unions (marital and nonmarital combined) dissolved after 20 years is more than 20 percent. Further results show that the risk of divorce is higher for those partnerships that began as non-marital unions and later married, than for those couples marrying right away.

5.9. Fertility and Timing of Birth

As shown in Table 5.4 the numbers of children ever born to women varies significantly over age groups. For the younger age groups this is, of course, partly due to the fact that persons have not yet completed their reproductive career by the time of the interview. But the pattern also reflects a change in fertility over time with a decreasing mean number of children per woman, a decline in the incidence of high parity births, and a changing pattern in the time of births.

Table 5.4: Distribution of women interviewed by the number of children born alive in Austria.

Number of	In age groups, in percentages							
children	20-24	25-29	30-34	35-39	40-44	45-49	50-54	Total
0	73.3	32.9	15.0	10.8	7.1	7.6	6.5	23.8
1	19.0	34.8	24.9	24.0	21.9	19.1	18.9	23.8
2	6.2	27.2	46.1	44.2	41.9	40.5	42.1	34.6
3	1.2	3.9	9.8	15.2	21.6	21.3	21.1	12.4
4	0.0	0.7	3.1	4.4	4.8	8.2	5.9	3.6
5+	0.0	0.0	1.0	1.0	2.8	3.0	4.8	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
n=	*723*	*787*	*771*	*624*	*602*	*557*	*517*	*4584*
Average number	0.4	1.0	1.6	1.8	2.1	2.1	2.2	1.5

A reconstruction of the fertility histories of the interviewed women shows that teenage fertility has clearly declined over time. For the cohorts older than 40 years today, more than 30 percent had their first child by the age of 20. For the youngest age groups, this portion declined to 16-18 percent. More than half of the cohort aged 45-49 today had their first child by the age of 22, compared to only one-third of the cohort aged 25-29. As to the birth intervals, the pattern has not changed significantly. For the cohorts above age 30, approximately half of all the women who had a first child had a second child before the fifth birthday of the first child. Most of these second births are concentrated in the first two years following the first birth (see Table 5.5).

Table 5.5: First births by union status of mother, Austria.

Type of union	20-24	25-29	30-34	35-39	40-44	45-49	50+	Total
Marital	35.1	51.6	60.2	61.4	70.2	71.9	75.7	63.2
Nonmarital	26.5	24.7	18.1	15.4	8.8	3.9	3.2	13.5
No union	38.4	23.7	21.8	23.3	20.9	24.2	21.1	23.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
n=	*191*	*525*	*655*	*554*	*559*	*513*	*480*	*3479*

The proportion of first births born out of wedlock has always been very high in Austria. Especially in the rural regions of central and southern Austria there is a long tradition of having a baby and then marrying. This is reflected in the fact that even for women in the oldest cohorts between 25 percent and 30 percent of all first births were born out of wedlock. For cohorts below age 40 the proportion of first births born to women living alone remains high; in addition the proportion to women in nonmarital unions increases. Consequently the portion of first births born in a marital union decreases for the youngest cohorts to 52 percent (25-29) and 35 percent (20-24). For this youngest age group the largest fraction (38 percent) of first births is to women not living with a partner. Since, however, many women will only have their first child after that age group, this youngest group has a strong selection bias and is not indicative of a strong behavioral change.

5.10. Children and Women's Employment

Another significant change over time relates to the way women combine gainful employment with raising their children. Table 5.6 reflects the fact that younger women combine employment with the rearing of children to a larger degree than members of the older cohorts. Although Table 5.6 does not consider the age of children – another important determinant of female employment – it shows, e.g., that the proportion of employed women with two children at home increased from 7 percent in the age group 50-54 to 19 percent in the age group 35-39.

Table 5.6: Employed women (part- or full-time) and the number of children in the household in Austria.

Number of children	In age groups, in percentages							
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	Total
0	38.0	22.8	11.5	8.8	8.8	18.8	25.5	19.4
1	4.2	13.3	10.5	14.1	18.0	21.6	14.8	13.3
2	1.3	5.8	15.6	19.4	19.3	11.2	7.3	11.2
3+	0.0	0.3	2.9	7.9	8.9	5.8	2.4	3.8
Total	43.4	42.2	40.6	50.2	55.0	57.4	49.9	47.6
n=	*723*	*787*	*771*	*624*	*602*	*557*	*517*	*4584*

With respect to the extent of employment, the data also reveal that an increasing proportion of women prefer to combine children with part-time work at least while the children are young. More than half of all employed women with children of pre-school age work only part time. This preference for part-time and flexible arrangements of working hours is also clearly indicated in the section of the FFS asking for opinions and expectations to family policies.

5.11. Conclusion

The Austrian FFS constitutes the empirical basis for the FAMSIM-Austria prototype model. This chapter has mentioned, in a very selective manner, some of the key aspects of the data that have an impact on the estimation of the behavioral equations for FAMSIM. The first descriptive findings of the FFS-Austria were published in early 1997 in a volume by the Austrian Institute for Family Studies (ÖIF) (Doblhammer et al., 1997). They give tabulations and some interpretations for the whole of Austria as well as for pairs of provinces (with a separate volume on Vienna). More in-depth scientific analysis of the FFS data is presently under way at several Austrian institutions, and will soon find its way through the usual channels of publications.

References

Doblhammer, G., W. Lutz, and C. Pfeiffer. 1997. Familien- und Fertilitätssurvey (FFS) 1996 (Family and Fertility Survey (FFS) 1996). Austrian Institute for Family Studies, Vienna, Austria.

Chapter 6
The FAMSIM Prototype for Austria: Analysis of FFS Data

Douglas A. WOLF

6.1. Scope and Objectives of Analysis

This chapter describes the analysis of the Austrian Family and Fertility Survey (FFS) data for purposes of developing the equations used in the FAMSIM prototype. These equations produce estimates of probabilities of making transitions between states representing four domains of life-cycle experience: childbearing; the formation and dissolution of partnerships, both marital and nonmarital; the acquisition of schooling; and the cumulation of labor market experience. For these four life-cycle phenomena, the FFS data provide unusually complete "biographies," or retrospective data on the dates and circumstances of life course events.

The equations for transition probabilities are intended to represent the interdependence across behavioral domains, as each develops over the life course. Furthermore, while the set of equations, taken together, are fitted to the historical experience reported in the FFS biographical data, they are also intended to provide a basis for projecting such behaviors into the future. Accordingly, in each equation we include a variable representing calendar time. The trend effects thus estimated may, or may not, extend into the future; they may accelerate, dampen, or reverse. FAMSIM itself provides a vehicle for examining the consequence of alternative assumptions regarding the future evolution of trends in any or all of the transition probabilities used in the model.

The FFS data also are used to initiate the dynamic process simulated. A data file representing a cross-section of the female Austrian population, in July 1995, is used for this purpose. The starting population data file is an excerpt from the data base developed for estimating the equations for transition probabilities. In the next section, the creation of the data base is described. Then, the status (stock) and transition (flow) variables used in the analysis are described. This is followed by presentation and discussion of the estimated equations for each possible transition. We then describe the algorithm used to carry out microsimulation projections, using the model of transition probabilities. The chapter concludes with a brief discussion of ways in which the analysis could be extended in order to develop a more complete and complex (and hence more realistic) version of FAMSIM.

6.2. Processing of FFS Data

6.2.1. Creation of person-month observations

The analysis uses data supplied by women aged 20 through 49 at the time of interview. Women younger than 20 were not interviewed; the reason to limit the sample to women under 50 was the desire to restrict the analysis to the years of potential reproductive behavior. However, women were asked about all childbirth, partnership, schooling and work episodes in their past. Therefore, we constructed histories of these domains back to the month following these women's fifteenth birthday.

Women were asked about the timing of births, marriages, periods of cohabitation, and so on; in each case, the month and year of these events was recorded. Therefore, our "history" file contains codes representing women's statuses, and indicators of the occurrence of events, in each month lived from the month after the fifteenth birthday to the month preceding the FFS interview. "Status" variables (such as the number of children ever born, or the number of months that a woman has lived with her cohabiting partner) are interpreted as measures that pertain to the beginning of the month in question, while "event" variables (such as live birth, beginning a job, ending a marriage, and so on) are interpreted as occurrences during the month in question. Thus, for example, if a live birth takes place in some month, then the parity variable is updated in the following month.

Because of the fact that FFS interviews were taken at a point in time, but collected retrospective histories, our history file contains varying numbers of monthly data records for women of different ages. Women 20 years old at the time of the interview provide monthly data for at least five years of their lifetime, or 60 months of historical data. Women interviewed in the month before their fiftieth birthday, however, provide monthly data for a 35-year period, giving us a total of 420 months of historical data. Therefore, although our sample uses the data provided by a total of 3855 women, our history file contains a total of 866,786 person-months of information. In all of our analyses, we treated all of these person-months as independent observations.

As is commonly true in survey data, we encountered many instances of missing or contradictory data. In many cases the year but not the month of important events was reported. Wherever possible, we imputed a value for the missing month information rather than discard the observation. In some cases, the data provided were clearly incorrect, but there was no obvious way to resolve the error; for example, women might report that a marriage ended before it began, and no other information was available with which to make a judgmental recoding of the information. In these cases, we simply discarded the woman from the data file. The total number of records lost in this way is 726, representing 15.8 percent of the 4581 respondents potentially available for analysis.

Most of our coding of analysis variables is quite straightforward: for periods of employment, schooling, nonmarital co-residence, and marriage, women provided a date for the beginning and (if relevant) the end of the episode (episodes in progress at the time of the interview have not ended). We treat all these codes as representing a complete history of the women's life-cycle experiences in the respective domains. However, with respect to fertility our histories are incomplete. Dates for live births only were obtained in the FFS, and the existence and timing of pregnancy outcomes other than live births is not recorded. Consequently, our fertility data represents a history of live births only. While this is adequate for many policy issues, it is clearly not complete from the viewpoint of reproductive behavior. The missing data introduces a small amount of error into our analysis; for example, some women suffer fetal loss and are subsequently unable to conceive, and such women, if included among FFS respondents, are incorrectly treated as at-risk of pregnancy leading to a live birth. The error introduced through this missing data is, however, likely to be quite small. Also, the FFS data include no information on the term of pregnancy, so we assumed that all live births occurred in the ninth month of pregnancy. Accordingly, our history file records the event "initiation of pregnancy" nine months before the event "live birth." It is necessary to introduce variables indicating pregnancy status, and the duration of pregnancy, since our analysis uses monthly data and there are strong reasons to suspect that women's employment and schooling behavior will be influenced by their pregnancy status.

In the coding of the episodes of schooling, it is evident that women report the beginning and ending of periods in which they attended a particular type of school (for example, Hochschule or University). These episodes span a period of two or more years. We code these as unbroken sequences of months in which the woman is "in school" despite the fact that in fact, the sequence is broken by summer holidays. The analysis recognizes the fact that women may be "in school" and "at work" in the same month. While there are clear calendar-time patterns found in the timing of starting and ending periods of schooling (starts occur disproportionately in September, and endings occur disproportionately in June), and distinctive but less powerful patterns for the timing of beginning and ending employment, we disregard these seasonal patterns in our analysis. While introducing seasonality into the model would improve its realism and accuracy, this improvement would come at the cost of greatly increased complexity, and would probably change the substantive conclusions reached only slightly if at all.

Finally, in our processing of the FFS data we encountered a small number of cases in which two events reportedly took place in the same month, in the same behavioral domain (for example, the ending of a period of cohabitation and the beginning of another period of cohabitation). While this can occur in reality, it cannot, by assumption, in our discrete-time analysis in which one month is the smallest time unit. One possible solution to this problem would be to define new types of events, representing combinations of other events, but this adds great complexity to the model and is, at any rate, impractical since so few compound events take place. Another possible solution, which we did adopt, was to arbitrarily move the second event forward in time by one month, creating, for example, a one-month-long period of being without a partner between two successive episodes of partnership. While this clearly introduces error into the data, any such errors are few and have minimal consequences for the results.

6.2.2. Variables used in analysis

Here we summarize the variables used in the later analysis, and provide definitions and coding schemes for each. Each variable in this list is a "status" variable, as discussed above.

Variable	**Definition/Coding Scheme**
age	age (in months)
time	calendar time (in months)
	1 = Oct 1960
	2 = November 1960, and so on
ltrend	natural logarithm of time
parity	current parity (number of live births)
	= 0, 1, 2, ...
pregmnth	month of pregnancy
	= 0 if not pregnant
	= 1, ..., 9 if pregnant
curbint	current birth interval in months
	= 0 if parity = 0
	= 1, 2, ... in months after a child is born, etc.
ptstatus	partnership status;
	= 0 if no partner
	= 1 if living with nonmarital partner
	= 2 if married
livmnth	number of months of cohabitation with this partner
marmnth	number of months in this marriage
	note: when a woman marries her cohabiting partner the "livmnth" variable STOPS growing and the "marmnth" variable STARTS growing.
school	schooling status
	= 1 during periods of school enrollment
	= 0 otherwise
csch	cumulative number of months of schooling since the 15th birthday

work	employment status = 1 during episodes of paid employment = 0 otherwise
cwrk	cumulative number of months of work since 15th birthday

The "event" variables in our history files indicate transitions between statuses, or the beginning or ending of episodes. Each event, therefore, is associated with changes from month to month in "status" variables. The events in our analysis include (1) initiation of a pregnancy leading to live birth (and followed, automatically, by a live birth nine months later); (2) beginning a nonmarital cohabitation; (3) marrying, without a preceding period of cohabitation (that is, a transition from *ptstatus*=0 to *ptstatus*=2); (4) ending a period of nonmarital cohabitation; (5) marrying one's cohabiting partner; (6) ending a marriage; (7) beginning a period of schooling; (8) ending a period of schooling; (9) beginning a period of work; and (10) ending a period of work. Events in different domains may happen in the same month, but we do not make special note of such joint events in our analysis.

6.2.3. Some descriptive analyses

Table 6.1 provides a summary of our event variables. The percentage of person-months in which each type of event is recorded is shown, classified according to selected "status" variables. Most of these numbers are quite small, but it must be remembered that these are to be interpreted as average *monthly* probabilities of transitions. In all cases, the numbers represent averages across all the ages and calendar years found in our data file, and therefore show only the aggregate patterns. Nonetheless some striking differences can easily be seen in the table. For example, childless women are much more likely to begin a nonmarital cohabitation, or to begin a period of schooling or work, than are women who have had one or more children. Being pregnant women greatly increases the chances of getting married, especially in the second trimester of pregnancy. Pregnancy also increases the chances of ending employment, as would be expected.

Table 6.1 illustrates some of the patterns of interdependence across behavioral domains in the life cycle. However, it does not control for age or changes over time in behavioral tendencies. Figures 6.1 through 6.6 provide some graphical information about age and trend effects. Note that, due to the design of the FFS, we observe different segments of trends in behavior for women of different ages. For example, women age 45 when interviewed in 1995 can provide us with information about the behavior of 20-year-olds in 1970. However, there are no FFS respondents to tell us about the behavior of 45-year-olds in 1970. This sort of limitation appears quite clearly in each of the graphs. For example, Figure 6.1 shows graphs of average parity in each of four age groups, for the period 1970-1995. We have shorter historical periods with which to observe the trends for successively older groups of women.

The figures show clear patterns of variation in life-cycle events by age and, in most cases, indicate changes over time as well. Mean parity, for example, increases with age but has fallen over time in every age group. The trends in childlessness, shown in Figure 6.2, are not as clear as in Figure 6.1, suggesting complex changes over time in the timing and ultimate number of children, and in the parity distribution. Cohabitation has risen sharply over time (Figure 6.3), mirrored by a nearly universal pattern of decline in the percentage of women married at each age (Figure 6.4). School attendance has also risen, with women aged 20-24 much more likely to be in school in 1995 than in all previous years (Figure 6.5). Employment patterns, however, show little evidence of trend effects (Figure 6.6).

There are clearly complex patterns of association between events and statuses in the various behavioral dimensions of women's lives, as well as the expected strong effect of age and several quite evident patterns of change over time. Because of the need to simultaneously control for many factors that might jointly influence the probability that a woman will experience a transition at any point in her lifetime, it is necessary to employ multivariate analytic techniques. We now describe the results of our multivariate analysis.

Figure 6.1: Mean parity by age group: 1970-1995.

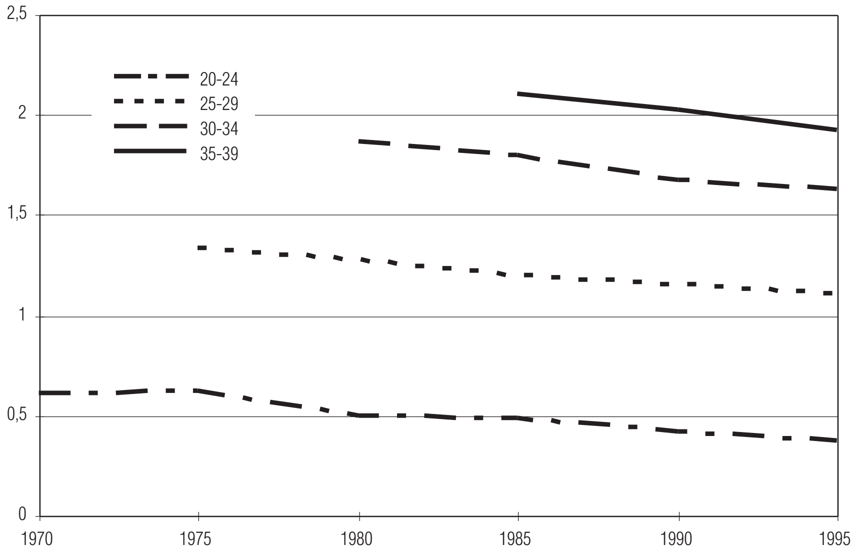


Table 6.1: Percentage of person-months in which selected transitions occurred by status.

STATUS	TRANSITION									
	Become Pregnant	Begin Cohabitation	Begin Marriage	Marry Cohabitor	End Cohabitation	End Marriage	Begin School	End School	Begin Work	End Work
Not Pregnant										
Parity = 0	0.71	0.43	0.18	0.16	0.07	0.02	0.58	0.81	0.90	0.31
Parity = 1	1.21	0.18	0.11	0.20	0.05	0.12	0.05	0.01	0.56	0.34
Parity = 2	0.32	0.04	0.02	0.04	0.01	0.09	0.02	0.02	0.34	0.20
Pregnant										
First Trimester		0.48	0.79	0.82	0.02	0.04	0.05	0.28	0.29	0.94
Second Trimester		0.39	1.52	1.07	0.03	0.04	0.02	0.20	0.09	2.36
Third Trimester		0.46	0.36	0.43	0.05	0.04	0.01	0.33	0.11	7.85
No Partner	0.38	0.63	0.37				0.61	0.82	0.92	0.38
Cohabiting	0.99			1.72	0.49		0.11	0.37	0.66	0.75
Married	0.81					0.13	0.03	0.05	0.36	0.52
Not in School	0.72	0.27	0.17	0.19	0.05	0.07	0.34		0.62	0.55
In School	0.21	0.29	0.08	0.04	0.04	0.01		2.80	0.72	0.10
Not Working	0.59	0.20	0.10	0.12	0.03	0.05	0.51	0.68	1.21	
Working	0.71	0.35	0.22	0.22	0.06	0.07	0.05	0.13		1.01

Figure 6.2: Percent of women without children ba age group: 1970-1995.

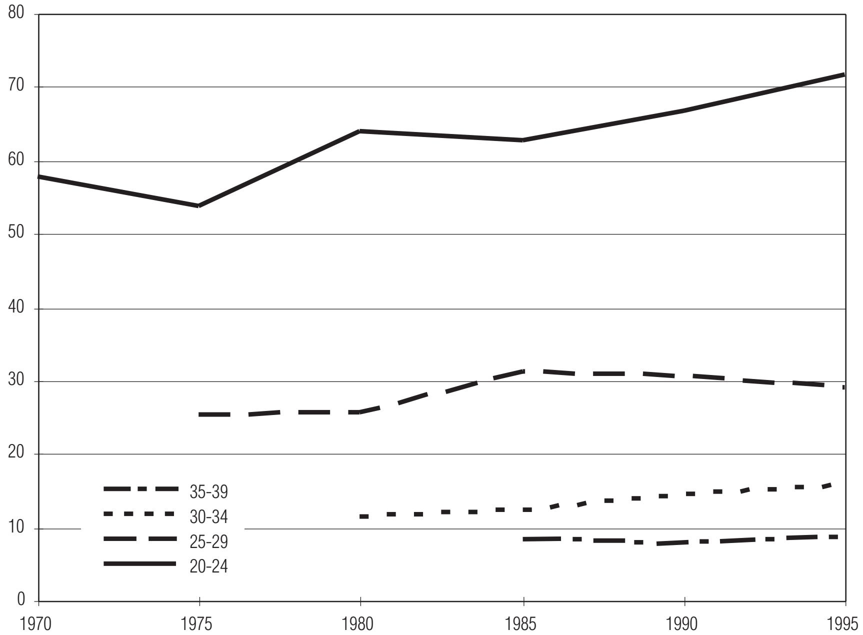


Figure 6.3: Percent of women who are cohabiting by age group: 1970-1995.

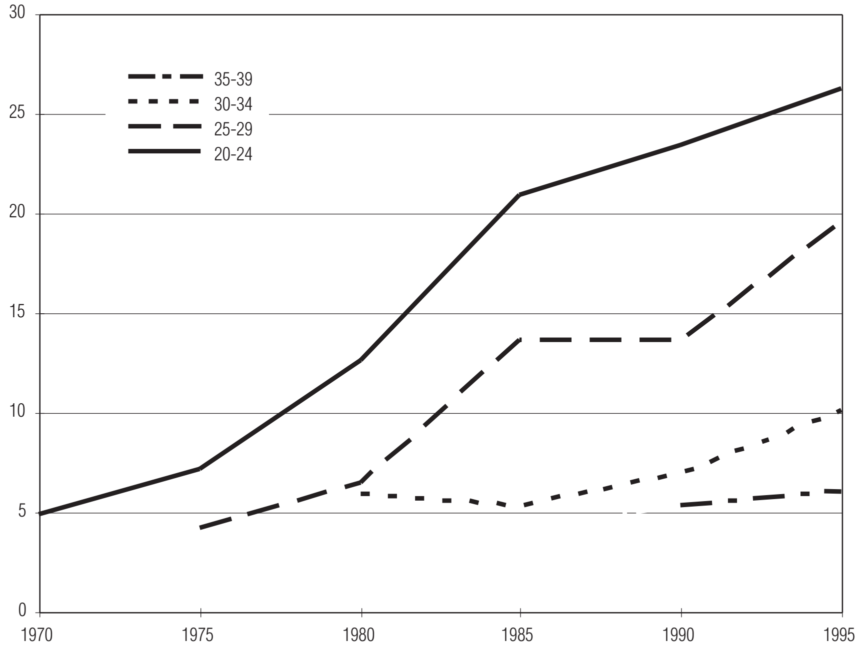


Figure 6.4: Percent of women who are married by age group: 1970-1995.

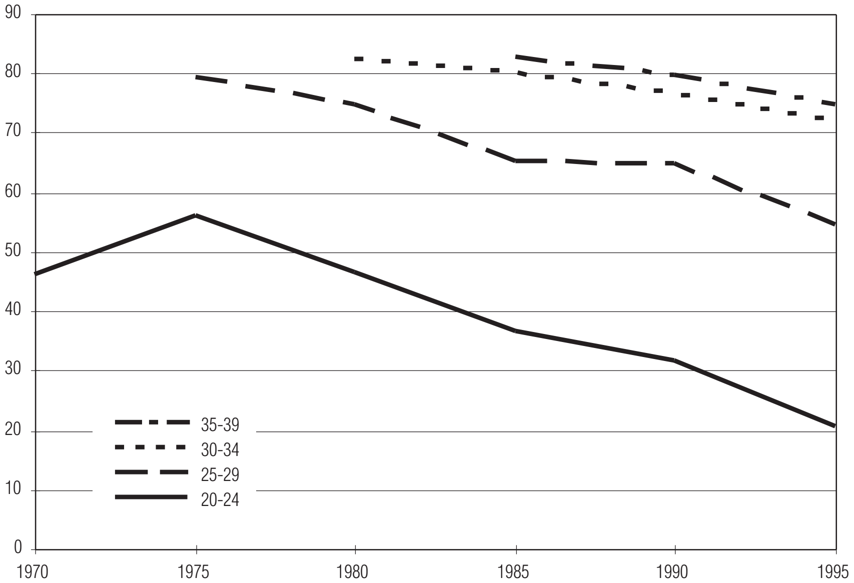


Figure 6.5: Percent of women who are in school by age group: 1970-1995.

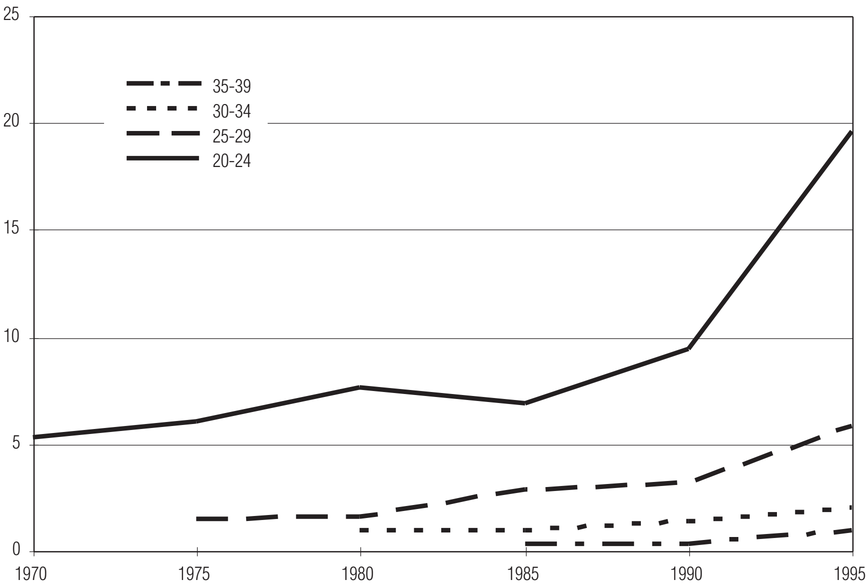
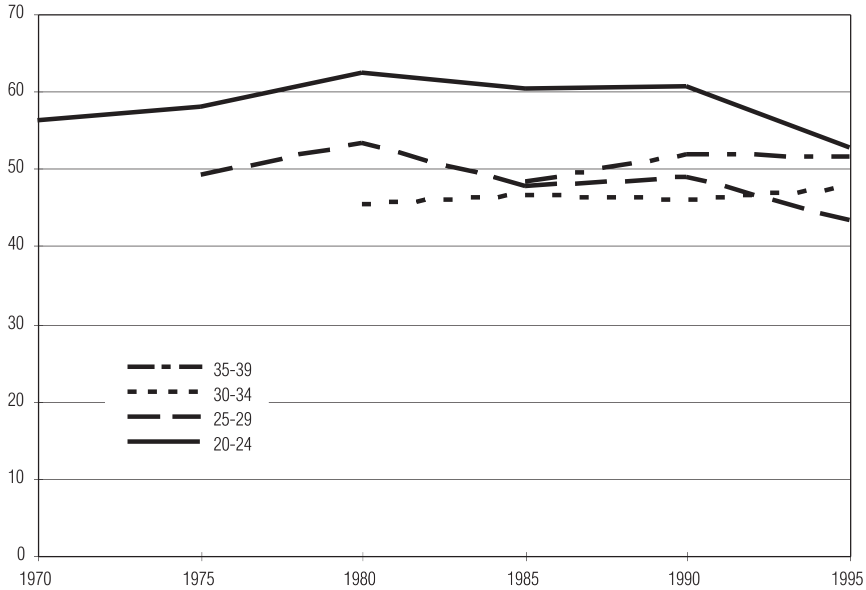


Figure 6.6: Percent of women who are working by age group: 1970-1995.



6.3. Estimated Equations for Dynamic Outcomes

Table 6.2 summarizes the structure of the model used in FAMSIM. The rows of this table correspond to possible transitions. The columns indicate which "status" variables appear as explanatory factors in the equation for each transition. In Table 6.2, the factors upon which transition probabilities depend are abbreviated as follows:

M = month in pregnancy
C = parity (number of live births)
BI = birth interval (months since last live birth)
P = partnership status
PD = duration of current partnership
S = schooling status
SD = cumulative amount of schooling
W = work status
WD = cumulative amount of work

All the listed transitions depend, additionally, on age and calendar time.

Table 6.2: Random transitions and their dependence on other state variables.

Transition	Factors on which transition depends								
	M	C	BI	P	PD	S	SD	W	WD
1 not pregnant to month 1 of pregnancy		x	x	x	x	x	x	x	x
2 no partner to (a) cohabiting partner or (b) married	x	x	x			x	x	x	x
3 Cohabiting partner to (a) married (to same partner) or (b) no partner	x	x	x		x	x	x	x	x
4 married to no partner	x	x	x		x	x	x	x	x
5 not in school to in school	x	x	x	x	x		x	x	x
6 in school to not in school	x	x	x	x	x		x	x	x
7 not working to working	x	x	x	x	x	x	x		x
8 Working to not working	x	x	x	x	x	x	x		x

All transitions are analyzed using logistic regressions. For binary transitions (numbers 1 and 4-8 in Table 6.2) the form of the equation is

$$pr\ (\text{transition}) = \frac{e^{\beta' x}}{1+e^{\beta' x}}$$

For the two cases in which more than one possible transition can take place (numbers 2 and 3 in Table 6.2) the form of the equation is

$$pr\ (\text{transition of type 1}) = \frac{e^{\beta_1' x}}{1+e^{\beta_1' x}+e^{\beta_2' x}}$$

with an analogous expression for the probability of a transition of type 2.

The logistic regression coefficients are presented in Tables 6.3-6.5. The numbers appearing in parentheses are the standard errors of the estimated coefficients, although it must be borne in mind that the apparent sample sizes for these regressions is greatly inflated by our pooling of person-months in the analysis. Each regression is estimated using only the person-months for which a woman is "at risk" of the transition in question. For example, only nulliparous women are at risk of a first pregnancy, only women in school are at risk of ending a period of schooling, and so on. Accordingly, there are different numbers of person-months used in each regression.

Many of the fundamental variables from our history file, described above, appear in recoded form in the regressions, and the specific lists of variables included differ from equation to equation. These variations in equation specification are the result of a limited amount of exploratory analysis. We provide little interpretive discussion of the regression results; in many cases it is unclear what the a priori expectations concerning the direction and relative size of covariate effects should be. It should be noted that significant trend effects are found in nearly every regression, suggesting that sensitivity analysis of the results of FAMSIM, produced with a range of assumptions about the future path of trends in transition probabilities, will be important. Also, in every regression we have included both age and the square of age, in order to allow for curvilinear but "smoothed" age-profiles of the propensity for each transition (holding constant other factors). In nearly every case we find strong evidence of these curvilinearities, in most cases in accordance with prior findings from demographic research. At every parity, for instance, the chances of pregnancy rise, and then fall, with age.

Table 6.3: Logits for pregnancy.

	First (BNL1)	Second (BNL2)	Third (BNL3)	Fourth+ (BNL4)
INTERCPT	-10.0003	-8.5642	-6.4242	-7.1259
	(0.5129)	(0.7400)	(1.3178)	(2.7225)
PARITY4				0.4167
				(0.1743)
PARITY5+				0.4186
				(0.2990)
AGE	0.5258	0.4002	0.2510	0.4587
	(0.0423)	(0.0528)	(0.0869)	(0.1638)
AGESQ	-0.0107	-0.0081	-0.0048	-0.0083
	(0.0009)	(0.0009)	(0.0014)	(0.0025)
BINT1324		0.4224	0.4361	0.4705
		(0.0659)	(0.1323)	(0.2052)
BINT2536		0.4971	0.5065	0.0794
		(0.0746)	(0.1430)	(0.2467)
BINT37P		0.0986	0.3309	0.1828
		(0.0790)	(0.1405)	(0.2135)
COHAB	0.9736	0.5398	1.2682	0.0478
	(0.0622)	(0.1153)	(0.2434)	(0.4961)
MAR	1.8785	1.3722	1.2739	0.5166
	(0.0578)	(0.0974)	(0.2147)	(0.3285)
TOTLIV	-0.0413	-0.0348	-0.1078	-0.0131
	(0.0160)	(0.0154)	(0.0287)	(0.0494)
TOTMAR	-0.1540	-0.1151	-0.1335	-0.0918
	(0.0153)	(0.0118)	(0.0167)	(0.0236)
SCHOOL	-1.0040	-0.6082	-1.3749	0.6006
	(0.0803)	(0.2049)	(1.0074)	(1.0277)
TOTSCH	-0.0040	0.0221	-0.0325	0.0097
	(0.0128)	(0.0136)	(0.0239)	(0.0388)
WORK	-0.2979	-0.3293	-0.1895	-0.1232
	(0.0585)	(0.0571)	(0.1121)	(0.2082)
TOTWRK	0.0309	0.0172	-0.0020	-0.0216
	(0.0106)	(0.0093)	(0.0130)	(0.0203)
LTREND	-0.2338	-0.2533	-0.4668	-0.7650
	(0.0441)	(0.0688)	(0.1376)	(0.2813)
# at risk	401,119	157,928	176,122	81,174
# transitions	2,845	1,916	605	221

Table 6.4: Logits for partnership transitions.

From:	No partner		Cohabiting		Married
To:	Cohabiting (MNL01)	Married (MNL02)	No partner (MNL10)	Married (MNL12)	No partner (BNL5)
INTERCPT	-14.0895	-11.9936	-12.7482	-3.1252	-7.3859
	(0.4959)	(0.7225)	(1.5410)	(0.6496)	(1.2227)
AGE	0.4261	0.8628	0.2218	0.2632	-0.1809
	(0.0350)	(0.0632)	(0.0836)	(0.0475)	(0.0615)
AGESQ	-0.0085	-0.0171	-0.0054	-0.0049	0.0016
	(0.0007)	(0.0013)	(0.0015)	(0.0009)	(0.0009)
PGDUR13	1.1014	2.1987	-1.4610	1.3097	-1.0758
	(0.1151)	(0.0955)	(0.5804)	(0.0941)	(0.4129)
PGDUR46	1.1234	3.1686	-0.8149	1.7788	
	(0.1282)	(0.0750)	(0.4518)	(0.0855)	
PGDUR79	1.4587	1.8499	-0.2159	0.9206	
	(0.1202)	(0.1367)	(0.3431)	(0.1270)	
PGDUR49					-1.1768
					(0.2963)
PARITY1	0.3710	0.6752	-0.6452	0.1644	-0.7162
	(0.1148)	(0.1210)	(0.2270)	(0.1045)	(0.2262)
PARITY2					-1.0290
					(0.2373)
PARITY2P	-0.0602	0.1361	-0.4025	0.1749	
	(0.1479)	(0.1876)	(0.2590)	(0.1319)	
PARITY3P					-0.9601
					(0.2592)
BINT1324	-0.3549	-0.2937	0.0742	0.1195	0.7820
	(0.1758)	(0.1757)	(0.2845)	(0.1259)	(0.2326)
BINT2536	-0.2206	-1.0581	-0.0897	-0.2422	0.9793
	(0.1765)	(0.2431)	(0.3381)	(0.1583)	(0.2371)
BINT37P	-0.2955	-0.9623	0.4308	-0.2673	1.3009
	(0.1318)	(0.1673)	(0.2463)	(0.1222)	(0.2145)
TOTLIV			0.1069	-0.0306	0.0384
			(0.0193)	(0.0125)	(0.0284)
TOTMAR					0.0105
					(0.0164)
SCHOOL	-0.7307	-1.2448	0.1472	-1.1579	0.5542
	(0.0716)	(0.1208)	(0.1948)	(0.1614)	(0.3207)
WORK	0.1008	-0.0335	-0.2275	-0.0576	0.3818
	(0.0577)	(0.0750)	(0.1471)	(0.0743)	(0.1126)
TOTSCH	0.0637	0.0417	0.0020	0.0432	-0.0248
	(0.0127)	(0.0185)	(0.0270)	(0.0143)	(0.0244)
TOTWRK	-0.0060	0.0363	0.0182	0.00368	0.0030
	(0.0103)	(0.0147)	(0.0207)	(0.0111)	(0.0118)
LTREND	0.7141	-0.7617	0.9151	-0.7840	0.7593
	(0.0566)	(0.0542)	(0.2150)	(0.0735)	(0.1714)
# at risk	373,673	372,714	82,940	83,982	407,331
# transitions	2,347	1,388	412	1,454	525

Table 6.5: Logits for schooling and work transitions.

	School		Work	
	Start (BNL6)	End (BNL7)	Start (BNL8)	End (BNL9)
INTERCPT	3.9111	-11.2473	-2.8432	-6.7523
	(0.3937)	(0.5654)	(0.2538)	(0.3367)
AGE	-0.6961	0.8050	0.0312	-0.1299
	(0.0313)	(0.0542)	(0.0191)	(0.0197)
AGESQ	0.0081	-0.0181	-0.0029	0.0025
	(0.0007)	(0.0013)	(0.0004)	(0.0003)
PGDUR13	-1.3213	0.6880	-1.0233	1.1225
	(0.3362)	(0.1537)	(0.1470)	(0.0844)
PGDUR49	-2.8173	0.8792	-2.4874	3.1418
	(0.4502)	(0.1171)	(0.1741)	(0.0379)
PARITY1		0.1192	-1.6776	0.5872
		(0.1457)	(0.0730)	(0.0706)
PARITY2	-2.6700	0.0704	-2.0063	0.4047
	(0.2472)	(0.2176)	(0.0834)	(0.0858)
PARITY3P		0.4267	-1.7641	0.3487
		(0.4224)	(0.1007)	(0.1086)
BINT1324	0.5160	0.1242	0.4101	-1.0422
	(0.3387)	(0.2057)	(0.0828)	(0.1159)
BINT2536	1.4997	-0.5344	0.6862	-0.9077
	(0.3110)	(0.2834)	(0.0877)	(0.1141)
BINT37P	1.8828	0.2104	1.0868	-0.7185
	(0.2811)	(0.1882)	(0.0753)	(0.0774)
COHAB	-0.9748	0.2175	0.0996	0.1120
	(0.1198)	(0.0818)	(0.0593)	(0.0573)
MAR	-0.9748	-0.1783	-0.7353	0.2342
	(0.1198)	(0.1255)	(0.0668)	(0.0512)
TOTLIV	0.0668	-0.0787	-0.0286	-0.0045
	(0.0379)	(0.0302)	(0.0133)	(0.0106)
TOTMAR	0.0315	0.1214	0.0466	-0.0240
	(0.0191)	(0.0242)	(0.0076)	(0.0054)
SCHOOL			-1.9805	0.0369
			(0.0407)	(0.0941)
WORK	-3.0774	0.0327		
	(0.0877)	(0.0619)		
TOTSCH	0.3586	0.0588	0.2496	-0.0178
	(0.0155)	(0.0134)	(0.0075)	(0.0089)
TOTWRK	0.0791	0.0439	0.1376	-0.0288
	(0.0161)	(0.0154)	(0.0064)	(0.0055)
LTREND	0.3993	-0.1997	-0.0422	0.6141
	(0.0386)	(0.0326)	(0.0288)	(0.0483)
# at risk	738,972	127,814	451,288	415,498
# transitions	2,488	3,582	5,462	4,178

6.4. Microsimulation Algorithm

Here we provide a short summary of the algorithm used to simulate women's life cycle patterns of childbearing, partnership, schooling and work. This algorithm is embedded in the computer program for the FAMSIM prototype. The logistic regressions shown in Tables 6.3-6.5 are used in the algorithm; these equations provide probabilities for the random transitions simulated by FAMSIM. In addition, several "transitions" occur automatically rather than at random. The nonrandom transitions include from month m to m+1 in a pregnancy, since all pregnancies in this model result in live births. If the current month is month 9 in a pregnancy, then parity in month t+1 will automatically equal current parity plus one, while pregnancy status in month t+1 will automatically equal zero. Age and calendar time also advance automatically each month.

The main features of the FAMSIM algorithm are as follows:

1) The "start" file represents the population of Austrian women 20-49 at "simtime=0" (July 1995).
2) The simulation updates these records, month by month, for up to 300 cycles (i.e., until "simtime=300" which is July 2020).
3) One "cycle" of the simulation requires (a) "dynamic" updating, which is to say finding the values of selected variables NEXT month, depending on the values of selected variables THIS month, followed by (b) "static" updating which changes the values of selected variables NEXT month depending on the results of the dynamic updating.
4) Dynamic updating in most cases is stochastic. Probabilities of a transition are found by evaluating a logistic expression. A random number (drawn from a uniform distribution with values between 0 and 1) is drawn. If the random number is less than the calculated probability the transition is simulated to occur.

The sequence of calculations for a cycle of this algorithm is as follows:

(a) calculate all derived/transformed values of CURRENT (period "t") variables (for example, dummy variables indicating which category of current parity, or of current birth interval, and so on);
(b) do dynamic updates (note: the abbreviations BNLi and MNLij refer to the logistic regressions as labeled in Tables 6.3-6.5):

```
if pregmnth(t)=0 then
    if curpar(t)=0 then pregmnth(t+1)=1 with probability BNL1
    if curpar(t)=1 then pregmnth(t+1)=1 with probability BNL2
    if curpar(t)=2 then pregmnth(t+1)=1 with probability BNL3
    if curpar(t)<=3 then pregmnth(t+1)=1 with probability BNL4
if pregmnth(t) gt 0 and lt 9 then pregmnth(t+1) = pregmnth(t)+1
```

```
if pregmnth(t)=9 then
    pregmnth(t+1)=0
    parity(t+1)=parity(t)+1
    curbint(t+1)=0
if ptstatus(t)=0 then
    ptstatus(t+1)=1 with probability MNL01
    ptstatus(t+1)=2 with probability MNL02
if ptstatus(t)=1 then
    ptstatus(t+1)=0 with probability MNL10
    ptstatus(t+1)=2 with probability MNL12
if ptstatus(t)=2 then ptstatus(t+1)=0 with probability BNL5
if school(t)=0 then school(t+1)=1 with probability BNL6
if school(t)=1 then school(t+1)=0 with probability BNL7
if work(t)=0 then work(t+1)=1 with probability BNL8
if work(t)=1 then work(t+1)=0 with probability BNL9
```

(c) do static updates (some of which depend on the updated values of derived/transformed values):

- age(t+1)=age(t)+1 (note: as soon as someone's age reaches 600 – i.e. 50 years old--she is dropped from further processing)
- time(t+1)=time(t)+1
- livmnth(t+1)=livmnth(t)+cohab(t+1)
- marmnth(t+1)=marmnth(t)+mar(t+1)
- csch(t+1)=csch(t)+school(t+1)
- cwrk(t+1)=cwrk(t)+work(t+1)

(d) if t < 300 then go to (a).

6.5. Extensions to the Model

There are many ways in which the model structure developed for the FAMSIM prototype could be extended and improved. The model in the form described here must be viewed as preliminary, since its main purpose was to show the feasibility of both using the FFS data for the basis of microsimulation and developing a flexible framework for simulating family dynamics. Among the possible extensions of the model are:

- include men. At present only women are analyzed, although the simulated births include both males and females. A more ambitious model would include separate data records for men, and would simulate cohabiting and marital relationships between men and women. Implementation of such an option would require attention to the issue of using "closed" versus "open" modeling of partnerships. It will also be necessary to develop a model of "assortive mating" in order to include the formation of partnerships.

- extend the predictive equations. The FFS data include several variables that could usefully be added to the logistic equations. For example, respondents were asked about the size of their birth family, and the region and type of place in which they spent their childhood. Past research has shown, in several countries, that women from large families tend, on average, to have more children themselves.
- include "unmeasured heterogeneity." The equations developed so far treat every person-month of data as an independent observation. A superior alternative is to recognize that each month of each woman's history has in common an additional factor, represented as an unmeasured variable, in its simplest form treated as a constant over her lifetime. There is no clear, agreed-on method of introducing such "unmeasured heterogeneity" (or, in the context of mortality analysis, "frailty") in multivariate analyses. A number of alternative approaches might be taken, and different versions of the model run as a way of judging the sensitivity of the results to this type of variation. In the current form of the model, longitudinal summaries of women's simulated life-cycle behavior must be treated with some skepticism in view of the fact that all women's propensities are modeled as identical, conditional on observed past behavior.
- allow for joint occurrences of events in different domains. As noted already, we treat the occurrence of each possible random event in the next period as an event independent from all other possible events, conditional on past and present values of all variables. That is, for example, the probability of ending a partnership and starting a job in the same month is simply the product of the probabilities of ending a partnership and of starting a job. We feel that with small time units, such as one month, the error introduced by this simplifying assumption is negligible; however, it is a topic worthy of further investigation.
- model mortality. In the present formulation no deaths occur; or, they occur with uniform probabilities that depend on age, but not on other factors. In the algorithm sketched out above, it is impossible for a woman's marriage to end by the death of her husband. Also, infant and childhood mortality, which in principle could have feedback effects on a woman's subsequent fertility behavior, is not explicitly treated.
- introduce seasonal effects. As noted above, we did not incorporate into the model observed patterns of movement into and out of school, or in other domains of behavior, with respect to the month of the year. To do so would introduce a further degree of realism in the model, but its effects on summary measures of women's lifetime behaviors are unclear.

Acknowledgement
This work could not have been completed without the extraordinary efforts and superb technical skills of Gretchen Olson Kopp.

Chapter 7
Consideration of Income and Economic Incentives in the FAMSIM Model

Hans-Peter KOHLER

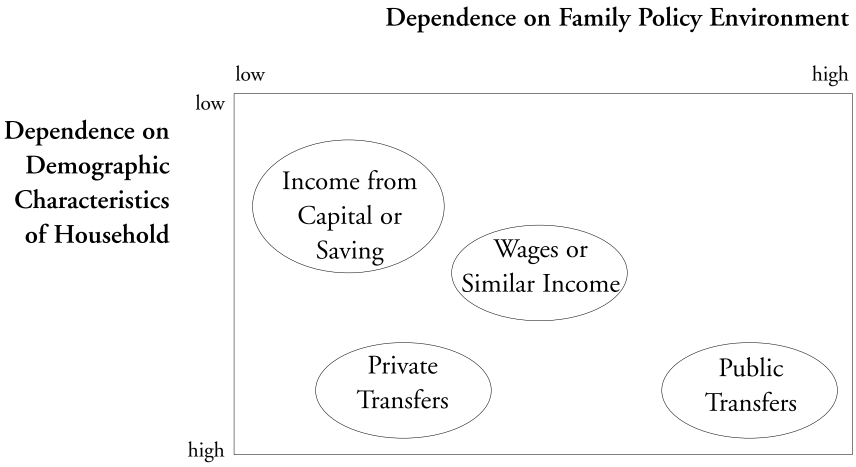
7.1. Introduction

Fewer marriages, more cohabitation, more births out of wedlock, increases in divorce and remarriage, increased female labor force participation, etc., are already dominant features in all Western European countries. The persistence of these trends will shape the future development of the family, fertility and population over the coming decades. Therefore, the projection of changing demographic behavior and the resulting "new" demographic patterns is of essential importance.

An indication of the significance of these demographic trends is their increasing presence in political and policy discussions (see Chapter 2). Existing policies will have to accommodate changing demographic behavior and population composition. Moreover, policy makers may attempt to support or counter these trends through new policy measures. The debates about the legal status of consensual unions, economic and other aid to single parents, child-care facilities for working parents, or child support in cases of divorce are only a few of the prominent examples. The discussions in these debates usually include two central questions: First, how many families or children are likely to be in certain demographic categories (for instance, in a single-parent family) at some future date, given that the past behavior and past trends prevail? Second, what are the effects of new or adjusted policy measures on individuals' behavior, and how does this alter the demographic development after the implementation of the policy change?

A demographic simulation model, such as FAMSIM, is a potentially valuable tool to study the interaction between changing demographic behavior, economic conditions, the well being of households, and policy measures. To illustrate how economic conditions depend on the two dimensions of household characteristics and government policies, Figure 7.1 exhibits some primary income sources and their dependence on demographic characteristics of individuals or households on the one hand, and the (family) policy environment on the other.

Figure 7.1: Income sources and their dependence on demographic characteristics and policy environment (family relevant policies).



Private transfers, for instance, depend to a large extent on the presence of potential remitters, such as parents, siblings and in particular ex-partners paying for children, and on the legal responsibility in the case of divorced or separated couples. These transfers hence depend substantially on demographic characteristics of the household, and to a lesser extent on the specific family policy environment. Public transfers, such as unemployment aid or public assistance for children, are similarly dependent on the demographic characteristics of the household since frequently eligibility to programs is determined by certain demographic household characteristics. In addition, since this income source is an explicit policy instrument, it depends essentially on the respective family policy environment. Wages, income from capital and savings, or similar income, on the other hand, depend both less on demographic characteristics and less on policy situations. Although age, education or parity influence the income flows from these sources, they are subject to macroeconomic fluctuations, geographic variations and many unobserved factors such as attitudes and motivation, wealth of parents, etc. The more an income source is in the top left of Figure 7.1, the more it is determined by factors that are neither represented, nor easily representable, in FAMSIM. Hence, the application of a family simulation program, such as FAMSIM, is particularly fruitful with respect to income sources that depend strongly on demographic and possibly political factors. Labor earnings (especially of women), public and private transfers are prime candidates for such endeavors.

The application of FAMSIM to questions of income, welfare and social policy analysis, however, faces an important limitation. Economic concerns, such as the prevalence of poverty for children in various family settings, or the incentives of parents to "choose" single parenthood versus traditional families, are an important aspect of policy debates and considerations. In addition, the development of the above-described demographic trends is likely to be related to macroeconomic trends, for instance future wages and employment opportunities for women, or the future returns to higher education. In the current form of the FAMSIM model, income and economic incentives are neither a determinant of the transitions between different demographic "states" (as for instance from parity zero to parity one of a married couple; see Chapter 6), nor are income from labor market activities or transfer payments a part of the simulated biographies in FAMSIM. The simulated behavior in FAMSIM is entirely determined by a woman's biographic characteristics, such as marital status or education, and by time trends. The program hence focuses on demographic behavior and individual biographies. In terms of the two 'policy relevant' questions mentioned in the previous paragraph, FAMSIM, in its current form, can be easily augmented to provide answers for the first question. It can be used to estimate changes in the population composition and their respective distributional effects on income level and composition. The second question, namely, the behavioral responses to exogenously changing incentives, for instance wage levels, and adjusted policy measures, for instance increases or decreases in the public support for single parents, can either be endogenized in a future extended version of FAMSIM or can be dealt with through externally determined alternative scenario assumptions.

This chapter addresses the possibilities of including income and economic incentives in future versions of the simulation program. It alludes to possibilities to estimate the respective 'augmented' transition equations from panel data. The next section will emphasize the relevance of this endeavor. In order to provide an example, Section 7.2 compares single parents and traditional two-parent families with respect to various economic and related characteristics, such as income level and composition, well being, and living standard. It confirms that an increased prevalence of these lone parents provides a challenge for both society and the policy maker, since economic hardship and poverty are more prevalent among these families. Section 7.2 hence emphasizes the need to project family and population composition into the future. The third section discusses possibilities to include income and incentives in the FAMSIM framework. It compares the structure of FAMSIM to other existing simulation models, and illustrates possibilities to extend the current FAMSIM structure. The nature of this chapter is necessarily speculative and somewhat subjective. However, it should be clear that the challenge to incorporate income and incentives is less in the software itself, which is a quite general simulation platform, Micro-Sim, as will be described in Chapter 8. The difficulties are primarily in the formulation and inference of augmented transition equations, and in the formulation and estimation of equations that determine income and public transfers. The limitations that arise from the lack of economic considerations in FAMSIM are clearly surmountable. Yet, they are also non-trivial and need careful consideration in future revisions of the program.

7.2. An Example: Single- versus Two-Parent Families in Austria, Using Data from the European Community Household Panel (ECHP)

The Austrian Family and Fertility Survey (FFS) provides the starting population for current prototype of the FAMSIM model. The biographies of the women in the FFS are utilized to estimate the respective transition equations. The FFS provides little information about the economic situation of families at the time of the interview, and it is almost completely silent with respect to the economic situation over the time period of women's biographies since the European FFS project on partnership, fertility and education/employment histories. It also seems to be infeasible to collect income biographies retrospectively. On the basis of the FFS it is therefore impossible to evaluate the changing economic conditions with respect to different demographic transitions.

The European Community Household Panel (ECHP) is a data set that is available for a large number of countries which conducted a Family and Fertility Survey. Its focus is on a detailed description of employment, public and private transfers, the income and poverty situation of households. In Austria the first ECHP wave was conducted in 1995. The survey consisted of a household questionnaire to be answered by the head of the household, and a personal questionnaire to filled out by all members living in the same household above age 16. A general discussion of the survey as well as an overview of the economic situation of households in Austria is, for instance, provided by Giorgi (1997). In this section the Austrian ECHP is utilized to show differences in the economic situation of single- and traditional two-parent families. The subsequent section discusses how the ECHP can be used to introduce economic considerations into the FAMSIM model. The standardized form of the ECHP survey across all participating countries allows a quite general 'interface' between these two data sets to be developed. This in turn can be implemented in the future revisions of FAMSIM.

The Austrian ECHP contains 849 families with two parents and a youngest child below the age of 16. In addition there are 107 female-headed and 7 male-headed single-parent households.[1] Families that include members other than parents and their non-adult children were excluded from the subsequent ana-

1 The analysis treats biological and stepparents identically. Multi-generation households and household which include additional persons besides parents and their children are not contained in the comparison.

lysis. With the respective sampling weights these households represent respectively 86 percent, 13 percent and 1 percent of the households with dependent children. For simplicity we concentrate in the subsequent comparison on the female-headed single households, and report only results with the respective sample weights.

Table 7.1: Analysis of economic conditions and subjective well being of families with children under the age of 16, ECHP-Austria 1995.

	Two-parent families	Single-parent families[a]	Single-parent families[a] (age adjusted)[b]
Is your accommodation affected by			
❑ Pollution or other environmental problems caused by industry?	9.90%	15.00%	16.90%
❑ Crime or vandalism in the area?	8.70%	10.20%	9.70%
❑ Are total housing costs (rent or mortgage, repairs, taxes, etc.) a heavy burden on the household?	13.36%	37.50%	36.80%
❑ Are you receiving any allowance or subsidy from public schemes for housing costs?	10.42%	38.64%	42.13%
Household receives income from			
❑ Wages or salaries	93.50%	52.70%	53.20%
❑ Unemployment benefits	5.70%	18.70%	19.20%
❑ Other social benefits or grants	95.40%	96.40%	96.80%
❑ Private transfers	12.30%	77.10%	81.70%
The largest source of income is[c]			
❑ Wages or salaries	87.60%	47.50%	49.70%
❑ Pensions	1.10%	11.70%	9.90%
❑ Unemployment benefits	0.80%	14.50%	14.90%
❑ Other social benefits or grants	1.30%	12.10%	11.10%
❑ Private transfers	0.20%	8.30%	8.90%
Household savings			
❑ Household is not able to accumulate private savings on a regular basis	44.80%	77.40%	79.10%
❑ Household's financial situation clearly deteriorated compared to the previous year	7.90%	15.40%	14.70%
❑ Household has to repay debts other than mortgage	27.80%	27.50%	28.70%
❑ Repayment of these debts is a heavy burden	26.50%	54.30%	51.70%

a Only female-headed households are included.
b The age distribution of female household heads is adjusted to the age distribution of mothers in two-parent families.
c Catagories do not add up to 100% because some small catagories are omitted.

Table 7.1 provides an overview of the economic conditions and the well being of households with dependent children. The female heads of single-parent households do not exhibit the same age distribution as the women in the respective two-parent families with dependent children. In particular, lone-parent households are over-represented in the younger and older age categories. Besides columns for two-parent families and (female-headed) single-parent families, the table includes an additional column that adjusts the age distribution of single-parent families to the age distribution of their 'traditional' counterparts. This adjustment corrects the effects in the comparison due merely to different age distributions in the two subpopulations and not to differences according to the status of single- or two-parent households.

The higher exposure to environmental problems and crime indicates that single-parent families tend to live in less favorable living conditions. In addition, more than one-third of these families state that mortgage/rent payments and repairs are a heavy burden for them, and more than one-third of the single-parent households receive public housing assistance. The respective percentages for two-parent families are 13 percent and 10 percent, respectively. The differences do not diminish if one accounts for the different age distribution.[2]

The situation of households with respect to income sources confirms expectations.[3] Single-parent families have less access to wage and labor income, and they rely to a larger percentage on unemployment benefits, other social benefits and private transfers. In particular, more than one-third of the single-parent families relies on pensions, unemployment benefits and other public transfers as their primary income source, and an additional 8 percent depend primarily on private transfers. Public and private transfers hence constitute a much more important income source for single-parent than for two-parent households. These transfers, however, do not completely compensate for the missing income of a second parent and the lacking 'economies of scale' within the household. More than three-fourths of the single-parent households are not able to accumulate private savings on a regular basis after paying their monthly expenses. The percentage for their traditional counterparts is less than one-half. In addition, almost twice as many single-parent (versus two-parent) households state that their financial situation has clearly deteriorated compared to the previous year. The same pattern is reflected in the debt burden of households. Whereas an equal percentage of households have to repay debts (this question considers only debts that are not related to housing), this repayment is a heavy burden for

2 The respective age distributions were calculated with eight-year intervals.

3 The analysis here uses the Austrian ECHP files which were standardized to the EUROSTAT specification. The Austrian data in its original version is not available at the moment. If it becomes available, a more detailed analysis of the composition of household income is possible.

almost half of the lone parents, but only for 26 percent of those households where both parents are present.

Table 7.2 compares the income distribution of single- and two-parent families. The household income (including all private and public transfers) of the latter clearly exceeds the respective incomes of the single parents. To account for the different household composition, the table also calculates the equivalent income per person. It is obtained by dividing the total household income by the number of household members, accounting for the respective economies of scale within the household. In particular, Table 7.2 follows the EUROSTAT conventions and counts the first adult member with 1, each additional adult member with 0.5 and each child below age sixteen with 0.3. (For a detailed discussion of equivalence scales and their use in comparisons see for instance Burkhauser et al., 1996.) The comparison of the household size-adjusted income distribution reflects the pattern that emerged above. Despite their higher reliance on public and private transfers, single-parent families have substantially fewer resources available to satisfy the needs of their families, and they are less able to accumulate savings for future expenditures. These findings, however, are to some extent controversial and depend on the existence of positive economies of scale within the household. These scale economies are captured in the calculation of equivalent income by assigning weights smaller than unity to any additional household members besides the head. The extent of these scale economies is reflected in the respective weights. However, there is no common consensus among researchers about the correct weighting scheme (see Burkhauser et al., 1996, for a discussion). In the absence of scale economies, the per capita income is the correct comparison for the economic well being of individuals in households with different demographic characteristics. In Table 7.2 the comparison between single-and two-parent families exhibits the same overall trend with per capita income and with equivalent (EUROSTAT) income per person. The relative disadvantage of single-parent households persists, even if there are no scale economies. The magnitude of differences, however, is diminished in the last case.

Table 7.2: Household income and equivalent income per person of families with children under the age of 16 (in Austrian Schillings), ECHP-Austria 1995.

	Two-parent families	Single-parent families[a]	Single-parent families[a] (age adjusted)[b]
Household income (per month)[c]			
25% Quartile	24,000.00	13,365.00	13,500.00
Median	30,000.00	17,600.00	17,600.00
75% Quartile	39,000.00	22,050.00	23,000.00
Equivalent income per person[c,d]			
25% Quartile	10,869.00	8,624.00	8,653.00
Median	13,889.00	11,584.00	11,667.00
75% Quartile	17,952.00	14,461.00	14,692.00
Per capita income (per month)[c,e]			
25% Quartile	5,868.00	5,000.00	5,083.00
Median	7,550.00	6,617.00	6,667.00
75% Quartile	10,166.00	9,057.00	9,057.00

a Only female-headed households are included.
b The age distribution of female household heads is adjusted to the age distribution of mothers in two-parent families.
c Income is measured in Austrian Schillings.
d Equivalent income per person is calculated by dividing the total household income by an equivalent measure of the number of persons in the household. The analysis here follows EUROSTAT and counts the first adult member with 1, each additional adult member with 0.5 and each child below age 16 with 0.3.
e Per capita income is the household income divided by the number of household members.

This section used the comparison between single- and two-parent families to emphasize the importance of demographic household characteristics for the economic conditions of families and also for the role of public assistance in ameliorating these conditions. Although more sophisticated analyses are necessary to account properly for selection and endogeneity problems, and issues related to the scale economies within households, the analysis is suggestive of substantial differences in economic well being and the demand for public assistance among different household types. Another important comparison would be that between households with large and small numbers of children that also exhibit great differentials in economic conditions. Therefore, an important application of family simulation programs, even under an economic perspective, is the projection of behavioral trends and the evaluation of public policy in the context of demographic behavior.

7.3. The Consideration of Income and Economic Incentives in the FAMSIM Model

Several alternatives exist for the integration of income and economic incentives in the FAMSIM model. Demographic behavior is clearly interdependent with macroeconomic and policy changes, and with the diffusion of new behaviors or ideas in a population. These interdependencies also influence the future evolution of the demographic population structure. Possible extensions to FAMSIM differ in the extent to which they account for these interactions. A simulation model that accounts comprehensively for all these interactions is, to the author's knowledge, missing and may also not be feasible.

Since the rise of microsimulation as an analytic tool in the 1960s, several applications have been developed within economics and demography (see for instance Chapter 3). Many of these applications focus on a specific question or application, for instance, the social security or pension system (Nelissen, 1994; Wagner, 1984), tax-transfer analyses (e.g., Cilke and Wyscavrver, 1990), or the evaluation of family planning programs (Horvitz et al., 1972). These models differ in the extent to which individual behavior – or equivalently, the transition probabilities to and from different 'states' – is determined by personal characteristics of the individual or alternatively economic incentives, such as wage levels and macroeconomic trends. The models also differ in their incorporation of interactions between the realm of micro behavior and macro trends. Most of the above analyses include feedback from the macroeconomic level on individual behavior, but they usually do not account for the feedback in the reverse direction. The importance of such micro-to-macro feedback to understand demographic behavior is, however, emphasized by Easterlin (1980) and other researchers. In addition, some scholars argue that additional 'ideational' effects, such as the diffusion of behavior and ideas, is an important element in understanding demographic processes (Lesthaeghe and Moors, 1995) and that such effects should be included in the projection of future demographic changes. The investigation of such interactions may be a fruitful extension to demographic simulation models. The extent to which these interactions are incorporated is important for the potential areas of application of these models.

Table 7.3 indicates such applications of a demographic microsimulation model, like FAMSIM, depending on the feedback between the micro and macro level within the program. If neither macro-to-micro nor micro-to-macro interaction exists, the simulation is an extrapolation of past behavioral patterns and trends and is primarily suited for the projection of demographic characteristics in the population. If the former is included in the simulation, the program becomes a tool for policy analysis and for the investigation of different 'macro scenarios.' In these scenarios the analyst chooses a path for the future development of relevant aggregate socio-economic characteristics, such as wage levels, unemployment rates and benefits, or the generosity of the assistance for children or single parents. The analyst is then in a position to investigate individual behavior under the different scenarios and time paths of aggregate characteristics.

Table 7.3: Incorporation of feedbacks in FAMSIM and applications of family simulation.

		Macro-to-micro feedback	
		No	Yes
Micro-to-macro effects	**No**	Extrapolation of past patterns and trends	Policy scenarios: focus on changing individual behavior
	Yes	Analysis of distributional effects	Policy scenarios: focus on evolution of socio-economic and demographic system

If only micro-to-macro effects are included in the simulation model, then the model allows the investigation of distributional effects under the assumption that past behavioral patterns and trends continue. An analysis, for instance, can study changes in the income distribution, in the demand for certain public and private transfers, the labor force participation and similar aggregate socio-economic characteristics. The inclusion of feedback in both directions is desirable in a simulation model since it provides an endogenous joint evolution of the socio-economic and demographic system. The presence of these multiple interactions, however, makes the analysis rather difficult: The simulation program needs to rely on strong assumptions about the pathways of these different feedbacks. There are problems in the econometric inference, requiring large longitudinal data sets and sophisticated estimation techniques. In addition, because of multiple feedbacks any errors in the specification of the model tend to magnify over time.

The FAMSIM model provides a platform in which these different interdependencies between the micro and macro level can be included. For future revisions of the model with respect to the inclusion of economic consideration several 'strategic' decisions are necessary: (a) To which extent should FAMSIM provide comprehensive income biographies for different income categories, or should the simulation package focus on distributional income changes in the population? (b) To which extent should FAMSIM include economic incentives in the behavioral transition equations, and to which extent should there be feedback between the macro structure and micro behavior? The possibilities in this respect range from the inclusion of general macroeconomic trends, such as unemployment rate, male and female wage levels, to a detailed simulation of labor force participation, wages and returns to human capital, savings, etc.

The consideration of economic issues in FAMSIM is hindered by the fact that the FFS data set, which provides the base population and was used to estimate the transition equation, provides comprehensive biographies but is relatively silent with respect to economics. In order to include economic considerations the FFS information needs to be augmented by additional data, as for instance the Austrian ECHP used above.

It is possible to analyze distributional income changes on the basis of a specified demographic behavior, time trend and economic environment. In FAMSIM, the estimated coefficients in the transition equations determine the behavior via transition probabilities. In FAMSIM's present form, the population evolution is determined by each individual's own biography and secular time trends. There is no explicit interaction with the macroeconomic or policy environment. For the simulation the respective coefficients for the transition equations are estimated from the FFS data (see Chapter 6) and possibly adjusted to account for expected future deviations from the observed pattern. The analysis then assumes that the behavioral pattern captured in these coefficients persists in the future. But also alternative scenarios can be specified which assume certain behavioral changes.

Changes in the demographic composition of the population resulting from this behavioral pattern, however, affect the average income, income composition, poverty level, and demand for public and private transfers. These distributional effects can be estimated using 'hot-decking' techniques (or other imputation techniques) which match observations in different data sets according to observed characteristics (e.g., Ford, 1983). These can either be 'exact matches' or some form of 'nearest neighbor imputation.' In principle the imputation searches for the most similar people in the two data sets and merges the respective information. A random choice is performed if several alternatives provide an equally good match. The simulated biographies in FAMSIM provide the observed characteristics to which the missing income information is imputed from a second data set, e.g., the Austrian ECHP. Once the FAMSIM biographies have been augmented with the missing information about income, the simulated population can be analyzed with respect to poverty and income levels, or with respect to the reliance of households on public and private transfers.

This procedure can be implemented without major changes to FAMSIM and allows an analysis of how changes in the demographic composition affect the composition of household income and the demand for specific public and private transfers. The limitations of this procedure, however, are apparent. The data matching assumes that the economic conditions that prevailed at the date of the source survey (1995 for the Austrian ECHP) are an accurate description of the economic situation at the projection date. That is, there is neither a micro-to-macro feedback, nor is there a change in macroeconomic conditions. In addition, there is a problem related to unobserved heterogeneity. The imputation is based on observable characteristics, and the variance in the imputed values in the source population is maintained through the random assignment of individuals with same characteristics. If unobserved heterogeneity also influences the transition probabilities, these effects would be ignored in the imputation.

The limitations of FAMSIM are particularly relevant if one intends to evaluate the effect of policy changes. Adjustments in the level of public benefits for children or single parents have no automatic effect on the transitions into and out of the respective demographic 'states.' Although the effect of policy changes on the income distribution could be evaluated in the imputation that assigns income to households, the behavioral reactions of individuals to the new policy environment is not accounted for in this imputation. The potential importance of such effects is apparent in the AFDC (aid for families with dependent children) debate in the United States (e.g., Hoynes and Macurdy, 1994; Hoynes, 1996). AFDC primarily provides aid for single parents with dependent children. Recent adjustments to this program were motivated by the prediction of economic theory that increases (decreases) in the AFDC benefits should encourage (discourage) individuals to choose single parenthood. The econometric findings in this debate, however, are quite inconclusive and are not necessarily supportive of the theoretical predictions. At the moment the empirical relation between AFDC levels and the 'choice' of single parenthood remains an issue of controversy despite very active research.

This controversial welfare debate shows that the relation between individual behavior and welfare levels is quite complicated and does not necessarily follow standard economic predictions. Similar controversy exists about the empirical robustness of the 'new home economics' which constitute the leading economic theory about individual demographic behavior. For instance, Willis (1987, p. 78) concludes that "[f]amily economists do not have as yet a body of empirically tested, qualitatively stable estimates of the major behavioral relationships suggested by the theory...", despite their growing ability to generate hypotheses about the family behavior.

In light of this empirical inconclusiveness about determinants of household behavior, the estimation of transition equations that capture these relations and the subsequent simulation of household biographies including economic-demographic interactions seems like a daunting task. Nevertheless the author favors an extension of the FAMSIM model that accounts for some influences of macroeconomic and policy influences on behavior. In particular the FFS data, which provides the basis for the estimation of the transition equations, should be augmented by time series that reflect major economic and political changes over the time period covered by the biographies in the FFS. These time series should include an index of male and female wages (possibly for different education levels), unemployment rates and some indices reflecting the 'generosity' of policy measures for mothers or single parents. These time series would be included in the estimation of the transition equations. The simulation of the population into the future then requires assumptions about the respective future development of these time series. These scenarios can either be based on expert opinions, on official macroeconomic projections or on specific policy scenarios that vary the level of public child and family support.

This addition to the transition equation is relatively easily implemented. It allows for some basic influences of macroeconomic and political trends on individual demographic behavior. The projection of the aggregate time series also enables the analyst to conduct some policy experiments and evaluate their effect on the evolution of the population. Moreover, this variant can be combined with an imputation technique to estimate the income level and composition of households in the simulated population. (Needless to say, the imputation technique needs to be adjusted so that it reflects or is consistent with the assumptions about the future macroeconomic and policy environment.)

None of the above alternatives generates income biographies that correspond to the education/labor market experience, the history of childbearing and partnerships of an individual. This extension of the FAMSIM model is substantially more complicated than the previous alternatives, both from the standpoint of estimation and the computational implementation.

A prerequisite for the accurate estimation of an individual's income dynamics is the availability of panel data that covers an extended period of an individual's life. The panel study of income dynamics (PSID, for the US) and the socio-economic panel (SOEP, for Germany) are frequently used for this type of analysis, whereas the Austrian ECHP consists of only a single wave and is not yet suitable for this purpose. The estimation for the different income categories then needs to account for unobserved heterogeneity across individuals and for autocorrelation of incomes over time for each given individual. In addition, the estimation and simulation of these income biographies needs to account for the interdependencies between demographic behavior and the economic realm. The need to include both demographic and economic information in the estimation demands very comprehensive data sets and most likely prevents the use of the detailed biographies in the FFS due to the lack of corresponding economic information. The PSID or SOEP provide possible alternatives, however, at the cost of less demographic information. In this case, the respective base population for the simulation should also be obtained from these data.

An outline of a specific implementation of 'income biographies' in FAMSIM is beyond the scope of this chapter. A substantial amount of research has been devoted to economic simulation models, and a careful review of the existing models can provide a guideline to the design, estimation and simulation of such biographies in FAMSIM. A comprehensive model that accounts for the multitude of interactions between demographic behavior, income, economic incentives and macro trends, however, does not seem feasible. Rather, extensions should be targeted towards a specific policy or economic question, and the incorporated interactions should focus on interactions that are most relevant in the specific context. Given the uncertainty that prevails among researchers about the relations between household behavior and economic conditions, the simulation will have to rely on strong assumptions. In addition, the multitude of feedbacks that exist in simulation models with a greatly expanded list of transition equations makes an 'intuitive understanding' of any changes to variables and coefficients substantially more complicated.

7.4. Summary and Conclusions

The current prototype version of FAMSIM is based on a simulation platform, Micro-Sim (see Chapter 8), which allows an extension of the simulation model beyond its current scope. One relevant candidate to be included in future revisions of the program is economic concerns, ranging from household income level and composition to the influence of changing economic conditions on individual behavior and income biographies. This in itself would be an important expansion of the more conventional approach of "model families" because the full income distribution can be studied instead of selected discrete cases.

The first part of this chapter shows that demographic characteristics, economic well being, and the demand for public assistance are clearly intertwined. For instance, singe-parent families rely to a higher percentage than their two-parent counterparts on public (and private) transfers, but nevertheless are more constrained and burdened by economic pressures. Changes in the population composition over the next decade, which are interdependent with the development of aggregate economic conditions and policy schemes, are therefore extremely relevant for the future planning of public expenditures on families and for the well being of children in the population.

At the moment, FAMSIM does not include economic factors in its simulations. This chapter sketches possible extensions to the model to overcome this limitation. These extensions include a simple imputation of incomes in the simulated population to reflect the effects of demographic changes on income distribution and composition. A more comprehensive alternative is outlined which includes the reactions of individuals and households to changes in aggregate economic conditions and policy environments. In this form FAMSIM becomes a tool to assess relatively easily the demographic consequences of economic and political trends, such as changes in (female) wages or increased benefits for children and single mothers. As with any simulation model, the results of these different scenarios depend on a multitude of underlying assumptions, and a sensitivity analysis, with respect to these assumptions, is necessary. Nevertheless, the macro-to-micro interaction is a useful addition to the FAMSIM model, and should be included in future revisions. The most comprehensive extension of the model is the simulation of income biographies that parallel the respective labor market, partnership and childbearing biographies. The complications that arise in the estimation and simulation, however, are substantial. A careful study of existing economic simulation models and a well-defined analytic objective are necessary before a specific implementation can be suggested. This task could well be performed in the context of a broader international effort to apply FAMSIM to several European countries.

References

Burkhauser, R.V., T.M. Smeeding, and J. Merz. 1996. Relative inequality and poverty in Germany and the United States using alternative equivalence scales. Review of Income and Wealth 42(4):381-400.

Cilke, J. and R.A. Wyscarver. 1990. The Treasury Individual Income Tax Simulation Model. Office of Tax Analysis, U.S. Department of the Treasury, Washington, D.C.

Easterlin, R.A. 1980. Birth and Fortune: The Impact of Numbers on Personal Welfare. University of Chicago Press, Chicago, Illinois.

Ford, B.N. 1983. An overview of hot deck procedures. Pages 185-209 in D.B. Rubin, W.G. Madow and I. Olkin, eds. Incomplete Data and Sample Surveys. Academic Press, New York.

Giorgi, L. 1997. Zur Sozialen Situation von Österreichischen Haushalten. Report. Interdisiplinary Center for Comparative Research in the Social Sciences, Vienna, Austria.

Horvitz, D.G., B.V. Giesbrecht, B.V. Shah, and P.A. Lachenbruch. 1972. POPSIM, A Demographic Microsimulation Model. Monograph No. 12. Carolina Population Center, Chapel Hill, North Carolina.

Hoynes, H.W. 1996. Welfare transfers in two-parent families--labor supply and welfare participation under AFDC-UP. Econometrica 64(2):295-332.

Hoynes, H. and T. Macurdy. 1994. Has the decline in benefits shortened welfare spells. American Economic Review 84(2):43-48.

Lesthaeghe, R. and G. Moors. 1995. Is There a New Conservativism That Will Bring Back the Old Family? Ideational Trends and the Stages of Family Formation in Germany, France, Belgium and the Netherlands, 1981-1990. IPD-Working Paper 1995-1. Vrije Universiteit, Brussels, Belgium.

Nelissen, J.H.M. 1994. Income Redistribution and Social Security. An Application of Microsimulation. Chapman and Hall, London.

Wagner, G. 1984. Umverteilung in der gesetzlichen Rentenversicherung. Campus, Frankfurt, Germany.
Willis, R.J. 1987. What have we learned from the economics of the family? American Economic Review 77(2):68-81.

Chapter 8
FAMSIM Software: An Implementation of the Austrian FFS Data on Micro-Sim

Christian KRAMER

8.1. A Definition of Microsimulation from an Electronic Data Processing Point of View

Microsimulation, as an alternative to the analytic approach or to macrosimulation (Keilman and Keyfitz, 1988) of social issues has a tradition of several decades. As described in previous chapters microsimulation can be used as a scientific instrument for policy analysis. The technique itself benefits from the fast development in the area of microcomputing, which provides low-cost resources to simulation models which could not be afforded 20 years ago. This enables the software engineer to build a high-level design and to implement the strategy for a generic tool.

How do we understand microsimulation and where is Micro-Sim positioned? Microsimulation is, as any other simulation, a process that tries to predict "real world behavior" in a computerized mathematical model. It is an abstraction of this "real world." While macrosimulation models try to predict the "average behavior" of large-scale starting entities, microsimulation focuses on the behavior of a single unit of such a starting entity.

Microsimulation is, therefore, a two-fold process. It requires the creation of a scientific model which describes the "real world" behavior, and it requires a mechanism to create the projection from the specification and test the consistency of the result with real world behavior. Combining a toolbox (Micro-Sim) with a specific scientific model thus results in a microsimulation model for a specific application.

Micro-Sim is not a ready-made program to create a specific set of microsimulations. It is more a generic microsimulation toolbox that provides the basic infrastructure to model situations that should be simulated using this approach. Micro-Sim, therefore, can be used for a variety of different problems and is not limited to the area of demography.

In order to use Micro-Sim, a scientific model has to be described (Micro-Sim will not help with this task). Once the mathematical model has been developed, Micro-Sim can be used to perform the calculations, generate microdata output and perform analyses.

8.2. Design Goals for Micro-Sim

When considering a generic simulation model, flexibility must be a design goal. Flexibility refers to the data structure that goes in and comes out of the model, as well as to the processes which govern the transition of variables between states. This will be discussed more in the following sections.

We live in a world of applications dominated by graphical user interfaces (GUI). We accept the fact that this is a definite necessity for the general acceptance of a new product, although a lot of overhead and the need for detailed work are the consequences.

In a general product it is not possible to assess in advance the requirements that may be necessary in a specific model. Micro-Sim, therefore, supports the integration of external program components which take over specific tasks in a simulation loop. An example of this feature, "GENMIC," will be referred to later on.

At the moment, Micro-Sim is implemented as a prototype using WINTEL technology (i.e., Intel processors on Windows platforms). It does have constraints that mainly exist in the area of processing time and capacity.

The design goals under which Micro-Sim was developed are a) flexibility; b) Windows-based graphical user interface; c) open architecture; d) not limited to demography; e) PC based.

8.3. The Micro-Sim Models

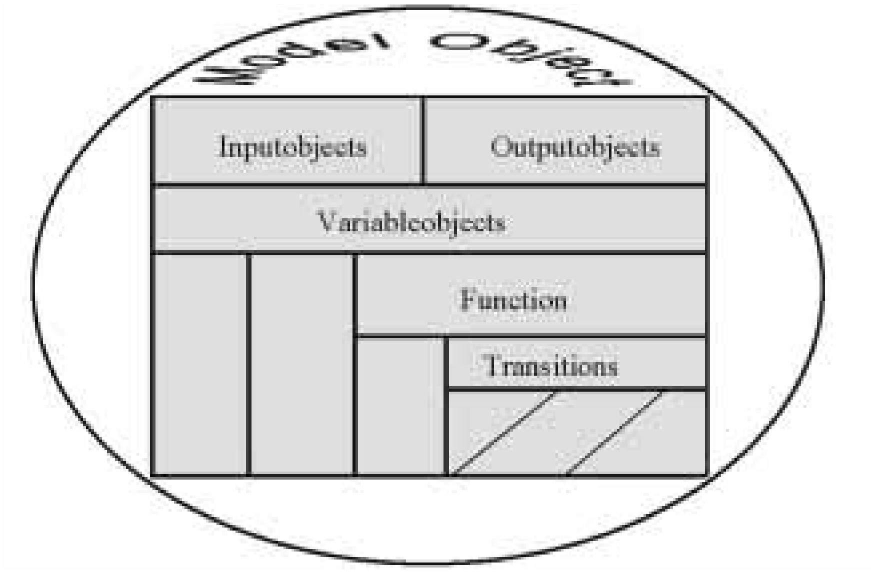
Apart from the general design goals mentioned above, this section covers the internal structure and design of Micro-Sim, its main data definitions as well as a description of the simulation engine that has been implemented.

8.3.1. The data model

The basic starting point is the model object that forms the highest hierarchical definition in Micro-Sim (see Figure 8.1). The model contains other objects that need further definition and attributes that control the specific environment of a simulation run. Examples of such attributes are the "End-of-Simulation" condition and the "Simulation Run Parameters." In each step of the simulation the environment variables and conditions are evaluated and new values are assigned to the variables depending on the expressions defined in the variable definition.

The other two major components of the model are the descriptions of the microdata input and output objects. Both are composed of variable objects. The sequence in which the variable objects appear in the output object definition determines the simulation execution sequence. Variables have two attributes defining the class and the type of variable; a third attribute associates a function with the variable. These functions govern, on the one hand, the transition between the states of the variables. On the other hand, they are used to derive the values of dependent variables within the model.

Figure 8.1: The Micro-Sim data model.



The standard function definition provides for all "simple" mathematical expressions. These can be numerical functions or modeling conditions (e.g. if partner status = married and number of children greater than 3 then the probability of starting in a job is reduced by x percent). These expressions can be nested; simple condition elements are possible. Transition functions are implemented by supporting logic expression evaluations and age schedules.

8.3.2. Input and output objects

As already mentioned, input and output objects are a collection of variables that appear in the respective information stores. All variables have been defined using the "Variable Definition" function in Micro-Sim. Simple cut-and-paste commands allow the user to easily create the layout for a new input file. All input data is validated against the specification in the variable definition. Invalid records are omitted. The sequence in which the fields appear in the input file is exactly the sequence in which they have to appear in the physical input data stream.

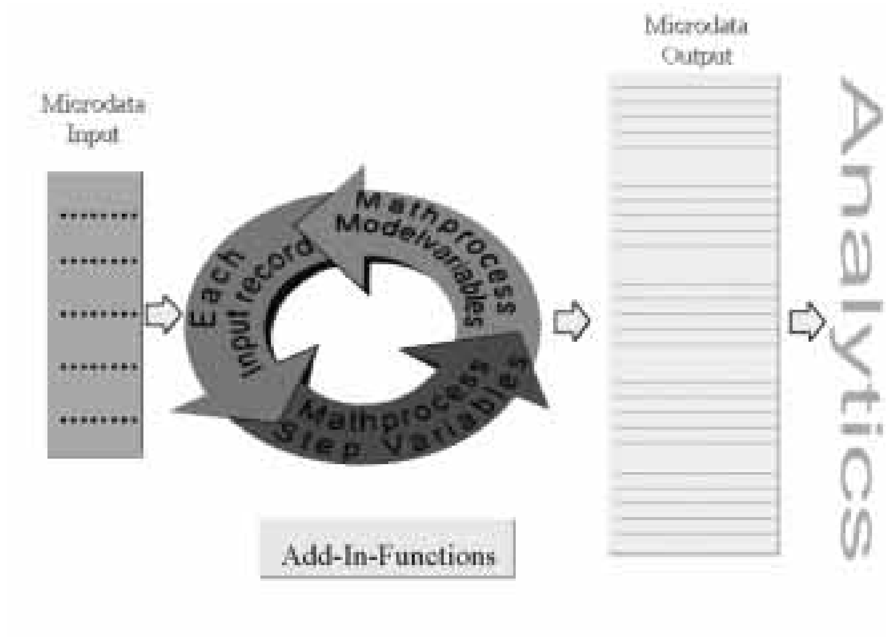
The main logic for the model is implemented through the output objects. The elements of output objects, therefore, contain variables that have been defined in the input stream. They also contain variables that are generated as dependent values in the course of the simulation. Output variables are associated with a function attribute that is used in Micro-Sim to manipulate the variable as the simulation is running. The sequence in which the output variables appear in the output object definition determine the sequence in which the respective variables change their values.

8.3.3. The process model

The second major component of Micro-Sim is its process model (see Figure 8.2). Although the process model heavily interacts with the data model, it is completely independent from its structure. The program provides an interpreter-like function evaluation mechanism which allows pseudo code to be processed during the simulation run. This code interpreter is the key element of Micro-Sim and its biggest problem as well, because the efficiency of this process determines to a great extent the performance of the model.

Microdata records are read into the simulation model. They generate microdata output records until the "end-of-simulation" attribute in the model definition is fulfilled. One record for each simulation loop is generated. In the simulation process all variables change their status depending on the transition function attribute which has been assigned to the variable in the variable definition or in the run time variable set of the model definition. After completing the simulation of all input records, a microdata outfile is created which can be processed for subsequent analytical analysis.

Figure 8.2: The Micro-Sim process model.



8.4. The FAMSIM Implementation

As part of the project conducted by the Austrian Institute for Family Studies, a working prototype was created to prove the feasibility of using FFS data in microsimulation models. Based on the approach described in the earlier chapters of this volume, a model was developed which resulted in a mathematical definition of transition functions as well as a starting population whose event history has been used to determine the transition equations (see Chapter 6). The actual implementation of the FAMSIM model was, therefore, a process of integrating the transition functions into the Micro-Sim infrastructure. The generic approach chosen to build the Micro-Sim infrastructure turned out to be adequate to provide the required functionality. The model equations were translated into the Micro-Sim language syntax.

Figure 8.3: Screen shot of Variable Definition Screen

For the prototype version, approximately 3,700 women (as given by the FFS data), who form the microdata input for FAMSIM, were included in the FAMSIM microsimulation model. The data were preprocessed (as described in Chapter 6) to validate and check the consistency of the data records. Together with the microdata, the scientific model forms the input to Micro-Sim. The goal was to project monthly biographies of women aged 15-50 according to births, partnerships, and schooling/work experience.

8.4.1. The FAMSIM transition functions

The model deals with two types of transitions: those with a binary outcome and those with a three-category outcome. These transitions are determined by a logistic expression representing the probability that a variable changes its state in a specific simulation period. One step in FAMSIM is one month. The general pattern upon which all transitions are built is described in Figure 8.4.

Figure 8.4: FAMSIM model features/1 transitions.

- All transitions for binary outcomes based on logistic expressions of the form

$$prob = \exp(\sum B_i * x_i) / (1 + \exp(\sum B_i * x_i)$$

All transitions for 3-category outcomes based on

$$prob_1 = \exp(\sum B_{1i} * x_i) / (1 + \exp(\sum B_{1i} * x_i) + \exp(\sum B_{2i} * x_i))$$

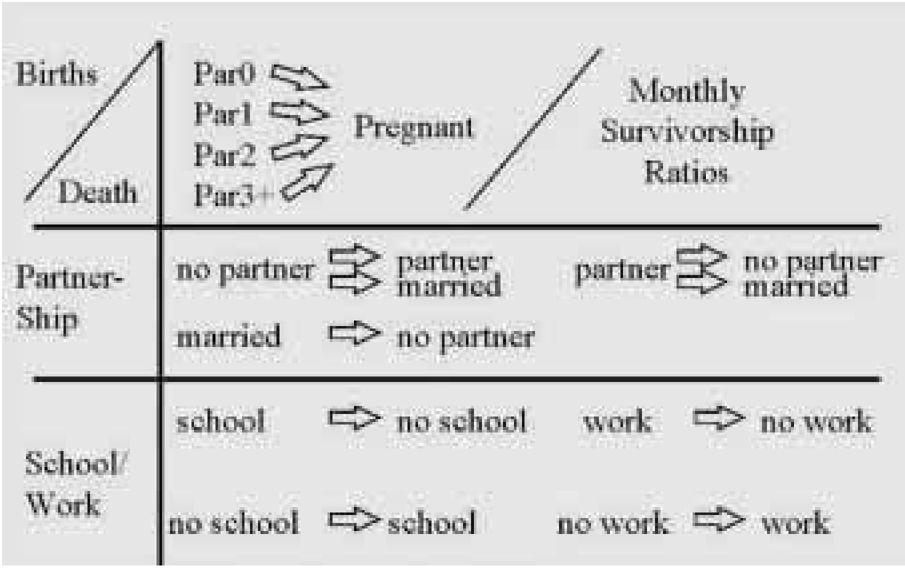
All logit parameters Bi as well as the question “Which variables xi have a significant contribution to the probability that a status change occurs?” are part of the scientific judgement to be made by experts (as given in Chapter 6) and cannot be performed by the software.

An additional type of age-dependent transition was implemented to control the mortality of the underlying population. The annual survivorship ratios for women, based on the Austrian Demographic Yearbook, 1991 (1992, pp. 119-126), have been transformed into monthly survivorship ratios. Since mortality is not very significant in the age groups we are observing, it was decided to assume a linear relationship between monthly and annual ratios.

8.4.2. The transition functions in detail

The transitions are specified in Figure 8.5. Transitions have been defined for movements from all parities (0 to 3+) to the pregnant state. For simplification pregnancies were defined in such a way that they always last 9 months and do not end with anything other than birth. Abortion, pre-mature birth or other “irregularities” have therefore not been considered.

Figure 8.5: FAMSIM model features/2 transitions.

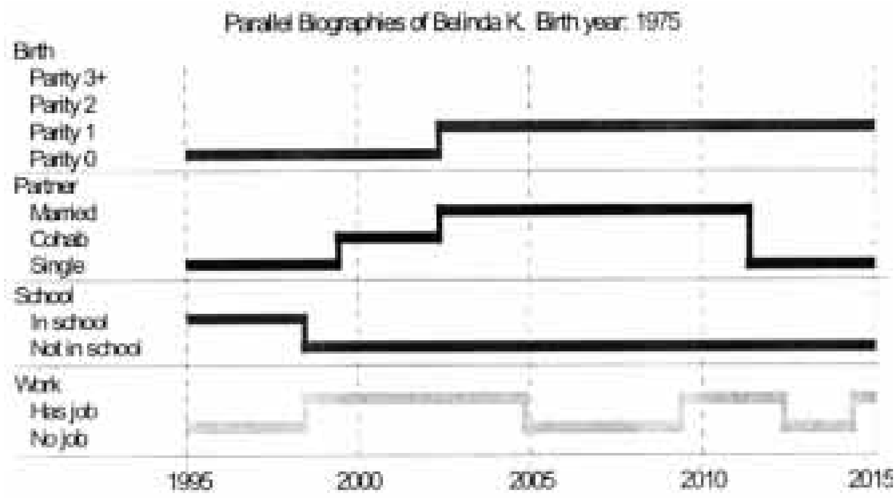


Under partnership, two three-category transitions have been implemented: a transition from no partner to a nonmarital partner or married, and moving from an existing nonmarital partnership to married or single. The change from married to no partner forms a two-category transition.

Separate functions for “schooling” and “work” have been defined governing the states “not in school” to “in school” and vice versa. The same is applicable for the “work” variable.

For the FAMSIM-Austria prototype a process was chosen in which births born to the simulated women also enter the simulated population, i.e., having a self-reproducing model. As the individuals get older in the simulation, the model would also age the children of these women. Once these children pass the age of 15, 50 percent (the girls) constitute a new and separate individual to be simulated in the model. This feature was implemented using the “open architecture” approach called the “GENMIC” procedure. GENMIC generates input records to the original microdata input object. As an attribute, it evaluates an expression that determines if a record should be added to the microdata input file. The initialization of the variables in the input record depends on the “Default Value” field in the variable definition. Therefore GENMIC can be considered a generic tool to be used to generate input records based on the definition of the input object. Using the GENMIC feature the actual number of individuals to be simulated depends on the birth ratio which is implemented in the model. As an example, one case of the FAMSIM simulation run ended up simulating approximately 5,200 individuals of whom only 3,700 were in the original data set.

Figure 8.6: Micro-Sim Produces graphical as well as verbal descriptions of all individual biographies. Below the screen shot of one sample biography



For further expansion of the model to include economic variables, provision has been made to cover personal income, transfer payments and residual income. As no exact data for these variables can be derived from the FFS, other sources will be used to create a distribution of income variables depending on age and education as indicated in Chapter 7. Micro-Sim will provide the statistical functions to generate income distributions "on the fly." But the parameters determining the previously mentioned income variables will have to be estimated by experts.

8.5. Micro-Sim, Present and Future

At present Micro-Sim is not yet a ready environment. It has been developed enough to prove that microsimulation can be done in a flexible and transferable form using input data from the FFS. Several additions and changes will have to be made to provide a comfortable operating environment. The user interface will also have to be customized to be more "intuitive" to potential users.

In the current version of Micro-Sim, basic and advanced specification of microsimulation models is possible. To validate the output of the model some simple summary statistics have been incorporated.

- A significant number of enhancements are possible, out of which the following are just some examples:
- Micro-Sim still needs a more user-friendly and consistent graphical user interface;

- Analytic tools and graphical output should be further developed;
- A "Toolbox" library to handle some standard procedures similar to GENMIC should be created; and last but not least
- The system needs to be optimized for performance.

8.6. Conclusion

The goal of producing a flexible design prototype microsimulation model that can be used directly for FFS-type data has been achieved. Micro-Sim can be used as a carrying platform to create event histories based on the described approach. Undoubtedly, an additional effort must be made to answer the generic questions that will arise from policy makers. In the case of FAMSIM applications to a group of European countries, a data base can be incorporated in such a way that the user can easily switch from one country to another and compare, e.g., the results of similar models in different countries.

References

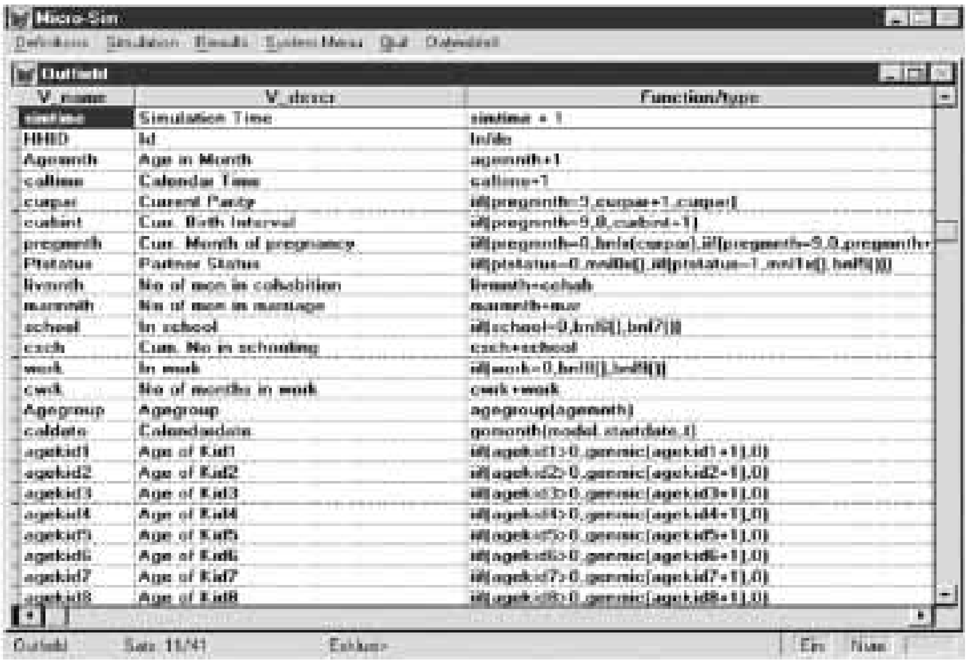
Austrian Demographic Yearbook, 1991. 1992. Demographisches Jahrbuch Österreichs, 1991, No. 1059. Österreichisches Statistisches Zentralamt (Austrian Statistical Office), Vienna, Austria.

Keilman, Nico and Nathan Keyfitz. 1988. Recurrent issues in dynamic household modelling. Pages 254-285 in N. Keilman, A. Kuijsten, and A. Vossen, eds. Modelling Household Formation and Dissolution. Oxford University Press, Oxford, U.K.

Laditka, Sarah and Douglas A. Wolf. 1995. New Methods for Modelling and Calculating Active Life Expectancy. Paper presented at the REVES 8 Conference, 5-7 October 1995, Chicago, Illinois.

Appendix – Figure

Example of a syntax definition screen



V_name	V_descr	Function/type
simtime	Simulation Time	simtime + 1
HHID	Id	Infile
Agemnth	Age in Month	agemnth+1
caltime	Calendar Time	caltime+1
curpar	Current Parity	iif(pregmnth=9,curpar+1,curpar)
cubint	Cur. Birth Interval	iif(pregmnth=9,0,cubint+1)
pregmnth	Cur. Month of pregnancy	iif(pregmnth=0,bnla(curpar),iif(pregmnth=9,0,pregmnth+
Ptstatus	Partner Status	iif(ptstatus=0,mnl0a(),iif(ptstatus=1,mnl1a(),bnl5()))
livmnth	No of mon in cohabition	livmnth+cohab
marmnth	No of mon in marriage	marmnth+mar
school	In school	iif(school=0,bnl6(),bnl7())
csch	Cum. No in schooling	csch+school
work	In work	iif(work=0,bnl8(),bnl9())
cwrk	No of months in work	cwrk+work
Agegroup	Agegroup	agegroup(agemnth)
caldate	Calendardate	gomonth(model.startdate,t)
agekid1	Age of Kid1	iif(agekid1>0,genmic(agekid1+1),0)
agekid2	Age of Kid2	iif(agekid2>0,genmic(agekid2+1),0)
agekid3	Age of Kid3	iif(agekid3>0,genmic(agekid3+1),0)
agekid4	Age of Kid4	iif(agekid4>0,genmic(agekid4+1),0)
agekid5	Age of Kid5	iif(agekid5>0,genmic(agekid5+1),0)
agekid6	Age of Kid6	iif(agekid6>0,genmic(agekid6+1),0)
agekid7	Age of Kid7	iif(agekid7>0,genmic(agekid7+1),0)
agekid8	Age of Kid8	iif(agekid8>0,genmic(agekid8+1),0)

Chapter 9
How Can FAMSIM Be Applied to Other European Countries?

Wolfgang LUTZ

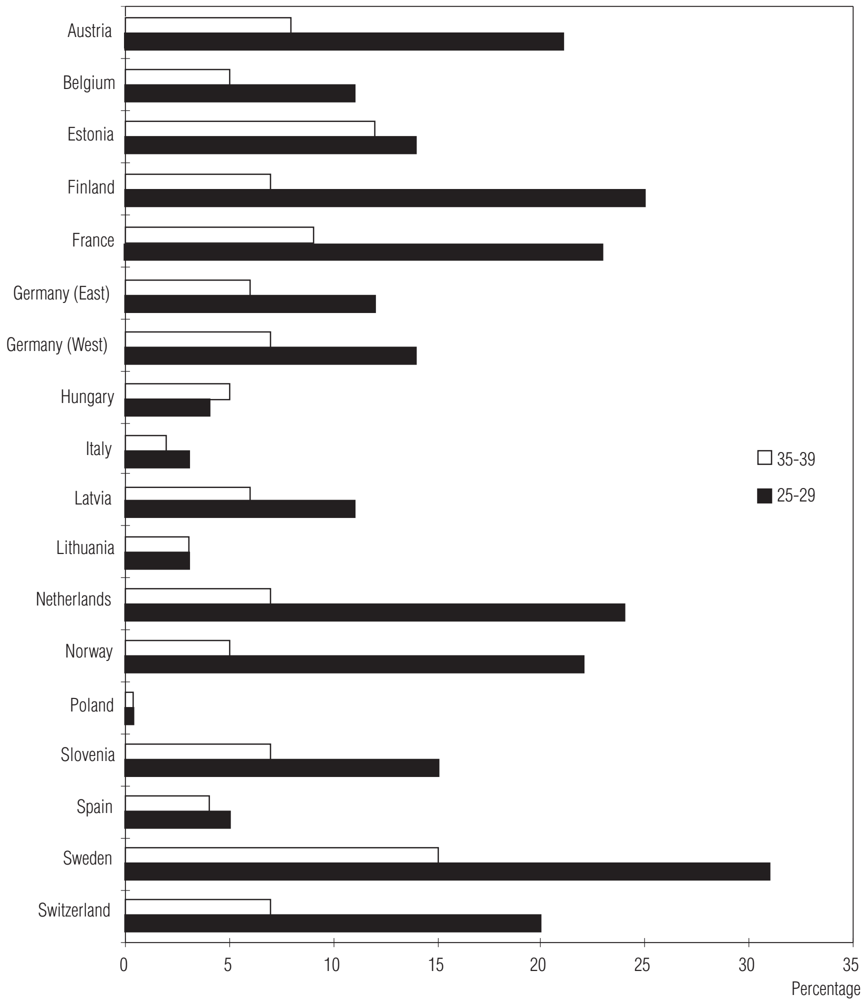
9.1. Benefiting from International Diversity in Family Patterns

One of the explicit goals of the FAMSIM-Austria project has been to study the feasibility of applying the model to other European countries, in particular, to the member countries of the European Union. For this reason the discussion below will mostly focus on the EU. Other countries that also participated in the FFS are clearly candidates for an application of FAMSIM, and even those industrialized or developing countries that do not have an FFS but other analogous event history data might be considered.

Within the European Union the patterns of family formation and dissolution as well as the ways women and men combine employment with children are very different, as has been described in Chapter 2. Also, the ways in which governments view recent changes in family structures, divorce or childbearing differ significantly, as do the policy measures that are being implemented to counteract presumably undesired trends. While some national governments are clearly concerned about certain demographic trends, and for this reason have specific measures to support larger families, other countries may have similar policies, but for purely social concerns to avoid poverty, while yet in another group of countries, families with children receive only very limited government support.

To illustrate the diversity in the forms of union formation in different parts of Europe, Figure 9.1 shows the proportions of all women living in nonmarital unions for all European FFS countries for which data are already available. In seven of the 18 countries more than 20 percent of all women aged 25-29 live in nonmarital unions. These are the Nordic countries, Holland, France, Austria and Switzerland. On the other extreme there are Poland (0 percent), Italy (3 percent) and Spain (5 percent). It is interesting to note that although the southern European countries have some of the lowest fertility rates in Europe, they are more "conservative" with respect to nonmarital unions. Another interesting aspect of the figure is that in some countries the proportions living in nonmarital unions decrease sharply to the age group 35-39, whereas in some other countries it still remains sizable for this age group. This has to do with the broader question of whether nonmarital unions have mostly become a precursor to marriage (as we found it to be in Austria) or an alternative to marriage (as seems to be the case in Sweden). Furthermore, it is a completely open issue whether trends in European countries are moving toward a converging pattern, or whether we are likely to see even stronger diversity.

Figure 9.1: Percentage of all women living in nonmarital unions (for age groups 25-29 and 35-39) in European countries participating in the FFS.



For an analytical tool such as FAMSIM, international differences imply an additional source of variation to be considered. This makes things a bit more complex but also provides several great opportunities. First, projections with FAMSIM using the assumptions of constant conditions (as estimated from the data including a trend) for a number of countries can reveal some of the momentum imbedded in current structures which may help on the question of convergence/divergence. Also, different behavioral patterns may be viewed in relation to specific policies in the countries and therefore help to understand the effects of different family policies. Finally, FAMSIM could be used to test hypothetical new policies on the data of the different countries and observe to what degree the consequences differ from one country to another.

In this sense the diversity of family patterns in Europe is an asset to analysis rather than an obstacle. The same, however, does not apply to the diversity of analytical tools. Too many different tools used by different people cause confusion rather than enlightenment. For this reason it is desirable that not every country use a different tool for projection of family structures and in particular the evaluation of alternative policies, but that compatible models sharing some of the basic features are applied to the specific conditions in each country. Only such a common approach can facilitate true comparisons. FAMSIM is one possible candidate for such a tool, if it were to be adopted in a sufficiently large number of countries.

9.2. Practical Steps Involved in Developing a New National FAMSIM Application

For countries that have FFS survey data, there seem to be essentially seven practical steps involved in getting a meaningful national application utilizing the work already produced for FAMSIM-Austria:

1) Conversion of FFS event history data to monthly occurrence/exposure data on the individual level.

Since this rather time-consuming kind of conversion is necessary for some of the more sophisticated event history analysis with time variant covariates, several countries may already have performed this kind of conversion.

2) Estimation of behavioral equations.

There are several ways to estimate such equations from the data, and a large choice of which variables to include as independent variables. This is, in the end, a matter of judgement of the scientist doing the analysis. It is, of course, also possible to essentially replicate the estimation procedures that have been described for Austria in this volume. When discussing the possibility of preparing a clear recipe for estimating the equations, the concern was raised, however, that in any case some plausibility check of the estimated parameters is necessary. Hence the critical involvement of a scientist cannot be avoided in the process of estimation.

3) Choice of appropriate starting population.
The FFS sample with the characteristics as observed at the time of the interview need not necessarily be used as the starting population of the simulation runs. If there is great interest in specific income variables, the European Community Household Panel (ECHP), for example, might provide a better starting population. Since this Panel does not have event histories, the behavioral equations still need to come from the FFS. It also needs to be decided whether new cohorts should be added to the sample through births or one is only interested in the further biographies of the individuals included in the starting population.

4) Acquaintance with software and entering of data.
Although the software is very user-friendly once it is set up for a specific data set and running, to come to that state still needs some preparatory work by a skilled person. Further development of the software and improved documentation specifically with users from other countries in mind may reduce this threshold in the future.

5) Definition of model and alternative scenarios.
This step is already part of the real country-specific application after successful operationalization of the model. It is, however, important that such definitions and assumptions are carefully considered and made explicit to the user. It would also be desirable that such implementations be conduced in cooperation with other countries working with FAMSIM in order to achieve some of the advantages of the international dimension described above.

6) Interpretation and summary of findings.
A model that is not documented properly tends to be of little use for persons other than those who developed the model. In addition, the findings of specific alternative model runs to be presented to interested colleagues and other users should not only be well documented and reproducible on the computer, but they should also be appropriately interpreted in order to become useful. This sounds trivial, but it is often neglected under real-life modeling situations.

7) Science-policy dialogue.
Since FAMSIM is not only supposed to be a toy for scientists but should also have some impact toward a better planning, design and execution of various government policies with respect to families, it is important to have a well-structured process of communication with the relevant levels of policy making. Although it may be useful to demonstrate FAMSIM at highest political level, contact to those who are actually involved in planning the more detailed aspects of policies can be expected to be more fruitful. Generally, such science-policy dialogues should not be a one-time event. Ideally they are initiated at the early stages of model implementation in order to assure that some of the alternative

scenarios specified actually correspond to the alternative views of the specific policy makers.

Certainly these seven steps are not entirely independent of each other and overlap to certain degrees. As far as FAMSIM-Austria is concerned, the first four steps have been essentially completed. This volume is an effort to contribute to the documentation. Definition of alternative scenarios, interpretation of results and science-policy dialogue are three processes currently under way. These processes in Austria would also benefit greatly from FAMSIM applications in other countries and from a process of international discussion of these issues.

9.3. Different Levels of Interest for FAMSIM in Europe

The FAMSIM-Austria project included a component of networking with other European research institutions and individual scientists in order to explore the interest in FAMSIM applications in the different member countries of the European Union. Such explorations were done in a rather informal way through visits to several European capitals, discussions at several international meetings, and two meetings in Vienna in July 1996 and June 1997. Without naming individual countries, scientists or institutions, the EU member countries can be grouped into four categories according to level of interest:

1) Strong scientific interest in FAMSIM by certain individuals or institutions.

There is a small group of scientists at universities or national population research institutes who indicated strong interest in actively participating in the further development of FAMSIM on an international basis. Typically such persons are working on family issues and have already had, at some point in time, experience with microsimulation and therefore appreciate the potentials of microsimulation in this field of study. Several members of this group have indicated their readiness to start working on FAMSIM given that some additional funds become available. Since all of the countries concerned have FFS survey data, this group seems to be a natural starting point for an internationalization of FAMSIM. Drawing on the scientific experience of this group of persons, FAMSIM could be further developed to go beyond a simple replication by including further expansions and methodological improvements of the model.

2) Interest and existing FFS data, but presently limited research capacities.

In this group of countries, the FAMSIM project was generally seen with great interest and as a possible future project, but no individual researcher or research institution could be identified who would have both the experience and the flexibility in shifting the research priorities in a way to start a FAMSIM effort immediately. Generally, teams concerned with the analysis of the national FFS surveys had an appreciation of the desirability of adding on a counterpart to the descriptive analysis of the data that would study the possible future implications of the observed patterns. There was a desire to learn more about microsimulation and what has been done in the case of FAMSIM-Austria. This was the main reason for deciding to publish this kind of volume at an early stage. It intends to give both a general and a digestible introduction to the research questions and the microsimulation methodology, and describes the specific case of Austria. In summary, many in this sizable group of countries could well see themselves involved in an international FAMSIM effort, given that some guidance is provided in addition to funding.

3) Interested in participation, but no FFS data.
In a small number of countries data availability is a problem although there would be some general interest in FAMSIM. For such countries several options exist. The most desirable, but most costly, would be to conduct an FFS-type survey. A much cheaper solution, which would still yield some interesting results, would be to use the European Community Household Panel for the starting population and for whatever relevant information can be extracted from it. In addition one could use the behavioral equations as estimated in a similar country or based on groups of countries with adjustments being made in order to cover obvious country-specific peculiarities. This would clearly be a compromise solution, but would be much better than doing nothing.

4) No directly interested persons could yet be identified.
In a small number of countries it was not possible to identify someone interested and willing to invest some time and effort in exploring the possibility of some national FAMSIM applications. This may be due in part to the fact that the time frame for establishing connections was very tight and therefore countries without obvious partners got less attention. This situation will hopefully change in the future.

In conclusion, it can be said that the FAMSIM-Austria project demonstrated clearly that the original idea of having a flexible microsimulation tool based on the FFS data to be applied in a number of European countries is feasible, timely and meets interest in the European research community. The development of the Austrian prototype model now needs to be followed by a phase of dissemination and discussion which could soon result in the formation of a consortium of institutions and researchers in a number of countries (mostly from Group 1 as described above) to put together a proposal to apply FAMSIM on a broader European basis.

About the Authors

Heinz P. Galler
Martin-Luther-University Halle-Wittenberg
Germany

Kathleen Kiernan
London School of Economics and Political Science
United Kingdom

Hans-Peter Kohler
Max Planck Institute for Demographic Research
Rostock, Germany

Christian Kramer
CA-IB Investmentbank
Vienna, Austria

Wolfgang Lutz
International Institute for Applied Systems Analysis (IIASA)
Laxenburg, Austria
and
Austrian Institute for Family Studies
Vienna, Austria

Vera Nowak
Austrian Institute for Family Studies
Vienna, Austria

Christiane Pfeiffer
Austrian Institute for Family Studies
Vienna, Austria

Douglas A. Wolf
Syracuse University
Syracuse, New York