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Nico Keilman and Helge Brunborg

Household Projections for Norway, 1990-2020

Part I: Macrosimulations

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Statistisk sentralbyrå • Statistics Norway
Oslo-Kongsvinger 1995

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Summary

Nico Keilman and Helge Brunborg

Household Projections for Norway, 1990-2020. Part I: Macrosimulations

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This report contains projection results for the household structure of the population of Norway during the period 1990-2020. This is the first time that Statistics Norway publishes household projections. The results are largely consistent with the national results of Statistics Norway's 1993-based population forecast. The model employed is a dynamic projection model of the multidimensional cohort-component type, and the computer program LIPRO has been used for the simulations. The model distinguishes individuals by age (five-year age groups), sex and 15 household positions: a person can be a dependent child, live together with a partner in a consensual union (with 0, 1, 2, or 3+ children), live with a marriage partner (with 0, 1, 2, or 3+ children), live alone, be a lone parent (with 1, 2, or 3+ children), be in another position in a private household, or live in an institution for the elderly. Household dynamics are introduced by means of so-called household events, i.e. jumps from one household position to another. The household events are modelled using age- and sex-specific rates. Fertility, mortality and immigration are also included in the model. A special algorithm guarantees consistency between various events that occur to members of the same household, for instance, men and women who start a consensual union or who marry. The algorithm also makes it possible to achieve consistency with births, deaths, and net immigrations in other population projections.

A sample of 10,000 households from the November 1990 Population and Housing Census was used for constructing the initial population by age, sex and household position. Special attention was given to the fact that the Census reflects the *de jure* number of private households, which is estimated to be approximately 170,000 below the *de facto* number. Rates for the formation and dissolution of consensual unions, marriages and one-parent families have been estimated on the basis of retrospective information from the 1988 Family and Occupation Survey. Parameters for fertility, mortality, and migration were derived from vital statistics. Projected numbers of births, deaths and immigrations were reconciled with corresponding numbers from Statistics Norway's 1993-based national population forecast.

According to the six projection variants that are presented in this report, the *de facto* number of private households will grow from today's 1.92 million to between 2.37 and 2.62 million in 2020. The most striking result under all scenarios is the strong growth in the number of one-person households, from 740,000 in 1990 to between 1.037 and 1.369 million in 2020. The strong growth in one-person households is explained, to a large extent, by two factors: first, the ongoing general ageing process of Norway's population - particularly elderly women often live alone -, and second, divorce and the break-up of consensual unions, which leads to many middle-aged men who live on their own.

Other persistent trends, independent of the variant chosen, are the relative decline in the number of married couples with children, the growth in lone-parent families, and a strong rise in the demand for places in institutions for the elderly. Consensual unions also show a relative increase but their share in all private households will remain modest.

This report contains only macrosimulation results: the population, broken down by age, sex and household position is projected forward in time. A follow-up report (Part II) will present microsimulation results: in those calculations, the future household characteristics of a sample of individuals will be simulated. On the basis of those microsimulations one will be able to tell who lives together with whom in a particular household.

The current project is closely linked to Statistics Norway's MOSART project, of which the aim is to simulate individual life courses with respect to education, marriage, births, labour market participation and social security in Norway. MOSART's current demographic module is based on a person's marital status. That module will be replaced by a more comprehensive household module, on the basis of the findings of the household projections in this report.

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Key words: Dynamic household model, LIPRO, household formation and dissolution, combined macro-micro-simulation.

Contents

Index of figures

Index of tables

1. Introduction

Dynamic household models describes household events that individuals experience. These individuals are broken down by household and family position, age, sex and possibly additional characteristics. This multidimensional breakdown defines a state space, and a vector in the state space is called a state vector. There are commonly two approaches to the simulation of household and family dynamics: macrosimulation and microsimulation. In the macrosimulation approach the state vector represents the whole population, and each element of the state vector contains the number of individuals in a certain state, i.e. with one particular combination of the characteristics, for example the number of females aged 40-44 who are head of a one-parent family. In microsimulation, each individual may be represented by means of his or her own state vector, which contains a 1 in the appropriate element, the other elements being 0.

The dynamics in both approaches are introduced by means of transition probabilities, which link the state vector at two successive points in time. They describe the probability that an individual is in state j of the state vector at time t_1, given that he or she was in state i at time t_0. An example of such a transition probability is that for a transition from being a married spouse aged 35-39 with children at time $t=0$, to being head of a one-parent family aged 40-44, at time $t=5$. In the macrosimulation approach, the state vector is multiplied by the complete matrix of transition probabilities to yield the population broken down by the relevant characteristics at some further point in time. In microsimulation, the whole life course (or just a part of it) of one individual is simulated at a time, on the basis of only those transition probabilities in the full matrix that apply to the state the individual occupies at the beginning of the interval. The dynamics of the whole population are simulated by successive treatment of all individuals.

Because the arithmetical operations are relatively easy in microsimulation, compared to macrosimulation, the models used in microsimulation may include more relationships and variables than those used in macrosimulation. For example, in case one has sufficiently theoretical and empirical knowledge about the link between household dynamics and such covariates as education, labour and other background factors, behavioural relationships with household dynamics as a dependent factor can easily be included in the micromodel. This is particularly useful in case the covariates are modelled, and these change over time. But even in purely demographic models of the accounting type microsimulation is useful, because information about household relationships between individuals may be traced relatively easily. For instance, one might compile a table of households cross-classified by age of oldest household member and age of youngest member. This is infeasible in usual macrosimulation approaches to household modelling.

The most important advantages that a microsimulation approach to household dynamics has over macrosimulation are that information on household structures can be included, as well as decision rules (such as those determining which household to join when household formation takes place), and behavioural links between household dynamics and time-dependent covariates. Examples of microsimulation models for household and family dynamics are the Frankfurt model (Galler, 1988), the NEDYMAS model developed in the Netherlands (Nelissen, 1991, 1993; Nelissen and Vossen, 1989), the regional model constructed by Clarke (1986) for Yorkshire and Humberside, the Darmstadt model (Heike et al., 1987) and a model constructed by Egidi and Tomassetti (1988) for Italy. But in spite of its advantages, microsimulation of household dynamics has an important drawback compared to macrosimulation: the development of a computer program takes much time and the demands for computer size and computing time are usually high. Instead, a number of macrosimulation models which project household dynamics have been constructed in the past (for a review, see Keilman, 1988). Van Imhoff and Keilman (1991) present the so-called LIPRO-model for macrosimulation of households, and apply it to household dynamics in the Netherlands. A flexible PC-program bearing the same name is also available. The LIPRO approach has also been followed in household projections for Belgium (Boulanger et al., 1994) and Italy (Righi and Sorvillo, 1992; Righi, 1994), while attempts to apply the approach to Finland and England are currently under way.

This report describes the first phase of a project concerning the construction of a *combined* macro-micro model for the simulation of household and family dynamics. By using both micro- and macrosimulation we combine the advantages of the two approaches. The model's construction is strongly connected to that of a larger model system called MOSART[1]. MOSART projects and analyses individual life courses with respect to education, marriage, births, labour market participation, and social security in Norway. It is run by a microsimulation programme which simulates the life course of a sample of the population of Norway. Presentations of MOSART are given by Andreassen (1992), Andreassen et al. (1992, 1993, 1994), Fredriksen and Spurkland (1993), and Fredriksen (1995). MOSART consists of a number of modules, one of which is the *demographic module*. This module not only takes account of the death and birth of men and women, but also of their marital status, and of the number of children ever-born to women. The purpose of the household model described in this report is twofold. First, it should be able to produce household projections for Norway. Second, in a somewhat simplified version, it will extend the current demographic module of MOSART, which is marital status based, to a more comprehensive *household module*, involving household positions for both males and females (in addition to birth, death and external migration), see below.

The household model consists of two parts. First, a *macrosimulation model* projects the population by sex, age group and 15 individual household positions. The macrosimulations are based on the LIPRO modelling approach. The model contains an option to simulate the development of a population in agreement with externally given numbers of births, deaths and external migrations, irrespective of household position of the individuals concerned. This option gives the user the possibility to make a projection which is consistent with the official population projection of Statistics Norway. (This option has actually been used in the projections reported in Chapter 4.) Input parameters for the macromodel are occurrence-exposure rates describing the various events. Together with an initial population structure this results, for each projection interval, not only in a set of aggregate household projections, but also in transition probabilities between pairs of states defined by the model's state space.

The *microsimulation model* describes individuals and the events they experience as they move through the same state space as that used in the macrosimulation model. Its input parameters are the transition probabilities produced by the macroprojection step. A random number procedure determines whether or not each individual experiences the transitions he or she is exposed to, given the person's current position in the state space. The microsimulation model groups individuals into separate households, and it simulates their decisions regarding the household to which these individuals will move when they leave their original household.

The microsimulation model results not only in detailed projections of the household structure in the future, but it also generates parameters that will be used in the new household module of MOSART, see above. That new household module will focus on a combination of marital status and "partner status" (whether or not a person lives with a partner), which is a somewhat different perspective than that taken in this report. Moreover, for reasons of simplicity, partnership formation and dissolution in MOSART will be female dominant, whereas the sexes are treated symmetrically here.

By using both micro- and macrosimulation in the current project we combine the advantages of the two approaches. Microsimulation of households facilitates detailed insight into household structures. For instance, we might compile a table of households cross-classifying age of eldest household member with age of youngest household member on the basis of the microsimulation results of the household projection. This is infeasible in usual macrosimulation models. However, the latter type of models facilitates taking account of external constraints, as noted above. In microsimulation models this would be much more complicated.

The focus of this report is on the macrosimulation part of the project. A follow-up report will give details about the microsimulations. Together these two reports constitute the methodological description of the project. As such they complement the article with first projection results, written in Norwegian and published in *Samfunns-*

[1] MOSART is a Norwegian acronym for Model for Microsimulation of Schooling, Labour Supply and Pensions (*MO*dell for mikrosimulering av *S*kolegang, *AR*beidstilbud og *T*rygd).

speilet nr. 2/1994 (Keilman, 1994a). The main difference between the results reported in that article and those contained in Chapter 4 is that we now have incorporated international migration.

In Chapter 2 of this report we present various theoretical issues connected to the model which has been used. As we use the LIPRO modelling approach for the macrosimulations, only general modelling principles will be given. The interested reader may consult the extensive text by Van Imhoff and Keilman (1991) for details. Chapter 3 deals with the compilation of the initial population and the estimation of the occurrence-exposure rates that describe household dynamics. Results of the macrosimulations are found in Chapter 4, in which several projections with different underlying assumptions are presented.

2. The model

2.1. State space and events

The model describes *individuals* classified by age, sex and household position. These persons move from one household position to another as they grow older. When confronted with the choice between individuals and households as the unit of analysis and modelling, we have chosen the former. The reason is that within the context of household dynamics, opting for the household as the unit of analysis would lead to conceptual problems: the moments at which households are formed or dissolved are not always well defined. Certain rules may be set up, but these are largely arbitrary, and moreover, may have large impact on the results (McMillan and Herriot, 1985; Keilman and Keyfitz, 1988). An individual person, however, clearly has his or her own dates of birth and death, as well as points in time when a change in household status occurs. But the consequence of the fact that the individual is the unit of analysis is that the model should take care of interrelationships between members of the same household when the household is being formed, or when it dissolves. This leads to the so-called consistency problem (Keilman, 1985), which will be discussed in Section 2.3.

Based upon various considerations related to the purpose of the project, data availability and model complexity, we decided to choose the following set of household *positions* for individuals:

1.	CHLD	dependent child
2.	COH0	cohabiting, no children
3.	COH1	cohabiting, 1 child
4.	COH2	cohabiting, 2 children
5.	COH3	cohabiting, 3+ children
6.	MAR0	living with spouse, no children
7.	MAR1	living with spouse, 1 child
8.	MAR2	living with spouse, 2 children
9.	MAR3	living with spouse, 3+ children
10.	SIN0	adult in one-person household
11.	SIN1	head of one-parent family, 1 child
12.	SIN2	head of one-parent family, 2 children
13.	SIN3	head of one-parent family, 3+ children
14.	OTHR	other position in private household (for instance other adult in household with members in positions 2-9 or 11-13, or member of a multiple family household, or adult sharing the same household with one or more adult persons without having a partner relation to any of them)
15.	INST	person in institutional household.

A *household* is defined as any group of persons living in the same dwelling. This definition corresponds to the so-called dwelling unit definition of the household. An alternative household definition is based on the housekeeping unit concept. The latter definition requires, in addition that persons live in the same dwelling, that household members have combined housekeeping. Although the housekeeping unit definition is recommended for many household analyses, we had to use the dwelling unit definition, because our main data source for household detail of Norway's population, i.e. the 1990 Census, only employs the dwelling unit definition, see Section 3.2. Information on combined housekeeping has not been collected in the 1990 Census. A *family* is defined here as two or more persons living in the same household (either private or institutional) who are related as husband and wife or as parent(s) and children by blood or adoption. A couple living in a consensual union is regarded as a family, too (cf. UN, 1980: 72). Note that there are no restrictions on a person's marital status, except for positions MAR0, MAR1, MAR2 and MAR3. Anyone having one of the latter four positions is necessarily married. But a person who occupies one of the remaining 11 household positions may have any marital status. For instance, a lone parent may be married (in that case, he or she will usually be separated, but not divorced), and both partners in a consensual union may be married (but not to each other).

The 15 household positions which individuals may occupy at any point in time result in the following 14 *types* of households:

A. cohabiting couple without dependent children
B. cohabiting couple with one dependent child
C. cohabiting couple with two dependent children
D. cohabiting couple with three or more dependent children
E. married couple without dependent children
F. married couple with one dependent child
G. married couple with two dependent children
H. married couple with three or more dependent children
I. one-person household
J. one-parent family with one dependent child
K. one-parent family with two dependent children
L. one-parent family with three or more dependent children
M. other household (such as multiple family household, or co-resident adults without partner relation)
N. institutional household.

Households of types A-H and J-L are all *family* households (one family only - multiple family households are of type M). These households may include related and non-related other adult members, who have no partner relation to anyone else in the household. In the model, the maximum age of a "child" is 25 years. When a child exceeds that age before leaving the parental household, or when that child gets an own child, its household position becomes "other" (no. 14).

Regarding institutions, we have chosen to restrict this type of household to institutions for the elderly. Hence, only persons beyond a certain age may occupy this household position. This minimum age has been set to 65 years. We have followed the definition employed in the data source used for this type of households, that is to say, institutions comprise homes for the elderly, nursing homes, service homes, etc. A common aspect is that an institution is an entity of one or more buildings of which part is common for its residents and which has personnel providing services to its residents (*Statistisk ukehefte* 35/1991, p. 1). In addition, those who live at an institution follow common rules.

The number of private households of various types may be inferred easily from the number of adult persons in the 15 private household positions. Thus, a household projection in terms of individuals may be translated into one in terms of households. The only exception is the number of households of type "other" (see M in the list above), which is assumed to be equal to the number of persons in household position "other" divided by the average number of persons in "other" households. This average size was estimated as 2.80 persons for the year 1990, and that value has been applied for the entire projection period. The number of institutions is not calculated by the model.

Given the classification of household positions, a matrix of *household events* can be identified. Events are direct jumps between two distinct household positions, taking place in infinitesimally short periods. Some individuals enter the population (birth, immigration), others leave it (death, emigration). Such jumps are also called events. They are labelled as *external events*, to distinguish them from jumps between two household positions, which are called *internal events*.

Not every pair of distinct household positions defines an event. Some events are impossible by definition, or by assumption. An example of an inherently impossible household event is the *direct* jump from CHLD to SIN1: a dependent child living with its parent(s) (CHLD) has several *indirect* possibilities to reach the state "head of a one-parent family with one child" (SIN1). He or she may pass through the intermediate state "with marriage partner, one child" (MAR1), or through the sequence of intermediate states "single" (SIN0), "cohabiting, no child" (COH0) and "cohabiting, one child" (COH1), before he or she can occupy the position SIN1. Other paths are feasible as well, but a direct jump is impossible.

We identified altogether 123 events, both internal and external. Appendix 1 contains a list of these events. The list of events and the corresponding matrix (see Table 1) are based on the following four *assumptions*.

1. Partners who divorce or separate do not co-reside any longer.
2. A return to the position of dependent child is only possible from the positions "adult in one-person household" (SINO) and "other" (OTHR).
3. Adults can only leave the household they are in through the (possibly intermediate) positions of SINO (however short the duration in this state may be), head of one-person household, or upon entering an institution, emigration or death. In other words, it is assumed that an immediate change of partner (a jump from "married, two children" to "cohabiting, no children", for instance) would involve two events, and hence is impossible.
4. A lone parent does not leave his or her child(ren).[2]

Table 1. Events matrix of the household model

From \ To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Dead	Abroad
	Intra-household events															Death and emigration	
1. CHLD	-	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+
2. SIN0	+	-	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+
3. COH0	-	+	-	+	-	-	+	-	-	-	-	-	-	+	+	+	+
4. COH1	-	+	+	-	+	-	-	+	-	-	+	-	-	+	+	+	+
5. COH2	-	+	-	+	-	+	-	-	+	-	+	+	-	+	+	+	+
6. COH3	-	+	-	-	+	+	-	-	-	+	+	+	+	+	+	+	+
7. MAR0	-	+	-	-	-	-	-	+	-	-	-	-	-	+	+	+	+
8. MAR1	-	+	-	-	-	-	+	-	+	-	+	-	-	+	+	+	+
9. MAR2	-	+	-	-	-	-	-	+	-	+	+	+	-	+	+	+	+
10. MAR3	-	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+
11. SIN1	-	+	-	+	+	+	-	+	+	+	-	+	-	+	-	+	+
12. SIN2	-	-	-	-	+	+	-	-	+	+	+	-	+	+	-	+	+
13. SIN3	-	-	-	-	-	+	-	-	-	+	-	+	+	+	-	+	+
14. OTHR	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
15. INST	+	+	+	+	+	+	+	+	+	+	-	-	-	+	-	+	+
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
	Birth[1]																
1. CHLD	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-		
2. SIN0	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3. COH0	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
4. COH1	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
5. COH2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
6. COH3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
7. MAR0	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
8. MAR1	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
9. MAR2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
10. MAR3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
11. SIN1	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
12. SIN2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
13. SIN3	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
14. OTHR	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-		
15. INST	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+		
	Immigration																
Abroad	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		

\- = impossible event.
\+ = possible event.
[1] Position of mother before birth columnwise, position of child after birth rowwise.

[2] A child, however, may leave his or her parent(s).

Items on the main diagonal in Table 1 need some clarification. Most of them are "non-events", and these are left out of consideration. However, for some "aggregate" positions, such as COH3 (in consensual union with *3 or more* children) and MAR3 (with marriage partner and *3 or more* children), the arrival of an additional child (due to birth or return to parental home), or the exit of a child (due to home-leaving, death or emigration - only in those cases where at least three children stay behind), causes the adults to remain in the same household position. On the other hand, only a few of the persons who remain in the position COH3 or MAR3 during some period will experience the arrival or exit of a child, but most of them will not. Thus, for these "aggregate" positions the one-to-one correspondence between an event on the one hand and a pair of states on the other does not hold.

A few of the pairs of positions listed in Appendix 1 represent so-called "double events". These apply to the start of a partnership (cohabiting or married couple) immediately followed by the birth of a child (or in reverse other). Thus, these double events include the entry into position "cohabiting, 1 child" (COH1) or "married, 1 child" (MAR1) from "dependent child" (CHLD), "one-person household" (SINO) or "other" (OTHR). The reason why these double events have been included in the model as if they were usual events, is that it may be assumed that the probability for a transition between SINO and COH1, say, on the basis of usual, single, events will be underestimated in the model used here, in which the probability of a first birth in position COH0 is the same irrespective of the duration spent in that state.[3] By including a rate for the "event" SINO -> COH1 we take account of the possibility that a (young) woman has a relatively high probability of childbearing shortly after she started to cohabit. Similar reasons apply to the "double events" including a jump from CHLD or OTHR to COH1 or MAR1. Indeed, for three of these "double events" we found small but non-zero rates, indicating that the two events had occurred within a period of one month (see Section 3.3.2).

2.2. Main principles

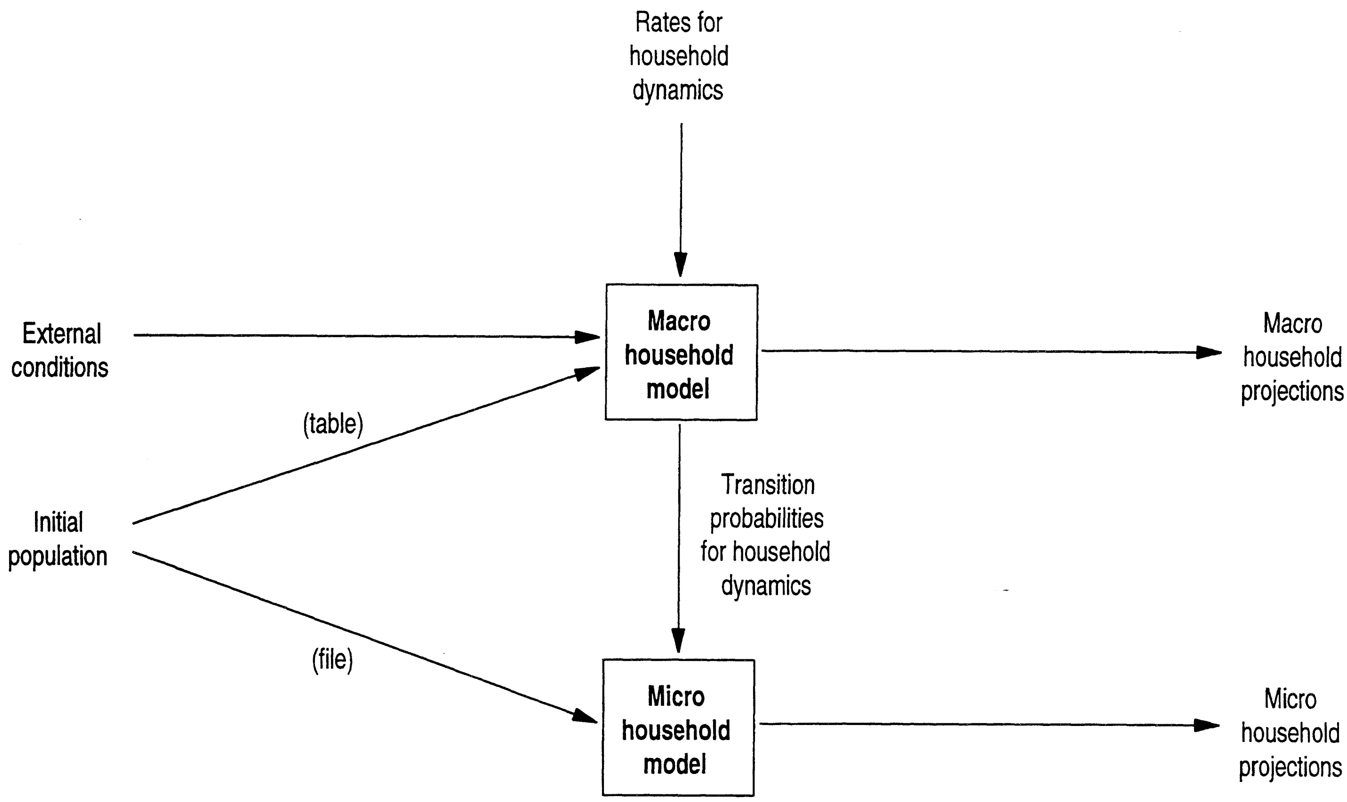
Figure 1 gives a summary overview of the links between the macrosimulation and the microsimulation model. Input to the macrosimulation model consists of a table with the population, in 1990, broken down by age, sex and household position, a set of occurrence-exposure rates (representing household dynamics, fertility, mortality and external migration), and external conditions (i.e. numbers of births, deaths and immigrations for future years taken from population projections). The results of the macrosimulation step are a set of aggregated household projections, and a set of transition probabilities for household dynamics (and fertility, mortality and migration). These probabilities are input to the microsimulation model, which operates on the basis of the initial population. The latter population, however, is not given in the form of a cross table, but rather as a file of records, each representing one person. A household number links individuals who live in the same household.

In principle, both the macrosimulation and the microsimulation model may be characterized as models representing a first-order Markov process with constant intensities for intra-household events, death and emigration, and with a uniform distribution of events over the unit projection interval (equal to one year for the microsimulation model, and to five years for the macrosimulation model) for the events of birth and immigration. Intensities for intra-household events, death and emigration, and numbers of live births and immigrations represent the parameters of the model. For each combination of age and sex, an initial state vector containing persons by household position at the beginning of the interval is multiplied by a matrix of transition probabilities for internal events, death and emigration. Next, a vector of entries representing numbers of live births and immigrants, multiplied by transition probabilities that take account of the events that newborns and immigrants may experience, is added to that product. The result is an updated state vector at the end of the interval. Projection is carried out by successively updating the state vector on the basis of the same or different parameter values for each unit projection interval. Because jump intensities are assumed constant, the matrix of transition probabilities is an exponential function of the matrix of jump intensities. The latter matrix has intensities at off-diagonal elements of the matrix, each intensity representing one event. The mathematics of such a model were derived by Van Imhoff (1990).

For the macrosimulation model, time is a continuous variable, and each intensity is estimated by means of the corresponding empirical occurrence-exposure rate (o-e rate). An empirical o-e rate, defined as the observed number of occurrences divided by the observed exposure time in the original household position, is a Maximum Likelihood estimator for the corresponding jump intensity (Hoem and Funck Jensen, 1982: 203).

[3] The model used here is basically that of a first-order Markov process, see Section 2.2. A semi-Markov model would take duration dependence into account.

Figure 1. Main structure of the household model



The parameters of the microsimulation model are the transition probabilities that result from the macrosimulation step. The reason for choosing transition probabilities rather than intensities is that time is chosen to be a discrete variable in the microsimulation model, whereas it is a continuous variable in the macrosimulation model. When time is a discrete variable, one cannot define intensities, and one has to resort to (discrete-time) transition probabilities. For the current microsimulation model, continuous time is computationally inconvenient, due to the interaction between individuals in the marriage market and the "cohabitation market". Although in reality the markets are cleared continuously, this would be problematic in microsimulation models: the number of persons who "want" to marry or start a consensual union would be zero in an infinitesimally short period, and thus these candidates cannot be matched. Therefore, clearing the market is done at discrete points in time (usually one year apart). Thus, the time-advance methodology in microsimulation models for the partner market may be characterized as *fixed-increment time advance* (or time-driven approach), see Law and Kelton (1982: 5). In case individuals do not interact during their life course, one could use a continuous-time microsimulation model based upon a *next-event time advance* (event-driven approach), and simulate each individual from birth to death before the next person is simulated.

An individual's behaviour is reflected by events, and the transitions computed by the microsimulation model are only the net result of these events within a unit interval. (It will be clear that the probability of multiple events within one transition decreases with shorter unit projection intervals.) In principle it is possible to extend the discrete-time microsimulation model to a model in which time is a continuous variable, and after this is done events (and corresponding intensities) can be inferred from transitions (and the corresponding probabilities). However, this involves computing the logarithm of a matrix, which does not always exist (the so-called embeddability problem, see Singer and Spilerman, 1976). Moreover, it is computationally cumbersome to perform matrix calculations in microsimulation models. Therefore, we chose on pragmatic grounds a microsimulation approach in which it is assumed that one transition is equivalent to one event. Since we work with unit projection intervals of one year in the microsimulation model, the probability that a transition involves multiple events is small for most transitions. The transition probabilities resulting from the (continuous-time) macrosimulation model are first broken down into probabilities for one-year age groups spanning a one-year period, and next these are entered into the microsimulation model. Competing risks are dealt with in the microsimulation model as follows: an individual who is in position i is first exposed to the risk of experiencing a transition (assumed equal to an event) to position *j*, or *k*, or *l* ... etc. In case the model decides that this person *will* leave position *i*, and hence that an event will occur, a random choice mechanism determines *which* of the competing events will be realized.

The focus in the macrosimulation model on continuous-time intensities and o-e rates as the basic parameters of the process, facilitates dealing effectively with competing risks and multiple events within the unit projection interval (Andreassen, 1992: 8). If we had only worked with discrete-time transition probabilities this would have been impossible, because each risk is represented by an intensity, not by a transition probability.

The fact that a macrosimulation model may easily handle multiple events within one transition is not the only reason why the microsimulation of household structures is preceded by a macrosimulation step. Another reason is that household projection results regarding numbers of births, deaths and international migrants have to correspond with those resulting from the national population forecast produced by the BEFREG model (Statistics Norway, 1994a).[4] The LIPRO model, from which the macrosimulation model described here is adapted, contains a very flexible algorithm which takes full account of such externally imposed constraints. To implement these in a microsimulation model would be more difficult (although not impossible). The algorithm referred to above is part of the so-called consistency module, which will be described in Section 2.3.

2.3. Consistency in the macrosimulation model

Within the context of household models, the consistency problem can be considered a generalization of the well-known two-sex problem in marital-status models. Unless the model builder includes a two-sex algorithm in the marital-status model, male marriages will *not* be equal to female marriages (nor will male divorces correspond to female divorces, or deaths of married persons to transitions to widowhood of the other sex). In household projection models, numbers of male entries into cohabitation have to correspond to numbers of female entries into cohabitation in a certain period, and the number of last children who leave a one-parent household must be equal to the number of heads of such households who become single. These requirements are but a few of the many consistency relations that may appear in the framework of a household projection model.

The LIPRO computer program contains a very flexible consistency module that automatically produces consistent numbers of events once the user has specified which sets of events are linked in linear combinations. The algorithm solves a weighted least squares problem, which minimizes the difference between initial events and consistent events (Van Imhoff, 1992).

Most of the consistency constraints (e.g. the two-sex requirements) stem from the nature of the household classification chosen; this type of consistency is referred to as *internal* consistency. Other constraints may occur because of imposed interrelationships between different models. For instance, numbers of events computed from models of a low aggregation level may be required to add up to the corresponding numbers in the national population forecasts, which is of a higher aggregation level. The latter type of constraints is referred to as *external* consistency (Keilman, 1985). LIPRO's consistency algorithm ensures that the projected numbers of events satisfy certain linear constraints, thus allowing for both internal and external consistency requirements. The external consistency conditions in the household model follow from Statistics Norway's population projections.

On the basis of the 15 individual household positions and the 123 household events we identified 68 different constraints for various events, see Appendix 2. Four *assumptions*, in addition to the four assumptions listed in Section 2.1 (p. 15), turned out to be necessary for the formulation of the consistency requirements.

5. Divorced partners do not continue to live together.
6. The formation and dissolution of homosexual unions can be disregarded as far as the two-sex requirement for cohabitation (numbers of male and female new cohabitees are equal in each interval) is concerned.
7. Only complete households can immigrate.
8. When dependent children change household type, they do so together with at least one adult.

The 68 consistency relations hold for each unit projection interval.

[4] Projected numbers were taken for the period 1993-2020, observed numbers for the years 1990-1992, see Chapter 4.

3. Preparation of input data and input parameters

3.1. Data sources

The household model requires two types of data:
- data on the initial population to be simulated forward in time, and
- occurrence-exposure rates for internal and external events.

The system of Personal Identification Numbers (PIN) in Norway makes it possible to match data on individuals from many different sources, including population registers, population censuses, and sample surveys, see Byfuglien (1991). This system has been used while constructing the initial population on the basis of a sample taken from the November 1990 Census of Housing and Population (the so-called household file, see Section 3.2). Regarding the required set of occurrence-exposure rates, various sources have been used. The 1988 Family and Occupation Survey (Statistics Norway, 1991) provides retrospective information on, amongst others, couple formation and dissolution (both marriages and consensual unions), and on young adults who leave the parental home. The survey contains information for six female birth cohorts (women born in 1945, 1950, 1955, 1960, 1965, or 1968) and two male cohorts (1945 and 1960). The respondents reported the month and the calendar year in which they had experienced specific events. This facilitated estimation of many of the rates for internal events (Section 3.3). However, not all 123 types of events could be estimated from the Family and Occupation Survey. For instance, entrance into and exit from household position "other" is not known. Also, information on flows into or out of institutions is lacking. Regarding the latter, published statistics on institutions for the elderly gave some aggregate numbers, and these were broken down by age, sex and household position of origin or destination on the basis of some reasonable assumptions. Occurrence-exposure rates for household position "other" were borrowed from Dutch data used in the LIPRO projections (Van Imhoff and Keilman, 1991).

The Personal Identification Number has been used to link a file with birth histories of women to the household file. This facilitated estimation of birth rates broken down by age and mother's household position. Regarding death and immigration, aggregate statistics broken down by age, sex, and marital status have been used. Household detail was added to these data on the basis of certain assumptions regarding the link between marital status and household position.

3.2. Initial population

The initial population is based on a sample of the population of Norway, collected in the November 1990 Population and Housing Census. First, a random sample of 10,000 individuals was drawn from the census file. Next, information on persons living in the same household was added, which resulted in a file containing 28,384 individuals. The file will be referred to as the "household file" henceforth.

For each person in the household file we know the date of birth, sex, marital status, family number and household number. Except for the household number, which was added in the data collection stage of the census, this information stems from the Central Population Register (CPR). We also have, for at least one person

in each household, the answer to the first question in the census form: "With whom do you share this dwelling?"[5] Respondents could tick off one or more of the following responses:
- nobody
- spouse
- partner in consensual union (cohabitee)
- daughter, son
- mother, father
- sibling
- parents-in-law, sister-in-law, brother-in-law, children-in-law, aunt, uncle, niece, nephew
- grandparents, grandchildren
- other persons.

The determination of the household positions of all individuals in the sample and their household types proved to be a complicated and labour intensive process. We discovered various errors and inconsistencies, including for example, some respondents who ticked off both "marriage partner" *and* "cohabitee". There were also many inconsistencies between the response to the question and the number of persons in the household and their age and sex. Many persons were missing from the household, in particular partners in consensual unions. These inconsistencies were solved by making reasonable assumptions about the correct household composition. For example, in the case of missing consensual partners, an arbitrary superfluous partner of the appropriate age and sex in another household was assigned to the household. Most of the inconsistencies were solved through automatic algorithms, but the hardest cases had to be corrected manually. Yet the overall data quality of the household file is quite good: the number of problematic cases was only 1 per cent of all cases.

After the household structure did not show any apparent inconsistencies any longer, a three-step weighting procedure was carried out on the households and the persons contained in the household file. Appendix 3 gives a full account of the weighting procedures which were used in order to correct for three types of bias in the initial sample. In summary, the following procedure has been applied.

First, there was a bias due to unequal sample probabilities for persons living in households of different sizes. The sample was, initially, in terms of *households*, whereas our goal was to construct a file of *individuals*. Persons living in large households had a larger sample probability than persons in small households, and we applied, to each private household, a weight which is inversely proportional to the household's size.

Second, information obtained from published statistics on the number of elderly persons living in institutions showed that such persons were severely underrepresented in the sample, as compared to persons living in private households. At the same time, there were relatively few institutionalized persons under 85 years of age in the sample, and too many over 85. Published statistics for institutions for the elderly were used to correct for this bias.

Finally, after the previous two steps of the weighting procedure had been carried out, the age distribution of the weighted individuals (irrespective of household position) turned out to be such that there were too many elderly aged 75-89 (in particular males), and relatively few young adults (20-24) and children under 15. The shares of intermediate age groups were somewhat irregular, as compared to official statistics. Therefore, it was decided to carry out a third and final weighting step in order to obtain an unbiased age distribution for males and females in the sample. In order to maintain the distribution by household size of the sample, weights for this third step were applied to persons living in one-person households only. Consequently, this third weighting procedure could only be carried out for persons in age groups 15-19 and over. A correction for children under 15 is described below.

All three weights are multiplicative, and consequently the total weight for each individual is the product of the three separate weights. Weighting was carried out by duplicating and deleting randomly chosen households of appropriate size (step 1) or persons with appropriate combination of age, sex and household position (steps 2 and 3).

[5] The 1990 Census was a complete count in municipalities with less than 6,000 inhabitants. In these municipalities everyone born in 1973 or before answered this question. In larger municipalities the census was a random sample, and for these municipalities we have information on household composition from one household member only.

As a further step in preparing data for the initial population another adjustment was carried out. The purpose was to obtain a better correspondence with the household structure based upon the 1988 Family and Occupation Survey, in particular the information regarding young adults living at the parental home or in consensual union. Only a summary description is given here. Full details can be found in Keilman (1994b).

Proportions of males and females in household positions "child", "living in consensual union" (irrespective of number of children), and "living with spouse" (irrespective of number of children) were compared between the two sources. The analysis revealed that the proportions of females who live with their parents at ages 19 and 22 were grossly overestimated in the household file, as compared to the Family and Occupation Survey. This was explained by the close link between the Central Population Register and the household file: the information included in the household file corresponds largely to the *de jure* household situation, and, for reasons described in Appendix 3, the proportion of young adults living in the parental household is much higher in the register than it is according to the *de facto* household situation.

At the same time, the proportions of females aged 19 and 22 living in consensual unions were severely underestimated in the household file: 5 versus 19 per cent at age 19, and 14 versus 34 per cent at age 22, both in the household file and in the Family and Occupation Survey, respectively. Too low proportions of cohabiting females in the household file were most probably caused by too high proportions of females being categorized as "dependent child": 83 and 44 per cent for females aged 19 and 22, respectively, and 79 and 71 per cent for males of those ages. It was assumed that proportions "dependent child" and "living in consensual union" according to the Family and Occupation Survey are closer to reality than those according to the household file after the three-stage weighting procedure.[6] Therefore the latter numbers were corrected, according to the following principles.

1. For females

- numbers of females aged 19 or 22 who were categorized as dependent child (CHLD) were decreased in such a way that the proportions correspond to those from the Family and Occupation Survey;
- numbers of females aged 19 or 22 living in a consensual union without children (COH0) were increased to levels found in the Family and Occupation Survey;
- females aged 19 or 22 who were forced to leave their parents but did not become COH0 were labelled as living in a one-person household (SIN0);
- for each of the three household positions CHLD, COH0 and SIN0, proportions at ages 18, 20-21 and 23-24 were found by linear interpolation between the proportions found above (proportions for ages up to and including 17, and 25 and over remained unchanged).

2. For males

the percentage point difference between proportions before and after correction for each combination of age and household positions CHLD and COH0 was made equal to that for females in the corresponding age/household position combination. Next, numbers in position SIN0 were found by requiring that for each age the sum of positions CHLD, COH0 and SIN0 be the same before and after correction.

For position "dependent child" the decreases in the age-specific share ranged from 15 percentage points (age 24) to 37 percentage points (age 19). For cohabiting persons without children (COH0) the increase was between 3 (age 24) and 20 (age 22) percentage points. The increases ranged from 8 (women and men aged 22) to 30 (men aged 23) percentage points for position "living in a one-person household".

The fact that some males and females were assigned position COH0 instead of CHLD required matching of new males and females with position COH0. This led, similar to the young adults who moved from CHLD to SIN0, to a number of new households. In general, all household positions of the young adults in the household file were updated, as well as the household type they originally lived in.

Table 2 shows the distribution over the most important household positions and broad age groups, of the individuals contained in the household file, after all the corrections described above had been carried out.

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[6] The Family and Occupation Survey also has its limitations, caused by selective non-response. For the purpose of the current project it should be noted that the non-response was somewhat higher among the never-married than on average.

Table 2. Individuals by age-group and household position, 1990 (N=23,401)

	CHLD	SINO	COHO	COH+	MARO	MAR+	SIN+	INST	OTHR	All household positions
						Per cent				
0-14	17.6	-	-	-	-	-	-	-	0.1	17.7
15-29	8.3	5.5	3.1	0.5	0.8	2.3	0.8	0.0	2.1	23.3
30-44	-	3.1	1.1	0.8	1.3	13.5	1.3	0.0	1.3	22.4
45-59	-	2.1	0.4	0.1	5.6	5.9	0.5	0.0	0.6	15.3
60-74	-	3.9	0.2	0.0	8.6	0.5	0.1	0.2	0.7	14.1
75+	-	3.1	0.0	0.0	2.7	0.0	0.0	0.9	0.5	7.3
All ages ..	25.9	17.8	4.8	1.4	19.0	22.2	2.6	1.1	5.3	100.0

Codes for household positions are as follows:

CHLD	Lives as a child with parent(s); at age 25 not any longer considered as "child" but as "other member of the parental household" (as long as he/she continues to live with parents)
SINO	Lives alone, i.e. in a one-person household
COHO	Lives in non-married cohabitation, no children present
COH+	Lives in non-married cohabitation and with one or more children
MARO	Lives with marriage partner, no children present
MAR+	Lives with marriage partner and one or more children
SIN+	Is head of a one-parent family with one or more children
INST	Lives in an institution
OTHR	All other household positions

About one-fourth of the population lives as a child with parent(s), at least when we set the maximum age for a child equal to 25. Married couples without children are observed particularly among persons over 45, which reflects the "empty nest phase". All cohabitees taken together make up some 6 per cent of the population, and three out of every four of them are without children. Nearly 4 per cent of all adults are head of a one-parent family, most often with only one child. Persons who live alone (18 per cent of the population) are frequently between 15 and 30 years of age, or over 60.

Note that the file's original size has been reduced from 28,384 to 23,401 persons, mainly as a result of the first step in the three-stage weighting procedure, in which 1,846 households of size two or larger were removed (and the same number of one-person households were created). What has been the effect of this three-stage weighting procedure and the subsequent correction for too high shares of children living with their parents? We mention a few proportions in the unweighted file, which can be compared with those in Table 2. Weighting and subsequent correction has had the largest effects on the proportion of the population living alone: 7.0 per cent before weighting, and 17.8 per cent in Table 2. Step 1 in the weighting procedure led to 1.87*7.0=13.1 per cent persons in position "living in a one-person household"[7], while the remaining 4.7 percentage points are explained by the children that we removed from the parental household to become one-person households. Proportions in positions "cohabiting, no children" and "living with spouse, no children" went up (from 3.2 to 4.8 per cent, and from 16.1 to 19.0 per cent, respectively - all ages taken together) because the number of parents with one or more children in the same household was corrected downwards. This applies to middle-aged parents. In addition, proportions "cohabiting, no children" at ages below 25 went up (from 1.8 to 3.1 per cent for age group 15-29) because some of the children that we removed from their parental households were matched and labelled as "cohabiting, no children". The share of persons in position "living with spouse and one or more children" decreased from 29.6 per cent before weighting to 22.2 per cent in Table 2. The changes in other household positions were of less magnitude.

It should be noted that the corrections noted above agree, at least qualitatively, with the results of a postenumeration sample survey carried out immediately after the 1990 Census. This survey found that the census underestimated the number of small households. In particular there were 13 per cent too few one-person households in the census (Statistics Norway, 1994c, p. 39, p. 87).

[7] The factor 1.87 has been used in the first step of the weighting procedure and applies to one-person households, see Table A3.1 in Appendix 3.

As a final step, an estimate was made of the structure of the population by age (five-year age groups), sex and 15 household positions as of 31 December 1990. Each person in the corrected household file aged 15 or older received a multiplication factor equal to 178.8. This number equals the ratio of the total population aged 15+ as of 31 December 1990 and the number of individuals in the household file aged 15+. Concerning children aged 0-14, published statistics on numbers of girls and boys in five-year age groups were divided between household positions "dependent child" and "other" on the basis of the shares for each age/sex combination in the household file. The latter procedure guaranteed that children were no longer underrepresented: Table 2 shows that children under 15 years of age comprise 17.7 per cent of the whole sample, and this share is lower than the observed number for this age group at 31 December 1990 (19.0 per cent). As explained in Appendix 3, an important purpose for the weighting procedure was to obtain a correct distribution by household size and, at the same time, by age. In that procedure, this could be achieved for age groups 15 and higher only. The final step corrects for the underrepresentation of children under 15 years of age (p. 39).

The resulting population structure is given in the upper panel of Table 5, to be discussed in Chapter 4.

3.3. Occurrence-exposure rates

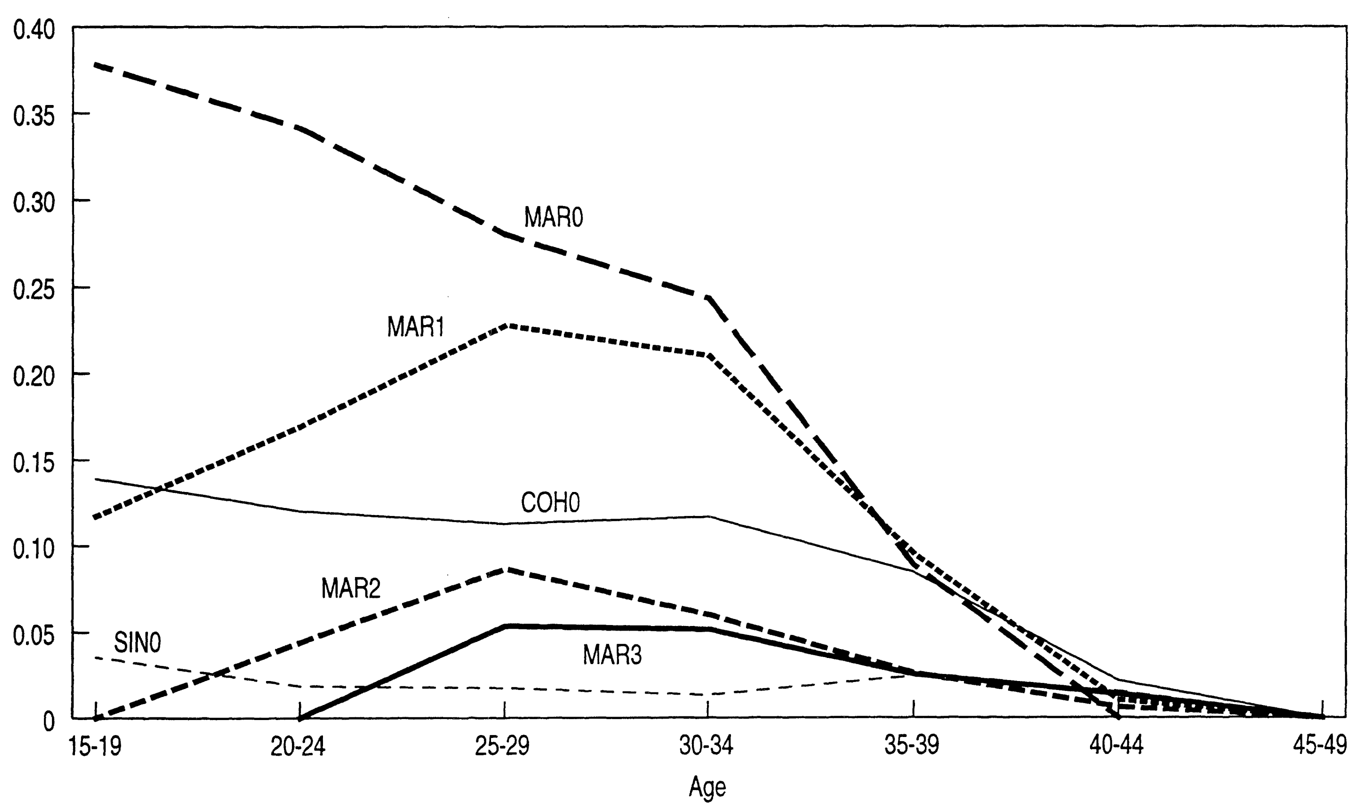
In the text, the tables and the figures that follow, "age" is always defined as "age at the beginning of the projection interval". This section presents the procedures that have been followed for calculating and adjusting the various occurrence-exposure rates. These procedures are illustrated by means of graphs with age- and sex-specific rates for selected events.

3.3.1. External events

Births

Birth rates have been estimated from the so-called Women file, which gives life-history data on live births and marital status for all women who have lived in Norway since 1964 (see Brunborg and Kravdal, 1986). The birth histories are almost 100 per cent complete for women born after 1935. However, this file does not contain any data on household position, which are needed to estimate the appropriate occurrence-exposure rates.

Figure 2. Birth rates by household position of the mother



To obtain the household positions we linked births in 1990 in the Women file to women born 1940-1977 in the household file. This made it possible to estimate most of the age-specific fertility rates by household position of the mother (see the lower panel of Table 1). It should be noted that we distinguished women according to the number of children present in the household ("household parity") rather than the number of children ever born ("biological parity"). Because of the small numbers of women in some age-household position groups, grouping and smoothing was necessary. Figure 2 gives birth rates for the most important household positions of the mother. Note the high rates for married women without children (MAR0) aged 15-24: the very few women who entered that household position at so young an age probably did so because a birth was expected or planned.

Deaths
Ideally we would have used death rates by age, sex and household position. There are, however, too few persons in the household file who die in one year to estimate reliable death rates. Therefore we decided to use deaths from the CPR, and estimated death rates by age, sex and *formal* marital status (never married, married, widowed, and separated/divorced) for the period 1986-1990. There are indications that recent mortality rates of Swedish cohabitees are higher than those of married persons (who live together with their spouse), but still lower than those of persons who live alone (Prinz, 1991), and it is not unreasonable to assume that marital status may serve as a proxy for actual household position at the prime ages of mortality (60 years and over). For each combination of age and sex, the following assumptions have been made:

- death rates for positions "dependent child", "other" and "living in a one-person household", and "lone parent" (irrespective of number of children) are the same as those for unmarried (i.e. never-married or divorced or widow(er)) persons;
- death rates for position "living with spouse" (irrespective of number of children) are equal to those for married persons;
- death rates for positions "cohabiting" (irrespective of number of children) are the average of the rates for married and unmarried persons;
- death rates for position "living in institution" (INST) are twice those of unmarried persons.

Figure 3a. Death rates by household position, females

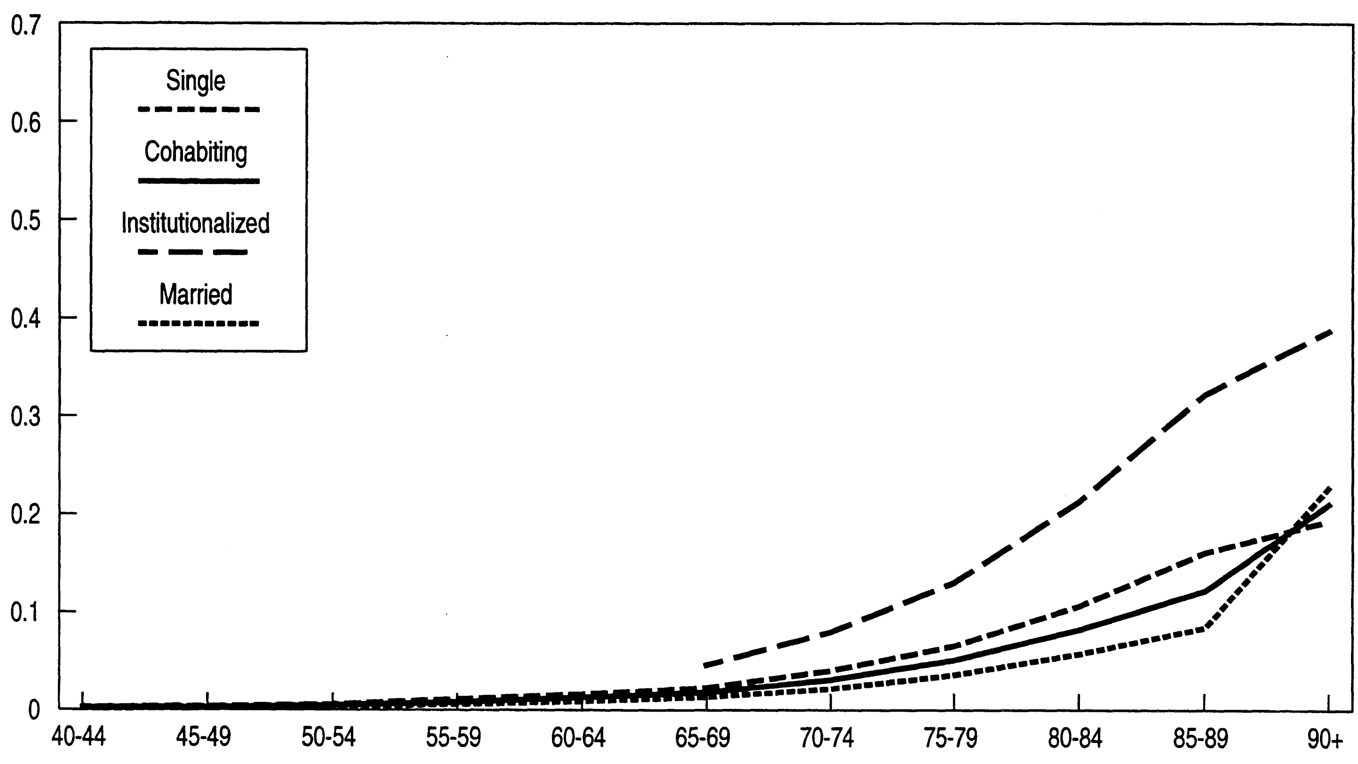
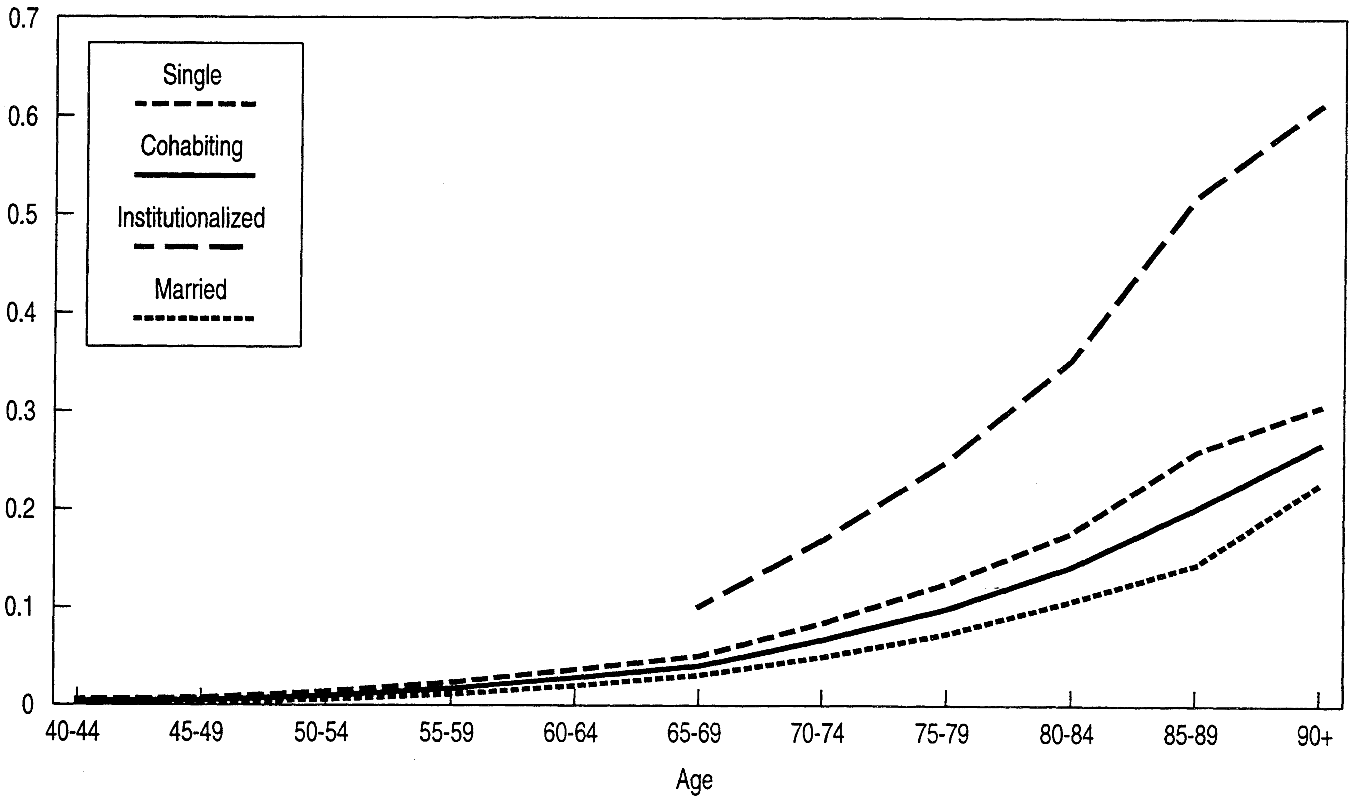


Figure 3b. Death rates by household position, males



The latter assumption was arrived at after some experiments with flows into and out of the position INST, see below. Figures 3a and 3b gives selected age-specific death rates.

Emigration and immigration
Since no data exist regarding the household position of emigrants and immigrants, an approximation has been used on the basis of observed marital status distributions of male and female migrants in broad age groups. The procedure was as follows.

Future numbers of immigrants and numbers of emigrants broken down by sex and five-year age group were taken from the Medium variant of the 1993 based population forecasts (the so-called M1 variant, see Statistics Norway, 1994a). These numbers were subdivided further according to household position on the basis of three assumptions.

1. For each combination of sex and age group, the distribution of the immigrants and the emigrants by marital status would be the same as that observed for *im*migrants in the years 1990-1992 (three year average). Data are available for four age groups (0-15, 16-44, 45-66 and 67+) and three marital statuses (never-married, currently married - including separated - and previously married). Preliminary inspection showed that the marital status distribution, in each age group and for each of the three years, of immigrants was close to that distribution for emigrants. Therefore, only immigrants were considered in the construction of the distribution over household positions.
2. For each combination of sex, age group (five groups: 0-14, 15-24, 25-44, 45-64 and 65+) and marital status (never-married, currently married, previously married), and for the entire projection period, the distribution of projected numbers of net immigrants by household position would be the same as that of the initial population. This aggregation of the five-year age groups used in the macroprojection into broader age bands corresponds as closely as possible to the four age groups used in published data mentioned above. Age group 15-44 in this procedure was split up into 15-24 and 25-44 in order to avoid migrants aged 25 or older with household position CHLD. Moreover, it was assumed that the distribution of migrants by marital status during the projection period in each of the five age groups would be the same as the observed average distribution for the years 1990-1992 for corresponding age groups described under point 1 (the age groups 15-24 and 25-44 in the projections both received the shares as observed for the 15-24-year olds).

3. The final assumption was that for each of the five broad age groups, marital status shares would be the same for its constituent five-year age groups.

With these three assumptions we were able to estimate, for the period 1990-1994, the level of net immigration broken down by sex, age group and household position. Numbers for the years 1990-1992 were observed, and those for 1993 and 1994 were taken from the population forecasts (variant M1). The four age groups between 40 and 60 showed small negative numbers of net immigration (i.e. more emigrations than immigrations) for males for some household positions, including cohabiting and married migrants. Because of the consistency requirement that only complete households may immigrate (see assumption 7 in Section 2.3), this would create problems in matching male and female married immigrants, for instance, in particular in the microsimulations. Therefore, the net immigration for categories with negative numbers was increased to zero, and numbers for other age groups for the same household position were proportionally decreased, in order to obtain the same total level of net immigration.

3.3.2. Internal events

Couple formation and dissolution

Rates for couple formation and dissolution were estimated with data from the 1988 Family and Occupation Survey. Two files were constructed with information for each respondent between age 14 and the time of interview: one file with the *parity* at the beginning of each month and another file with the *partnership position* at the same date. On the basis of these two files we were able to construct a sequence of household positions for each individual, which was utilized to estimate the intensities as ordinary occurrence-exposure rates. Events were defined as changes in household position between the beginning and the end of a certain month.

The sample consists of six female and two male cohorts (see Section 3.1), with approximately 700 women and 900 men in each cohort. Only data for the five years preceding the interview were used to estimate the rates, to avoid as much as possible bias from the changes over time that may have taken place.

We estimated rates for each sex and cohort. Non-zero estimates were found for 46 of the events for women and 33 for men.

Altogether six *double events* were accepted, all involving the start of partnership and a subsequent birth, see Appendix 1.

Small non-zero rates were estimated for three of these transitions:
from "dependent child" to "cohabiting, one child" (CHLD -> COH1): females aged 20-24
from "one-person household" to "cohabiting, one child" (SINO -> COH1): females aged 20-24 and 25-29
from "one-person household" to "living with spouse, one child" (SINO -> MAR1): females aged 20-24 and 25-29.

The oldest cohort, women born in 1945, was on average between 38¼ and 43¼ years during the five-year period we used for estimation, October 1983 - September 1988, with a midpoint of 40 3/4 years. We assumed, therefore, that the rates for this cohort apply to women who are 40-44 years old in the projection model. Similarly for the other cohorts. This implies a small bias in the rates, however, since the mid-point of the ages for each cohort during the period of observation is 1¾ years below the midpoint of the age interval to which we apply the rates (e.g. 40¾ years versus 42½ years for the 1945 cohort).

After the rates had been estimated we looked at the age structure of each of them and extrapolated the rates to ages below and above the age range we had estimates for, 15-19 to 40-44 for females and age groups 25-29 and 40-45 for males. Some of the estimated rates were changed because they were unrealistically low or high. The extrapolation was done taking the type of event into consideration. For example, it was assumed that women do not bear children above age 44.

Another example is the marriage rate for consensual partners, which for females was assumed to decline from the highest recorded age group in the Family and Occupation Survey (35-39) to zero for age group 65-69. For males the marriage rate was assumed to increase linearly from age group 15-19 to the observed rate for the age group 25-29, decline linearly between age groups and 25-29 and 40-44, and as for females, decline to zero for age group 65-69. Figure 4 illustrates these patterns.

Figure 4a. Exit rates from position COH0, females

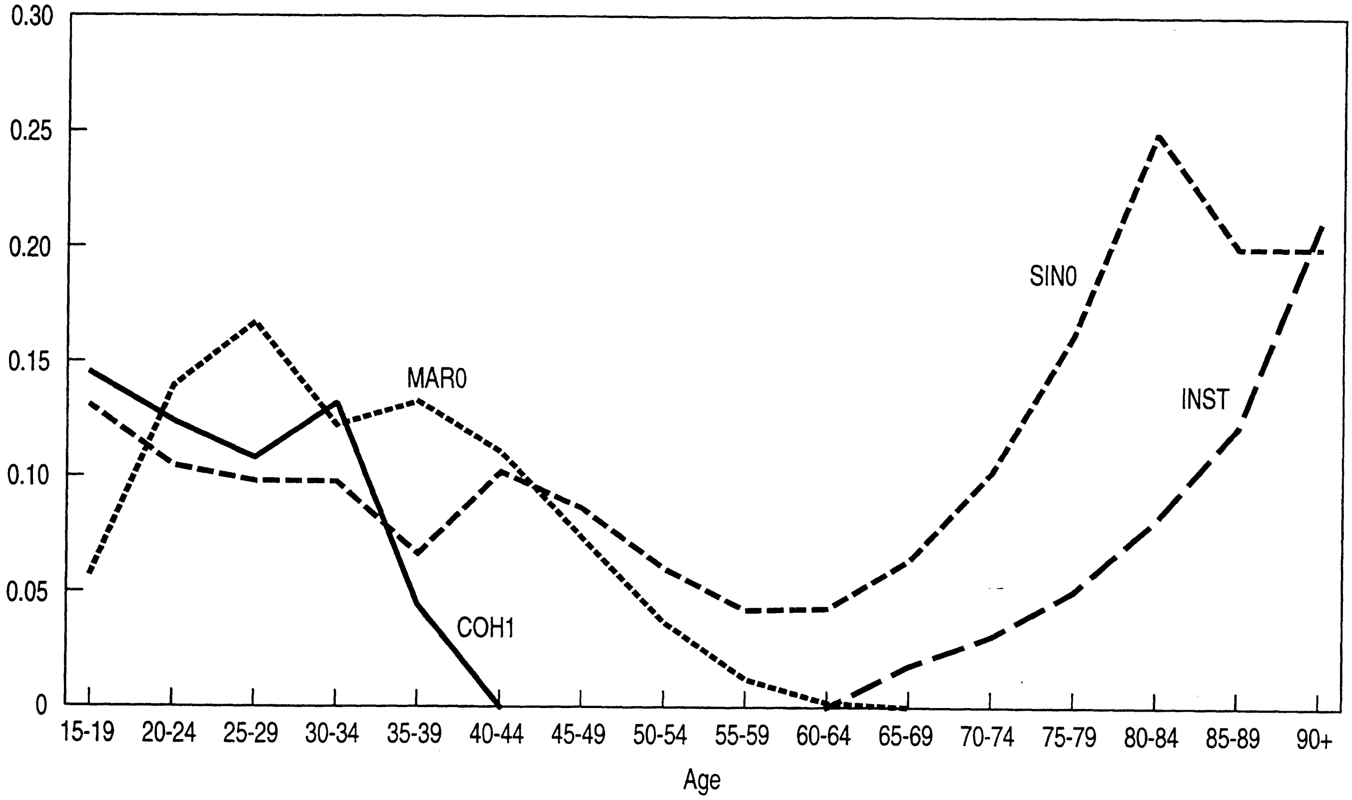
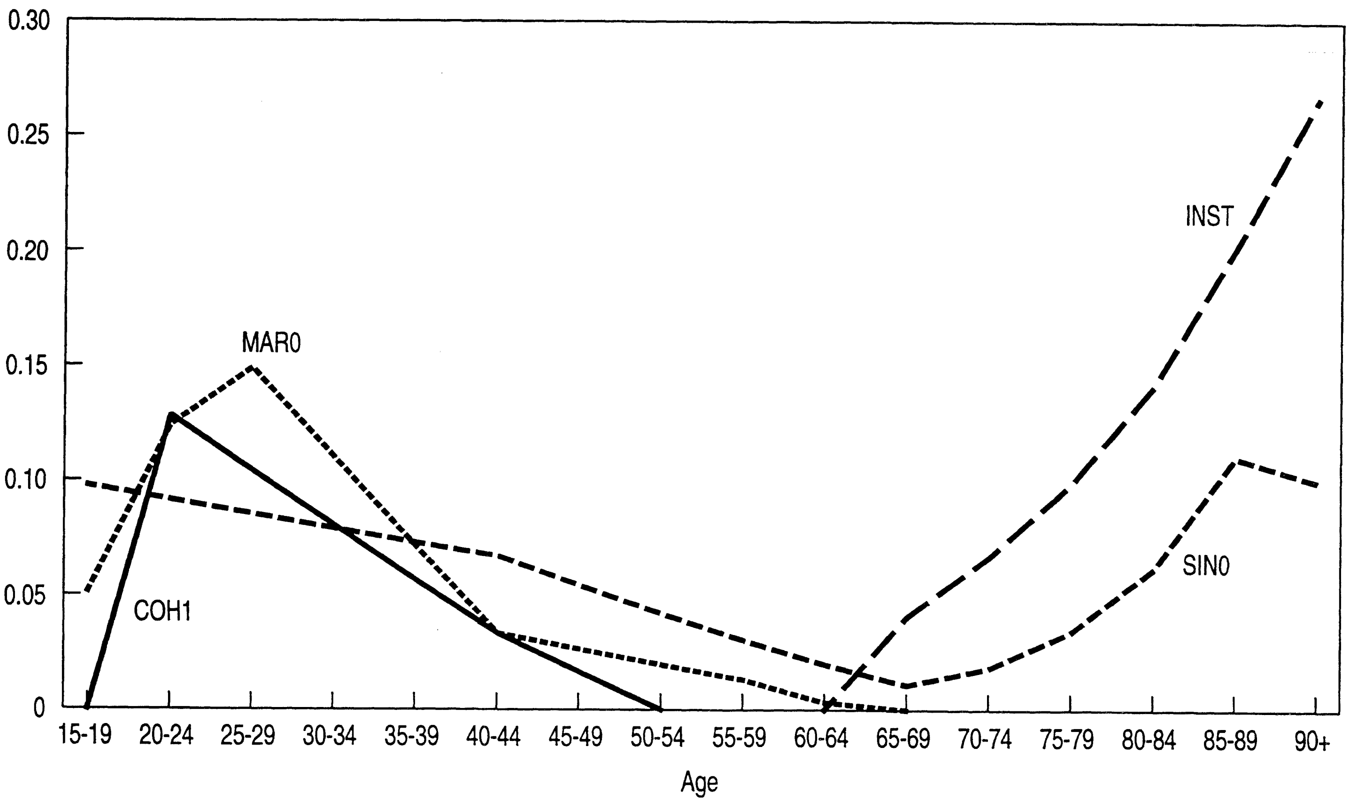


Figure 4b. Exit rates from position COH0, males



We do not have any information on the destination of the children when a marriage or a union is dissolved. The majority of children stay with or follow the mother while the rest follow the father. In order to distribute the children over the previous partners we have used Dutch data (Van Imhoff and Keilman, 1991: 73). According to Dutch observations for 1985, 93 per cent of children follow the mother. Consequently we assumed that 93 per cent of all mothers who leave the state "living with spouse, one or more children" because of separation will jump to "lone parent" together with all the children, and that 7 per cent of them become a one-person household. The proportions were assumed independent of age. For males leaving "living with spouse, one or more children", Dutch data indicate that 19 per cent would jump to "lone parent" together with all the children, and 81 per cent to "one-person household" The same assumptions were made for dissolutions of consensual unions.[8] More refined distributions, for instance that the partners "share" the children between them so that both wife and husband become lone parents, were not attempted.[9] Although some arbitrariness is involved in the assumptions stated here, the consistency algorithm controls the division of the group of separating couples with children into lone parents and one-person households, see constraints 6-9 and 31-34 in Appendix 2. The lines indicated with SIN0 and SIN1 in Figure 5 illustrate dissolution rates of a consensual union with one child, whereas Figure 6 gives corresponding dissolution rates for a married couple with one child.

A jump from "cohabiting" or "married" to "single" or "lone father/mother" (depending on the number of children) may not only be caused by union dissolution, but also by death of the spouse. Separation and divorce dominate at younger ages, and for the elderly death of the partner is the most important event. We have added, to the separation rates estimated from the Family and Occupation Survey, age-specific death rates for the opposite sex in the corresponding household position, see for example the lines indicated with SIN1 in Figures 5 and 6.

The high and increasing rates for transitions from consensual or married partner (COH1 or MAR1) with one child to single parent (SIN0) in Figures 5 and 6, which have been set equal to the death rates for partners of the opposite sex, are mostly of theoretical interest, as there are practically no persons at ages above 70 living with children - whose maximum age is assumed to be 25. For such households (COH1 and MAR1) to be formed one of the partners has to be much older than the other and the younger partner has to have children from a previous relationship.

Estimation of rates to and from position "other"
Rates for entry into or exit from the position "other" are not available from the Family and Occupation Survey, nor from other Norwegian data sources. We have applied the rates observed for the mid-1980s for the Netherlands (Van Imhoff and Keilman, 1991: 73).

Leaving the parental home
Rates for leaving the parental home have been estimated by Texmon (1992) with data from the Family and Occupation Survey. Unfortunately, this survey did not contain the type of household to which the respondent moved. The distribution by type of household of destination was borrowed from Dutch data (Van Imhoff and Keilman, 1991: 73). Figure 7 gives the most important rates for young adults. Note that marriage and child birth while living in the parental home are very rare events.

Neither do we have information on the *return* to the parental home. Data from the Netherlands have been used here as well for the change from household positions "other" and "one-person household" to "child". Return to parents from other positions are not allowed in the model.

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[8] Due to the symmetry in the household, one would expect that the female share for the event involving a jump from "living with spouse and two children" (MAR2) to "lone parent, two children" (SIN2) would be the same as the male share for the jump between "living with spouse and two children" to "one-person household" (MAR2 -> SIN0), and similarly for other positions. However, the shares discussed here divide *age-specific exit rates* for married and cohabiting couples according to destination: lone parent or one-person household. The shares do *not* distribute *events* over the household states of destination. Since married men with children generally are spread over somewhat more age groups than married women with children, the rates do not reflect the symmetry referred to above.
[9] In reality, children from broken families often live with the mother during some part of a certain period, and with the father for the remaining part. Such a refinement has not been modelled. Hence, results on lone parent families should be interpreted such that they give results for the number of children who spend the majority of time (possibly all the time) with that parent.

Figure 5a. Exit rates from position COH1, females

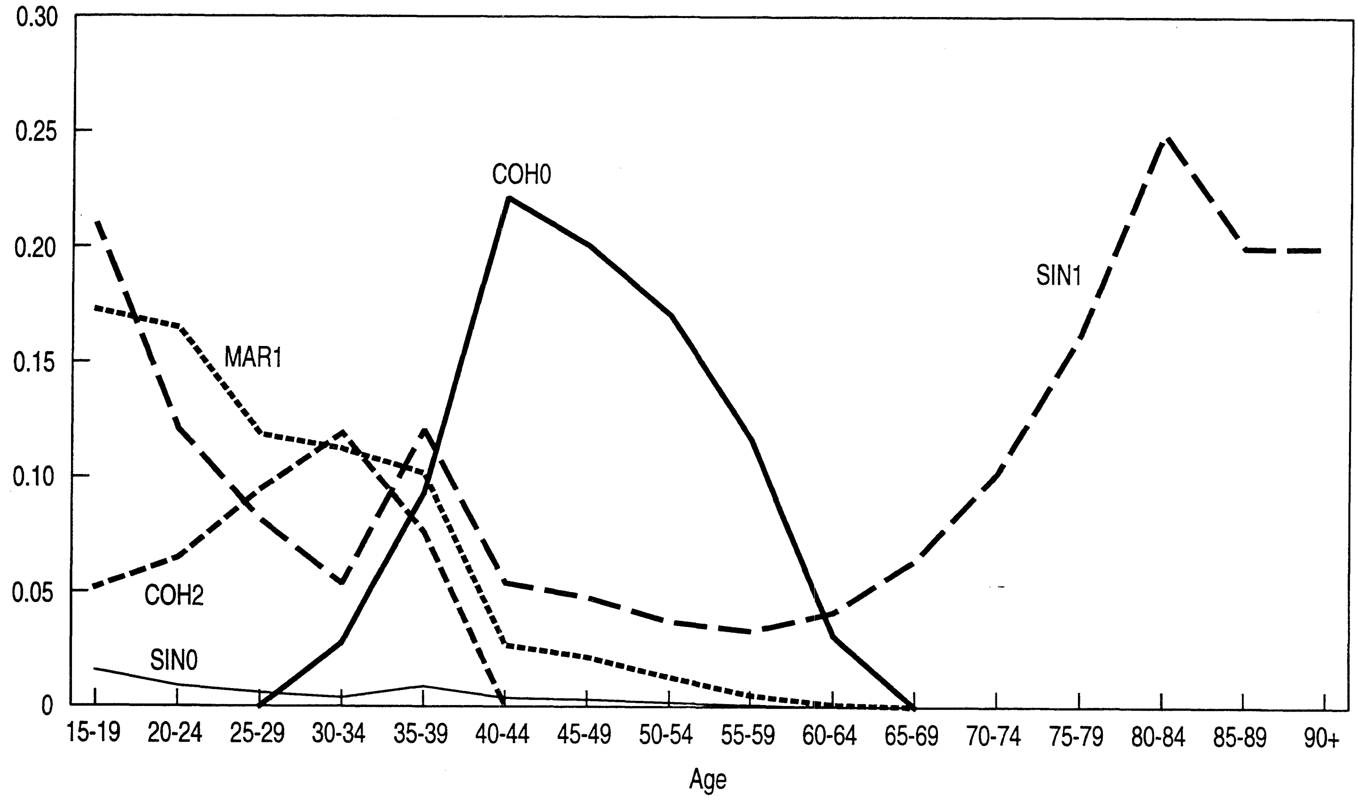


Figure 5b. Exit rates from position COH1, males

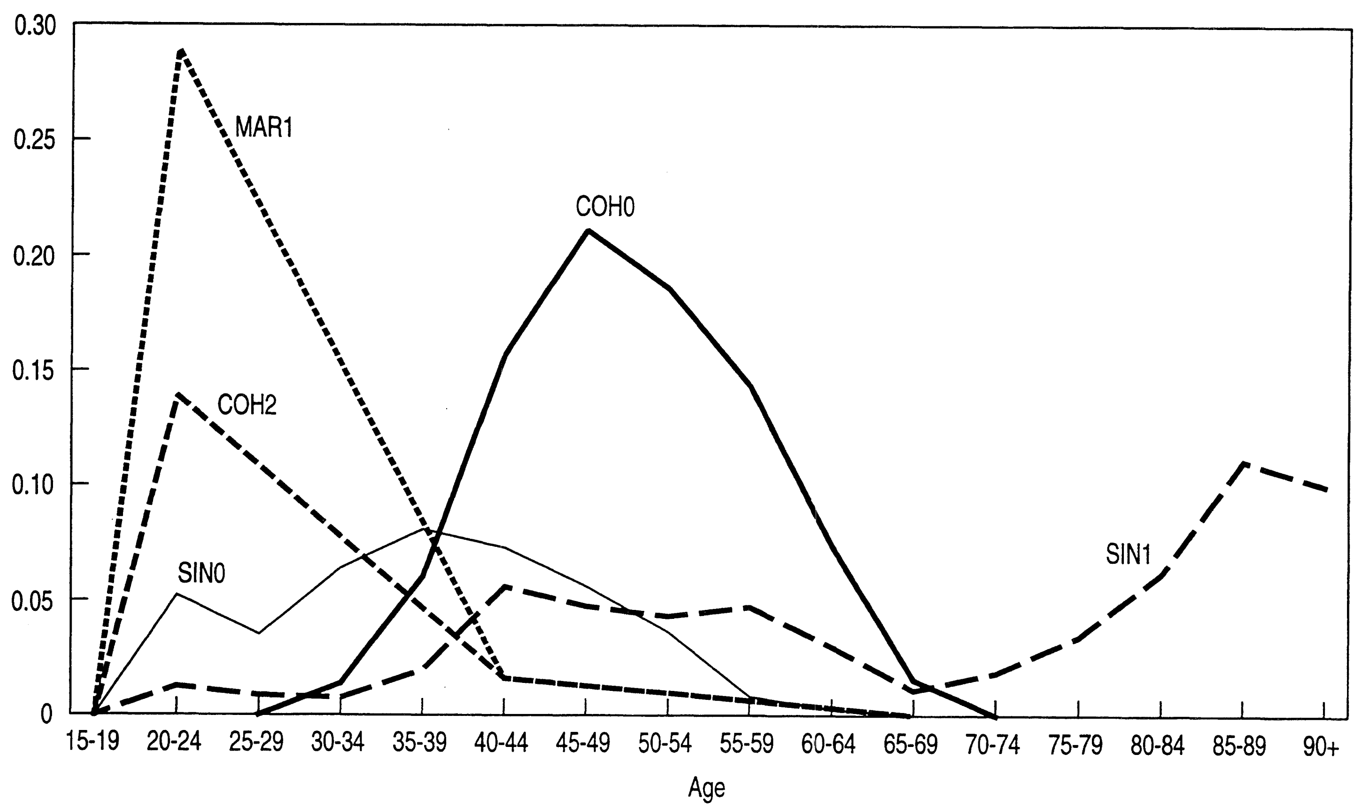


Figure 6a. Exit rates from position MAR1, females

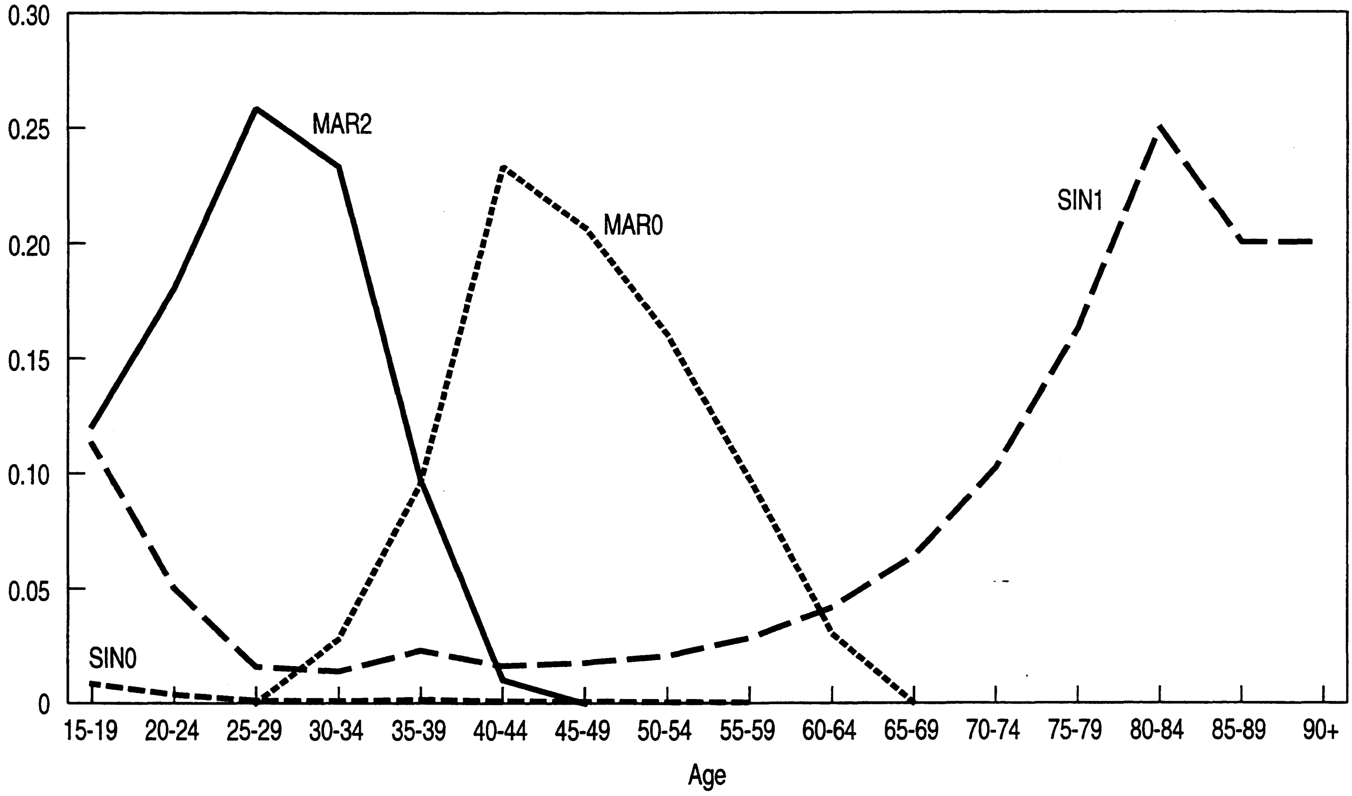


Figure 6b. Exit rates from position MAR1, males

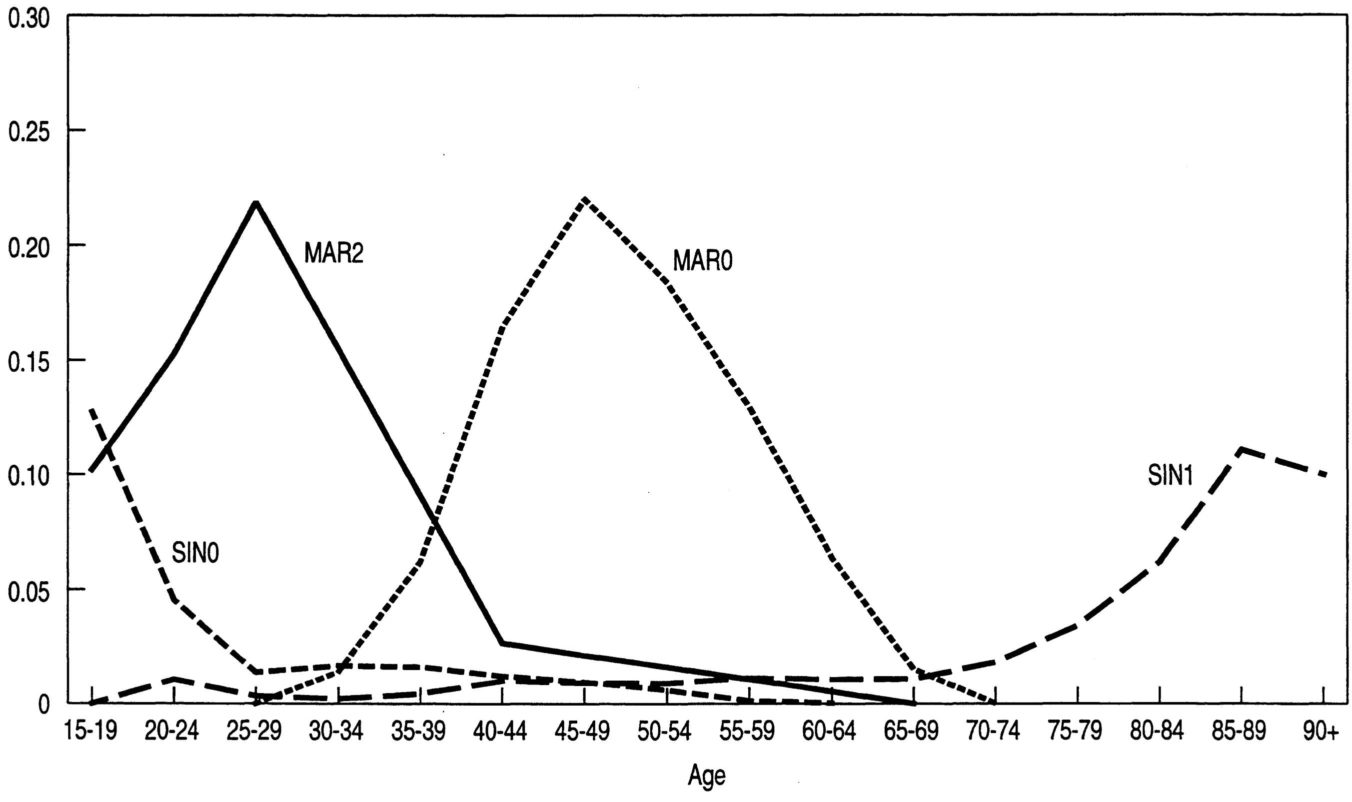


Figure 7a. Exit rates from position CHLD, females

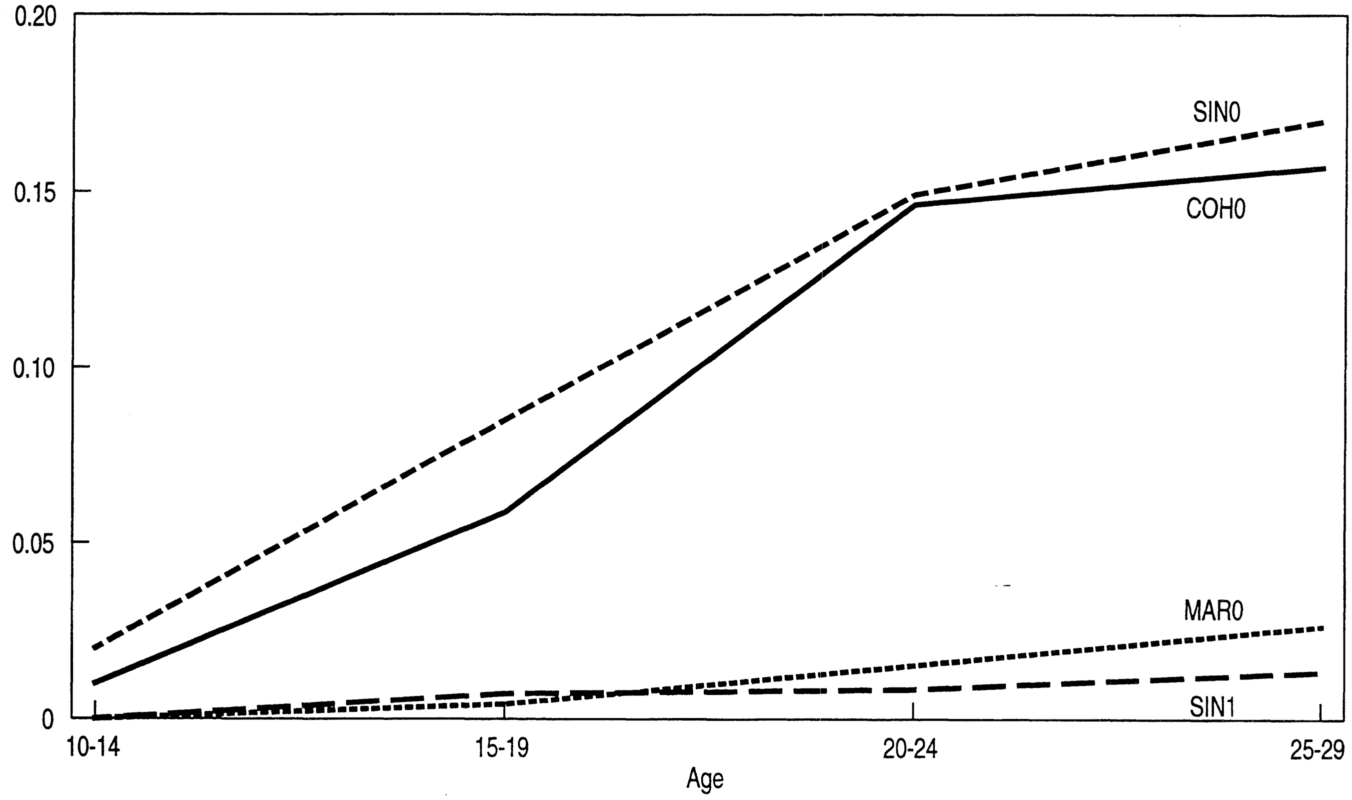
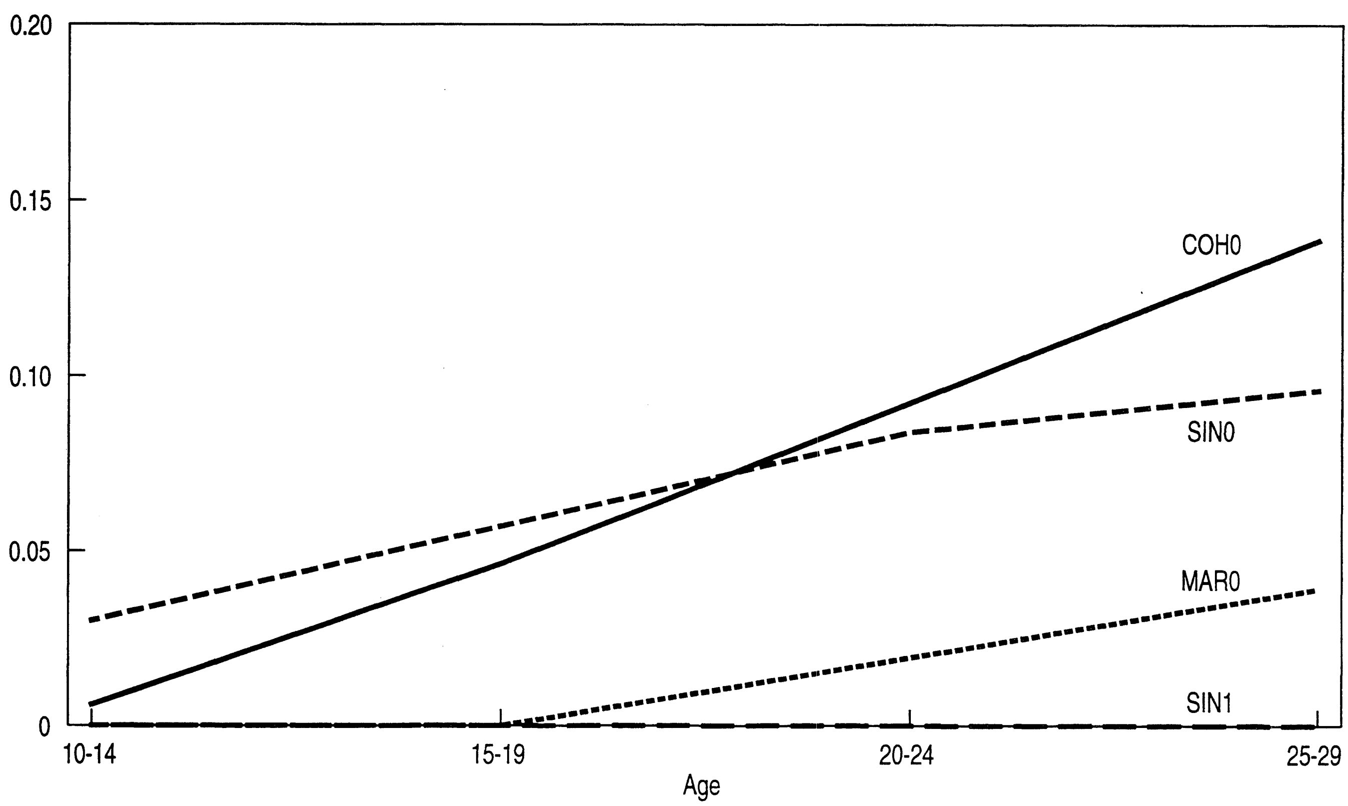


Figure 7b. Exit rates from position CHLD, males



When a child leaves the parental home, the parent(s) experience a decrease in household parity. No data were available for the latter event, and we used therefore an indirect estimation technique to construct such rates on the basis of a convolution of fertility rates and combined home leaving/death rates. The algorithm is described in Appendix 4.

Institutionalization
Data on institutionalization are very scarce. Fortunately, institutionalization is a rare event for all ages except the old ones. Thus, we have assumed that no persons younger than 65 live in an institution. Hence all o-e rates into an institution are zero for these ages. For older ages we have estimated the entry and exit rates on the basis of aggregate data for admittances to institutions, together with some simplifying assumptions. The following procedure has been used.

The point of departure was the stock of persons living in an institution as of 15 January 1991 (see *Statistisk ukehefte* 35/1991, p. 3). Information is available for broad age groups (<67, 67-79, 80-84, 85-89, 90+) and sex. We also have, for the year 1991, an estimate of the total number of entries from and returns to private households, as well as the number of deaths in institutions (*Statistisk ukehefte* 37/1992, p. 8). These data facilitated calculation of crude rates (for the institutionalized) for return to a private household and death, and a crude rate for re-entry (among the 65 and over) to private households.

Next, age- and sex-specific return rates were approximated by an adjustment of the crude rate. Age groups 65-69, 70-74, 75-79, 80-84, 85-89 and 90+ were first given a weight factor equal to 1, 0.9, 0.7, 0.4, 0.1 and 0, respectively, on the assumption that the propensity to return from an institution to a private household declines with age. Next, the return rate for sex s, age group x, and household position h was computed as the crude return rate multiplied by the weight for age x and the share that household position h and sex s have in age group x in the initial population (see Section 3.2). Entry rates by age, sex and household position were assumed to be the same as the death rate in that age/sex/household category. Finally, it was assumed that death rates for the institutionalized are twice as large as those for unmarried persons of the same age and sex. The two proportionality factors (a factor of one for entry rates and a factor of two for death rates) were arrived at after some experimentation in a trial projection, in which we tried to achieve stable results, i.e. modest adjustment factors in the consistency algorithm. The resulting entry and exit rates are exhibited in Figures 8 and 9.

The consistency algorithm has been used to control for the growth in the stock of the institutionalized population: the latter algorithm facilitates setting the net inflow to institutions exogenously, in accordance with (expected future) changes in capacity. See for instance consistency requirements 64 and 65 in Appendix 2, which dictate that entries equal exits, and thus guarantee a constant number of institutionalized persons during the entire projection period. This was done not only because this capacity is a policy variable (rather than entry and exit rates), but also to minimize the risks connected to the admittedly crude approximations we had to make for the institutionalized population.

3.3.3. A summary view of the rates

A concise way of presenting the set of occurrence-exposure rates is by means of some summary results of the multidimensional life table implied by these rates. A fictitious cohort's life course is explored by assuming that its members follow the age- and sex-specific rates during their life span. The LIPRO program contains a facility for computation of such a table, and Table 3 presents a few results. The table shows that a woman who would be exposed to the rates constructed in this section would live, on average, 78.7 years and give birth to 1.80 children, of which 0.45 child would be born when she cohabits, and 1.10 child when married. She would be a dependent child for 20.4 years, live alone for 17.4 years (of which 8.0 years after age 65, not shown in Table 3), and she would spend 27.3 years with a husband (possibly more than one), of which 14.0 years without children at home. The life expectancy of an average man would be 72.4 years, of which 10.8 years would be spent living alone (2.0 years after age 65) and 29.2 years with a wife.[10] The excess mortality of men is clearly reflected in these summary indicators.

[10] The number of years spent with a marriage partner differs between men and women. This is explained by the fact that these results follow from two separate *life tables*, one for each sex. The *projection model* used for the actual projections does, however, contain an algorithm which guarantees consistency between numbers of men and women, see Section 2.3.

Figure 8a. Entry rates into institutions, females

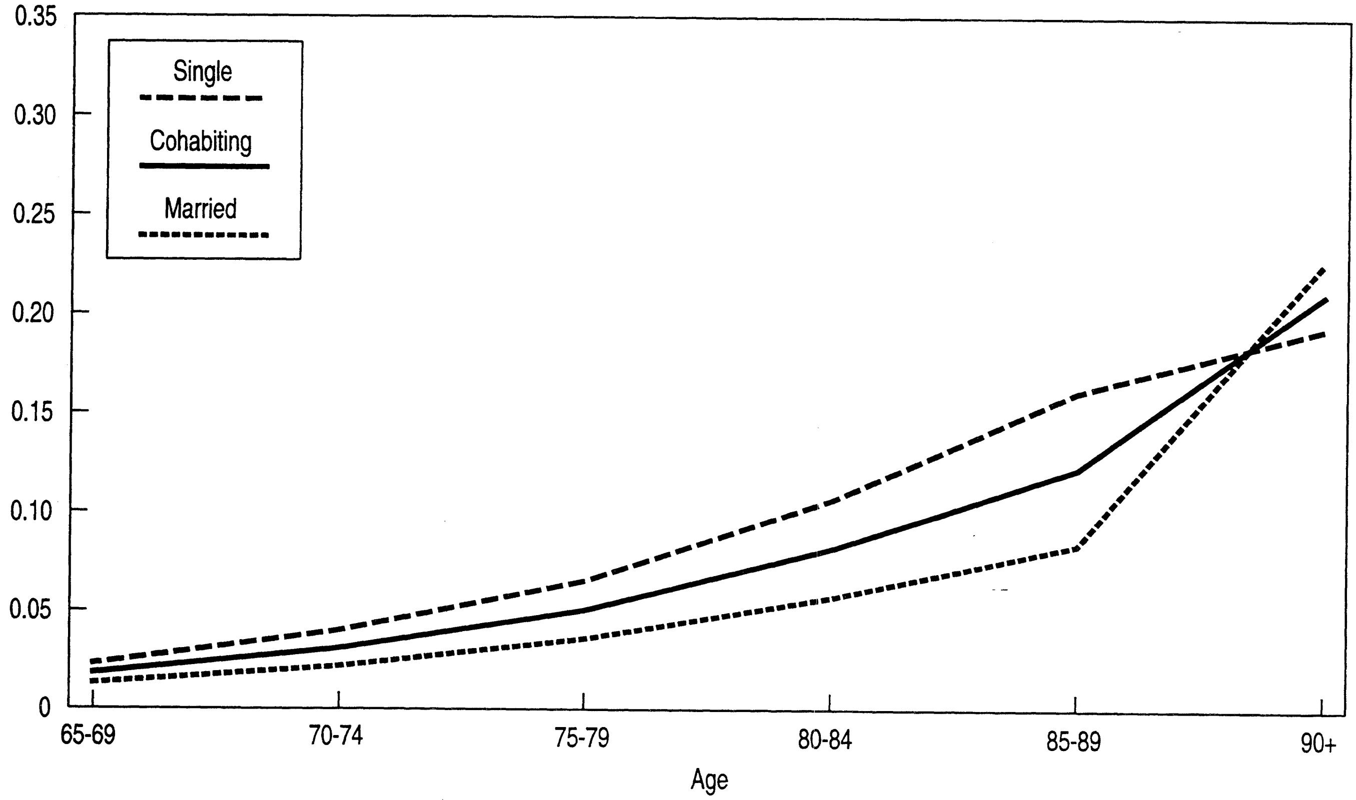


Figure 8b. Entry rates into institutions, males

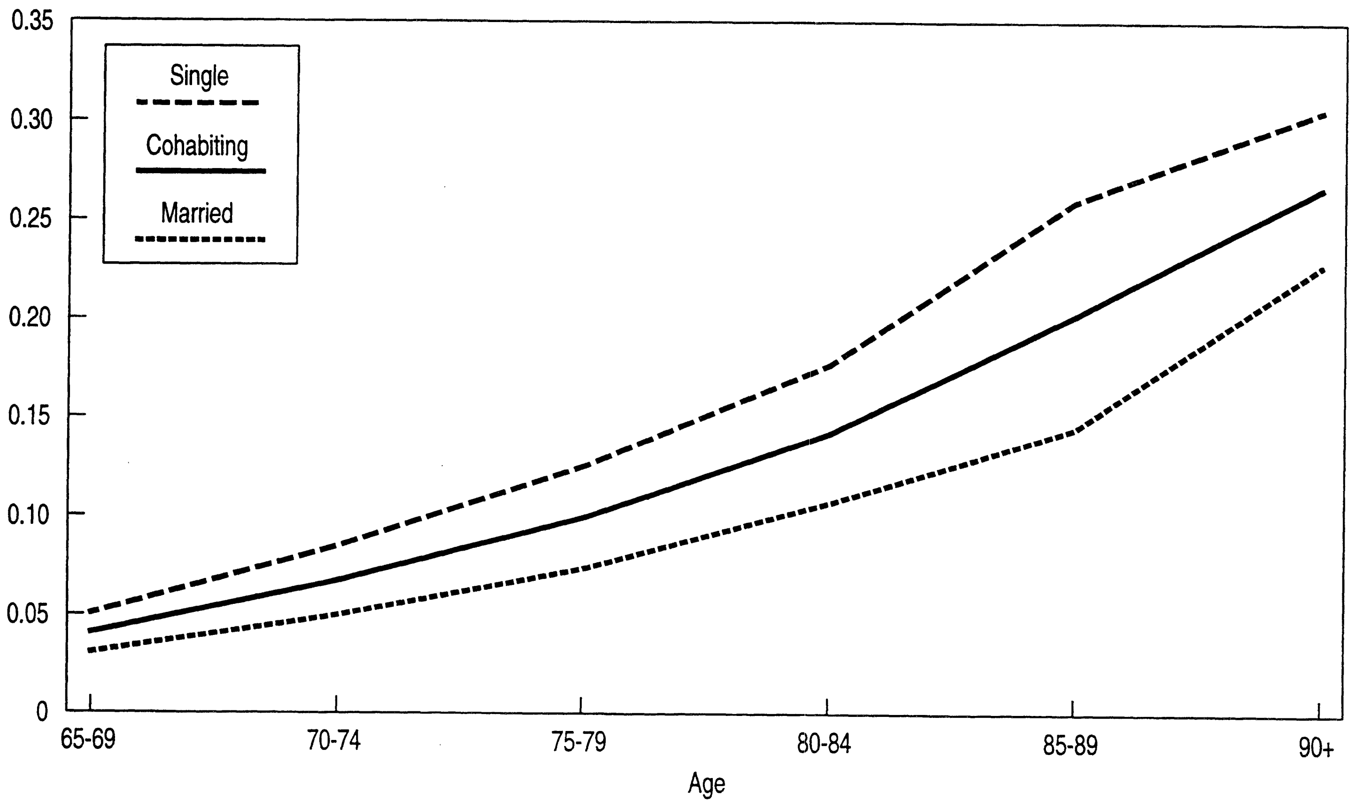


Figure 9a. Exit rates from institutions, females

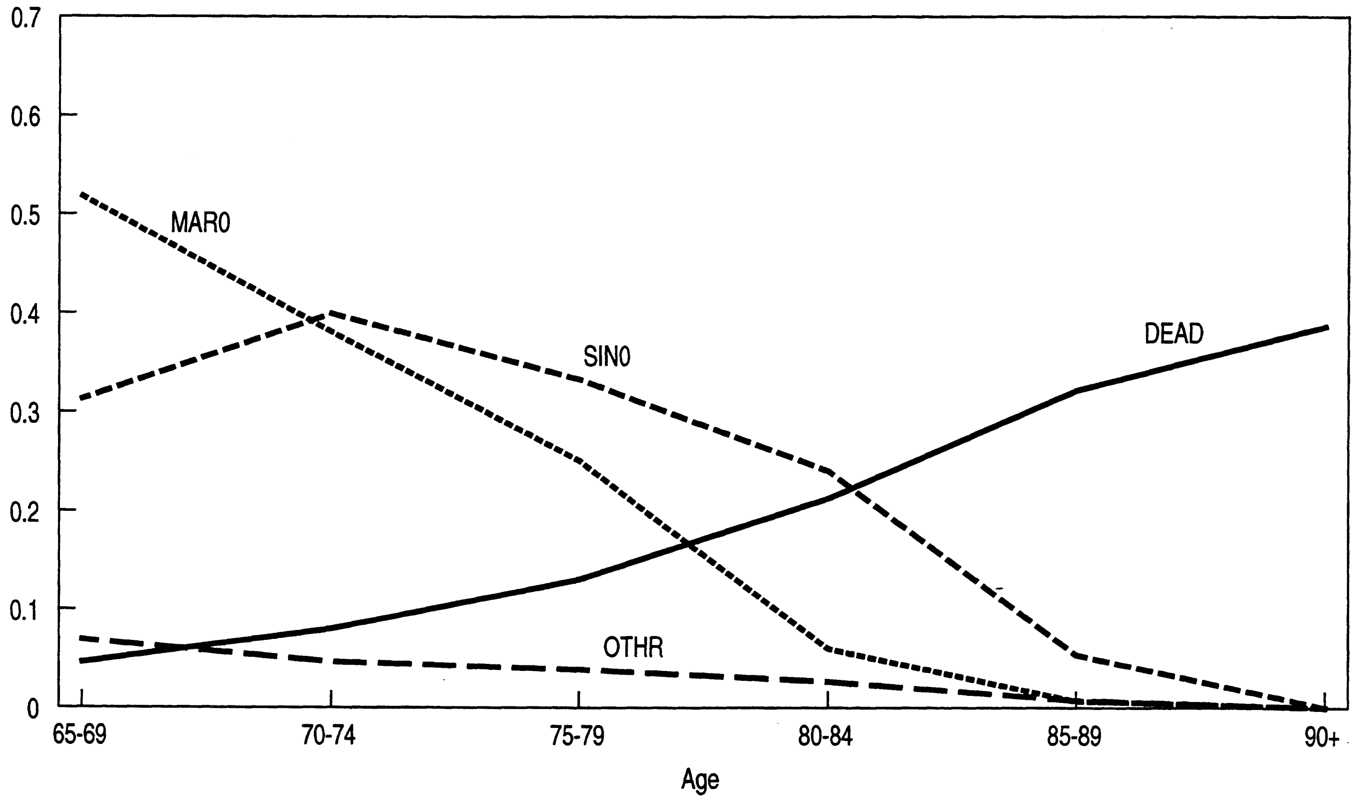
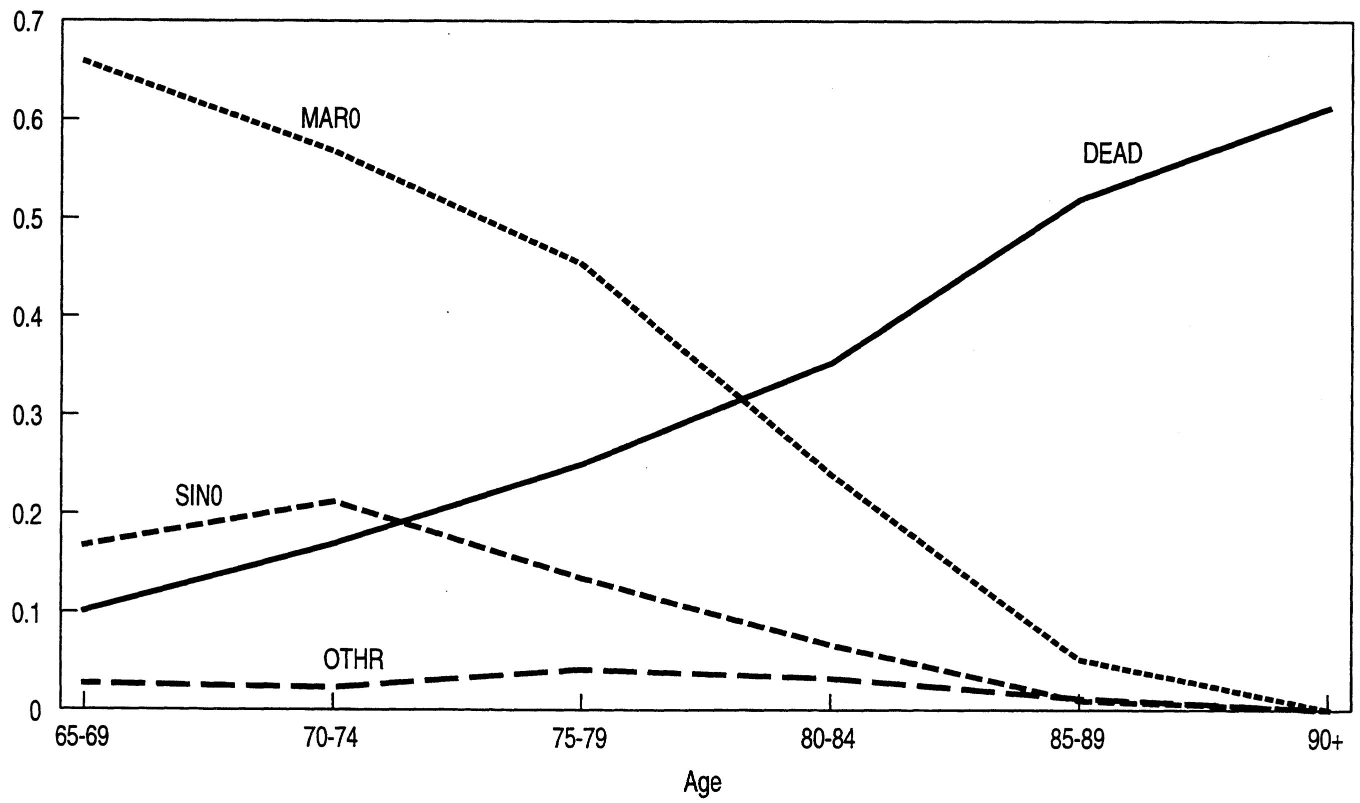


Figure 9b. Exit rates from institutions, males



Since the results in Table 3 concern a hypothetical cohort they differ somewhat from recent period observations. The life expectancies are, for example, almost two years lower than the period life expectancies for 1992. The main reason for this is that the death rates are assumed to depend on household position and the hypothetical cohort on average spends more time as single, where there is excess mortality, than the proportion of single persons in the actual 1992 population.

When we restrict the computation of the life table to persons who have experienced a certain event, a so-called "experience life table" will show to what extent these persons experience further events (Van Imhoff and Keilman, 1991: 55). Table 4 presents some results. 61 per cent of the women who cohabit would marry her partner, and 25 per cent of married women with children would become a lone mother. Among lone mothers, remarriage is less popular (5 per cent) than a consensual union (27 per cent). A woman who lives alone enters a consensual union more frequently (41 per cent) than a marriage (10 per cent). Differences between males and females partly reflect the fact that the two life tables are not consistent with each other.

Table 3. Expected duration spent in different household positions, and expected number of children born, by mother's household position

	CHLD	COH0	COH1	COH2	COH3	INST	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	All household positions
Duration (years)																
Females . .	20.4	3.7	1.8	0.9	0.4	1.0	14.0	5.0	5.6	2.6	2.3	17.4	2.3	0.7	0.4	78.7
Males . . .	20.7	5.9	1.1	0.4	0.1	0.6	14.0	6.7	5.6	2.9	2.8	10.8	0.5	0.1	0.0	72.4
Expected number of children .	0.01	0.30	0.12	0.03	0.01	0	0.38	0.46	0.19	0.07	0.10	0.08	0.03	0.01	0.00	1.80

Table 4. Probability for some selected events, based upon experience life table

	COHn->MARn[1]	COH0->MAR0	MARn->SINn[2]	MAR0->SIN0[3]	SINn->MARn[2]	SIN0->MAR0	SINn->COHn[2]	SIN0->COH0
				Per cent				
Females	61.0	33.2	24.6	15.3	4.8	9.6	27.3	40.9
Males .	58.4	39.1	9.0	10.6	1.8	20.1	6.5	48.3

[1] n=0, 1, 2, 3.
[2] n=1, 2, 3.
[3] Up to age 65 only. All ages: 53.7 per cent (females) and 23.3 per cent (males).

4. Projection results

This chapter gives results of our household projections for the period 1990-2020. Six sets of assumptions have been used for mapping the uncertain future household structure of Norway. The basis of each set consists of the input parameters as obtained through estimation procedures described in the previous chapter. The Basic scenario (Section 4.1) applies these rates as initial input parameters (and does not change them during the projection), together with the conditions for internal and external consistency as described in Appendix 2. Hence numbers of births, deaths and net immigrations under this scenario correspond to those of the Medium variant of the official 1993 based national population forecasts for the years 1993-2020, and to observed numbers for the years 1990-1992. The scenarios reported in Sections 4.3-4.5 all start from the Basic scenario, but they differ from that scenario in various ways.

In order to trace the effects of high and low fertility, mortality and immigration, Section 4.2 presents results in which numbers of births, deaths and net immigrations correspond to the High (H1) and the Low (L1) variant of those forecasts. Similar to many other western countries, Norway recently experienced increases in cohabitation and divorce. This warrants a sensitivity analysis in which the rates for these two types of events are set to higher levels than those contained in the Basic scenario, which describes the household dynamics of the mid-1980s. The two scenarios "High cohabitation" (Section 4.3) and "High divorce" take these recent developments into account. Finally, we report the results of a simulation in which the capacity constraints on institutions were removed (Section 4.5). The ageing of the population of Norway will lead, other things remaining equal, to an increased demand for institutional care among the elderly. The Basic scenario contains a constraint which keeps the capacity of these institutions at its 1990 level, see Section 4.1 and the paragraphs on institutionalization in Section 3.3.2. By removing this constraint one gets an impression of the future increase in demand.

Projections were carried out for unit intervals of five years. The exponential version of the model has been used (in which intensities are assumed constant during the unit interval), together with the harmonic-mean version of the consistency algorithm (Van Imhoff and Keilman, 1991).

The following sections only summarize the main results of the various scenarios. More detailed tables (the population broken down by household position, sex and five-year age group, and private households by type, both for the years 1990, 1995, ... 2020 and for each scenario) are available from the authors.

4.1. Basic scenario

The estimated and adjusted rates described in Chapter 3, reflecting household dynamics as observed during the mid-1980s, were used in the basic projection, assuming initially constant rates over the projection period 1990-2020. The input rates underwent changes because of internal and external consistency, but the initial set of rates was the same for the whole projection period.

If household dynamics, as observed during the mid-1980s, were to apply to the future three decades, the household structure of the population in Norway would undergo major changes. Tables 5 and 6, and Figures 10 and 12, give the main results of the Basic scenario. The following trends are noteworthy.

- A strong growth in the number of one-person households: from a little over 740,000 in 1990 to 1,235,000 thirty years later. While this household type made up already 39 per cent of all private households in 1990, its share will have risen to 49 per cent by 2020. Particularly men above 30 and middle-aged women experience strong increases.

- The total number of couples (married or cohabiting, with or without children) is fairly constant. However, married couples with children will lose importance (a fall from 465,000 in 1990 to 390,000 in 2020), in particular those with two or more children.
- In spite of a strong percentage growth in the number of consensual unions this household type will remain of secondary importance. Those without children will go up by half in thirty years time (from 100,000 to nearly 155,000), and those with children will almost double (from 30,000 to nearly 60,000). Yet only 8 per cent of the private households will consist of a cohabiting couple (with or without children) in 2020, compared to nearly 7 per cent in 1990.
- A relatively sharp increase is to be expected in the number of lone parents: from 110,000 in 1990 to 200,000 thirty years later.

The total number of households will increase under this scenario from 1.9 million in 1990 to 2.5 million in 2020. This implies an average annual growth of 0.8 per cent, which is stronger than that of the total population (0.5 per cent per annum). The consequence is a drop in the mean size of private households: from 2.2 persons per household in 1990 to 1.9 in 2020. However, this decrease is considerably less strong than the one observed between 1970 and 1990, when average household size dropped by 0.5 person (Noack and Keilman, 1993:294). The fall in household size during the past few decades has mainly been caused by the drop in fertility, which came to an end in the mid-1980s. The fact that future households will become smaller on average is caused, to a considerable extent, by the general ageing of the population. It becomes clearly reflected in one-person households. Large shares of the elderly who live in a private household live alone. For example, for the age group 75+ the percentages living in a one-person household in 2020 are 74 for women and 47 for men. In 1990 these shares were 55 and 20 per cent, respectively.

The decrease in the number of married couples with one or more children is not only explained by the general ageing effects in the population, but also by changes in demographic behaviour: more married couples stay childless or have only one or two children, and divorce propensities while young children still live at home are increasing.

An interesting feature is the ageing of cohabiting couples. In 1990, 89 per cent of the cohabiting women without children are younger than 45 years of age - in 2020 the share under 45 has dropped to 75 per cent. For cohabiting childless men the share decreases from 86 to no more than 47 per cent over the same period. This ageing effect is much stronger than that of the total population, for which the share below 45 goes down 9 percentage points only. The ageing of cohabiting couples may be explained by the fact that modern consensual unions were first observed only two decades ago among young adults. The trend setters of the 1970s will have reached pensionable ages in 2020. Although quite many among them no longer will cohabit with their original partner by that time (because they have married or separated) a considerable number will live in consensual union, either with the same partner, or with a new one after a possible separation or divorce. In general, the entry and exit rates for cohabitation used in this basic scenario reflect a further acceptance of this type of living arrangement, also at higher ages. It is quite striking that in 2020 the man who lives in a consensual union without children will be much older, on average, than his female partner, cf. the age-specific shares mentioned above. This is explained by the rise in divorce embodied in the Basic scenario, combined with the fact that divorce, when children are involved, in the vast majority of cases leads to a lone mother and a man living alone (cf. the assumptions on the distribution of children over the former spouses mentioned in Section 3.3.2). Most consensual unions without children are recruited from persons living alone, and these medium-aged single men are apparently rather attractive partners for young childless women who want to start such a union. A further illustration of the fact that divorce is an important factor behind the relatively high mean age of cohabiting men is supplied in Section 4.4 where we present the results of a scenario which contains increased divorce risks, relative to those in the Basic scenario.

Table 5. Population by age, sex and household position, Basic scenario

	CHLD	COH0	COH1	COH2	COH3	INST	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	Total
								1000s								
31 December 1990																
Females																
0-14	392	0	0	0	0	0	0	0	0	0	1	0	0	0	0	393
15-29	159	70	9	3	0	0	19	29	26	8	28	104	25	5	1	487
30-44	0	18	9	5	2	0	27	63	149	79	12	53	26	17	3	462
45-59	0	7	1	0	0	0	133	65	32	8	12	47	11	3	1	323
60-74	0	3	0	0	0	3	173	4	0	0	19	116	1	0	0	319
75+	0	0	0	0	0	28	45	0	0	0	13	107	0	0	0	195
Total	551	99	20	8	2	31	397	162	207	96	86	427	63	25	5	2179
Males																
0-14	412	0	0	0	0	0	0	0	0	0	1	0	0	0	0	413
15-29	187	60	7	2	0	0	14	18	12	3	59	126	1	0	0	489
30-44	0	27	11	6	1	0	25	58	143	73	41	78	5	3	1	473
45-59	0	10	2	1	0	0	101	73	49	19	14	41	4	2	0	317
60-74	0	3	0	0	0	3	187	12	3	1	9	49	1	0	0	269
75+	0	0	0	0	0	10	70	0	0	0	8	22	0	0	0	110
Total	599	100	20	8	2	13	397	162	207	96	134	316	11	5	1	2071
31 December 2000																
Females																
0-14	441	0	0	0	0	0	0	0	0	0	0	0	0	0	0	441
15-29	161	61	16	4	0	0	3	32	17	2	42	62	29	2	1	431
30-44	0	41	16	10	6	0	19	64	112	85	15	51	43	24	11	498
45-59	0	12	1	1	0	0	179	51	40	20	4	94	19	8	2	430
60-74	0	6	0	0	0	3	132	12	2	0	8	108	5	1	0	276
75+	0	1	0	0	0	28	29	0	0	0	12	159	0	0	0	229
Total	601	122	33	15	7	31	362	158	171	107	81	473	95	35	14	2304
Males																
0-14	458	0	0	0	0	0	0	0	0	0	1	0	0	0	0	459
15-29	196	40	7	3	0	0	8	17	11	1	55	95	1	0	0	435
30-44	0	47	19	10	5	0	34	56	102	63	36	132	1	0	0	506
45-59	0	26	6	1	2	0	128	58	51	41	13	98	5	1	1	430
60-74	0	8	1	0	0	3	137	27	6	1	8	45	2	0	0	241
75+	0	1	0	0	0	12	55	0	0	0	6	48	0	0	0	123
Total	654	123	33	15	7	15	362	158	171	107	120	418	9	2	1	2194
31 December 2010																
Females																
0-14	430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	430
15-29	186	64	15	3	0	0	2	27	13	1	34	60	26	1	1	434
30-44	0	46	18	10	6	0	18	63	102	65	21	53	56	25	11	493
45-59	0	16	1	1	0	0	166	47	48	27	4	116	26	15	5	473
60-74	0	11	0	0	0	3	160	14	4	0	4	146	10	2	0	353
75+	0	1	0	0	0	28	21	0	0	0	10	164	0	0	0	224
Total	616	137	34	14	7	31	367	152	167	93	73	538	118	42	18	2408
Males																
0-14	442	0	0	0	0	0	0	0	0	0	1	0	0	0	0	443
15-29	225	36	6	3	0	0	10	13	10	1	53	94	1	0	0	451
30-44	0	42	18	10	4	0	41	47	98	52	39	140	1	0	0	491
45-59	0	38	7	1	2	0	117	55	48	38	13	140	6	1	1	467
60-74	0	20	2	0	0	3	151	35	10	3	6	86	4	1	0	323
75+	0	2	0	0	0	12	48	1	1	0	7	50	1	0	0	122
Total	666	138	34	14	7	15	367	151	167	93	119	510	12	2	1	2297
31 December 2020																
Females																
0-14	416	0	0	0	0	0	0	0	0	0	0	0	0	0	0	416
15-29	184	70	18	4	0	0	1	32	16	2	40	65	29	2	1	463
30-44	0	45	18	9	6	0	13	56	89	55	21	49	51	21	10	443
45-59	0	21	1	2	1	0	175	47	46	22	5	142	32	15	5	514
60-74	0	14	0	0	0	4	167	17	8	1	5	196	14	3	1	430
75+	0	2	0	0	0	27	28	0	0	0	9	188	0	0	0	254
Total	600	152	37	15	6	31	384	152	158	80	80	639	127	41	17	2519
Males																
0-14	425	0	0	0	0	0	0	0	0	0	1	0	0	0	0	426
15-29	223	37	8	4	0	0	12	15	11	1	61	102	1	0	0	474
30-44	0	35	17	10	4	0	39	43	89	43	41	131	1	0	0	453
45-59	0	44	8	1	2	0	126	53	44	32	12	168	6	1	1	497
60-74	0	32	3	0	1	5	153	40	13	3	7	126	5	1	0	389
75+	0	7	0	0	0	11	50	1	2	0	7	70	1	0	0	150
Total	648	154	37	15	6	16	380	151	158	80	130	597	14	2	1	2389

Table 6. Private households by type, Basic scenario

	COH0	COH1	COH2	COH3	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	Total
							1000s							
31 December														
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
2000	122	33	15	7	362	158	171	107	72	890	104	36	15	2093
2010	138	34	14	7	367	152	167	93	69	1048	130	44	19	2281
2020	153	37	15	6	382	152	158	80	75	1235	141	43	18	2495

Figure 10. Private households by type, Basic scenario

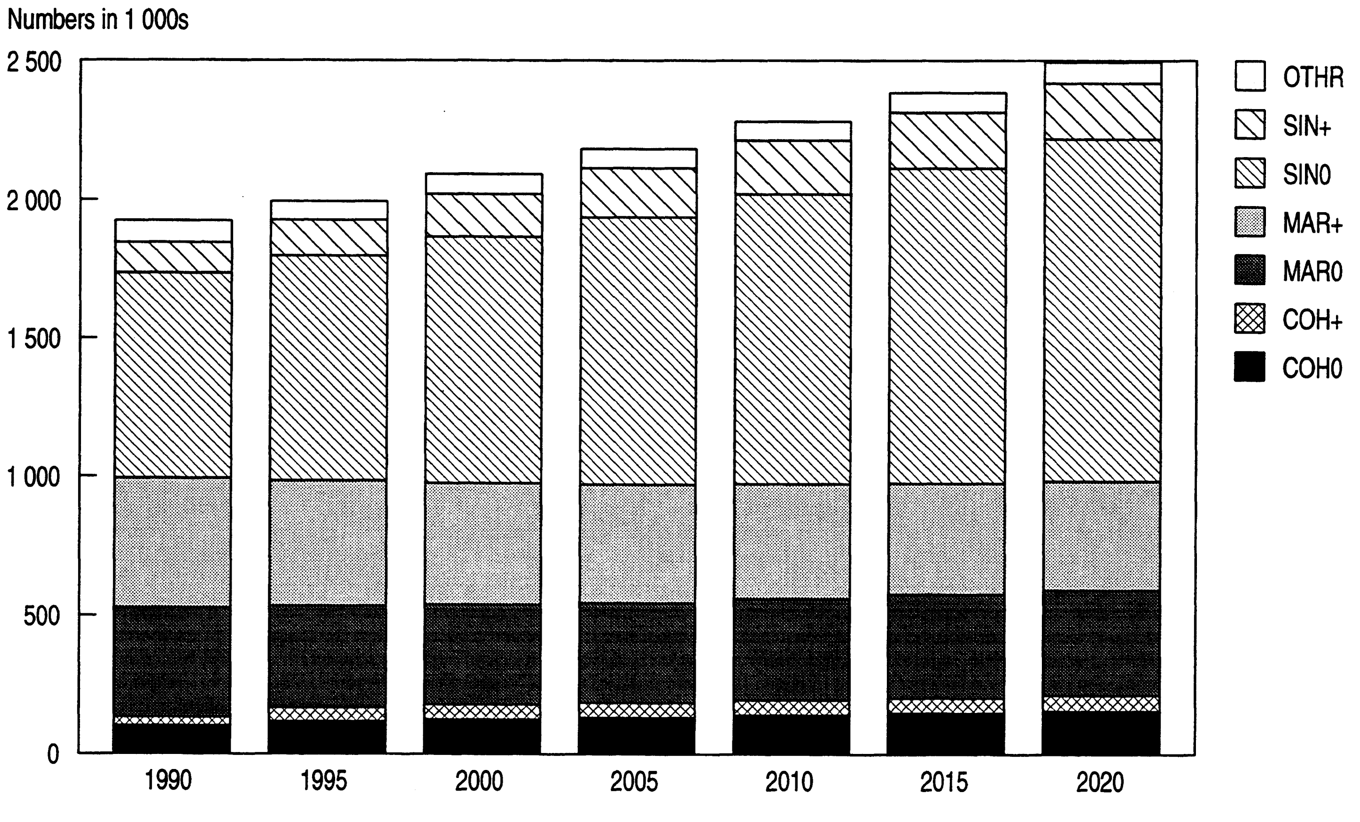


Figure 11. Population by age, sex and household position, 1990, observed

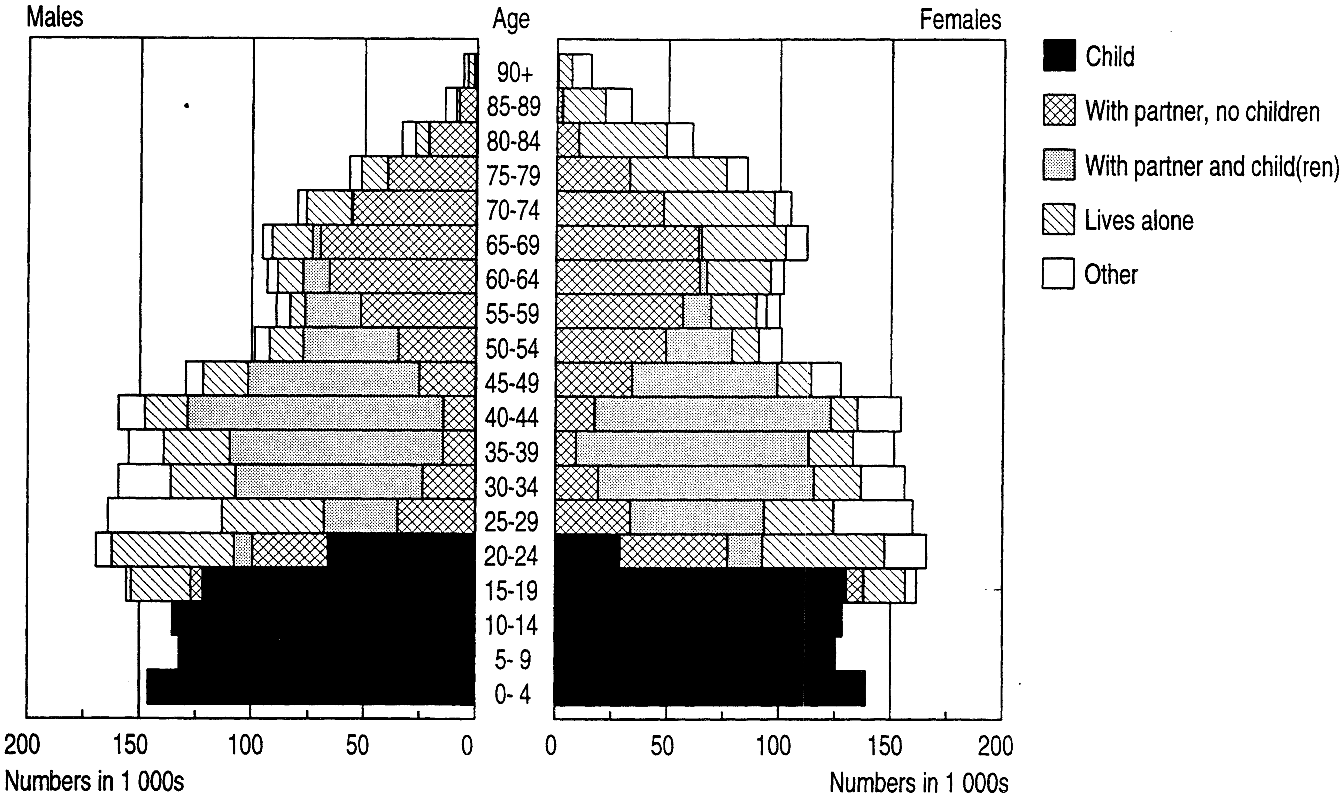
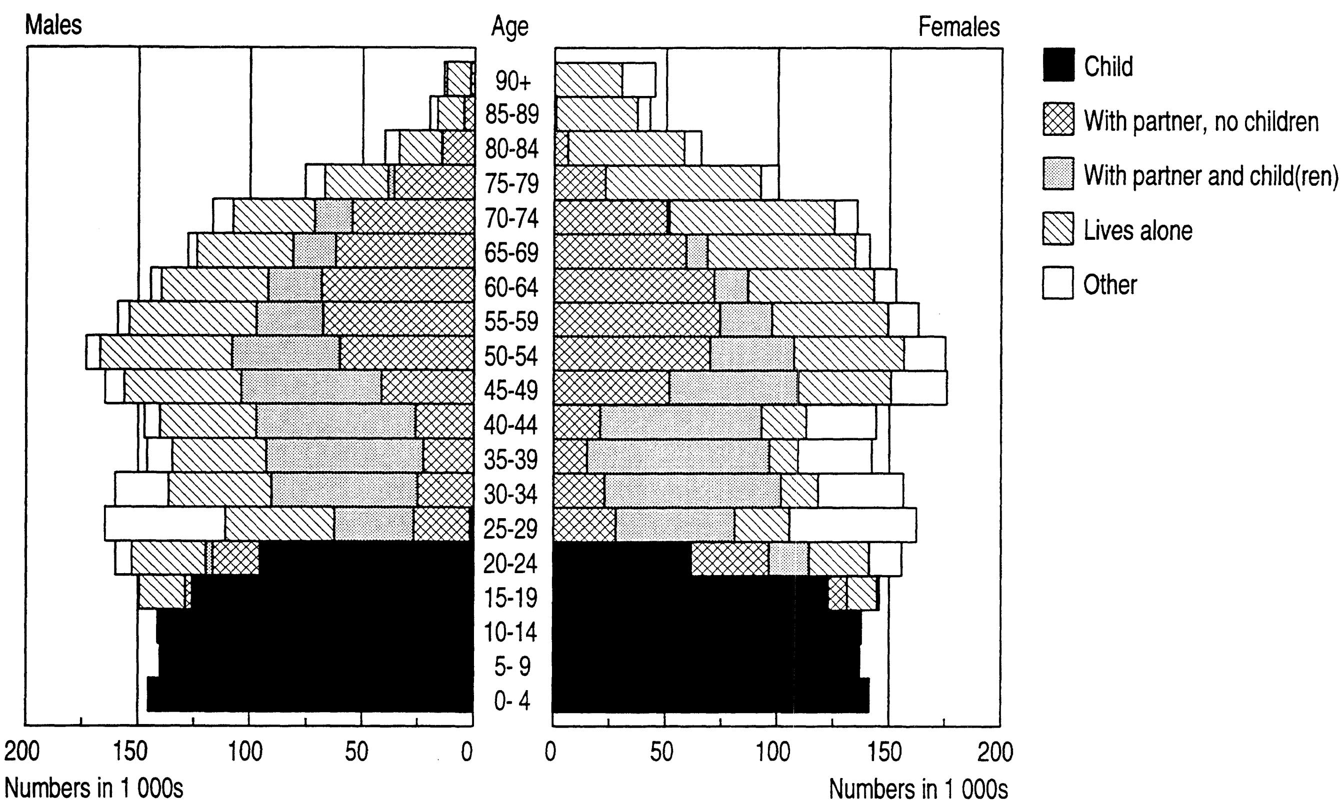


Figure 12. Population by age, sex and household position, 2020, Basic scenario



4.2. High and low fertility, life expectancy and migration

The Basic scenario uses the Medium variant of Statistics Norway's 1993 based population forecasts (more precisely, the M1 variant, see Statistics Norway, 1994a). Key assumptions for this variant are constant fertility, increasing life expectancy at birth, and a level of net immigration which is somewhat below that of recent years, see Table 7. However, the population forecasts also include a high and a low variant, with variant assumptions for the three components of growth. How would the household structure evolve with the high or the low set of these assumptions, combined with household formation and dissolution as contained in the Basic scenario? The household scenarios for high and low fertility, life expectancy and migration below have been constructed by taking numbers of births, deaths and net immigrations from the High variant and the Low variant of the official population forecasts, and using these numbers as external consistency constraints for each of the five-year periods until 2020. The other parameters are the same as those in the Basic scenario.

Table 7. Key assumptions in 1993 based population forecasts, and recently observed values

	Low variant	Medium variant	High variant	Observed
Fertility (children per woman)				
* Completed Cohort Fertility generations 1980 and later	1.68	1.88	2.10	
* Total Fertility Rate 1991-1993				1.89
Mortality				
Life expectancy at birth (years)				
* Males 2050	76.0	79.0	82.0	
* Females 2050	81.5	84.5	87.5	
* Males 1991-1993				74.1
* Females 1991-1993				80.2
Net immigration (persons per year)				
* 1998 and later	4,000	8,000	12,000	
* 1991-1993				10,200

Tables 8 and 9 present the outcomes of the high and the low variants for fertility, life expectancy and migration. The general pattern is similar to that of the Basic scenario, although some trends are accelerated or attenuated. The total number of households grows with between 0.7 (Low variant) and 1.0 (High variant) per cent per year on average. In 2020 the average size of private households will be between 1.91 (L) and 1.99 (H) persons, with a share of one-person households close to one-half. The increase in the number of one-person households is much stronger in the High variant than in the Low variant, to a large extent due to relatively large numbers of elderly persons (which in turn is caused by higher life expectancies). At the same time, high fertility rates in the High variant lead to many households with one or more children, as compared with the Low variant. The net effect is a drop in mean household size. Relatively large difference between the two variants may be noted for households with two or more children. Total numbers of couples without children (married or cohabiting) are not affected by the variant levels of fertility, mortality and migration, although there is an effect on the age composition: better survival chances cause married men and women to be somewhat older in the High variant than in the Low variant.

Table 8. Population by age, sex and household position, 2020. High and low variants for fertility, life expectancy and net immigration

	CHLD	COH0	COH1	COH2	COH3	INST	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	Total
								1000s								
								High variant								
31 December 2020																
Females																
0-14	480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	480
15-29	201	70	22	4	0	0	1	35	18	2	41	67	32	2	2	498
30-44	0	42	19	11	7	0	11	55	99	67	22	48	54	24	12	471
45-59	0	22	1	3	1	0	174	49	50	25	5	143	35	16	6	529
60-74	0	15	0	0	0	3	171	18	8	1	5	199	15	3	1	438
75+	0	2	0	0	0	28	31	0	0	0	10	209	0	0	0	281
Total	681	151	42	18	8	31	388	157	174	95	84	667	136	46	20	2698
Males																
0-14	493	0	0	0	0	0	0	0	0	0	1	0	0	0	0	494
15-29	243	37	11	5	0	0	11	17	13	1	63	109	1	0	0	509
30-44	0	32	19	12	5	0	32	42	99	53	43	138	1	0	0	477
45-59	0	43	9	1	2	0	122	55	47	37	13	173	6	1	1	511
60-74	0	33	3	0	1	4	154	42	13	4	7	131	6	1	0	399
75+	0	7	0	0	0	12	55	1	2	0	9	81	1	0	0	168
Total	737	153	42	18	8	16	373	157	175	95	136	632	15	2	1	2559
								Low variant								
31 December 2020																
Females																
0-14	358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	358
15-29	167	69	15	3	0	0	3	28	13	1	39	62	27	1	1	428
30-44	0	48	16	8	5	0	17	58	80	45	20	49	48	18	8	419
45-59	0	21	1	2	1	0	175	45	42	19	5	141	30	14	4	499
60-74	0	14	0	0	0	5	163	17	7	1	5	192	14	3	1	420
75+	0	2	0	0	0	27	25	0	0	0	8	167	0	0	0	227
Total	525	153	31	13	5	31	382	148	142	66	76	610	118	36	14	2351
Males																
0-14	364	0	0	0	0	0	0	0	0	0	1	0	0	0	0	365
15-29	202	37	6	3	0	0	13	13	9	1	59	95	1	0	0	438
30-44	0	37	15	8	3	0	44	44	79	35	39	124	1	0	0	429
45-59	0	44	7	1	2	0	129	50	40	27	12	163	6	1	1	482
60-74	0	31	2	0	1	5	152	38	12	3	7	121	5	1	0	377
75+	0	6	0	0	0	11	45	1	2	0	6	59	1	0	0	131
Total	565	155	31	13	5	16	383	147	142	66	123	561	13	2	1	2222

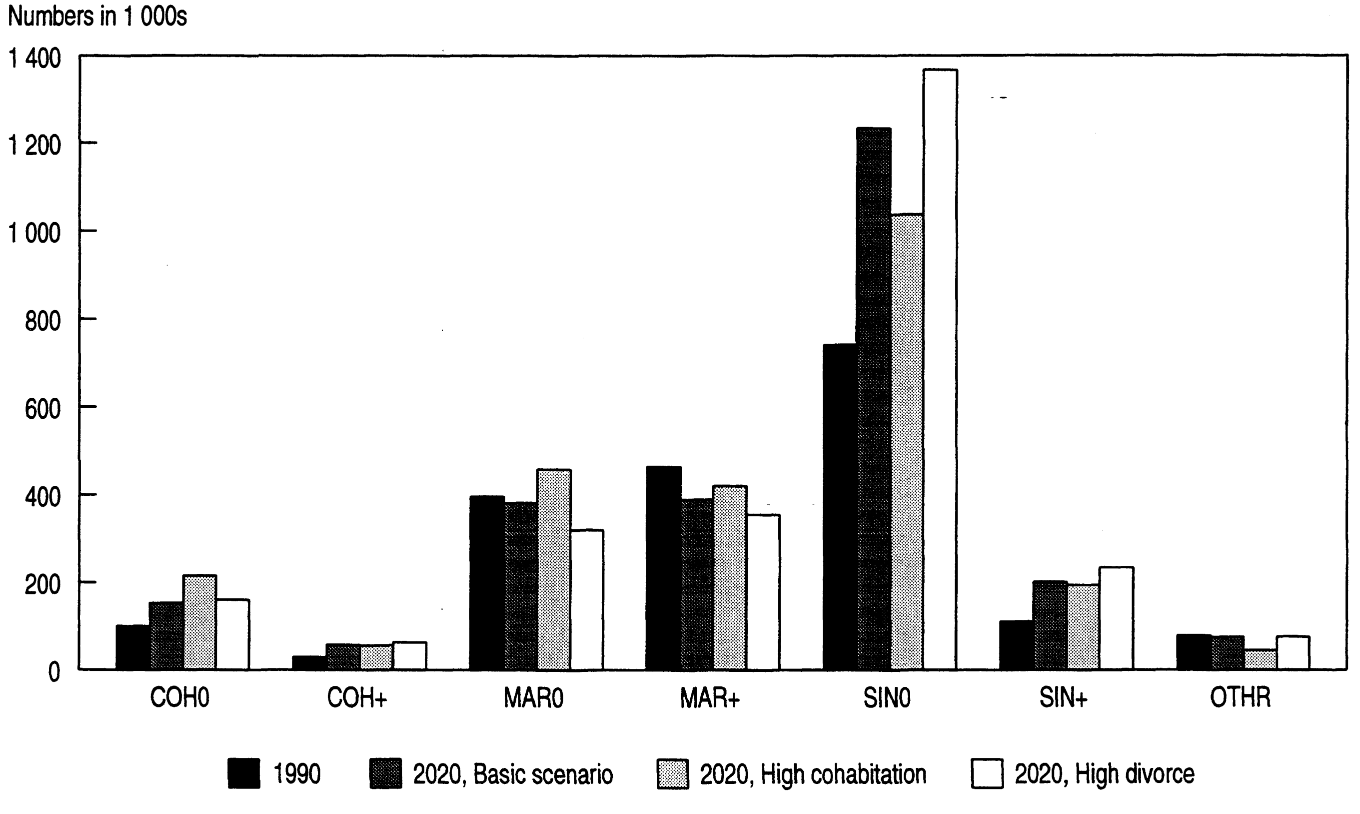
Table 9. Private households by type, 2020. High and low variants for fertility, life expectancy and net immigration

	COH0	COH1	COH2	COH3	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	TOTAL
							1000s							
High variant	152	42	18	8	380	157	174	95	79	1299	150	48	21	2623
Low variant	154	31	13	5	382	147	142	66	71	1171	131	38	15	2367

4.3. High cohabitation

Recent data from Statistics Norway's Omnibus Survey reveal that cohabitation is continuing to gain popularity for at least twenty years. Among women aged 20-44, the share living in a consensual union was 5 per cent in 1977, 18 per cent in 1987 and 22 per cent in 1993 (*Ukens statistikk* nr. 12, 1994). Moreover, the number of cohabiting couples with one or more joint children was approximately 60,000 in 1993, according to Statistics Norway's family statistics (Statistics Norway 1994b: Tables 3.1 and 3.2). These recently observed numbers are much higher than the corresponding results of the three scenarios presented so far. Therefore, we also computed the consequences of a high scenario for cohabitation: taking the assumptions of the Basic scenario as a starting point, we have doubled all rates for entry into a consensual union for childless men and women (i.e. entries into "cohabiting, no children" from "dependent child", "other" or "one-person household") of all ages. The number of cohabiting couples with at least one child turns out to be 57,000 in 1995, and the share of cohabiting women in the age group 20-44 is 24 per cent in 1995. These results correspond better to the trend mentioned above than those obtained with the Basic scenario. Other results of this High cohabitation scenario are illustrated in Figure 13.

Figure 13. Private households by type, 1990, observed, and 2020



With higher entry rates into the position "cohabiting, no children" we observe, obviously, a larger number of consensual unions without children in 2020 than under the Basic scenario. But also the number of married couples is higher than under the Basic scenario. This is explained by the fact that many of the consensual partners marry.[11] Figure 13 shows also that an increase in cohabitation rates will lead to fewer one-person households. The reason is that cohabiting couples are recruited, to a large extent, from the group of persons living alone.

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[11]One could argue that marriage rates should be decreased under this scenario, assuming that part of the new consensual unions would have been marriages if cohabitation rates would have remained the same. However, the competing risks model which is an essential part of the LIPRO approach, leads to fewer marriages among persons in positions "dependent child" (CHLD), "one-person household" (SIN0), and "other" (OTHR) as a result of higher cohabitation rates, even with the same marriage rates as under the Basic scenario. When the cohabitation rate is increased and all other exit rates (including the marriage rate) remain unchanged, this leads to fewer persons in position CHLD, SIN0 or OTHR who are at risk of experiencing any exit event during the unit interval. The same rate, multiplied by fewer persons at risk then results in fewer marriages.

4.4. High divorce

Divorce propensities have grown strongly for at least 20-30 years. The period probability for women of experiencing a divorce before age 65 on the basis of age-specific divorce rates observed in 1980 was estimated at 28.2 per cent (Statistics Norway 1994b: 112). Corresponding probabilities were 34.6 and 42.5 per cent in 1985 and 1990, respectively. The Basic scenario reflects the divorce level of the mid-1980s quite well: a multidimensional life table with the rates of the latter scenario as input results in an estimated 37.8 per cent of ever married women who will experience marriage dissolution before age 65. Moreover, the Basic scenario projects 59,000 marriage dissolutions (death of the spouse not included) for women under 65 during the period 1990-1994, implying an annual figure of 11,800. Observed separations in the years 1990-1992 are only a little higher: 12,500 per year on average (Statistics Norway, 1994b, 108).[12]

In spite of these realistic marriage dissolution projections in the Basic scenario we wanted to give account to the upward trend in divorce and separation. We have, therefore, traced the implications of a set of substantially higher marriage dissolution propensities. The High divorce scenario in Figure 13 shows private households of various types based upon the assumption that marriage dissolution rates are 50 per cent higher than those under the Basic scenario.[13] The model does not distinguish between divorce and death of the spouse as a reason for the breakup of a marriage (cf. Section 3.3.2). However, mortality is relatively low at ages under 65 and thus we can safely assume that the vast majority of all exits from the position "living with spouse" (irrespective of number of children) for persons under 65 years of age are caused by marriage dissolution. On the other hand, few marriage separations or divorces take place after age 65. Consequently, the increase in marriage dissolution rates was applied to ages below 65 only.

The number of lone parents increases somewhat steeper under this High divorce scenario, and it reaches a level of nearly 235,000 in the year 2020. The strongest effect, however, is to be found for one-person households, which climbs to a level of almost 1.4 million in 2020, which constitutes fully 53 per cent of all private households. The effect of increased marriage dissolution is stronger for men who live alone (12.6 per cent more one-person households in 2020 than under the Basic scenario) than for women (+9.1 per cent), because most couples with children who dissolve their union result in a lone mother and a man living alone. The number of married couples is lower in 2020 than under the Basic scenario, in particular those without children. The reason is that marriage dissolution rates are lower for couples with children than for those without. Consensual unions are slightly more numerous, because these are largely recruited from one-person households and, to a smaller extent, from lone parents. Both groups show a relatively strong growth under this scenario.

The ageing of cohabiting men, which was already noted in Section 4.1 for the Basic scenario, is slightly stronger under the High divorce scenario. For example, 43 per cent of the cohabiting men without children are younger than 45 years of age in 2020, whereas the corresponding share was 86 per cent in 1990. In the Basic scenario, the share under 45 among cohabiting men without children was 47 per cent. Although the effect of increased divorce risks on this share in 2020 is rather small (4 percentage points), it is still larger than the corresponding effect for cohabiting women without children, which is only 2 percentage points (from 90 per cent in 1990 down to 73 per cent in 2020 under the High divorce scenario, and to 75 per cent under the Basic scenario in 2020). These figures are a further illustration of the explanation which was given in Section 4.1 for the relative ageing of cohabiting men, viz. the increase in the number of middle-aged men living alone as a consequence of divorce. These single men are an important recruitment group for consensual unions.

4.5. Increased capacity in institutions for the elderly

The capacity of institutions for the elderly was around 45,000 in 1990. In the future we may expect a strong increase in the number of elderly. Assume now, that the demand, per elderly person, for the type of facilities these institutions provide, will remain constant in future decades. The fact that Norway's population ages will then lead to an increased total demand for beds in such institutions. In order to illustrate this growing demand,

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[12] The observed number of divorces is somewhat lower: 10,200 per year on average for the period 1990-1992. However, divorce usually occurs a few years after separation and therefore the time series shows a time lag compared to the one for separations.

[13] The purpose of this scenario is mainly to trace the consequences of increased instability in formal marriages. One could also argue that both marriages and consensual unions might become less stable in the future, but this is not investigated here. After all, it is a well-established fact that dissolution rates for consensual unions are already much higher than those for marriage dissolution, not only in Norway (for instance, by a factor 2 for cohabiting and married women without children, according to unpublished data from the 1988 Family and Occupation Survey) but also in Sweden (by a factor 3 to 4; see Trussell et al., 1992: 53; Hoem and Hoem, 1992: 74) and in the Netherlands (by a factor 5.6, see Manting, 1994: 158).

we have carried out a projection in which the capacity constraints for institutions have been removed. Thus, whereas the total number of elderly living in an institution was fixed to a level of 45,000 in all scenarios so far, under the scenario called "Increased capacity in institutions for the elderly" the size of institutional households is determined by the entry and exit rates contained in the Basic scenario for the period 1990-1994.

With unconstrained capacity, and constant average demand per elderly person for each combination of age, sex and household position, the number of elderly living in an institution will increase by a factor of nearly 4, and reach a level of 171,000 in 2020. Stated differently, if it can be assumed that there is no excessive demand today, and if capacity were to remain constant over a period of thirty years, there would be an unmet need of no less than 125,000 institution places. Compared to the Basic scenario, there would be 4 per cent fewer women and 7 per cent fewer men living alone. When we look at the elderly, the differences are larger, of course: 9 per cent fewer women and 26 per cent fewer men live alone in age group 65+. Indeed, the dramatic growth in the number of elderly persons living in an institution is caused, to a large extent, by the future increase in the number of elderly persons living alone. Under the Basic scenario, when capacity remains constant, the number of persons aged 65 or over who live alone will grow from 255,000 in 1990 to 475,000 in 2020. These persons have relatively high rates for entry into an institution, and those rates increase with age, see Figure 8. However, the *exit* rates from institution back to living alone are high at low ages (where there are very few institutionalized persons) and close to zero for the oldest. Even when *total* exit rates are considered (with "living with spouse, no children", "one-person household", and "dead" as the most important states of destination) the rates' age pattern slopes downward with increasing age. Thus, the result is a net inflow into institutions of between 8,000 (period 2005-2010) and 42,000 (period 1990-1995) persons. The variations are caused by fluctuations in the age and household structure of the elderly.

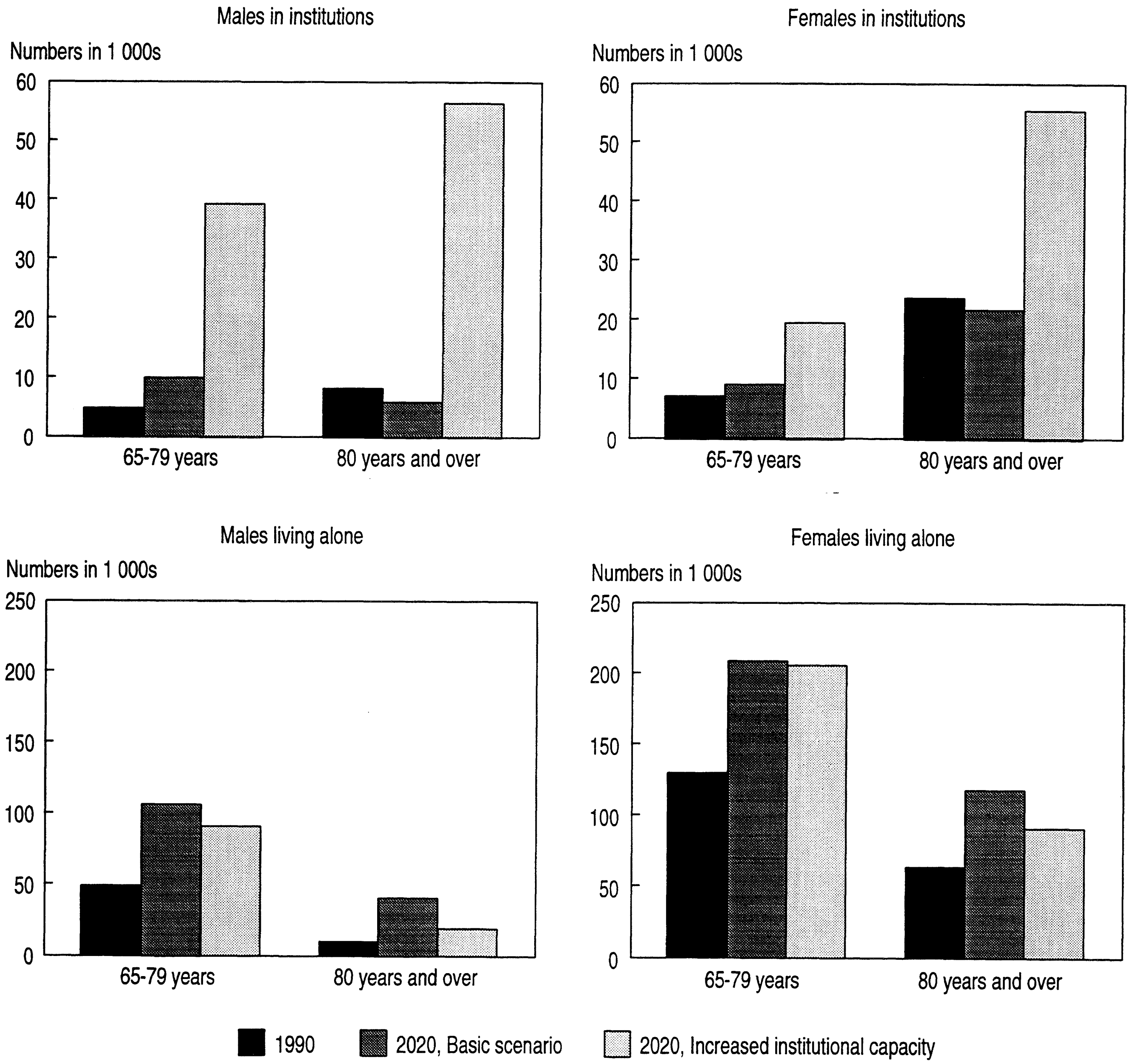
Ageing is of much less importance: the number of persons aged 80 or over will increase by 39 per cent from 1990 to 2020, from 163,000 to 227,000. 20 per cent of today's population aged 80+ live in an institution. If that share were to remain constant over time this would lead to an additional demand of 13,000 places. For the age group 65-79 the additional demand computed this way would be only 3,000 places.

Men, in particular, enter institutions to a much larger extent than under the Basic scenario. For women the effect is qualitatively the same, but it is much weaker than that for men. This is explained by the fact that men who live alone have much higher propensities to enter an institution than single women. The reason for this effect is unclear - women are probably better able to manage a situation of living alone than men. The consequences for the number of elderly who live alone are relatively large for men over 80 years of age, see Figure 14.

The figure of 171,000 places computed for the year 2020 under this scenario is most probably too high an estimate of real demand in that year, provided that currently there is no excessive demand.[14] Many of tomorrow's elderly will be healthier and in better condition than those of today who are of the same age. This means that the demand per elderly person (controlling for age, sex and household position) probably will diminish in the future. But it is not likely that the drop in average demand will be so steep that the net result is a constant demand in absolute numbers, in spite of the strong increase in the number of elderly. Therefore, one may expect that the future demand for beds in elderly institutions will lie between the current 45,000 and the numbers projected under the scenario in this section.

[14] There is considerable discussion about whether the current capacity is satisfactory. The situation is quite good in some municipalities, but there are severe shortages in many other ones. Future demand will also be strongly affected by the policies regarding the admission criteria for the elderly, as well as those regarding quality and standard, of course. There is an increasing emphasis on home-based care to make it possible for people to live in their own homes. There is also an increasing trend towards short-term stays in old-age institutions which implies that returning to a private household becomes more important. Many old-age homes have been converted to nursing homes.

Figure 14. Men and women who live in an institution or alone



4.6. A brief comparison of the scenarios

Tables 10-12, and Figures 15 and 16 facilitate a comparison of the results of the various scenarios. The total number of private households will increase in the future, irrespective of the scenario chosen, see Figure 15. In the long run (after 2010), the High variant and the Low variant establish the extremes of the bundle of trajectories for private households, because effects of births, immigration and longevity dominate. In the short run, however, the scenario that is based upon an increased capacity in institutions for the elderly and the High cohabitation scenario result in the lowest trajectories for total private households. Increasing the capacity in institutions implies the disappearance of a number of private one-person households. Also the High cohabitation scenario leads to relatively few households, because consensual unions are recruited, to a large extent, from persons living alone. Thus, for every additional consensual union (compared to the other scenarios, which have cohabitation rates as in the Basic scenario), two one-person households disappear. High divorce results in many households because after each divorce the existing household is replaced by two new ones, at least temporarily. The effects that the various scenarios have on one-person households are illustrated in Figure 16. For this household type the choice of high or low levels for fertility, mortality and migration is less important than the choice for high divorce rates or high cohabitation rates. Also for married couples without children we note that the High divorce scenario and the High cohabitation scenario result in extreme trajectories, compared to the other variants (see Table 10). On the other hand, Table 11 demonstrates that the number of children living in the parental household is influenced strongest by the choice for a particular level of fertility (High variant and Low variant), at least after the year 2000. In the short run, high cohabitation rates lead to relatively few children, particularly those over 20 (results not shown in Table 11). High divorce rates have no impact on the number of children, in spite of the fact that lone mothers have lower fertility rates than married mothers. The explanation is that lone mothers who are in the prime years of childbearing find a new partner quite soon.

Household growth in the next thirty years will be slow compared to that in the past, see Table 12. Average annual growth rates for the total of private households dropped from 1.9 per cent in the 1960s to 1.4 per cent in the 1980s. The various scenarios indicate a future growth of 0.5-1.0 per cent per year. Between 1960 and 1980, household growth was relatively strong because many young adults left the parental home. They had been born between 1935 and 1965, when the number of births increased from 41,000 to 66,000. But this trend reversed and births fell by 26 per cent between 1969 and 1983. This implies that the number of young adults who leave the parental household is of much less importance for household growth in the near future than it was in the past.[15] Yet the number of households will still grow, due to general (but weak) population growth and high divorce levels.

The lower panel in Table 12 illustrates that also one-person households will grow slower in the future than in the recent past. A possible explanation for the relatively high growth rates in the past is that the numbers concerned initially were low, and that the demographic phenomena that caused one-person households suddenly accelerated: excess male mortality in the 1960s led to many widows; divorces increased sharply in the mid-1960s, which caused a growth in the number of middle-aged men living alone. Both phenomena seem to have stabilized in recent years (although at much higher levels than before 1960).

[15] It should be mentioned, however, that births rose again by 22 per cent between 1983 and 1990. Since that year, the number has been stable at a level of around 60,000.

Table 10. Private households by type and scenario

	COH0	COH1	COH2	COH3	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	Total
						1000s								
						Basic scenario								
31 December														
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	116	32	13	5	368	162	179	109	67	813	88	31	11	1995
2000	122	33	15	7	362	158	171	107	72	891	104	36	15	2093
2005	129	33	15	7	361	154	170	101	69	967	118	41	18	2185
2010	138	34	14	7	367	152	167	93	69	1048	130	44	19	2281
2015	146	35	14	6	376	152	161	85	71	1139	137	44	19	2387
2020	153	37	15	6	382	152	158	80	75	1235	141	43	18	2495
						High variant								
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	116	33	13	5	368	162	180	109	68	816	88	32	11	2000
2000	122	35	15	7	362	159	174	109	73	901	105	37	16	2113
2005	127	36	16	8	361	155	176	106	71	985	121	42	19	2224
2010	135	38	16	8	366	153	177	102	71	1077	134	47	21	2343
2015	143	40	17	8	373	155	175	98	74	1182	144	48	21	2478
2020	152	42	18	8	380	157	174	95	79	1299	150	48	21	2623
						Low variant								
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	116	32	13	5	368	161	179	108	67	811	87	31	11	1990
2000	123	31	14	6	362	157	168	104	71	881	102	35	15	2072
2005	131	30	14	6	362	153	163	96	68	947	115	40	18	2143
2010	141	30	13	6	369	150	157	84	66	1016	125	42	18	2215
2015	149	30	12	5	377	150	148	73	69	1093	130	40	16	2293
2020	154	31	13	5	382	147	142	66	71	1171	131	38	15	2367
						High cohabitation scenario								
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	175	38	14	5	394	167	176	105	54	724	84	30	10	1975
2000	181	36	15	6	404	172	173	101	49	775	101	35	14	2064
2005	187	33	15	6	413	172	178	96	44	830	116	40	17	2147
2010	198	32	14	6	428	170	178	89	42	891	126	43	17	2235
2015	209	34	14	5	445	170	173	83	43	962	133	43	17	2332
2020	216	36	15	5	459	171	171	79	45	1037	136	42	16	2429
						High divorce scenario								
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	117	33	14	6	356	155	172	106	68	846	97	37	13	2020
2000	124	35	16	7	338	148	160	101	72	952	118	44	19	2136
2005	132	35	16	8	326	143	157	94	70	1052	135	51	23	2243
2010	142	36	16	8	321	139	153	86	69	1154	149	55	24	2351
2015	152	38	16	7	321	138	147	78	73	1261	157	54	23	2465
2020	160	39	17	7	321	138	144	73	76	1369	161	52	21	2578
						Increased institutional capacity scenario								
1990	100	20	8	2	397	162	207	96	79	743	74	30	6	1923
1995	116	32	13	5	358	162	179	109	66	790	88	31	11	1960
2000	122	33	15	7	346	158	171	107	70	855	104	36	15	2038
2005	129	33	15	7	345	153	170	101	68	923	119	41	18	2121
2010	137	33	14	7	352	151	166	93	67	999	130	44	19	2213
2015	145	35	14	6	360	151	161	85	69	1084	137	44	19	2311
2020	152	36	15	6	364	150	158	79	73	1168	141	43	18	2403

Table 11. Total population by household position and scenario

	CHLD	COH0	COH1	COH2	COH3	INST	MAR0	MAR1	MAR2	MAR3	OTHR	SIN0	SIN1	SIN2	SIN3	Total
							Basic scenario									
31 December																
1990	1150	199	40	16	4	44	794	324	414	192	220	743	74	30	6	4250
1995	1224	232	64	26	10	46	736	324	358	218	189	813	87	31	11	4372
2000	1255	245	66	30	14	46	724	316	342	214	201	891	104	37	15	4498
2005	1282	259	66	30	14	46	723	308	340	202	195	967	118	41	18	4609
2010	1282	275	68	28	14	46	734	303	334	186	192	1048	130	44	19	4705
2015	1263	293	70	28	12	47	751	304	322	170	200	1139	137	44	19	4801
2020	1248	306	74	30	12	47	764	303	316	160	210	1236	141	43	18	4908
							High variant									
1990	1150	199	40	16	4	44	794	324	414	192	220	743	74	30	6	4250
1995	1228	232	66	26	10	46	736	324	360	218	189	815	88	31	11	4384
2000	1278	243	70	30	14	46	724	318	348	218	203	901	105	37	16	4551
2005	1335	254	72	32	16	46	723	309	352	212	198	985	122	43	19	4718
2010	1374	269	76	32	16	46	732	305	354	204	197	1077	134	47	20	4885
2015	1395	286	80	34	16	46	747	310	350	196	208	1182	144	48	21	5061
2020	1418	304	84	36	16	47	761	314	349	190	220	1299	151	48	21	5257
							Low variant									
1990	1150	199	40	16	4	44	794	324	414	192	220	743	74	30	6	4250
1995	1220	233	64	26	10	46	735	322	358	216	188	811	87	31	11	4359
2000	1229	247	62	28	12	46	725	314	336	208	198	881	103	36	15	4442
2005	1225	263	60	28	12	47	725	306	326	192	190	947	115	40	18	4493
2010	1191	281	60	26	12	47	737	301	314	168	186	1015	125	42	18	4521
2015	1136	298	60	24	10	47	755	299	296	146	192	1092	129	41	16	4544
2020	1090	308	62	26	10	47	765	295	284	132	199	1171	131	38	15	4573
							High cohabitation scenario									
1990	1150	199	40	16	4	44	794	324	414	192	220	743	74	30	6	4250
1995	1181	350	76	28	10	46	788	334	352	210	153	724	85	30	10	4373
2000	1211	363	72	30	12	46	807	344	346	202	137	775	101	35	15	4500
2005	1238	374	66	30	12	46	827	343	356	192	123	830	117	41	17	4610
2010	1233	395	65	28	12	46	856	339	356	178	118	891	127	44	17	4707
2015	1212	417	68	28	10	47	891	341	346	166	121	962	133	44	17	4802
2020	1198	431	72	30	10	47	917	342	342	158	126	1037	136	42	16	4908
							High divorce scenario									
1990	1150	199	40	16	4	44	794	324	414	192	220	743	74	30	6	4250
1995	1225	234	66	28	12	46	712	310	344	212	190	846	96	37	14	4372
2000	1255	249	70	32	14	46	675	297	320	202	203	952	117	44	20	4498
2005	1282	265	70	32	16	46	652	285	314	188	196	1052	135	50	23	4609
2010	1282	284	72	32	16	46	642	278	306	172	195	1154	149	55	24	4705
2015	1263	304	76	32	14	47	642	277	294	156	203	1261	157	55	23	4803
2020	1248	319	78	34	14	47	641	275	288	146	214	1369	161	53	22	4910
							Increased institutional capacity scenario									
1990	1150	199	40	16	4	45	794	323	414	191	220	743	74	30	6	4250
1995	1225	232	65	27	11	94	716	323	358	217	184	790	88	31	11	4371
2000	1254	244	66	30	13	118	692	315	342	214	196	855	104	36	15	4495
2005	1281	257	66	30	14	130	690	306	339	202	189	923	119	41	18	4607
2010	1282	274	67	29	14	138	703	301	333	186	187	999	130	44	19	4706
2015	1262	291	70	29	13	150	719	302	322	170	195	1084	137	44	19	4805
2020	1248	303	73	31	13	172	727	301	315	159	204	1168	141	43	18	4914

Table 12. Average annual percentage growth rates for private households and one-person households

	Observed[1]	Basic scenario	High variant	Low variant	High cohabitation scenario	High divorce scenario	Increased institutional capacity scenario
			Private households				
1950-1960	1.1						
1960-1970	1.9						
1970-1980	1.6						
1980-1990	1.4						
Projected[2]							
1990-1995		0.7	0.8	0.7	0.5	1.0	0.4
1995-2000		1.0	1.1	0.8	0.9	1.1	0.8
2000-2005		0.9	1.0	0.7	0.8	1.0	0.8
2005-2010		0.9	1.0	0.7	0.8	0.9	0.9
2010-2015		0.9	1.1	0.7	0.9	1.0	0.9
2015-2020		0.9	1.1	0.6	0.8	0.9	0.8
			One-person households				
1950-1960	0.7						
1960-1970	6.0						
1970-1980	4.5						
1980-1990	3.5						
Projected[2]							
1990-1995		1.8	1.9	1.8	-0.5	2.6	1.2
1995-2000		1.8	2.0	1.7	1.4	2.4	1.6
2000-2005		1.7	1.8	1.5	1.4	2.0	1.5
2005-2010		1.6	1.8	1.4	1.4	1.9	1.6
2010-2015		1.7	1.9	1.5	1.5	1.8	1.6
2015-2020		1.6	1.9	1.4	1.5	1.7	1.5

[1] Between census dates.
[2] Between 31 December of each pair of years.

Figure 15. Private households

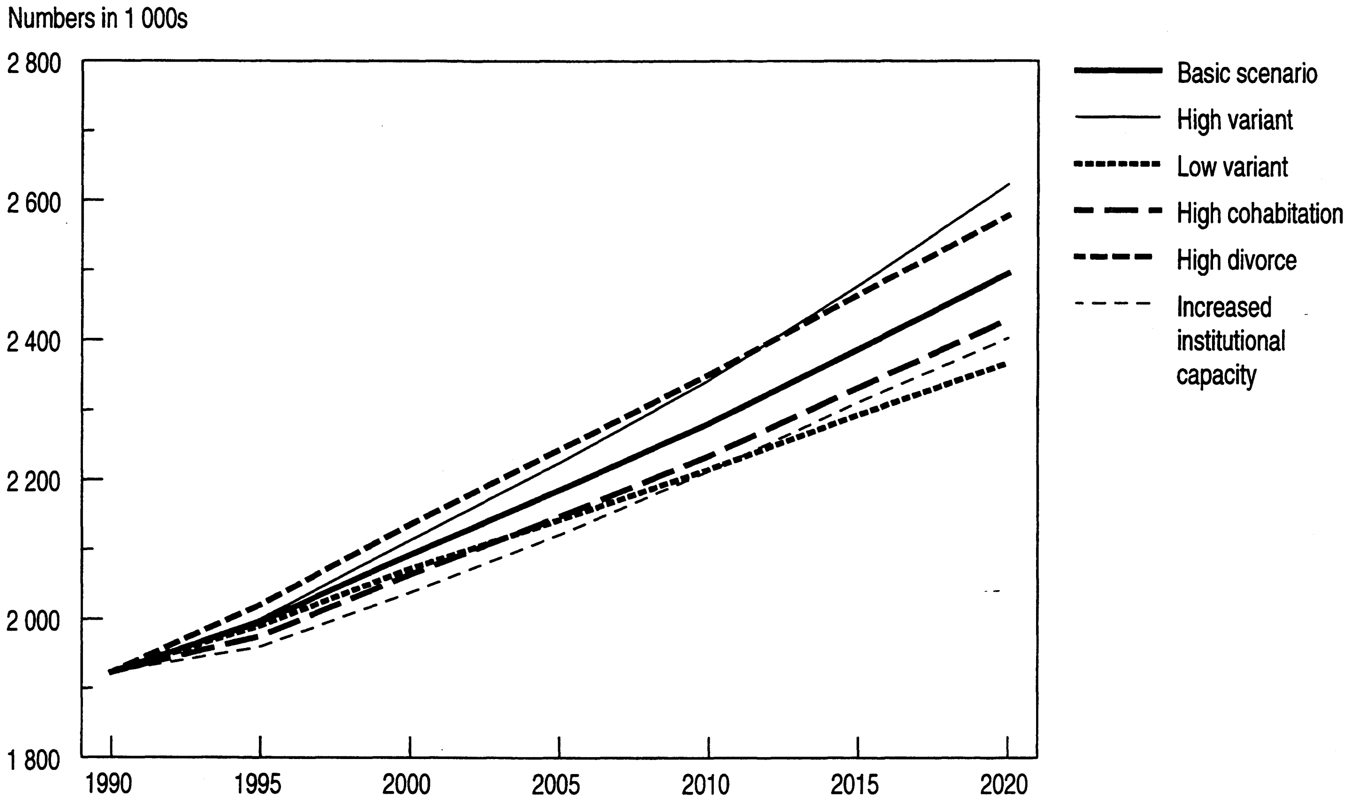
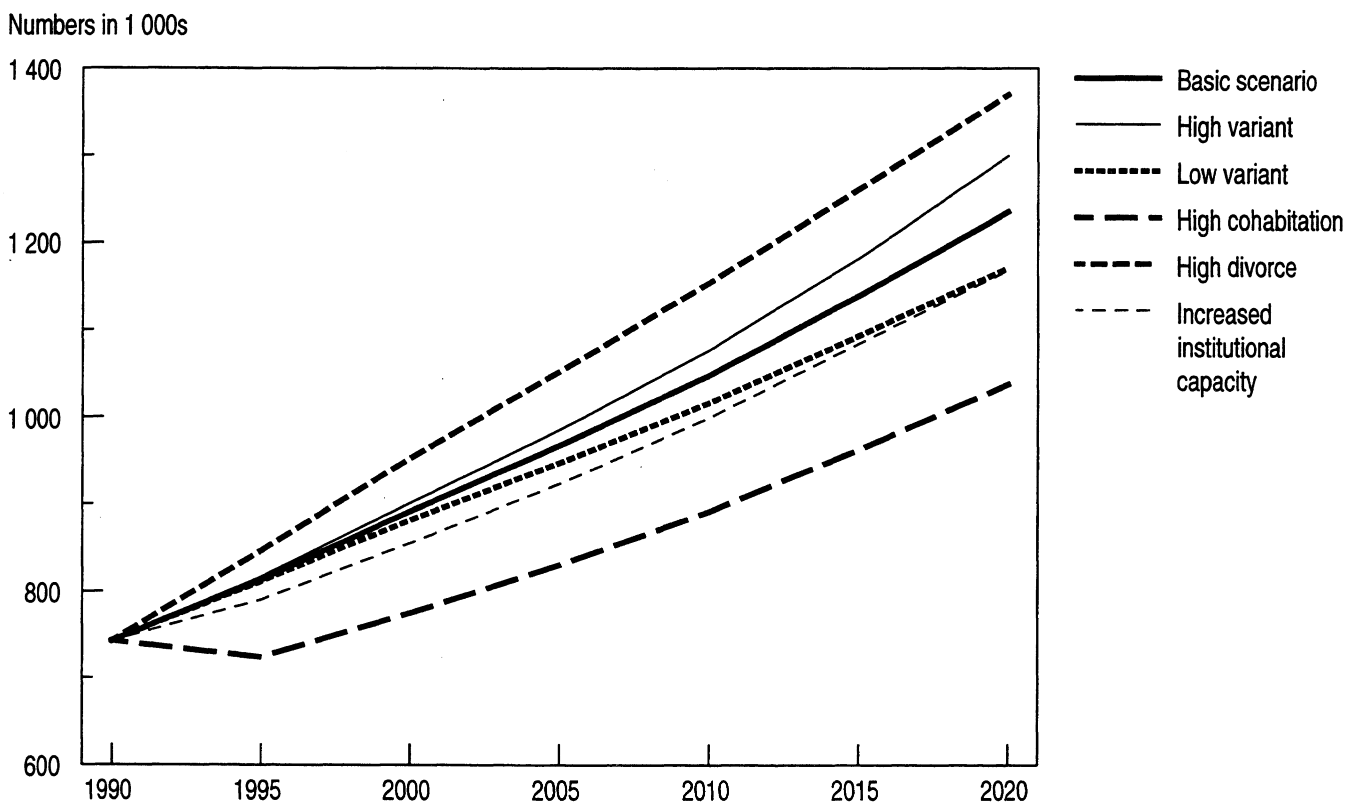


Figure 16. One-person households



5. Conclusions

This report presents projections of household dynamics for Norway for the period 1990-2020. The LIPRO modelling approach has been used, which is based on the individual as the unit of analysis. The model distinguishes individuals by age (five-year age group), sex and 15 household positions: dependent child, living together with a partner in a consensual union (and 0, 1, 2, or 3+ children), with a marriage partner (and 0, 1, 2, or 3+ children), living alone, lone parent (1, 2, or 3+ children), other position in private household, and living in an institution for the elderly. Household dynamics are introduced by means of rates which describe the intensity, for each combination of age and sex, of experiencing a jump from one household position to another one, the so-called household event. Fertility, mortality and immigration are included in the model. A special algorithm guarantees consistency between numbers of events among members of the same household, for instance for men and women who start a consensual union or who marry, for couples who experience union dissolution, and for parents and children.

The model requires two types of input data: (i) an initial population with age, sex and household position detail; (ii) a set of parameters consisting of rates which describe household events, fertility, and mortality, and absolute numbers for net immigration. The initial population has been estimated from data from the 1990 Population and Housing Census, thereby correcting for two types of biases in these data: the overestimation of young adults living with their parents, and the underestimation of consensual unions. The main data source for the set of parameters is the 1988 Family and Occupation Survey, which contains retrospectively collected life histories concerning union formation and dissolution. Rates covering the period 1983-1987 were estimated from this source.

The data requirements for dynamic household models are formidable, both in terms of the number of parameters needed but not the least because we need estimates of parameters for which data are rarely collected. Household changes have been given much less attention in demography and official statistics than other demographic components, such as fertility, mortality and nuptiality. We know, for example, very little about the rate at which adolescents move out of the parental home and to what *types* of households they move. Information about entry into and exit out of what we have called "other households" (a private multi-family household, or a private multi-person household that does not contain a married or cohabiting couple, or a lone parent) is entirely lacking. For institutions, only a few total numbers for the gross flows are available. Finally, the strong link between the 1990 Census and the Central Population Register must be regarded as unfortunate for the compilation of household statistics. Household data based on the register are seriously biased, and this has severe consequences for household statistics in the Census. Young adults living at their parents' home are severely overestimated in the Census, and consensual unions and one-person households are underestimated. After having adjusted for these biases we found that the number of private households in Norway in 1990 was 1.923 million, rather than the official figure of 1.751 million. A sample survey of sufficient size, in which respondents are asked about their current household position (*de facto*, rather than *de jure* position), as well as their household position at some previous point in time, together with information about other members of the respondent's current and previous household, would be an ideal basis for improved estimates of the initial population and the various rates.

Household projections were carried out for the period 1990-2020, with future numbers of births, deaths and net immigrations in accordance with those of Statistics Norway's 1993 based national population forecasts. These projections are *macro* projections. They tell us how many households there will be of various types, and how many men and women will live in particular household positions at different ages. However, the *micro* structure of these future households, in the sense of whom lives together with whom in the same household, is not investigated here. This will be the subject of a follow-up report, which will deal with *micro*simulation.

Six sets of projections have been computed. In the Basic scenario input rates remain constant for the entire projection period, except for adjustments due to internal and external consistency. Births, deaths and net immigrations were derived from the Medium variant of Statistics Norway's population forecasts. Moreover, under this Basic scenario, the total number of persons living in an institution for the elderly is maintained at its present level of approximately 45,000. The five other scenarios all start off from the Basic scenario, but they differ from that scenario in various ways. Two of these investigate the implications of high and low fertility, mortality and migration. The High variant and the Low variant from the population forecasts supplied the numbers of births, deaths and net immigrations for these two scenarios. A High cohabitation scenario looks into the consequences of rates for the entry into a consensual union which are twice as high as those of the period 1983-1987, used in the Basic scenario. The implications of 50 per cent higher marriage dissolution rates are investigated in the High divorce scenario. Finally, the constraint of constant capacity in institutions for the elderly has been removed from the Basic scenario in order to analyse the situation with an increased capacity in such institutions.

According to these scenarios, the total number of households will grow from today's 1.92 million to between 2.37 million (Low variant) and 2.62 million (High variant) in 2020. This implies a drop in the average size of private households from today's 2.2 to between 1.9 and 2.0 in thirty years' time. The most striking result under all scenarios is the strong growth in the number of one-person households, from 740,000 in 1990 to between 1.037 million (High cohabitation) and 1.369 million (High divorce) in 2020. It would imply that between 43 and 53 per cent of all private households would be one-person households in 2020 - presently this share is 39 per cent. The strong growth in one-person households is explained, to a large extent, by two factors: first, the ongoing general ageing process of Norway's population (particularly elderly women often live alone), and second, divorce and the break-up of consensual unions, which leads to many middle-aged men who live on their own.

Other persistent trends, independently of the scenario chosen, are the diminishing importance of married couples with children, the growth in lone-parent families, and a strong rise in the need for places in institutions for the elderly. Consensual unions will become more important, but their share in all private households will remain modest: between 8 per cent (High variant) and 11 per cent (High cohabitation) in 2020, which is only a few percentage points higher than the share of 7 per cent for 1990.

The scenarios cover a relatively wide spectre of possible household futures. Although it is not possible to select any of the scenarios presented here as the most probable one, none of them is entirely unlikely *a priori*. Hence, we may expect that the real development will be covered by the fan that these scenarios represent, which quite likely will include the persistent trends noted above. In this respect these trends are just a continuation of the trends observed in Norway and a number of other industrialized countries since World War II.

References

Andreassen, L. (1992): Demographic forecasting with a dynamic stochastic microsimulation model. Revised version of a paper presented at the Helsinki Seminar on Microsimulation Models, Helsinki, March 1992.

Andreassen, T., G. Spurkland and Y. Vogt (1992): MOSART, a micro simulation model. Paper Conference on Computing for the Social Sciences, Ann Arbor, May 1992.

Andreassen, L., T. Andreassen, D. Fredriksen, G. Spurkland and Y. Vogt (1993): *Framskriving av arbeidsstyrke og utdanning: Mikrosimuleringsmodellen MOSART*. Rapporter 93/6. Oslo: Statistics Norway.

Andreassen, L., D. Fredriksen and O. Ljones (1994): The future burden of public pension benefits: A microsimulation study. Discussion Papers no. 115. Oslo: Statistics Norway.

Boulanger, P. M., A. Lambert, P. Deboosere and R. Lesthaeghe (1994): La formation des familles: Etude prospective. Bruxelles: Services de Programmation de la Politique Scientifique.

Brunborg, H. and Ø. Kravdal (1986): *Barnetall blant norske kvinner: En paritetsanalyse på grunnlag av registerdata*. Reports 86/27. Oslo: Statistics Norway.

Byfuglien, J. (1991): Population databases in Norway. Paper Interregional Workshop on Population Data Bases and Related Topics, Jakarta, January 1991 (copy available from Statistics Norway).

Clarke, M. (1986): Demographic processes and household dynamics: A microsimulation approach. Pp. 245-272 in: R. Woods and Ph. Rees (eds.) *Population Structures and Models: Developments in Spatial Demography*. London: Allen and Unwin.

Egidi, V. and A. Tomassetti (1988): A method for projecting families: Some preliminary results on the consequences of actual demographic behaviour on family dynamics in Italy. Paper IIASA conference on "Future Change in Population Age Structure", Sopron, Hungary, October, 1988.

Fredriksen, D. (1995): MOSART: En modell for framskrivinger av befolkningen. *Økonomiske analyser* 95(1), 3-11.

Fredriksen, D. and G. Spurkland (1993): *Framskriving av alders- og uføretrygd ved hjelp av mikrosimuleringsmodellen MOSART*. Reports 93/7. Oslo: Statistics Norway.

Galler, H. (1988): Microsimulation of household formation and dissolution. Pp. 139-154 in: Keilman, Kuijsten and Vossen (1988).

Heike, H.-D., O. Hellwig, A. Kaufmann, M. Zafir, J. Cicsman, E. Papp and M. Rudas (1987): Experiences with the Darmstadt Microsimulation Model (DPMS). Paper IIASA Workshop on Demographic Microsimulation, Budapest, November - December, 1987.

Hoem, J. and U. Funck Jensen (1982): Multistate life table methodology: A probabilist critique. Pp. 113-264 in: K. Land and A. Rogers (eds.) *Multidimensional Mathematical Demography*. New York: Academic Press.

Hoem, B. and J. Hoem (1992): The disruption of marital and non-marital unions in contemporary Sweden. Pp. 61-93 in: J. Trussell, R. Hankinson and J. Tilton (eds.) *Demographic Applications of Event History Analysis*. Oxford: Clarendon Press.

Keilman, N. (1985): Internal and external consistency in multidimensional population projection models. *Environment and Planning A* 17, 1473-1498.

Keilman, N. (1988): Dynamic household models. Pp. 123-138 in: Keilman, Kuijsten and Vossen (1988).

Keilman, N. (1994a): Sterk økning i antall aleneboende. *Samfunnsspeilet* 2/94, 16-21.

Keilman, N. (1994b): Correction of initial population. Unpublished note, September 1994.

Keilman, N. and N. Keyfitz (1988): Recurrent issues in dynamic household modelling, in Keilman, Kuijsten and Vossen (1988), 254-285.

Keilman, N., A. Kuijsten and A. Vossen, eds. (1988): *Modelling Household Formation and Dissolution*. Oxford: Clarendon Press.

Manting, D. (1994): *Dynamics in Marriage and Cohabitation: An Inter-temporal, Life Course Analysis of First Union Formation and Dissolution*. Amsterdam: Thesis Publishers.

McMillan and Herriot (1985): Towards a longitudinal definition of households. *Journal of Economic and Social Measurement* 13(3/4), 31-44.

Nelissen, J. H. M. (1991): Household and education projections by means of a microsimulation model. *Economic Modelling* 9, 480-511.

Nelissen, J. H. M. (1993): *The Redistributive Impact of Social Security Schemes on Lifetime Labour Income*. Tilburg (the Netherlands): Tilburg Institute for Social Security Research.

Nelissen, J. H. M. and A. P. Vossen (1989): Projecting household dynamics: A scenario-based microsimulation approach. *European Journal of Population* 5, 253-279.

Noack, T. and N. Keilman (1993): Familie og husholdning. Chapter 8.1 in *Sosialt utsyn 1993*. Oslo: Statistics Norway.

Prinz, C. (1991): Marriage and cohabitation in Sweden. Paper European Population Conference Paris, October 1991.

Righi, A. (1994): An attempt to overcome the classic approach: The application of a multistate model to the Italian family projection. Paper ECE/Eurostat Joint Work Session on Demographic Projections, Mondorf-les-Bains, Luxembourg, June 1994.

Righi, A. and M. P. Sorvillo (1992): The evolution of Italian families: Results and open issues in the application of LIPRO model. Paper Summer Course "Demographic Perspectives on Living Arrangements", Wassenaar, the Netherlands, July 1992.

Singer, B. and S. Spilerman (1976): The representation of social processes by Markov models. *American Journal of Sociology* 82(1), 1-54.

Statistics Norway (1985): Forslag til standarder for kjennemerker knyttet til familier og husholdninger, Interne Notater no. 85/31. Oslo: Statistics Norway.

Statistics Norway (1991): *Family and Occupation Survey 1988*. NOS B 959. Oslo.

Statistics Norway (1992): *Folke- og boligtelling 1990: Hele landet*. Oslo-Kongsvinger: Statistics Norway.

Statistics Norway (1994a): *Framskriving av folkemengden 1993-2050: Nasjonale og regionale tall.* NOS C 176. Oslo: Statistics Norway.

Statistics Norway (1994b): *Befolkningsstatistikk 1993 Hefte III Oversikt.* NOS C 111. Oslo: Statistics Norway.

Statistics Norway (1994c): Folke- og boligtelling 1990 - Evaluering. Instilling fra et utvalg som har vurdert tellingen. Notater no. 94/3. Oslo: Statistics Norway.

Texmon, I. (1992): Flytting fra foreldrehjemmet. Working Paper 4/1992, Department for Statistics on Individuals and Households, 233-259.

Trussell, J., G. Rodríguez and B. Vaughan (1992): Union dissolution in Sweden. Pp. 38-60 in: J. Trussell, R. Hankinson and J. Tilton (eds.) *Demographic Applications of Event History Analysis.* Oxford: Clarendon Press.

United Nations - UN (1980): Principals and recommendations for population and housing censuses (ST/ESA/STAT/SER.M/67). New York, UN Statistical Office.

Van Imhoff, E. (1990): The exponential multidimensional demographic projection model. *Mathematical Population Studies* 2(3), 171-182.

Van Imhoff, E. (1992): A general characterization of consistency algorithms in multidimensional demographic projection models. *Population Studies* 46(1), 159-169.

Van Imhoff, E. and N. Keilman (1991): *LIPRO 2.0: An Application of a Dynamic Demographic Projection Model to Household Structures in the Netherlands.* Amsterdam: Swets & Zeitlinger.

Wachter, K. W. (1987): Microsimulation of household cycles. Pp. 215-227 in: J. Bongaarts, T.K. Burch and K.W. Wachter (eds.) *Family Demography: Methods and their Application.* Oxford: Oxford University Press.

Appendix 1

Events in the household model

Note: Household types A-N referred to below are listed in Section 2.1

No.	From	To	Demographic event
1	CHLD	SIN0	leaving the parental home to start one-person household
2	CHLD	COH0	start of consensual union
3	CHLD	COH1	a) start of consensual union with a lone parent having one child
			b) start of consensual union, immediately followed by birth of a child (double event)
4	CHLD	COH2	start of consensual union with a lone parent having two children
5	CHLD	COH3	start of consensual union with a lone parent having three or more children
6	CHLD	MAR0	marriage
7	CHLD	MAR1	a) marriage to a lone parent having one child
			b) marriage, immediately followed by birth of a child (double event)
8	CHLD	MAR2	marriage to a lone parent having two children
9	CHLD	MAR3	marriage to a lone parent having three or more children
-	CHLD	SIN1	not possible (involves multiple events)
-	CHLD	SIN2	not possible (involves multiple events)
-	CHLD	SIN3	not possible (involves multiple events)
10	CHLD	OTHR	a) entrance into an existing household of type B-D, E-H or J-L
			b) entrance into existing household consisting of persons with position OTHR (household type M)
			c) child, while living with parent(s), gets own child
			d) second family or couple moves in
			e) child marries, spouse joins household
11	CHLD	INST	child gets institutionalized
12	SIN0	CHLD	return to parental home
13	SIN0	COH0	start of consensual union
14	SIN0	COH1	a) start of consensual union with lone parent
			b) start of consensual union, immediately followed by birth of a child (double event)
15	SIN0	COH2	start of consensual union with lone parent
16	SIN0	COH3	start of consensual union with lone parent
17	SIN0	MAR0	marriage
18	SIN0	MAR1	a) marriage with lone parent
			b) marriage, immediately followed by birth of child (double event)
19	SIN0	MAR2	marriage with lone parent
20	SIN0	MAR3	marriage with lone parent
21	SIN0	SIN1	a) return of child to parent living alone
			b) birth
-	SIN0	SIN2	not possible (involves multiple events)
-	SIN0	SIN3	not possible (involves multiple events)
22	SIN0	OTHR	a) entrance into an existing household of types A-L
			b) entrance into existing OTHR-household
23	SIN0	INST	entrance into institution
-	COH0	CHLD	not possible (assumptions 2 and 3)
24	COH0	SIN0	a) separation
			b) institutionalization, death or emigration of partner

25	COH0	COH1	a) birth b) return of child to cohabiting parents
-	COH0	COH2	not possible (involves multiple events)
-	COH0	COH3	not possible (involves multiple events)
26	COH0	MAR0	marriage
-	COH0	MAR1	not possible (assumption 3)
-	COH0	MAR2	not possible (assumption 3)
-	COH0	MAR3	not possible (assumption 3)
-	COH0	SIN1	not possible (assumption 3)
-	COH0	SIN2	not possible (assumption 3)
-	COH0	SIN3	not possible (assumption 3)
27	COH0	OTHR	entrance into, or formation of OTHR-household
28	COH0	INST	entrance into institution
-	COH1	CHLD	not possible (assumptions 2 and 3)
29	COH1	SIN0	separation
30	COH1	COH0	exit, death or emigration of child
31	COH1	COH2	a) birth b) return of child to cohabiting parents
-	COH1	COH3	not possible (involves multiple events)
-	COH1	MAR0	not possible (assumption 3)
32	COH1	MAR1	marriage
-	COH1	MAR2	not possible (assumption 3)
-	COH1	MAR3	not possible (assumption 3)
33	COH1	SIN1	separation, exit to institution, death or emigration of partner
-	COH1	SIN2	not possible (assumption 3)
-	COH1	SIN3	not possible (assumption 3)
34	COH1	OTHR	a) entrance into, or formation of OTHR-household b) co-residing daughter gets a child
35	COH1	INST	entrance into institution
-	COH2	CHLD	not possible (assumptions 2 and 3)
36	COH2	SIN0	separation
-	COH2	COH0	not possible (assumption 3)
37	COH2	COH1	exit, death or emigration of child
38	COH2	COH3	a) birth b) return of child to cohabiting parents
-	COH2	MAR0	not possible (assumption 3)
-	COH2	MAR1	not possible (assumption 3)
39	COH2	MAR2	marriage
-	COH2	MAR3	not possible (assumption 3)
40	COH2	SIN1	separation from partner, one child remains with individual, other child stays with partner
41	COH2	SIN2	separation, exit to institution, death or emigration of partner
-	COH2	SIN3	not possible (assumption 3)
42	COH2	OTHR	a) entrance into, or formation of OTHR-household b) co-residing daughter gets a child
43	COH2	INST	entrance into institution
-	COH3	CHLD	not possible (assumptions 2 and 3)
44	COH3	SIN0	separation
-	COH3	COH0	not possible (assumption 3)
-	COH3	COH1	not possible (assumption 3)
45	COH3	COH2	exit, death or emigration of child
46	COH3	COH3	a) birth b) return of child to cohabiting parents c) exit, death or emigration of child, while at least three children remain in the household
-	COH3	MAR0	not possible (assumption 3)
-	COH3	MAR1	not possible (assumption 3)
-	COH3	MAR2	not possible (assumption 3)
47	COH3	MAR3	marriage
48	COH3	SIN1	separation from partner, one child remains with individual, other children stay with previous partner

49	COH3 SIN2	separation from partner, two children remain with individual, other child(ren) stay(s) with previous partner
50	COH3 SIN3	a) separation from partner, at least three children remain with individual, other children, if any, stay with previous partner b) exit to institution, death or emigration of partner
51	COH3 OTHR	a) entrance into, or formation of OTHR household b) co-residing daughter gets a child c) partner and all children leave, individual and OTHR person stay behind
52	COH3 INST	entrance into institution
-	MAR0 CHLD	not possible (assumptions 2 an 3)
53	MAR0 SIN0	a) separation or divorce b) institutionalization, death or emigration of partner
-	MAR0 COH0	not possible (assumption 1)
-	MAR0 COH1	not possible (assumption 3)
-	MAR0 COH2	not possible (assumption 3)
-	MAR0 COH3	not possible (assumption 3)
54	MAR0 MAR1	a) birth b) return of child to married parents
-	MAR0 MAR2	not possible (involves multiple events)
-	MAR0 MAR3	not possible (involves multiple events)
-	MAR0 SIN1	not possible (assumption 3)
-	MAR0 SIN2	not possible (assumption 3)
-	MAR0 SIN3	not possible (assumption 3)
55	MAR0 OTHR	entrance into, or formation of OTHR household
56	MAR0 INST	entrance into institution
-	MAR1 CHLD	not possible (assumptions 2 and 3)
57	MAR1 SIN0	separation or divorce
-	MAR1 COH0	not possible (assumption 3)
-	MAR1 COH1	not possible (assumption 1)
-	MAR1 COH2	not possible (assumption 3)
-	MAR1 COH3	not possible (assumption 3)
58	MAR1 MAR0	exit, death or emigration of child
59	MAR1 MAR2	a) birth b) return of child to married parents
-	MAR1 MAR3	not possible (involves multiple events)
60	MAR1 SIN1	separation or divorce, exit to institution, death or emigration of partner
-	MAR1 SIN2	not possible (involves multiple events)
-	MAR1 SIN3	not possible (involves multiple events)
61	MAR1 OTHR	a) entrance into, or formation of OTHR household b) co-residing daughter gets a child
62	MAR1 INST	entrance into institution
-	MAR2 CHLD	not possible (assumptions 2 and 3)
63	MAR2 SIN0	separation or divorce
-	MAR2 COH0	not possible (assumption 3)
-	MAR2 COH1	not possible (assumption 3)
-	MAR2 COH2	not possible (assumption 1)
-	MAR2 COH3	not possible (assumption 3)
-	MAR2 MAR0	not possible (assumption 3)
64	MAR2 MAR1	exit, death or emigration of child
65	MAR2 MAR3	a) birth b) return of child to married parents
66	MAR2 SIN1	separation from partner, one child remains with individual, other child stays with partner
67	MAR2 SIN2	separation or divorce, exit to institution, death or emigration of partner
-	MAR2 SIN3	not possible (involves multiple events)
68	MAR2 OTHR	a) entrance into, or formation of OTHR household b) co-residing daughter gets a child
69	MAR2 INST	entrance into institution
-	MAR3 CHLD	not possible (assumptions 2 and 3)

70	MAR3	SIN0	separation or divorce
-	MAR3	COH0	not possible (assumption 3)
-	MAR3	COH1	not possible (assumption 3)
-	MAR3	COH2	not possible (assumption 3)
-	MAR3	COH3	not possible (assumption 1)
-	MAR3	MAR0	not possible (involves multiple events)
-	MAR3	MAR1	not possible (involves multiple events)
71	MAR3	MAR2	exit, death or emigration of child
72	MAR3	MAR3	a) birth
			b) return of child to married parents
			c) exit, death or emigration of child, while at least three children remain in the household
73	MAR3	SIN1	separation or divorce from spouse, one child remains with individual, other children stay with previous spouse
74	MAR3	SIN2	separation or divorce from spouse, two children remain with individual, other child(ren) stay(s) with previous spouse
75	MAR3	SIN3	a) separation or divorce from spouse, at least three children remain with individual, other children, if any, stay with previous spouse
			b) exit to institution, death or emigration of spouse
76	MAR3	OTHR	a) entrance into, or formation of OTHR household
			b) co-residing daughter gets a child
77	MAR3	INST	entrance into institution
-	SIN1	CHLD	not possible (assumptions 2 and 3)
78	SIN1	SIN0	exit, death or emigration of child
-	SIN1	COH0	not possible (assumption 3)
79	SIN1	COH1	start of consensual union with single person
80	SIN1	COH2	start of consensual union with other lone parent
81	SIN1	COH3	start of consensual union with other lone parent
-	SIN1	MAR0	not possible (involves multiple events)
82	SIN1	MAR1	marriage with single person
83	SIN1	MAR2	marriage with other lone parent
84	SIN1	MAR3	marriage with other lone parent
85	SIN1	SIN2	a) birth
			b) return of child to lone parent
-	SIN1	SIN3	not possible (involves multiple events)
86	SIN1	OTHR	a) entrance into, or formation of OTHR household
			b) co-residing daughter gets a child
-	SIN1	INST	not possible (assumption 4)
-	SIN2	CHLD	not possible (assumptions 2 and 3)
-	SIN2	SIN0	not possible (assumption 4)
-	SIN2	COH0	not possible (assumption 3)
-	SIN2	COH1	not possible (assumption 3)
87	SIN2	COH2	start of consensual union with single person
88	SIN2	COH3	start of consensual union with other lone parent
-	SIN2	MAR0	not possible (involves multiple events)
-	SIN2	MAR1	not possible (involves multiple events)
89	SIN2	MAR2	marriage with single person
90	SIN2	MAR3	marriage with other lone parent
91	SIN2	SIN1	exit, death or emigration of child
92	SIN2	SIN3	a) birth
			b) return of child to lone parent
93	SIN2	OTHR	a) entrance into, or formation of OTHR household
			b) co-residing daughter gets a child
-	SIN2	INST	not possible (assumption 4)
-	SIN3	CHLD	not possible (assumptions 2 and 3)
-	SIN3	SIN0	not possible (assumption 4)
-	SIN3	COH0	not possible (assumption 3)
-	SIN3	COH1	not possible (assumption 3)
-	SIN3	COH2	not possible (assumption 3)

94	SIN3	COH3	a) start of consensual union with single person b) start of consensual union with other lone parent
-	SIN3	MAR0	not possible (assumption 3)
-	SIN3	MAR1	not possible (assumption 3)
-	SIN3	MAR2	not possible (assumption 3)
95	SIN3	MAR3	a) marriage with single person b) marriage with other lone parent
-	SIN3	SIN1	not possible (involves multiple events)
96	SIN3	SIN2	exit, death or emigration of child
97	SIN3	SIN3	a) birth b) return of child to lone parent c) exit, death or emigration of child, while at least three children remain in the household
98	SIN3	OTHR	a) entrance into, or formation of OTHR household b) co-residing daughter gets a child
-	SIN3	INST	not possible (assumption 4)
99	OTHR	CHLD	child leaves, with parent(s), multi-family household
100	OTHR	SIN0	a) exit (as OTHR person) from household of type A-M and start of one-person household b) household type A-L leaves, non-family related OTHR stays behind
101	OTHR	COH0	a) exit (as OTHR person) from household of type A-M and start of consensual union b) cohabiting couple without children leaves multi-family household
102	OTHR	COH1	a) exit (as OTHR person) from household of type A-M and start of consensual union with lone parent b) cohabiting couple with child leaves multi-family household c) exit (as OTHR person) from household of type A-M and start of consensual union, immediately followed by birth of child (double event)
103	OTHR	COH2	a) exit (as OTHR person) from household of type A-L and start of consensual union with lone parent b) cohabiting couple with two children leaves multi-family household
104	OTHR	COH3	a) exit (as OTHR person) from household of type A-L and start of consensual union with lone parent b) cohabiting couple with three children leaves multi-family household
105	OTHR	MAR0	a) exit from OTHR household of type A-L and marriage b) married couple without children leaves multi-family household
106	OTHR	MAR1	a) exit from OTHR household of type A-L and marriage with lone parent b) married couple with child leaves multi-family household c) exit (as OTHR person) from household of type A-M and marriage, immediately followed by birth of child (double event)
107	OTHR	MAR2	a) exit from OTHR household of type A-L and marriage with lone parent b) married couple with two children leaves multi-family household
108	OTHR	MAR3	a) exit from OTHR household of type A-L and marriage with lone parent b) married couple with three children leaves multi-family household
109	OTHR	SIN1	one-parent family leaves multi-family household
110	OTHR	SIN2	one-parent family leaves multi-family household
111	OTHR	SIN3	one-parent family leaves multi-family household
112	OTHR	INST	entrance into institution
113 -123	INST	all other positions, except SIN1, SIN2, SIN3	exit from institution

The events 3b, 7b, 14b, 18b, 102c, and 106c are not immediate jumps. They all involve two distinct demographic events: couple formation (marriage or consensual union) and childbearing (possibly in reverse order). For reasons discussed in Section 2.1, these "double" events have been defined separately.

Although it is not immediately clear from Table 1 in Section 2.1, the sub-table with intra-household events contains a clear structure. To show this, we compiled Tables A1.1 and A1.2. In Table A1.1, events for households containing a couple (cohabiting or married, with or without children) and one-parent families are selected, and they are displayed in block structure.

Table A1.1. Selected events in the household model

From \ To	3	4	5	6	7	8	9	10	11	12	13
	Intra-household events										
	Cons. unions				Marr. couples				Lone parents		
	A				B				C		
3. COH0	-	+	-	-	+	-	-	-	-	-	-
4. COH1	+	-	+	-	-	+	-	-	+	-	-
5. COH2	-	+	-	+	-	-	+	-	+	+	-
6. COH3	-	-	+	+	-	-	-	+	+	+	+
	D				E				F		
7. MAR0	-	-	-	-	-	+	-	-	-	-	-
8. MAR1	-	-	-	-	+	-	+	-	+	-	-
9. MAR2	-	-	-	-	-	+	-	+	+	+	-
10. MAR3	-	-	-	-	-	-	+	+	+	+	+
	G				H				I		
11. SIN1	-	+	+	+	-	+	+	+	-	+	-
12. SIN2	-	-	+	+	-	-	+	+	+	-	+
13. SIN3	-	-	-	+	-	-	-	+	-	+	+

Blocks A, E and I, which are on the main diagonal, represent the arrival and the departure of children in the household. Note that block A for consensual unions has exactly the same structure as block E for married couples. Moreover, block I for one-parent families may be obtained from block A (or E) by deleting the first row and the first column of A.

Block B represents marriage of two cohabiting partners. The number of children remains the same, and hence there are only events on the diagonal of block B. Because we have assumed that partners who divorce or separate do not co-reside any longer (assumption 1 in Section 2.1), its counterpart (block D), involving the jump from married to cohabiting, is empty. On the other hand, blocks C and G (from cohabiting to single parent, and vice versa), are strongly related. If C and G are represented as matrices (for example, with a zero for each minus sign, and a one for each plus sign) we could say that C and G are each others transpose. Also note that block F equals block C, and similarly that H equals G. Thus, conceptually speaking, separation (or divorce) of a married couple (block F) is similar to the break-up of a cohabiting couple (C), and, for lone parents, marriage (H) is the same as union formation (G).

The off-diagonal blocks in Table A1.1 display union formation and dissolution. By re-arranging rows and columns of Table A1.1, processes of arrival and departure of children can be highlighted. In Table A1.2, household positions involving the same number of children (0, 1, 2, 3 or more) are taken together. For reasons which will become clear below, the position SIN0 was added to the block with COH0 and MAR0.

Table A1.2. Selected events in the household model in rearranged order

From \ To	3	7	2	4	8	11	5	9	12	6	10	13
	Intra-household events											
	No children			1 child			2 children			3+ children		
		A			B			C			D	
3. COH0	-	+	+	+	-	-	-	-	-	-	-	-
7. MAR0	-	-	+	-	+	-	-	-	-	-	-	-
2. SIN0	+	+	-	+	+	+	+	+	-	+	+	-
		E			F			G			H	
4. COH1	+	-	+	-	+	+	+	-	-	-	-	-
8. MAR1	-	+	+	-	-	+	-	+	-	-	-	-
11. SIN1	-	-	+	+	+	-	+	+	+	+	+	-
		I			J			K			L	
5. COH2	-	-	+	+	-	+	-	+	+	+	-	-
9. MAR2	-	-	+	-	+	+	-	-	+	-	+	-
12. SIN2	-	-	-	-	-	+	+	+	-	+	+	+
		M			N			O			P	
6. COH3	-	-	+	-	-	+	+	-	+	+	+	+
10. MAR3	-	-	+	-	-	+	-	+	+	-	+	+
13. SIN3	-	-	-	-	-	-	-	-	+	+	+	+

Blocks A, F, K and P are located on the main diagonal of Table A1.2 - they represent processes of union formation and dissolution. Block B involves the arrival of the first child in the household. B is the transpose of E, which represents the departure of the last child. Adding the position SIN0 has resulted in blocks B, G and L being equal: each of these three stands for the arrival of an additional child. Similarly, blocks E, J and O represent the departure of a child. The structure in Table A1.2 may be expressed in matrix terms as follows (where X^T denotes the transpose of matrix X): $B=G=L=E^T=J^T=O^T$, $A=F=K$, $H=N$, and $C=D=I^T=M^T$.

The usefulness of searching for structure in a table of household events becomes clear on two occasions: when a check on the completeness of the list of households events is performed (initially, we actually missed a few events in Table 1), and when household positions have to be collapsed. For instance, when heads of one-parent families are considered irrespective of the number of children, a new table of household events may be inferred from Table A1.1 by replacing blocks C, F, G, and H by smaller blocks C', F', G', and H' according to the following rule (blocks are equivalent to matrices when a "+" and a "-" correspond to a 1 and a 0, respectively):

$$C' = F' = C \, . \, \mathbf{1},$$

$$G' = H' = (C')^T,$$

where **1** is a column vector with three elements, the first of which is a one, the other two elements being zero. Moreover, block I shrinks to a single "+".

Appendix 2

Consistency requirements

All relations below read in terms of absolute numbers of events (Van Imhoff and Keilman, 1991). Each type of event is described using the notation T(S,ORIG,DEST). Here T denotes the type of event (Internal event, eXit, i.e. death or emigration, Birth, eNtry, i.e. immigration); S denotes sex (Male, Female); ORIG and DEST denote the household positions immediately before and after the event takes place. For births, ORIG corresponds with mother's position prior to birth, and DEST corresponds with the position that the newly born child occupies (CHLD in the current application).

In certain cases the notation is T(S, $ORIG_1..ORIG_n$, DEST). Here the symbol $ORIG_1..ORIG_n$ denotes *the range of household positions 1,2,...,n,* where the range is a subset of the 15 household positions listed in Section 2.1 (in that order). Similarly, DEST may be expanded into a range of up to 15 destinations.

Constraints for married couples

Marriage of non-cohabiting partners and return from institution:

1. I(M,INST,MAR0) + I(M,SIN0,MAR0) + I(M,OTHR,MAR0) - I(F,INST,MAR0) - I(F,SIN0,MAR0) - I(F,OTHR,MAR0) = I(F,CHLD,MAR0) -I(M,CHLD,MAR0);
2. I(M,CHLD,MAR1) - I(F,CHLD,MAR1) + I(M,INST,MAR1) + I(M,SIN0..SIN1,MAR1) + I(M,OTHR,MAR1) = I(F,INST,MAR1) + I(F,SIN0..SIN1,MAR1) + I(F,OTHR,MAR1);
3. I(M,CHLD,MAR2) - I(F,CHLD,MAR2) + I(M,INST,MAR2) + I(M,SIN0..SIN2,MAR2) + I(M,OTHR,MAR2) = I(F,INST,MAR2) + I(F,SIN0..SIN2,MAR2) + I(F,OTHR,MAR2);
4. I(M,CHLD,MAR3) - I(F,CHLD,MAR3) + I(M,INST,MAR3) + I(M,SIN0..SIN3,MAR3) + I(M,OTHR,MAR3) = I(F,INST,MAR3) + I(F,SIN0..SIN3,MAR3) + I(F,OTHR,MAR3);

Marriage dissolution and separation

5. I(M,MAR0,SIN0) + I(M,MAR0,INST) + X(M,MAR0,DEAD) + X(M,MAR0,ABROAD) = I(F,MAR0,SIN0) + I(F,MAR0,INST) + X(F,MAR0,DEAD) + X(F,MAR0,ABROAD);
6. I(M,MAR1,SIN0) + I(M,MAR1,SIN1) + I(M,MAR1,INST) + X(M,MAR1,DEAD) + X(M,MAR1,ABROAD) = I(F,MAR1,SIN0) + I(F,MAR1,SIN1) + I(F,MAR1,INST) + X(F,MAR1,DEAD) + X(F,MAR1,ABROAD);
7. I(M,MAR2,SIN0) + I(M,MAR2,SIN2) + I(M,MAR2,INST) + X(M,MAR2,DEAD) + X(M,MAR2,ABROAD) = I(F,MAR2,SIN0) + I(F,MAR2,SIN2) + I(F,MAR2,INST) + X(F,MAR2,DEAD) + X(F,MAR2,ABROAD);
8. I(M,MAR2,SIN1) = I(F,MAR2,SIN1);
9. I(M,MAR3,SIN0..SIN3) + I(M,MAR3,INST) + X(M,MAR3,DEAD) + X(M,MAR3,ABROAD) = I(F,MAR3,SIN0..SIN3) + I(F,MAR3,INST) + X(F,MAR3,DEAD) + X(F,MAR3,ABROAD);

Marriage of cohabitees, and possibly, simultaneous childbearing

10. I(M,COH0,MAR0) = I(F,COH0,MAR0);
11. I(M,COH0,MAR1) = I(F,COH0,MAR1);
12. I(M,COH1,MAR1) = I(F,COH1,MAR1);
13. I(M,COH1,MAR2) = I(F,COH1,MAR2);
14. I(M,COH2,MAR2) = I(F,COH2,MAR2);
15. I(M,COH2,MAR3) = I(F,COH2,MAR3);
16. I(M,COH3,MAR3) = I(F,COH3,MAR3);

Immigration

17. N(M,ABROAD,MAR0)=N(F,ABROAD,MAR0);
18. N(M,ABROAD,MAR1)=N(F,ABROAD,MAR1);

19. N(M,ABROAD,MAR2)=N(F,ABROAD,MAR2);
20. N(M,ABROAD,MAR3)=N(F,ABROAD,MAR3);

Birth of child, or return to parents
20. I(M,MAR0,MAR1) = I(F,MAR0,MAR1);
21. I(M,MAR1,MAR2) = I(F,MAR1,MAR2);
22. I(M,MAR2,MAR3) = I(F,MAR2,MAR3);

Note that a constraint for position of origin MAR3 similar to constraints 20-22 for positions MAR0, MAR1 and MAR2 cannot be formulated because MAR3 is an aggregate position. This implies that the model does neither compute members of women nor men who are in position MAR3 and who experience the arrival of one additional child. The same holds for males and females in aggregate position COH3.

Exit, death, or emigration of a child
23. I(M,MAR1,MAR0) = I(F,MAR1,MAR0);
24. I(M,MAR2,MAR1) = I(F,MAR2,MAR1);
25. I(M,MAR3,MAR2) = I(F,MAR3,MAR2);

Formation of OTHR households
26. I(M,MAR0,OTHR) = I(F,MAR0,OTHR);
27. I(M,MAR1,OTHR) = I(F,MAR1,OTHR);
28. I(M,MAR2,OTHR) = I(F,MAR2,OTHR);
29. I(M,MAR3,OTHR) = I(F,MAR3,OTHR);

Constraints for cohabiting couples

Union dissolution
30. I(M,COH0,SIN0) + I(M,COH0,INST) + X(M,COH0,DEAD) + X(M,COH0,ABROAD) = I(F,COH0,SIN0) + I(F,COH0,INST) + X(F,COH0,DEAD) + X(M,COH0,ABROAD);
31. I(M,COH1,SIN0..SIN1) + I(M,COH1,INST) + X(M,COH1,DEAD) + X(M,COH1,ABROAD) = I(F,COH1,SIN0..SIN1) + I(F,COH1,INST) + X(F,COH1,DEAD) + X(F,COH1,ABROAD);
32. I(M,COH2,SIN0) + I(M,COH2,SIN2) + I(M,COH2,INST) + X(M,COH2,DEAD) + X(M,COH2,ABROAD) = I(F,COH2,SIN0) + I(F,COH2,SIN2) + I(F,COH2,INST) + X(F,COH2,DEAD) + X(F,COH2,ABROAD);
33. I(M,COH2,SIN1) = I(F,COH2,SIN1);
34. I(M,COH3,SIN0..SIN3) + I(M,COH3,INST) + X(M,COH3,DEAD) + X(M,COH3,ABROAD) = I(F,COH3,SIN0..SIN3) + I(F,COH3,INST) + X(F,COH3,DEAD) + X(M,COH3,ABROAD);

Formation of new consensual unions, and return from institution
35. I(M,CHLD,COH0) + I(M,INST,COH0) + I(M,SIN0,COH0) + I(M,OTHR,COH0) = I(F,CHLD,COH0) + I(F,INST,COH0) + I(F,SIN0,COH0) + I(F,OTHR,COH0);
36. I(M,CHLD,COH1) + I(M,INST,COH1) + I(M,SIN0..SIN1,COH1) + I(M,OTHR,COH1) = I(F,CHLD,COH1) + I(F,INST,COH1) + I(F,SIN0..SIN1,COH1) + I(F,OTHR,COH1);
37. I(M,CHLD,COH2) + I(M,INST,COH2) + I(M,SIN0..SIN2,COH2) + I(M,OTHR,COH2) = I(F,CHLD,COH2) + I(F,INST,COH2) + I(F,SIN0..SIN2,COH2) + I(F,OTHR,COH2);
38. I(M,CHLD,COH3) + I(M,INST,COH3) + I(M,SIN0..SIN3,COH3) + I(M,OTHR,COH3) = I(F,CHLD,COH3) + I(F,INST,COH3) + I(F,SIN0..SIN3,COH3) + I(F,OTHR,COH3);

Immigration
39. N(M,ABROAD,COH0)=N(F,ABROAD,COH0);
40. N(M,ABROAD,COH1)=N(F,ABROAD,COH1);
41. N(M,ABROAD,COH2)=N(F,ABROAD,COH2);
42. N(M,ABROAD,COH3)=N(F,ABROAD,COH3);

Birth of child, or return of child to parents
43. I(M,COH0,COH1) = I(F,COH0,COH1);
44. I(M,COH1,COH2) = I(F,COH1,COH2);
45. I(M,COH2,COH3) = I(F,COH2,COH3);

Exit, death, or emigration of child

46. I(M,COH1,COH0) = I(F,COH1,COH0);
47. I(M,COH2,COH1) = I(F,COH2,COH1);
48. I(M,COH3,COH2) = I(F,COH3,COH2);

Formation of OTHR households

49. I(M,COH0,OTHR) = I(F,COH0,OTHR);
50. I(M,COH1,OTHR) = I(F,COH1,OTHR);
51. I(M,COH2,OTHR) = I(F,COH2,OTHR);
52. I(M,COH3,OTHR) = I(F,COH3,OTHR);

Constraints for children

Birth in private households

53. I(F,MAR0,MAR1) = B(M+F,MAR0,CHLD);
54. I(F,MAR1,MAR2) = B(M+F,MAR1,CHLD);
55. I(F,MAR2,MAR3) = B(M+F,MAR2,CHLD);
56. I(F,COH0,COH1) = B(M+F,COH0,CHLD);
57. I(F,COH1,COH2) = B(M+F,COH1,CHLD);
58. I(F,COH2,COH3) = B(M+F,COH2,CHLD);
59. I(F,SIN0,SIN1) = B(M+F,SIN0,CHLD);
60. I(F,SIN1,SIN2) = B(M+F,SIN1,CHLD);
61. I(F,SIN2,SIN3) = B(M+F,SIN2,CHLD);

Children leaving the parental household

62. I(F,COH1,COH0) + I(F,COH2,COH1) + I(F,COH3,COH2) + I(F,MAR1,MAR0) + I(F,MAR2,MAR1) + I(F,MAR3,MAR2) + I(M+F,SIN1,SIN0) + I(M+F,SIN2,SIN1) + I(M+F,SIN3,SIN2) = I(M+F,CHLD,COH0..COH3) + I(M+F,CHLD,MAR0..SIN3) + X(M+F,CHLD,DEAD) + X(M+F,CHLD,ABROAD);

Immigration

63. N(M+F,ABROAD,CHLD) = N(M,ABROAD,MAR1) + 2*N(M,ABROAD,MAR2) + 3.49*N(M,ABROAD,MAR3) + N(M,ABROAD,COH1)+ 2*N(M,ABROAD,COH2) + 3.12*N(M,ABROAD,COH3) + N(M+F,ABROAD,SIN1) + 2*N(M+F,ABROAD,SIN2) + 3.14*N(M+F,ABROAD,SIN3);

Constants 3.49, 3.12 and 3.14 in constraint 63 represent the average numbers of children in households of types MAR3, COH3 and SIN3, respectively. These values were estimated from the "household file" which was used to construct the population by age, sex and household position as of 31 December 1990 (see Section 3.2).

Capacity constraints for institutions

64. I(M,COH0..SIN3,INST) = I(M,INST,COH0..SIN3) + X(M,INST,DEAD);
65. I(F,COH0..SIN3,INST) = I(F,INST,COH0..SIN3) + X(F,INST,DEAD);

Consistency constraints 64 and 65 require that the numbers of men and women who enter an institution during the unit projection interval equal the numbers who leave an institution, including deaths. This leads to constant numbers of men and women living in an institution during the entire projection period. These constraints have been used in the five scenarios presented in Sections 4.1-4.4, but they were removed in the scenario in which we looked at the consequences for private households of an increased capacity in institutions for the elderly (Section 4.5).

External consistency: deaths, births, and immigrants according to 1993 based national forecasts

Numbers of deaths

Y(1) C1=226329;
Y(2) C1=223406;
Y(3) C1=221626;
Y(4) C1=221320;
Y(5) C1=222441;
Y(6) C1=226231;

66. X(M+F,CHLD..SIN3,DEAD) = C1;

External constraint no. 66 requires that the total number of deaths be as specified by constant C1. The values for this constant are given immediately above constraint 66, for each of the six five-year projection intervals (Y(1)-Y(6)) of the period 1990-2020. They correspond to the results of the Medium ("M1") variant of Statistics Norway's 1993 based set of population forecasts (Statistics Norway, 1994a), with observed numbers of deaths for the years before 1993. These values have been used in the four scenarios described in Sections 4.1 and 4.2-4.4. They were replaced by high and low values when projections were made in accordance with high and low fertility and mortality, see Section 4.2. Constants C2 and C3 below are used to control absolute numbers of births and net immigrations, respectively.

Numbers of births
Y(1) C2=303212;
Y(2) C2=302703;
Y(3) C2=287919;
Y(4) C2=272942;
Y(5) C2=273553;
Y(6) C2=285711;

67. B(M+F,CHLD..SIN3,CHLD) = C2;

Numbers of net immigrations
Y(1) C3=42997;
Y(2) C3=42500;
Y(3) C3=40000;
Y(4) C3=40000;
Y(5) C3=40000;
Y(6) C3=40000;

68. N(M+F,ABROAD,CHLD..SIN3) = C3;

Appendix 3

Weighting procedures for the household file

In this appendix we give a description of the three-step weighting procedure which was used in order to obtain unbiased information regarding the household structure of individuals living in private and institutional households. This information was used to construct the initial population for both the macrosimulations and the microsimulations. A random sample of 10,000 households was drawn from the 1990 Population and Housing Census. Weights were applied to individuals living in these households in order to correct for (i) bias due to unequal sample probabilities for persons in households of different sizes (Section A3.1); (ii) underrepresentation of persons in institutions, and the bias in their age-sex-distribution (Section A3.2); and (iii) bias in the age distribution of the sample of individuals obtained after the previous two steps (Section A3.3). In order to maintain the household size distribution of the sample, weights for step (iii) were applied to persons living in one-person households only.

The main concern of the work described here was to obtain representative information with respect to a number of household and other demographic variables, as compared to official statistics.

It should be noted that the household data that we obtain as a result of our corrections are *not* the official household data as of census date, as published by Statistics Norway. The latter information (see, for instance, Statistics Norway, 1992) corresponds largely to the *de jure* situation, that is, according to the Central Population Register (CPR). In our project, we are primarily interested in the *de facto* household situation of the population. Reasons for the differences are explained below.

The Central Population Register (CPR) was used as the "correct" answer in the 1990 Census. Thus, information from the census was not used to correct the CPR. On the contrary, if a respondent entered an address on the census form different from the one registered in the CPR, this person's address was changed in the census file and not in the CPR. The same applies to marital status. Because some household positions are not very well reflected in the register (see below) we did not want to rely completely on the information from the CPR. Consequently, we have based our household file on the census returns *before* these were corrected so as to agree with the CPR.

There are several reasons for inconsistencies between the actual and registered CPR address of individuals. Besides errors and omission of reporting household changes, the most important reasons are caused by the peculiarities of the population register. The CPR has an extensive set of rules for registration, of which we mention two particular cases (see, for example, Statistics Norway, 1985: 4).[16]

(1) A never-married person who resides outside the home of the parents because of education or military service is registered as living at the parents' address.
(2) A married person who resides outside the partner's dwelling because of labour, education, military service etc. is registered at the partner's house.

These rules imply that the following categories will be underestimated:
- students who actually live in student or other housing;
- persons in consensual unions;
- marriage partners who live apart, without having been registered as "separated".

[16] To a large extent, these rules are the same in other Nordic countries.

Indeed, a postenumeration sample survey carried out immediately after the 1990 Census found that the number of private households had been underestimated by 4-6 per cent. In particular there were too few one-person households in the census: 13 per cent (Statistics Norway, 1994c, p. 39, p. 87). Finally, note that people living in institutions, particularly in homes for old people, are often registered at their home address. Moves are only supposed to be registered if they are assumed to be effective for at least six months.

A3.1. Household size

The starting point is a sample of 10,000 individuals born in 1974 or earlier. These persons are referred to as "primary persons" henceforth. Next, for each primary person in a private household, the census records of other household members were added, which resulted in a file containing 28,384 individuals living in nearly 10,000 households (a few primary persons belonged to the same household). For each person in this file we knew the date of birth, sex, marital status, family number and household number. This information stems from the Central Population Register (CPR). The number of persons with the same household number gave us the household size. We also had, for at least one person in each household, the answer to the first question in the census form: "With whom do you share this dwelling?" (see Section 3.2). These answers were used for constructing individual household positions for all persons in the file. Constructing a file with the required household information for *all* households in Norway, instead of only a sample of 10,000, would not have been possible within the framework of the household projection project.

The bias which results from the fact that individuals living in large households have a larger sample probability than those in small households has been corrected by applying, to all persons living in a private household[17] of size n in the sample, a weight factor a_n, where n equals the number of persons in the household born in 1974 or earlier. When we require that the total number of households remain unchanged after weighting, it is straightforward to show that a_n equals $\tilde{n}/n$, where $\tilde{n}$ represents the average household size in the population. The latter variable may be estimated by $h/\Sigma(p_k/k)$, where h is the number of households in the sample, k represents household size, p_k is the sample number of primary persons living in a household with size k, and the sum is taken over all values of k. The result is

$$a_n = \{h/\Sigma(p_k/k)\}/n \qquad \text{(A3.1)}$$

The factor between curled brackets in expression (A3.1) does not depend on household size, and it is the same for all individuals and households.

Weight factors calculated by means of expression (A3.1) will generally have non-integer values. However, in the microsimulation model we cannot handle "fractional" households and individuals. Therefore we proceeded by deleting (for weight factors below 100 per cent) and duplicating (for weight factors over 100 per cent) an appropriate share of the unweighted households. The latter households (given the share) were chosen randomly, for each household size, from the list of unweighted households. Children born in 1975 or later and persons living in institutions were first removed from the unweighted sample of 10,000 households. Table A3.1 presents results of the calculations.

Table A3.1. Results of the weighting procedure to correct for bias in the household size distribution

	Size n 1	2	3	4	5	6	7	1-7	Average household size
1. Number of households before weighting	2119	4420	1937	1129	305	53	6	9969	2.33
2. Weight factor	1.87	0.94	0.62	0.47	0.37	0.31	0.27		
3. Number of households after weighting	3965	4135	1208	528	114	17	2	9969	1.87
4. Number of households to be added(+)/removed(-)	+1846	-285	-729	-601	-191	-36	-4	0	
5. % incl. children	36.0	27.9	14.0	14.8	5.6	1.4	0.3	100[1]	2.32
6. % official	34.3	26.3	15.2	16.0	-------- 8.3[2] --------			100[3]	2.40

[1] Sizes 1-13. [2] Size 5 and more. [3] All sizes.
Source for the distribution in line 6: Statistics Norway (1992: 38).

[17] Institutional households are described in Section A3.2.

The first line gives the numbers of private households broken down by size, after children have been removed. It is truncated at size 7 - including larger households would not have changed the findings. Weighting is clearly necessary: the 9969 private households have an average size of 2.33, even when children are not counted. Including children would imply a rise in average household size by 0.5 approximately. Western countries nowadays have typical average household sizes of between 2.1 and 2.6.

The factor $h/\{\Sigma(p_n/n)\}$, which is an estimator for average household size in the population (not counting children), was evaluated as 1.871. Next, the factor a_n for each household size n was found as 1.871 divided by n (line 2). Line 3 gives the weighted number of private households (rounded to the nearest integer). The difference between weighted and original numbers of households in line 4 tells us how many households have to be duplicated (size 1) or deleted (sizes 2 and over). For instance, 1,846 new one-person households have to be created. This was done by choosing, at random, 1,846 households from the original 2,119.

The result is that after weighting there will be hardly any large households left (not counting children). Line 5 gives the size distribution of the weighted private households, after the children have been added again. This distribution may be compared with the official distribution in line 6. The average household size in our reweighted sample (2.32) is lower than the official figure (2.40). The shares of both one-person households and two-person households in our sample are about 2 percentage points higher, respectively, than the corresponding official figures. Shares of households with three or more persons are a few percentage points lower than those published by Statistics Norway. This does not come as a surprise. It may be explained by the fact that we have worked with raw data, which correspond better (although not perfectly) to the actual household situation than the official data, which rely strongly on the Central Population Register. A number of persons, although registered living with their parents, or living with a marriage partner, have reported that they actually live on their own.

A3.2. Weighting of persons living in institutions

The procedure described in the previous section applies to private households only. The reason is that, to the record of each primary person living in an institution, those for the other persons living in that institution were *not* added (as was done for household members of primary persons living in private households). Therefore, a check on sample members in institutional households was necessary, which revealed that they were underrepresented in the sample (see below). To correct this, a further weighting procedure was carried out, which consisted of two sub-steps:

1. a weighting of sample members living in institutions such that their share in the total sample corresponds to the population share;
2. an adjustment of the age distribution of the institutionalized sample members obtained in the previous sub-step, to make this distribution in agreement with the corresponding population distribution.

Both steps were done for males and females separately. The formulas are given below.

Denote the sample members aged x who live in a household of type h by $p_{x,h}$. (Note that p now stands for *all* individuals, not only primary persons.) The sum over all ages of $p_{x,h}$ is written as $p_{.,h}$. We write h=1 for private households, and h=2 for institutions.

To carry out the first sub-step, multiply each sample member living in an institution by a weight w such that

$$w.p_{.,2}/\{p_{.,1}+w.p_{.,2}\} = \alpha,$$

where α equals the observed share of the institutionalized population within the total population. Solving for w yields

$$w = \{p_{.,1}/p_{.,2}\}.\{\alpha/(1-\alpha)\}. \quad \text{(A3.2)}$$

Table A3.2 shows initial (unweighted) numbers of sample members in private and institutional households, and observed shares for the whole population. We note that both numbers of males and females have to be more than doubled. The reason for the underrepresentation is that census forms for persons living in institutions were generally filled in by the institution's administrative staff, following a guideline telling that only persons registered as living in the institution (according to the CPR) should be counted. This implies that only persons who intended to stay for at least six months (upon entrance) are recorded as institutionalized. However, published statistics for institutions for the elderly, which were used for computing the shares α, are

Table A3.2. Sample members in private households and in institutions, population shares of institutionalized population, and weight factors for institutionalized sample members

	Sample members in		Population share of institutionalized population[1]	Weight factor	Sample members in institutions, weighted
	Private households	Institutions			
	($p_{.,1}$)	($p_{.,2}$)	(α)	(w)	($w.p_{.,2}$)
Males	11335	33	0.0066	2.28	75
Females	11775	82	0.0147	2.14	175

[1] Computed on the basis of the observed population as of Census date, and the number of elderly in institutions as of 15 January 1991, see "Statistisk ukehefte 35/1991", p. 3, and "Norges offisielle statistikk B 961: Folke- og boligtelling 1990 - Foreløpige hovedtall", p.12.

based on the institutions' administrations, and these cover persons who stay there for a period shorter than six months as well. Since the interest is primarily in the *de facto* household situation of the population, the census information was adjusted to correspond to the data according to the published statistics on institutions for the elderly.

To control for the age distribution of the institutionalized, we computed, on the basis of numbers obtained in the previous sub-step, age-specific weights w_x such that

$$w_x.p_{x,2}/(\Sigma w_x.p_{x,2}) = ß_x, \tag{A3.3}$$

where $ß_x$ is the observed share of age x in the institutionalized population $p_{x,2}$. Information on $ß_x$ is obtained from Table 3 in "*Statistisk ukehefte* 35/1991", in which six age classes are distinguished. By collapsing the very young (under 16) with the next age class, we arrive at the following five groups: <67, 67-79, 80-84, 85-89, 90+. These five groups correspond to values for x ranging from 1 (<67) to 5 (90+). Writing expression (A3.3) for each of the five age classes and solving for w_1, ..., w_5 yields

$$\mathbf{w} = \mathbf{M}^{-1}.\mathbf{r},$$

where **w** is a column vector containing the five weights, **M** is a 5 by 5 coefficient matrix, and **r** is a column vector with the first four elements equal to zero, and the fifth element equal to $p_{.,2}$, i.e. the total number of institutionalized sample members. The bottom row of **M** consists of elements $p_{x,2}$, x = 1, ..., 5. The corresponding equation in the system preserves the total number $p_{.,2}$. Diagonal elements of **M** are equal to $(1-ß_x).p_{x,2}$ for x = 1,..., 4. Any off-diagonal element in column x and row y consists of the product $-ß_y.p_{x,2}$. Table A3.3 presents details of the computations.

Cells in columns "$p_{x,2}$ weighted" are obtained by rounding the product $w_x.p_{x,2}$, in such a way that the sum over all ages remains equal to $\Sigma p_{x,2}$ for each sex. The results in Table A3.3 indicate that relatively strong adjustments are required for females, whereas those for males are rather modest. Apart from sampling errors, one explanation is that females under 85 in particular experience intended stays shorter than six months in an institution.

A3.3. Reconciliation of the age distribution of all sample members

It is useful to check the distribution by age and sex against population statistics per Census date. However, in case of severe biases, it will not be possible to apply new individual weights to each person of a certain age in order to correct for such a bias, without distorting the distribution by household size - it would also imply that the set of households is no longer closed, as different members of the same household may get different weights. In other words, it would produce additional persons who cannot be located in a household.

Table A3.3. Age-specific shares, numbers, weights, and weighted numbers of institutionalized persons

Age	Males				Females			
	Share (%)	Number	Weight	Weighted number	Share (%)	Number	Weight	Weighted number
(x)	($ß_x$)	($p_{x,2}$)	(w_x)	($p_{x,2}$)	($ß_x$)	($p_{x,2}$)	(w_x)	($p_{x,2}$)
<67	7.8	5	1.16	6	2.8	4	1.23	5
67-79	29.8	23	0.97	22	20.7	30	1.21	36
80-84	23.7	18	0.99	18	24.7	32	1.35	43
85-89	23.5	18	0.98	18	28.8	60	0.84	51
90+	15.3	11	1.04	11	23.0	49	0.82	40
Sum		75		75		175		175

Therefore, we have used one-person households to adjust for the bias by sex and age. Leaving the weighted number of (persons in) one-person households unchanged we redistributed these persons inside the three-dimensional table containing persons broken down by age, sex and household size (1, >1) in such a way that the two-dimensional distribution for *all* weighted sample members (irrespective of household size) is the same as that for the whole population.

The calculations were performed for males and females separately. We applied age-specific weights v_x to persons living alone (denoted by $p_{x,11}$), such that the age distribution of all sample members, irrespective of household position, corresponded to that of the population, expressed by shares μ_x. We use $p_{x,0}$ for the individuals aged x in the sample who live in a household *other* than a one-person household. Provided that there are enough one-person households of each age, the weights v_x may be determined such that

$$(v_x.p_{x,11}+p_{x,0})/\Sigma(v_x.p_{x,11}+p_{x,0}) = \mu_x, \text{ and}$$

$$\Sigma\, v_x.p_{x,11} = \Sigma\, p_{x,11}. \qquad \text{(A3.4)}$$

Information on the age distribution of the population as of Census date in 5-year age groups has been used. The youngest age group in the sample for which we have one-person households is 15-19. Therefore, the computations were carried out for 16 age groups: 15-19 (x=1), 20-24 (x=2), ..., 85-89 (x=15), and 90+ (x=16). The shares μ_x, for which the sum equals 1, apply to ages 15 and over. The solution to the linear system defined by (A3.4) is given by

$$\mathbf{v} = \mathbf{N}^{-1}.\mathbf{s},$$

where **v** is a column vector with length 16 containing the weights $v_1, v_2, ..., v_{16}$; **N** is a 16 by 16 coefficient matrix; and **s** a vector with 16 elements. The last element of **s** equals $p_{.,11}$, and the x-th element is $\mu_x.p_{.,0}-p_{x,0}$ for $1 \le x \le 15$. The bottom row of the matrix **N** consists of elements $p_{x,11}$, where x is the number of the column ($1 \le x \le 16$). On the diagonal we find in row number x the element $p_{x,11}.(1-\mu_x)$, $1 \le x \le 15$. Any off-diagonal element in column x ($1 \le x \le 16$) and row y ($1 \le y \le 15$) consists of the product $-\mu_y.p_{x,11}$.

Table A3.4 presents details of the computations. The weights v_x are much more irregular for males than for females. Outliers for males are ages 15-19 and 85-89, with weights 3.95 and 0.16, respectively. The negative weight for females (-1.43 for ages 15-19) implies that there were too few females in one-person households to correct for the bias in the age distribution. It was decided to leave their number (17) unchanged, which implies that the share of age group 15-19 will not be (886-1.47*17)/(2076+7871)=8.7 per cent, but rather (886+17)/9988=9.0 per cent. The shares of the remaining age groups are virtually on target (μ_x-column).

Table A3.4. Computation of weights for one-person households to obtain unbiased age distributions for males and females

	Persons living alone ($p_{x,11}$)	Other persons ($p_{x,0}$)	Age group's share (%) (μ_x)	Weight (v_x)	Persons living alone, weighted ($v_x \cdot p_{x,11}$)	All persons, weighted
Males						
15-19	17	804	9.4	3.95	67	871
20-24	108	787	10.2	1.47	159	946
25-29	242	666	9.9	1.04	251	917
30-34	190	729	9.6	0.85	162	891
35-39	151	700	9.3	1.09	165	865
40-44	111	787	9.6	0.94	104	891
45-49	82	619	7.8	1.27	104	723
50-54	67	473	6.0	1.18	79	552
55-59	51	464	5.4	0.67	34	498
60-64	90	461	5.6	0.68	61	522
65-69	90	437	5.7	1.05	95	532
70-74	110	336	4.8	1.02	112	448
75-79	74	254	3.4	0.87	65	319
80-84	69	154	2.0	0.47	33	187
85-89	48	75	0.9	0.16	8	83
90+	14	15	0.3	1.11	15	30
15+	1514	7761			1514	9275
Females						
15-19	17	886	8.7	-1.43	17	903
20-24	101	769	9.3	1.58	159	928
25-29	145	722	9.0	1.18	172	894
30-34	113	756	8.8	1.05	118	874
35-39	73	737	8.5	1.51	110	847
40-44	54	807	8.7	1.04	56	863
45-49	70	638	7.2	1.07	75	713
50-54	66	509	5.7	0.84	56	565
55-59	77	416	5.3	1.43	110	526
60-64	156	412	5.7	1.01	158	570
65-69	183	417	6.3	1.14	209	626
70-74	338	312	5.9	0.82	277	589
75-79	294	236	4.8	0.82	242	478
80-84	229	123	3.4	0.95	218	341
85-89	121	82	1.9	0.87	106	188
90+	39	49	0.8	0.87	34	83
15+	2076	7871			2117	9988

Appendix 4

Constructing rates for decrease in household parity

When a child leaves the parental household, or when it dies, its parent(s) experience a decrease in household parity. In the macrosimulation part of the household model this is governed, for females, by the age- and sex-specific rates I(F,MARn,MARn-1), I(F,COHn,COHn-1) and I(F,SINn,SINn-1) for n=1,2,3, and by similar rates for males. There are no Norwegian data on the basis of which we can estimate such rates. Dutch and Swedish data cannot be used either, as these do not include household parity. Therefore we use an indirect estimation technique to construct such rates on the basis of a convolution of fertility rates for mothers and combined home leaving/death rates for children. The unit time interval and age interval are five years long.

Take a life table perspective and follow cohorts of women and young adults at successive ages. Let $h(x)$ be a set of rates describing home leaving or death for young adults aged x at time t. Assume that these rates are constant on the interval $(x,x+5)$. The probability that a child disappears from the parental home during this interval is

$$(1-\exp(-5h(x))) \tag{A4.1}$$

Let the share of women aged y who have a child aged x of a certain parity be denoted as $s(y,x)$. The probability that a woman aged y at time t experiences a child of any age leaving her household during $(y,y+5)$ is

$$\int_x s(y,x)\{1-\exp(-5h(x))\}dx \tag{A4.2}$$

Let $f(y)$ be a set of age-specific fertility rates for women aged y and a certain parity. The probability that a woman aged y has a child between ages y and $y+5$ is

$$1-\exp(-5f(y)).$$

Disregarding mortality among the mothers, and assuming that each child stays in the same household as the mother until it ultimately leaves her as result of $h(x)$, we find that

$$s(y,x) = \exp(-5\sum_{i=15}^{i=y-x-5} f(i))\{1-\exp(-5f(y-x))\}$$

The first exponential keeps track of the childless women up to age y-x-5 years old. The second exponential describes the children that were born in the 5-year interval immediately thereafter. With this expression we can write the probability of a decrease in household parity during $(x,x+5)$ as

$$\int_x \exp(-5\sum_{i=15}^{y-x-5} f(i))\{1-\exp(-5f(y-x)\}\{1-\exp(-5h(x))\}dx$$

In discrete time the above expression becomes

$$\sum_x \{\exp(-5\sum_{i=15}^{y-x-5} f(i))\}\{1-\exp(-5f(y-x))\}\{1-\exp(-5h(x))\} \tag{A4.3}$$

In case we make a second assumption, namely that fertility rates are constant over time ($f(y,t)=f(y)$ for every t), we can change from a life table to a projection model perspective and use expression A4.3 for the household projection. Home leaving is restricted to three age groups (age as of 1 January of a certain projection interval): 15-19 ($x=15$), 20-24 ($x=20$), and 25-29 ($x=25$). Fertility rates are defined for age groups 15-19 ($y=15$) to 40-44 ($y=40$). Thus, when writing $P_1(y-x-5)$ for the first factor in curled brackets in (A4.3), $P_2(y-x)$ for the second one, and $P_3(x)$ for the third factor in curled brackets, we obtain the following scheme:

Woman's probability for decrease in household parity			
age (y)	child's age (x) 25	20	15
30			$P_2(15).P_3(15)$
35		$P_2(15).P_3(20)+P_1(15).P_2(20).P_3(15)$	
40	$P_2(15).P_3(25)+P_1(15).P_2(20).P_3(20)+P_1(20).P_2(25).P_3(15)$		
45	$P_1(15).P_2(20).P_3(25)+P_1(20).P_2(25).P_3(20)+P_1(25).P_2(30).P_3(15)$		
50	$P_1(20).P_2(25).P_3(25)+P_1(25).P_2(30).P_3(20)+P_1(30).P_2(35).P_3(15)$		
55	$P_1(25).P_2(30).P_3(25)+P_1(30).P_2(35).P_3(20)+P_1(35).P_2(40).P_3(15)$		
60	$P_1(30).P_2(35).P_3(25)+P_1(35).P_2(40).P_3(20)$		
65	$P_1(35).P_2(40).P_3(25)$		

The 5-year probabilities obtained with this scheme may be transformed into rates according to $m=-\ln(1-p)/5$, where m is the rate and p is the probability.

When $f_n(y)$ denotes the rate for birth of a child of parity n ($n=1,2,3$), substitution of $f_n(y)$ for $f(y)$ in the expressions above yields the rate for decrease from household parity n to n-1. The rate for a decrease in household parity of men aged y will be assumed equal to the corresponding rate for women aged y-2.5.

Table A4.1 gives the fertility rates by household position of the mother as estimated from the Women file for the year 1990, see Section 3.3. The rates in Table A4.2 are obtained as the sum of the rates for home leaving and death, as both events lead to a decrease in household parity. Table A4.3 is derived from Table A4.1 using expression (A4.1), and Table A4.4 is based on expression (A4.3). In Table A4.4 and subsequent tables, COHn, MARn and SINn (n=0,1,2) denote the household positions of *destination*, i.e. the woman's new position after the child has left or died. Although the assumptions behind expression (A4.2) are not fulfilled in reality (particularly the assumption of constant fertility), the age-specific patterns in Table A4.4 look plausible. Yet the levels of the rates are a bit too low, which is reflected in the fact that the 40-year probability of experiencing a decrease in household parity (Table A4.5, last row) is below 100 per cent. To correct for this, we have applied to the elements in each column of Table A4.5 a proportionality factor such that the probability for a decrease in household parity between ages 30 and 69 (that is, one minus the product of the complements of the age-specific probabilities for each column) equals 99 per cent.[18] Table A4.6 gives corrected probabilities, which have been transformed into rates for females in Table A4.7. A simple linear interpolation (assuming that men are 2.5 years older than women) resulted in rates for males, see Table A4.8.

Table A4.1. Fertility rates by household position of the mother just before birth

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
15-19	0.1448	0.0518	0	0.7116	0.1206	0	0.0352	0.0249	0
20-24	0.1240	0.0647	0	0.5073	0.1802	0.0439	0.0184	0.0287	0.3158
25-29	0.1080	0.0946	0.0729	0.3465	0.2584	0.0878	0.0171	0.0407	0.0523
30-34	0.1319	0.1191	0.0561	0.2825	0.2331	0.0603	0.0131	0.0218	0.0114
35-39	0.0442	0.0763	0.0300	0.09	0.097	0.0258	0.0243	0	0
40-44	0	0	0.0139	0	0.0102	0.006	0.0154	0	0

[18] A level of 99 per cent was chosen to allow some rare cases to experience a decrease in household parity after age 69. The probability in the last row is $P_{30-69}=1-\prod_{i=1}^{8}(1-p_i)$, where i denotes a particular 5-year age group. In case we would have chosen 100 instead of 99 per cent the result would simply have been that the largest entry in each column in Table A4.5 would have to be adjusted to exactly 100 per cent, which is implausible.

Table A4.2. Rates and probabilities for the combined event of home leaving and death, both sexes

	Rate	Probability
15-19	0.0844	0.3443
20-24	0.2374	0.6949
25-29	1	0.9933

Table A4.3. Life-table probability for not having had a child at the end of each age group

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
15-19	0.4848	0.7718	1	0.0285	0.5472	1	0.8386	0.8829	1
20-24	0.2608	0.5585	1	0.0023	0.2222	0.8029	0.7649	0.7649	0.2062
25-29	0.1520	0.3480	0.6945	0.0004	0.0611	0.5176	0.7022	0.6241	0.1587
30-34	0.0786	0.1919	0.5247	0	0.0190	0.3829	0.6577	0.5596	0.1499
35-39	0.0630	0.1310	0.4516	0	0.0117	0.3366	0.5825	0.5596	0.1499
40-44	0.0630	0.1310	0.4213	0	0.0111	0.3266	0.5393	0.5596	0.1499

Table A4.4. Probability for childbirth during each age group, women

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
15-19	0.5152	0.2282	0	0.9715	0.4528	0	0.1614	0.1171	0
20-24	0.4621	0.2764	0	0.9209	0.5938	0.1971	0.0879	0.1337	0.7938
25-29	0.4173	0.3769	0.3055	0.8232	0.7253	0.3553	0.0819	0.1841	0.2301
30-34	0.4829	0.4487	0.2446	0.7565	0.6882	0.2603	0.0634	0.1033	0.0554
35-39	0.1983	0.3172	0.1393	0.3624	0.3843	0.121	0.1144	0	0
40-44	0	0	0.0671	0	0.0497	0.0296	0.0741	0	0

Table A4.5. Probability for decrease in household parity, women

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
30-34	0.1774	0.0786	0	0.3345	0.1559	0	0.0556	0.0403	0
35-39	0.4351	0.232	0	0.6841	0.4265	0.0678	0.1375	0.1220	0.2733
40-44	0.7048	0.4473	0.1052	0.9838	0.7311	0.2352	0.2331	0.2468	0.5679
45-49	0.3234	0.4119	0.2707	0.0275	0.4492	0.4404	0.1321	0.2373	0.8245
50-54	0.1644	0.3385	0.4466	0.0021	0.1918	0.3929	0.1191	0.1847	0.0532
55-59	0.0837	0.1974	0.2300	0.0003	0.0470	0.1695	0.1114	0.0640	0.0087
60-64	0.0155	0.0604	0.0937	0	0.0077	0.0529	0.1047	0	0
65-69	0	0	0.0301	0	0.0006	0.0099	0.0429	0	0
30-69	0.9300	0.8853	0.7555	0.9967	0.9452	0.8114	0.6363	0.6306	0.9483

Table A4.6. Corrected probabilities: proportional adjustment of entries in Table A4.5 so that the total (30-69) equals 99 per cent, women

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
30-34	0.2323	0.1328	0	0.3244	0.1949	0	0.1889	0.1269	0
35-39	0.5700	0.3921	0	0.6636	0.5331	0.1309	0.4675	0.3842	0.3170
40-44	0.9233	0.7560	0.2177	0.9543	0.9138	0.4539	0.7925	0.7773	0.6588
45-49	0.4236	0.6961	0.5604	0.0266	0.5615	0.8499	0.4491	0.7475	0.9564
50-54	0.2154	0.5721	0.9245	0.0020	0.2398	0.7584	0.4049	0.5817	0.0618
55-59	0.1097	0.3336	0.4760	0.0003	0.0588	0.3270	0.3787	0.2016	0.0101
60-64	0.0203	0.1021	0.1939	0	0.0096	0.1022	0.3561	0	0
65-69	0	0	0.0623	0	0.0007	0.0191	0.1458	0	0
30-69	0.9900	0.9900	0.9897	0.9899	0.9899	0.9898	0.9900	0.9899	0.9906
corr. factor	1.31	1.69	2.07	0.97	1.25	1.93	3.40	3.15	1.16

Table A4.7. Rates for decrease in household parity, women

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
30-34	0.0529	0.0285	0	0.0784	0.0433	0	0.0419	0.0272	0
35-39	0.1688	0.0995	0	0.2179	0.1523	0.0281	0.1261	0.0970	0.0763
40-44	0.5137	0.2821	0.0491	0.6172	0.4903	0.1210	0.3145	0.3004	0.2151
45-49	0.1102	0.2382	0.1644	0.0054	0.1649	0.3793	0.1193	0.2752	0.6264
50-54	0.0485	0.1698	0.5166	0.0004	0.0548	0.2841	0.1038	0.1743	0.0127
55-59	0.0232	0.0812	0.1293	0	0.0121	0.0792	0.0952	0.0450	0.0020
60-64	0.0041	0.0215	0.0431	0	0.0019	0.0216	0.0880	0	0
65-69	0	0	0.0129	0	0.0001	0.0039	0.0315	0	0

Table A4.8. Rates for decrease in household parity, men

	COH0	COH1	COH2	MAR0	MAR1	MAR2	SIN0	SIN1	SIN2
30-34	0.0264	0.0142	0	0.0392	0.0217	0	0.0209	0.0136	0
35-39	0.1108	0.0640	0	0.1482	0.0978	0.0140	0.0840	0.0621	0.0381
40-44	0.3412	0.1908	0.0245	0.4175	0.3213	0.0745	0.2203	0.1987	0.1457
45-49	0.3119	0.2602	0.1067	0.3113	0.3276	0.2502	0.2169	0.2878	0.4207
50-54	0.0794	0.2040	0.3405	0.0029	0.1099	0.3317	0.1115	0.2248	0.3196
55-59	0.0359	0.1255	0.3229	0.0002	0.0335	0.1816	0.0995	0.1097	0.0074
60-64	0.0137	0.0514	0.0862	0	0.0070	0.0504	0.0916	0.0225	0.001
65-69	0.0020	0.0108	0.028	0	0.0010	0.0127	0.0598	0	0
70-74	0	0	0.0064	0	0	0.0019	0.0158	0	0

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