IIASA
International Institute for
Applied Systems Analysis
www.iiasa.ac.at

Impacts of Demographic Events on US Household Change

Jiang, L. and O'Neill, B.C.

IIASA Interim Report
August 2006

International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 342
Fax: +43 2236 71313
E-mail: publications@iiasa.ac.at
Web: www.iiasa.ac.at

Interim Report **IR-06-030**

Impacts of Demographic Events on US Household Change

Leiwen Jiang (Leiwen_Jiang@brown.edu)
Brian C. O'Neill (oneill@iiasa.ac.at)

Approved by

Leen Hordijk (hordijk@iiasa.ac.at)
Director

August 8, 2006

Contents

Abstract

Understanding the determinants and consequences of changes in household size and structure is important to a wide range of social, economic, and environmental issues. In the U.S., living arrangements have undergone tremendous changes over the past 200+ years, but have been relatively stable since 1980. What drove these changes, and whether the recent stability can be expected to continue, are critical questions. While research has identified demographic events that drive particular types of changes in households, a systematic understanding of past and potential future changes is lacking. We use a household projection model to assess the sensitivity of household size and structure to various demographic events, and show that outcomes are most sensitive to changes in fertility rates and union formation and dissolution rates. They are less sensitive to the timing of marriage and childbearing and to changes in life expectancy. We then construct a set of future scenarios designed to reflect a wide but plausible range of outcomes, including a new set of scenarios for union formation and dissolution rates based on past trends, experience in other countries, and current theory. We find that the percentage of people living in households headed by the elderly may climb from 11% in 2000 to 20-31% in 2050 and 20-39% in 2100, while the average size of households could plausibly be as low as 2.0 or as high as 3.1 by the second half of the century.

Acknowledgments

This paper has been submitted to *Population and Development Review*. The authors wish to thank Zeng Yi and Zhenglian Wang for sending the ProFamy software and their input file describing base year conditions, which we use as a starting point for US household projections.

Work described in this article was supported in part by the U.S. Environmental Protection Agency (EPA) through grant/cooperative agreement # R-82980101, and the Office of Science (BER), U.S. Department of Energy, Grant No. DEFG02-01ER63216, both to Brown University. This research has not been subjected to the EPA's required peer and policy review and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred.

About the Authors

Dr. Brian O'Neill is the Leader of the Population and Climate Change Program at IIASA, and an Associate Professor (Research) at the Watson Institute for International Studies, Brown University, Providence, USA.

Dr. Leiwen Jiang is an Assistant Professor (Research) in the Global Environment Program at the Watson Institute for International Studies, Brown University, Providence, USA, and a Guest Research Scholar in the Population and Climate Change Program at IIASA.

Impacts of Demographic Events on US Household Change

Leiwen Jiang
Brian C. O'Neill

Background

Household size and composition have changed tremendously since the establishment of the United States, a result of a continuous process of household fission and decline in the importance of the family (Kobrin 1976; Ermisch and Overton 1985). Progression through the traditional family life cycle has become less common as people remain unmarried for longer, cohabitation and union dissolution have become easier and more acceptable, and the remarriage rate has declined. These social changes are reflected in large changes in demographic measures of household characteristics. The average household size has more than halved since 1790, dropping from 5.8 persons per household to 2.67 in 2000. The proportion of households with just one person increased from 3.7 percent in 1790 to 13 percent in 1960 and further to 26 percent in 2000. And non-family households which consist primarily of people who live alone or share housing with non-relatives have been on the rise.

While the change in household composition was a continuous process, it accelerated after 1960. In 1960, 85 percent of households were family households; this figure dropped to 69 percent by 2000. Two-parent family households with children declined from 44 percent to 24 percent of all households between 1960 and 2000. Over the same period, unmarried-couple households increased from less than 1 percent to about 5 percent of total households and have become progressively more likely to include children. The number of single-parent (particularly single-mother) households increased from 1.5 million in 1950 to 9.5 million in 2000 (Bianchi and Casper 2000).

Most of the changes in household formation and dissolution during this period happened before the early 1980s. Trends since the 1980s suggest a slowing or even in some cases cessation of changes in household living arrangements: very little change in the proportion of two-parent or single-mother household, stabilized living arrangements for young adults and the elderly, a slowing growth in divorce and cohabitation, and an almost unchanged average household size during the 1990s. It is unclear whether this recent stability indicates a new sustained equilibrium, or is just a temporary lull (Bianchi and Casper 2000).

Here we develop a set of projections of future living arrangements to explore this question. Anticipating changes in the number, size, and composition of households is an important element of many issues of social concern. For example, the living arrangements of the elderly are a key determinant of their needs for socio-economic, physical and emotional assistance. Older persons who live alone are more likely to be in poverty than older persons who live with their spouses (Dalaker 1999) and have greater needs for healthcare. Projections of household growth and its composition by size are also crucial inputs to the development of housing policy for many states and local governments (Holmberg 1987; King 1999; Muller et al. 1999; Canada Depository Service Program 1996; Scottish Executive 2000). In addition, much research stresses the importance of household characteristics, especially those linked to household life cycle stages, to understanding savings and consumption patterns. These patterns have important implications not only for welfare at the household level, but may also have substantial macro-economic effects (Deaton and Paxson 2000; Tsai et al. 2000; Gokhale et al. 1996). Household type and size are also important determinants of the mix of consumption across different types of goods (Wilkes, 1995).

Furthermore, there is a growing appreciation that shifts in distributions of households by type and size, through their effects on consumption patterns, can have important environmental consequences (O'Neill et al. 2001). Recent work links changing living arrangements to effects on biodiversity (Liu et al. 2003), land use (Perz 2001; MacCracken et al. 1999; Van Diepen 1995), carbon dioxide emissions (Dalton et al. 2006), household energy use (O'Neill and Chen 2002; Jiang 1999; MacKeller et al. 1995), transportation (Fuernkranz-Prskawetz et al. 2001; Carlsson-Kanyama and Linden 1999; Select Committee 1998), and water (Jiang 1999; Martin 1999). This emerging line of work is moving beyond the approach typical in the past of treating population size as the only relevant demographic variable when considering environmental impact.

In the past three decades, particularly in the 1970s and 1980s, a number of studies have been devoted to investigating the demographic determinants of past household changes in the US (Burch 1970; Burch and Mathews 1987; Carliner 1975; Ermisch and Overton 1985; Kobrin 1973, 1976; Richards, White and Tsui 1987; Santi 1987, 1988; Sweet 1984; Teachmen 1982; Watkins, Menken and Bongaarts 1987; White and Tsui 1986). While each is informative, taken as a group they are incomplete: most focus only on the determinants of a certain household type (e.g. family households, single-mother households, or elderly households), or on the influence of one demographic event (e.g., mortality or fertility). Conclusions have not always been clear since demographic events can have complex effects on household types. For example, the effect of immigration is complicated by a variety of patterns of residence upon arrival to the U.S. (Hunton 1998) and of changes after arrival as economic and social situations change (Burr and Mutchler 1993). The effects of fertility and mortality on household size have been shown to vary over time as underlying demographic conditions change (Kobrin 1976). In some cases studies have even been contradictory. For example, Burch (1970) concluded that under all family systems (nuclear, stem and extended family), life expectancy is positively correlated with average household size. On the other hand, Kobrin (1976) maintains that mortality decline increases the importance of one- and two-person households and therefore contributes to a fall in household size.

Simulation is an alternative approach, but although a number of household simulation models have been developed over the past three decades, we are not aware of any systematic study of the influence of demographic factors on household changes. Several studies have reviewed the changes in household headship and its determinants in the US, but either related those changes to general socioeconomic (rather than demographic) conditions (Carliner 1975), or decomposed the separate influences of changing population structure and overall propensity of household formation (Kobrin 1973; Sweet 1984). Such studies cannot identify how specific demographic events lead to particular changes in household composition. A recent effort by Zeng et al (2003), using the extended household projection model ProFamy, developed three scenarios of future household change for the U.S. Assumptions about future fertility, mortality, and migration were adopted from the US Census Bureau 2000 population projection, and, in the absence of available scenarios for rates of union formation/dissolution, arbitrary assumptions were adopted.

In this study we use ProFamy to (1) carry out a thorough sensitivity analysis of future living arrangements to various demographic events; and (2) construct a set of scenarios intended to span a wide but plausible range of outcomes for composition of the population by household age structure and size. The second goal requires the development of scenarios not only for familiar components of change in a population projection (fertility, mortality, and migration) but also for factors affecting household formation and dissolution such as divorce, cohabitation, age at leaving home and age at marriage, and propensity of the elderly to live with children. Here the literature is sparse and we break new ground in justifying our scenarios based on past trends and theoretical reasoning.

In section 2 we briefly describe the household projection model and the data used. Section 3 describes the sensitivity analysis, and section 4 develops the input assumptions for our set of scenarios. Section 5 discusses the results of our household scenarios, and a concluding discussion is provided in section 6.

Data and methodology

We adopt the macro-dynamic household projection model ProFamy developed by Zeng and his collaborators (Zeng, Vaupel and Wang 1997, 1998). Zeng extended Bongaarts's nuclear status life table model (Bongaarts 1987) into a general family household simulation macro model that includes both nuclear and three-generation family households (Zeng 1986, 1988, 1991). It was further extended and developed into a two-sex dynamic model, known as ProFamy, that permits demographic schedules to change over time and requires only the conventional data sources of survey data, vital statistics and census data (Zeng, Vaupel and Wang 1997, 1998). Projections are performed based on status transition rates, and then distributions of households by size and type are derived based on characteristics of reference persons (or household 'markers') in a manner that produces consistent projections of households and individuals. Individuals in the projected population are classified according to 8 dimensions of demographic status: age, sex, marital status, parity, number of children living at home, co-residence with parents, private or collective household, and races.

The ProFamy approach is attractive in that it allows for direct specification of demographic rates, requires data only from conventional sources, and produces a wealth of detailed output on projected household types. It has been used to make population and household projections for China (Zeng, Wang, Jiang and Gu submitted) and two regions of China (Jiang 1999), Austria (Prskawetz, Jiang and O'Neill 2004), Germany (Hullen 2003), and the U.S. (Zeng et al. 2003).

Projections require base-year population and household type data, as well as estimations of current summary measures and standard schedules, which we adopt from

Zeng et al. (2003). We develop our own scenarios of future summary measures of fertility, mortality, union formation and dissolution, migration, leaving parental home, and mean ages of leaving parental home, marriage and giving births. The model distinguishes four races (white non-Hispanic, black non-Hispanic, Hispanic and others) although in this study we assume that summary measures change by the same proportion across all race categories.

Sensitivity analysis

We carry out a sensitivity analysis by comparing a benchmark projection, in which all summary measures and standard schedules for demographic rates are held constant over the 21st century, to scenarios in which individual summary measures (and some combinations of measures) are changed. Based on the studies discussed in section 1, we investigate the effects of the measures expected to be most important to household outcomes: total fertility rate, life expectancy, number of migrants, the general rate[1] and mean age at union formation and dissolution, general rate and mean age at leaving parental home, and the proportion of elderly with adult children who co-reside with them. While impacts on a wide range of household characteristics could be studied, we focus on changes in population composition by household size and age of the householder (hereafter referred to as "household age") and on selected household types. Note that the composition of the population by household age is different from the population age structure, since composition by household age reflects not only population age structure but also the age composition of households.

To ensure at least numerical comparability across the different scenarios in the sensitivity analysis, in each case we perturb one or more variable relative to the benchmark case in identical ways: we specify a linear increase/decrease by 25% by 2050, and then a constant value thereafter. In contrast, the benchmark scenario assumes that all parameters remain constant over the entire century at their 2000 levels.

Figure 1a Sensitive analysis on the impacts of demographic events on household size composition

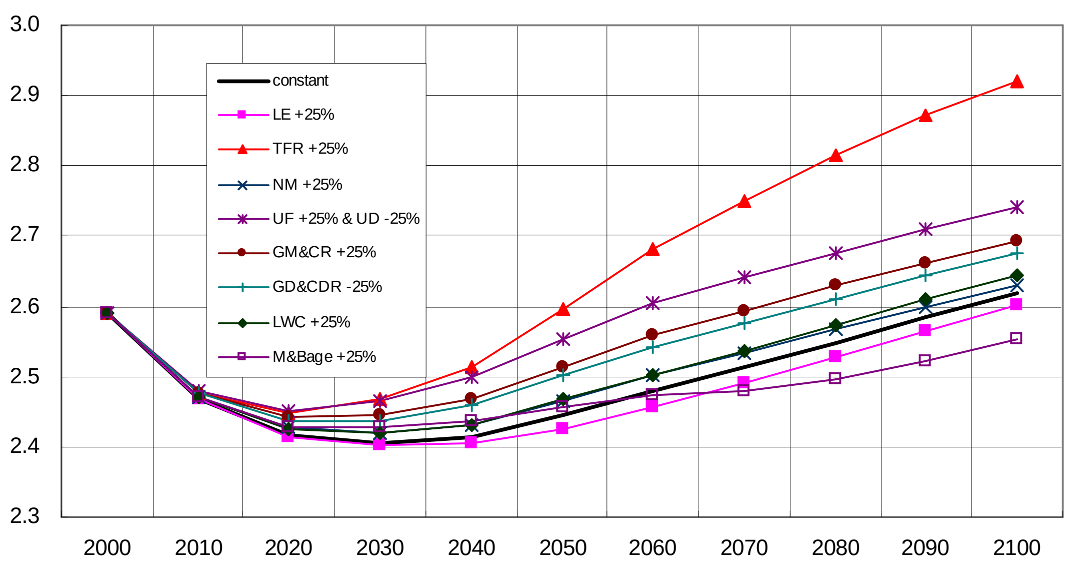
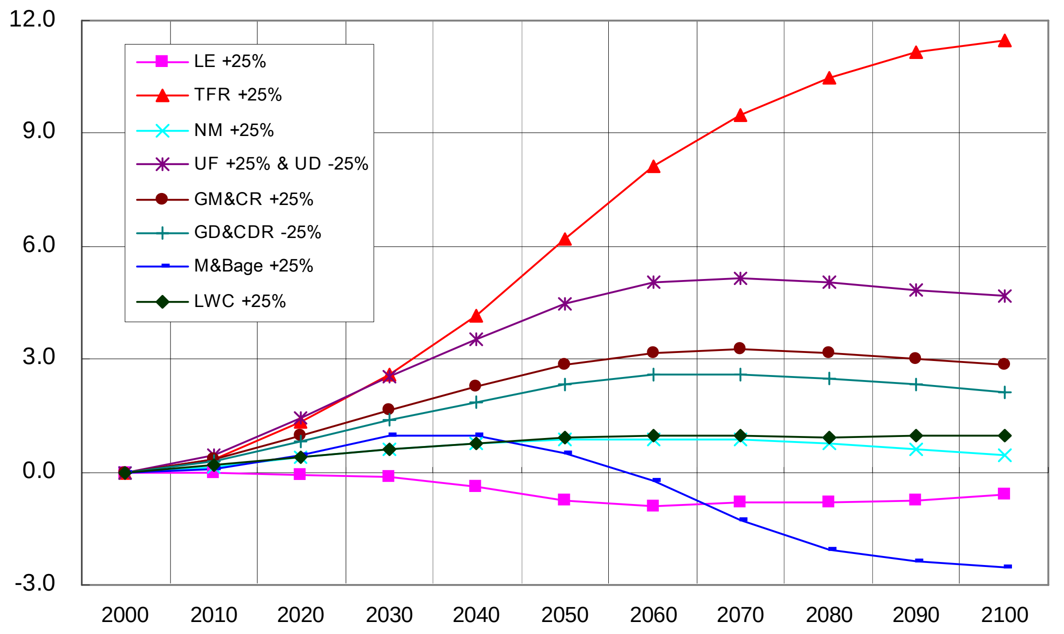


Figure 1b Percentage differences of average household size of changes in demographic events relative to the constant scenario



Note: 1.Constant: no change to any summary measures;

+25% or -25%: a 25% of increase or decrease of the demographic parameters by year 2050, and remain at that level afterwards;

LE: life expectancy;

NM: net migrants;

UF & UD: union formation and union dissolution;

GM&CR: general marriage rate and general cohabitation rate;

GD&CDR: general divorce rate and general cohabitation rate;

M&Bage: mean age at first marriage and mean age at all births;

Mage: mean age at first marriage;

Bage: mean age at all births;

LWC: propensity of living with children by the elderly who has adult child.

Results for average household size (Figure 1a) show that in all cases, average size is expected to decline for 20-30 years before beginning to rise. This decline represents a break from the past 20 years of relatively stable size, and occurs even in the benchmark scenario in which there is no change in any of the demographic variables. A decomposition analysis (details available from the authors) shows that 60% of the decrease of average household size in the period of 2000-2030 is due to shifts in population age structure while 40% is due to changes in household headship rates. Headship rates change due to the momentum of the demographic events affecting the process of household formation and dissolution (Zeng et al., 2003). Baby boomers experienced dramatic changes in demographic behaviour from the 1960s to early 1980s:

low level of and postponed marriage, rapid increase in the divorce rate, low fertility rate and late childbearing, and early and high propensity of leaving parental home. The effect of these changes on household size and structure persist as households pass through the life cycle, even after demographic rates stabilized in the late 1980s and the 1990s.

The parameter with the largest effect on household size is TFR: increasing TFR from about 2.0 in 2000 to 2.5 in 2050 increases the average household size relative to the benchmark case by 6% by 2050 and 11.5% by 2100 (Figure 1b). The difference in household size continues to increase even after TFR stabilizes in 2050 because (1) it takes about 35 more years for the entire childbearing population to have experienced the highest fertility rate, and (2) the echo effects of the larger cohorts born during the 2000-2050 will continue to influence the composition of population by household type (including size) in future decades.

The second largest effect is caused by general union formation and dissolution rates. Increasing the general marriage and cohabitation rates (or decreasing the general divorce and cohabitation dissolution rates) by 25% leads to about a 3% increase in household size relative to the benchmark case by 2050, with the effect remaining constant thereafter. The two effects are not precisely additive. When both changes are introduced simultaneously – representing the case of more pervasive and stable unions – the effect on average household size is somewhat smaller than would be obtained by adding together the results of the separate sensitivity analyses. This result serves as a caution regarding the interactions between demographic events affecting household formation.

We also analyzed separately the effect of changes in marriage and cohabitation, finding that changes in marriage rates produces more significant changes in average household size than changes in cohabitation rates. The reason is that while increases in the two rates generate similar changes in the proportion of couple households, increased marriage leads to a higher proportion of one-couple households with children, since married couples have higher fertility than cohabiting couples.

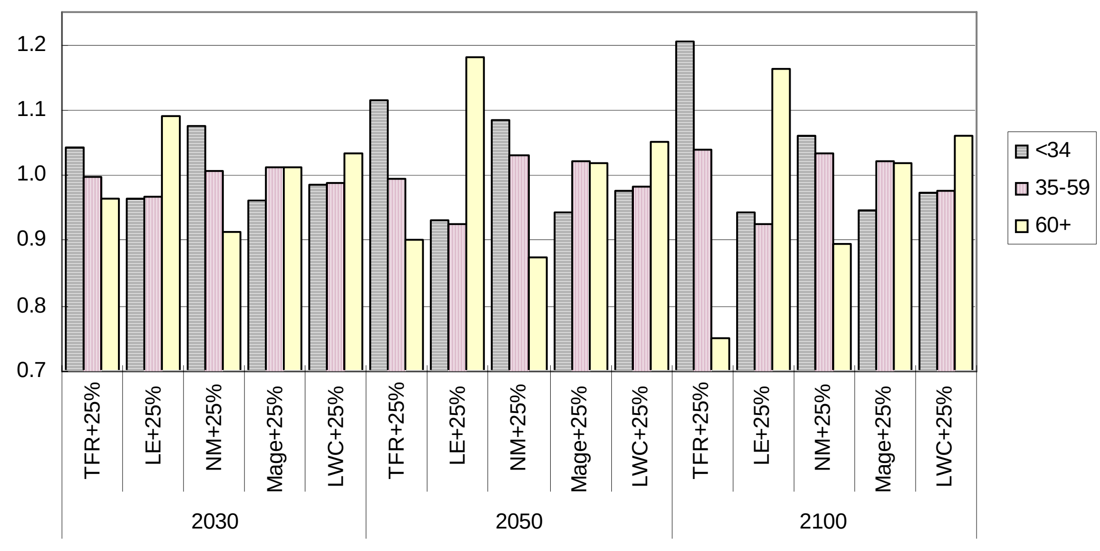
The effects of changes in other factors are smaller. Increasing life expectancy by 25% leads to only a 1% smaller average household size relative to the benchmark case in 2050. Increasing life expectancy increases the size of elderly households as more spouses live longer, but also increases the proportion of the population living in households headed by the elderly, a category whose household size is still small relative to the rest of the population.

Increasing the propensity of the elderly to live with adult children, or increasing the number of net migrants, both increase the average household size by about 1% by 2050. The immigration result is probably an underestimate in that we assume immigrants have the same reproductive (and other demographic) behaviour as the native born population, when in fact there is evidence that immigrants have a higher chance of living in large households and tend to have higher fertility than the native born (Burr and Mutchler 1993; Hunton 1998).

We also test the effects of changes in the timing of demographic events. Increasing the average age at first marriage and average age of all births by 25% generates larger households (relative to the benchmark case) until 2060, and smaller households thereafter. Scenarios not shown in the figures indicate that the independent effect of increasing age at marriage is always to drive down average household size. Postponement of marriage means more people living in small non-family households for longer. The fluctuation in the comparative household size is exclusively caused by the change in age at childbearing. Increasing the mean age at childbearing by shifting the period fertility schedule (as is done here) increases the fertility of women in older childbearing years, while decreasing the fertility of women in younger childbearing years. The net period effect on births depends on the age structure. In the U.S. during the period 2000-2030, this structure favors increased births and therefore has a positive effect on household size. Later, age structure favors fewer births and exerts a negative effect on average size.

Results for composition by household age (Figure 2) are more straightforward. Those variables that have a strong effect on population age structure – fertility and life expectancy – also have a substantial effect on composition by household age. Variables such as union formation and dissolution, age at leaving home, and proportion of elderly living with adult children do not affect the population age structure, but can affect composition by household age. However the magnitude of these effects is relatively small. For example, union formation/dissolution affects composition by household age to the extent that there are age differences between cohabiting or married couples, but these age differences are small. The scenarios testing sensitivity to age at leaving home and living with children show that these variables affect composition by household age much less than fertility or mortality.

Figure 2 Relative differences of proportion of population living in households by age of householder (constant=1)



We also examine the effect of these demographic rates on household types of particular significance: one-person, couple-only, couple with children, and single parent with children (Appendix Table 1). In the constant scenario, one person and couple-only households increase as a proportion of the population during the middle of the century, then decrease back to close to their original levels, while households consisting of couples with children do the reverse (decrease temporarily before returning to original levels). These effects are due to population and household momentum, as discussed above. Single parent with children households increase throughout the century in the constant scenario, while three generation households fall and remain well below original levels. The trends for one person and couple-only households are most sensitive to union formation and dissolution rates, particularly marriage and cohabitation, which leads to a strong decrease in the population living in single person households and an increase in couple households, relative to the constant scenario. Similarly, increasing TFR leads to a strong decrease in couple households and a strong increase in households consisting of couples with children, relative to the constant scenario. Single parent households are most affected either by fertility (increasing fertility leads to increases in the proportion living in these households) or by union formation/dissolution (more stable unions leads to a decrease in this household type). Three generation households are most sensitive to the timing of marriage and births, with delays leading to a reduction in the population living in this household type.

Scenarios for demographic events

To quantify a plausible range of household projection outcomes for the U.S., we develop three scenarios: a mid-range projection and two projections intended to span a wide but plausible range of outcomes in two of our primary characteristics of interest: composition by household age and household size. Based on the sensitivity analysis in the previous section, we define our scenarios in terms of alternative assumptions about future trends in TFR, the general rates of marriage and cohabitation formation and dissolution, life expectancy at birth, and number of net migrants, with particular attention paid to TFR and union formation/dissolution. We do not include changes in age at childbearing since it does not act in a single direction on household size, and therefore is less amenable to bounding scenarios. We don't include changes in the proportion of elderly living with adult child, or changes in the age at marriage, since they have only a weak effect on both household size and population composition by household age. The case for not considering changes in age at marriage or birth is also strengthened by the fact that the 25% changes used in the sensitivity analysis are very large in absolute terms, and therefore even an extreme scenario is likely to have a much smaller effect even than those shown in the previous section.

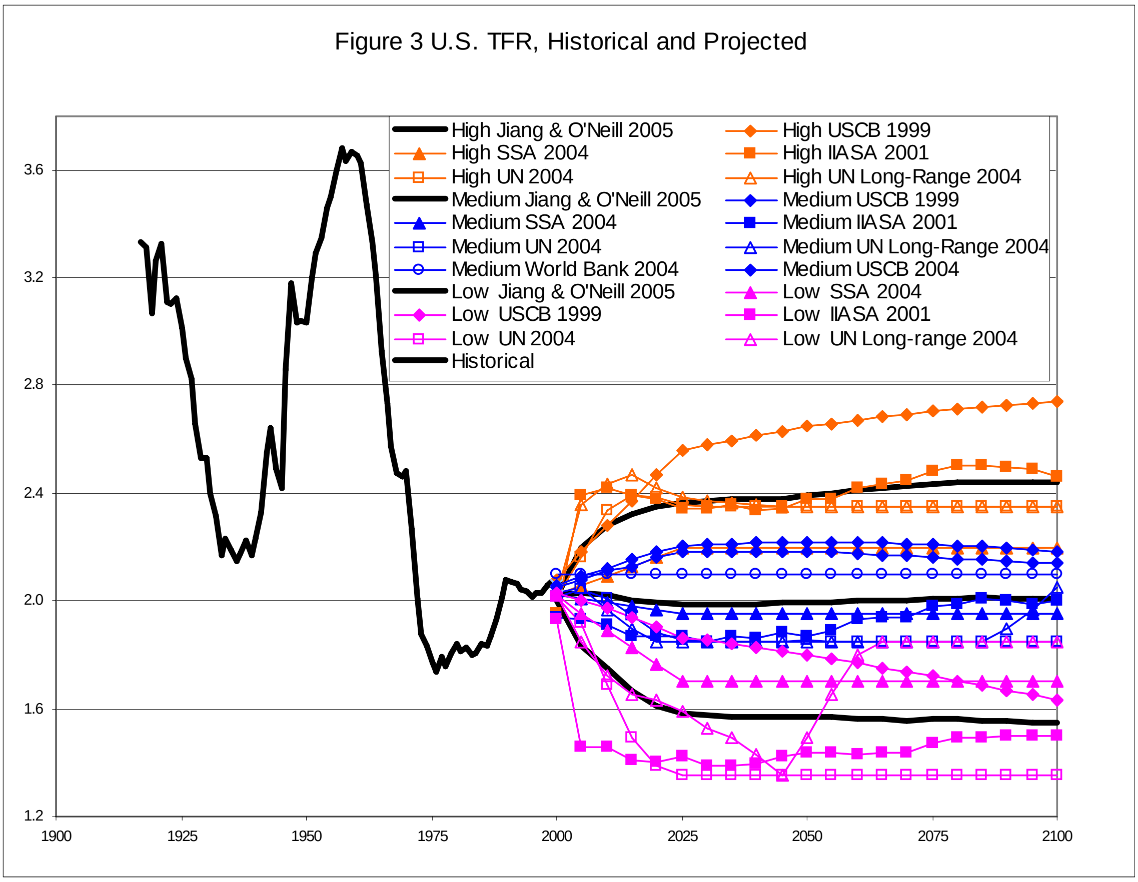
In general one pair of scenarios cannot be expected to bound outcomes for more than one variable; e.g., given a set of high and low assumption for fertility, mortality, and migration, the combination producing bounds for population size will not produce bounds for age structure (Lee, 1999). However in this case, bounds for average household size and for population composition by household age can both be created with the same set of input assumptions. The assumptions leading to large households – high fertility, low life expectancy, high migration, increased union formation and decreased union dissolution – are also the assumptions that lead to a young composition by household age. Our full scenario set therefore consists of large/young, medium, and small/old scenarios.

The rest of this section briefly describes the basis for our specification of alternative scenarios for inputs. In the case of TFR, life expectancy, and net migration, our approach is not to develop fundamentally new scenarios, but rather to specify scenarios that are reflective of the range of scenarios in the literature. In contrast, for union formation and dissolution, there is no such projection literature to draw on and we develop our own assumptions based on alternative reasoning. We also discuss the plausibility not only of the individual scenarios for each input assumption, but also of the particular combinations we use in formulating our large/young and small/old scenarios.

TFR, Life Expectancy, and Net Migrants

For TFR, life expectancy, and net migration assumptions, we calculate averages of the most recent projections made by well known institutions (Figs. 3, 4 and 5): the US Census Bureau (Hollmann et al. 2000; US Census Bureau 2004), the UN (UNPD 2004, 2005), the World Bank (2004), IIASA (Lutz et al. 2001), and the US Social Security Advisory Board (2003). We group the projections into high, medium, and low scenarios as described by the publishing institutions, and average each group separately to obtain three scenarios that are reflective of the literature. We pursue this averaging procedure since it is conservative (as compared to selecting the most extreme projections available in the literature), representative of the literature in a way that does not favor any particular institution's projection, and also has some theoretical and empirical support (Sanderson, 1999). Here, we only note non-obvious aspects of the selection of scenarios.

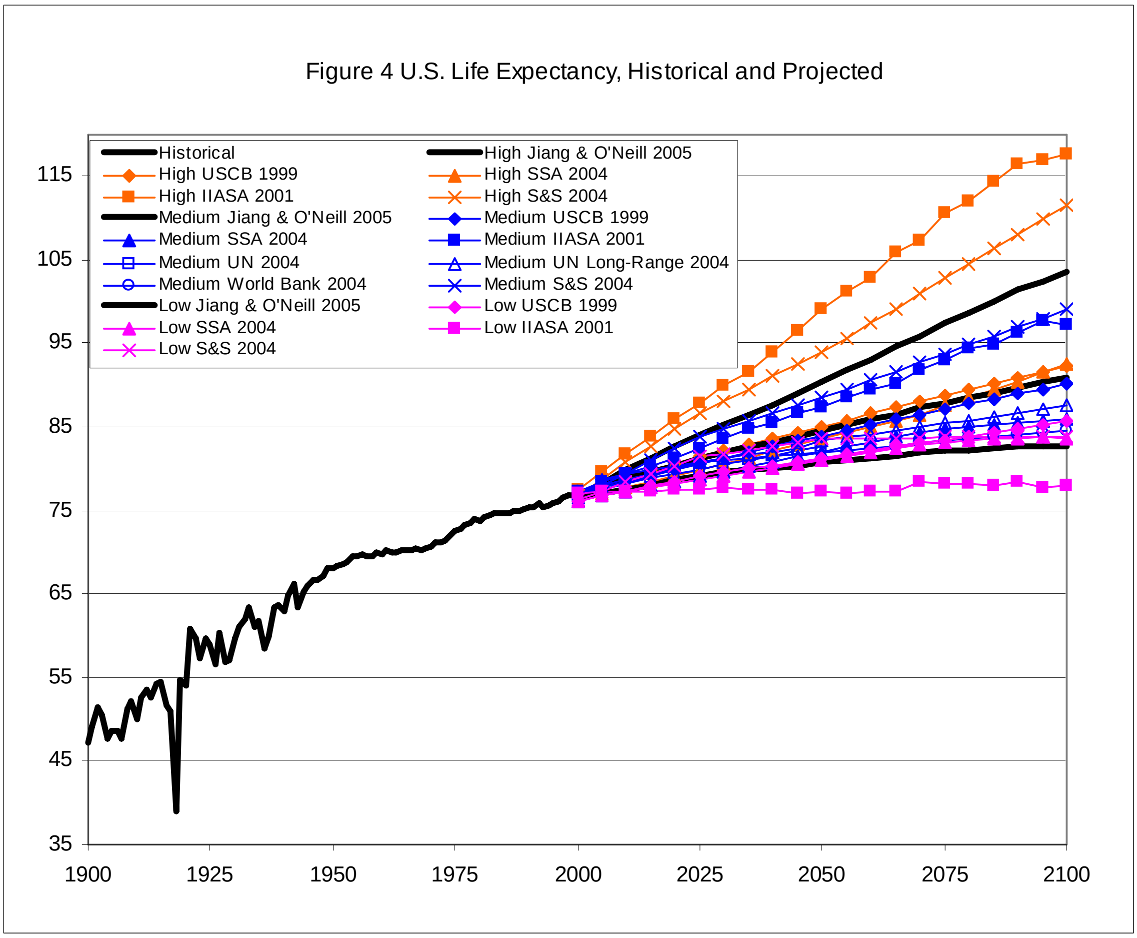
For TFR, we use the updated medium projection from the USCB (2004), and the high and low scenarios from previous projections (1999; to date these projections have not been updated). From the UN, we adopt the assumptions to 2050 from the most recent UN Population Prospects, and extend them by assuming they remain constant over the period 2050-2100. We prefer these projections to the UN long range projections, which extend to 2300, because the latter have idiosyncrasies caused by the algorithm used to create fertility projections with pre-specified very long-term fertility levels. From IIASA, we use the 10th, 50th, and 90th percentile of the uncertainty distribution for TFR as our low, medium, and high scenarios.



Sources for the historical data 1901-1999: Hauser, 1976; National Center for Health Statistics, 1974; Ventura et al., 2000, 2001; Martin et al., 2001, 2002.

For life expectancy, the USCB projections are all from 1999 in this case, since the 2004 revision did not change previous life expectancy projections. The UN only produces a single life expectancy projection, which we take from its long-range projection (UN, 2004). From IIASA, we again use the 10th, 50th, and 90th percentiles of the uncertainty distribution for the North America region. The difference between North America region and US is very small. For example, in year 2000, the life expectancy in North America is 74.2 for male and 80.7 for female, in contrast to 74.1 and 79.9 in the US.

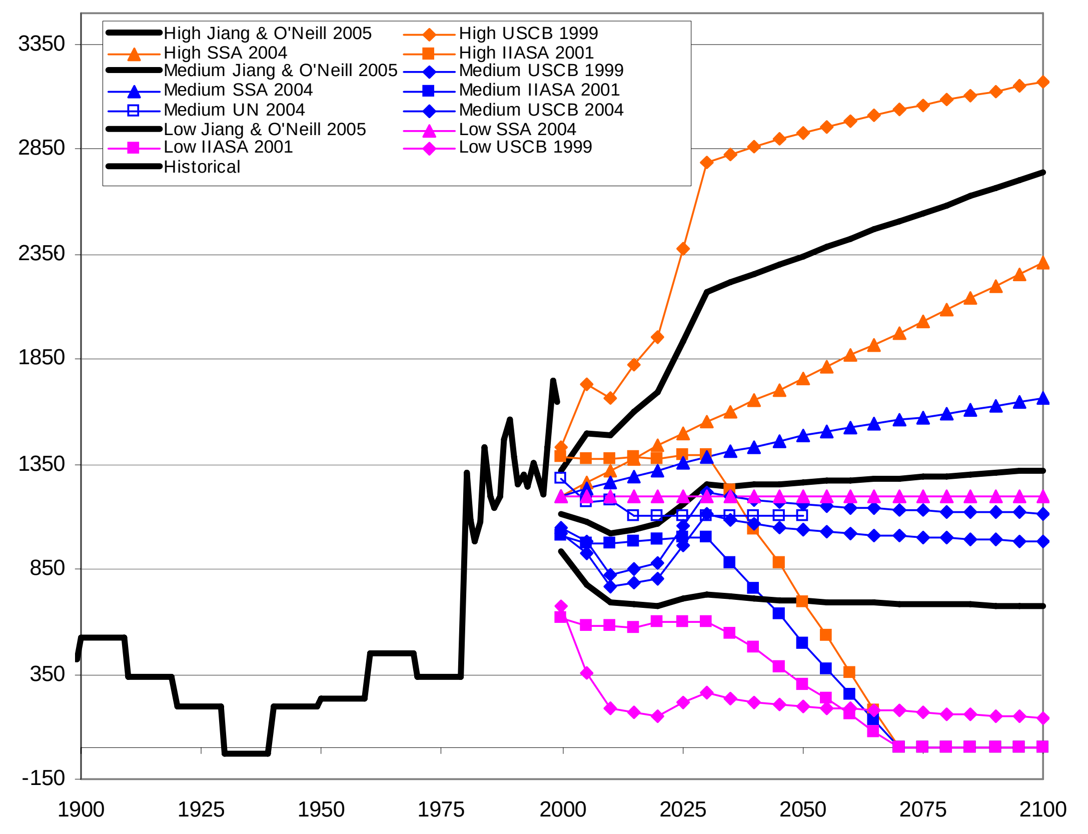
We add the projection of Sanderson and Scherbov (2004) in order to represent the possibility of relatively optimistic increases in life expectancy, an expectation of some researchers motivated by findings that the best-practice life expectancy has risen almost lineary from the 1850s to 2000 (Oeppen and Vaupel 2002). Sanderson and Scherbov operationalize this finding in a probabilistic projection algorithm, producing projected life expectancies well above those of other institutions. For example, the UN forecast is below the 0.025 fractile of their life expectancy distributions throughout the first half of the century, and by 2100 is just barely above it. Sanderson and Scherbov only provided their assumption of life expectancy for US female population. We estimate their implied life expectancy for US total population, using the proportionate differences of the life expectance between female and total population in North America.



Sources for the historical data 1900-1999: Arias et al., 2003.

For net migrants, we use only the projections of the USCB and the SSA. Projections from IIASA and the UN do not extend to 2100; in both cases projections are made up to the middle of the century, but thereafter mechanical assumptions are made that migration declines to zero in all scenarios. In our medium scenario we average USCB 2004 assumption and SSA assumption. In the low and high scenario, we average USCB 1999 assumptions and SSA assumption, since USCB 2004 projection only includes a medium assumption.

Figure 5 U.S. Net Migration, Historical and Projected



Source for the historical data 1880-1980: Unadjusted populations (U.S. Census Bureau, 1975, 1990); Births & Deaths 1870-1940 (Kuznets, 1958); Births & Deaths 1940-1980 (U.S. Census Bureau 1975, 1990); Net Migrants 1790-1820 (Gemery, 1984; Curtin, 1969); Net Migrants 1820-1860 (McClelland and Zeckhauser, 1982).

Source for the historical data 1980-1999: U.S. Census Bureau, 2000.

Union Formation and dissolution

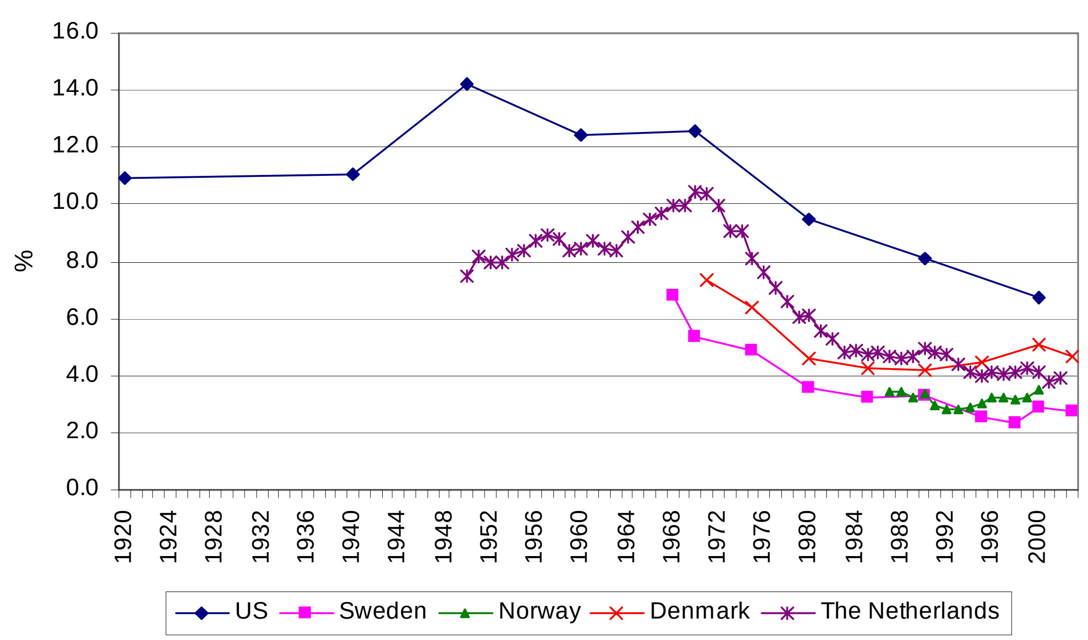
The past two decades have witnessed a surge in research on marriage and cohabitation in the US. However, most studies are descriptive and focus on past experiences; we are not aware of any reasoned projections of these trends into the future. Furthermore, quantitative studies tend to use crude rates as the measure of union formation and dissolution which do not reflect changes in the risk population. Since we use general rates in our projection, studies of trends in crude rates are not directly applicable.

Owing to these limitations in data and literature, Zeng et al. (2005) assumed that union formation/dissolution will either increase or decrease 15% by 2020 and 25% by 2050 in their scenarios. No justification for the plausibility of these trends was given; rather, the scenarios can be understood as a sensitivity analysis. Here, we develop a range of scenarios we consider plausible based on historical trends and analogy to experience in European countries. Union formation consists of both marriage and cohabitation, while union dissolution consists of both divorce and cohabitation dissolution. It is difficult to consider trends in each of these rates individually, since they are closely linked to one another. We therefore first briefly review literature and historical trends for the US and other (primarily European) countries for all these rates, and then describe the specification of assumptions for our scenarios.

Marriage and cohabitation

Over the past 50-100 years U.S. marriage rates have been generally high compared to many European countries and shared with them a substantial marriage boom after World War II (Figure 6). Following this boom, general marriage rates declined; in the Netherlands, Denmark, and Sweden these rates have stabilized or slightly increased since the 1980s, while in the U.S. they have continued to decline. Still, the general rate in the U.S. at the turn of the century was about 6.7%, whereas in these Nordic countries it was at or below 5%. This comparison suggests that the U.S. rate could plausibly continue its decline. At the same time, an increase in the U.S. is also plausible. A study forecasting for the cohorts born in the 1950s and 1960s concludes that marriage in the US will remain nearly universal for American women – close to 90 percent of women are predicted to marry. Moreover, forecasts by educational groups indicate that while in the past women with more education were less likely to marry, recent college graduates are forecasted to have the highest rate of eventual marrying despite their later entry into marriage (Goldstein and Kenney 2001). This implies that general marriage rates may increase in the future when the effect of postponing marriage for education vanishes.

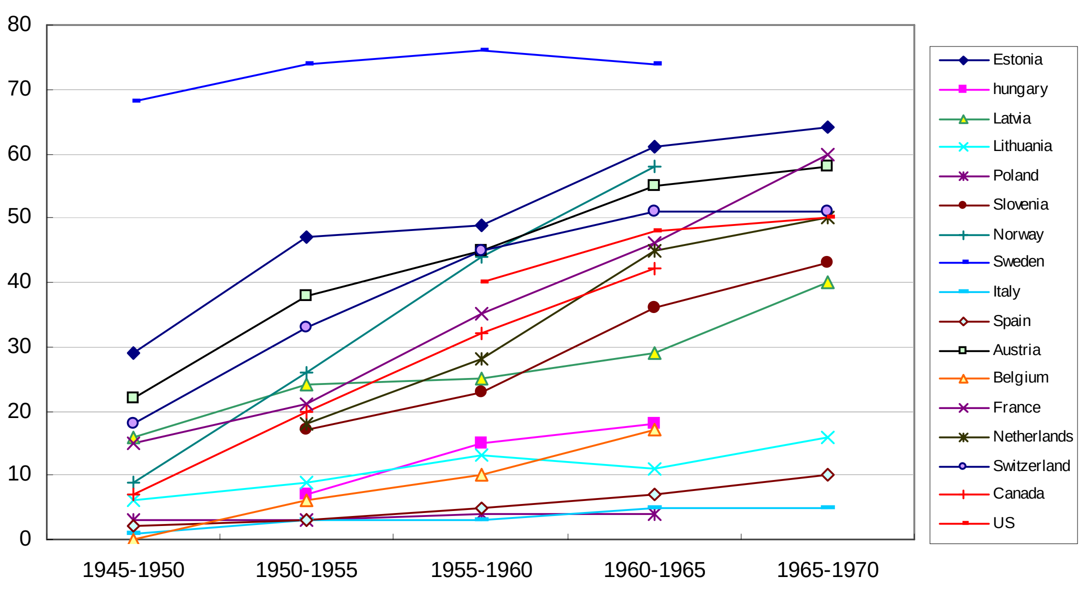
Figure 6 Comparison of general marriage rate



Sources: For the US, we obtain the number of marriages prior to 1970 from National Center for Health Statistics (1995), and after 1970 from US Census Bureau (2003).Using PUMS data, we calculate risk population by marital status; using the number of marriages and population of non-married, we calculate the general marriage rate. For other countries, we obtain the number of marriages and population by marital status, then calculate general marriage rates. Data is from Statistics Netherlands, Statistics Sweden, Statistics Norway, and Denmark Statistik.

The past decline in the general marriage rate has been partially offset by a rise in non-marital cohabitation. Recent studies have improved the measurement of cohabitation and indicate a larger increase than previously thought (Baughman, Dickert-Conlin and Houser 2002; Casper and Cohen 2000). According to an analysis of 1987-1988 National Survey of Families and Households (NSFH) and 1995 National Survey of Family Growth (NSFG), the general cohabitation rate among women age 15-29 increased from 2.1% in the early 1970s to 7.3% in the early 1990s, while the general marriage rate declined (Raley 2001). In 1995, the proportion of females who had entered cohabitation by age 25 reached about 45%. Continued increase appears plausible, since this measure has been rising with no obvious peak yet reached across a wide range of countries (Figure 7). Some Scandinavian and Western European countries have substantially larger percentages of women entering cohabitation by age 25 as compared to the U.S., for example 75% in Sweden, 60% in France, and 58% in Norway and Austria (UNPD 2003b).

Figure 7 Percentage of women had entered consensual union by birth cohorts



Source: UN, 2003b.

Examining the historical relationship between general marriage and cohabitation rates, the increase in the latter in the 1960s-1980s in the US has been almost as great as the decline in the former – with the result being that the total union formation rate has been relatively stable (Bumpass and Sweet 1989; Bumpass, Sweet and Cherlin 1991; Manning 1993, 1995). A number of more recent studies show that cohabitation continues largely to offset the decline in marriage, with a slight decrease in the total union formation rate (Bumpass and Lu 2000; Casper and Bianchi 2002; Heuveline and Timeberlake 2004; Toulemon 1997). For example, while the proportion married by age 25 declined from 71 to 52 per cent between 1977 and 1992, there was much less change over these cohorts (from 78 to 70 per cent) in the proportion of women who had lived in a union. This means that more than 60% of the reduction of the union formation due to declining marriage rate was offset by an increasing cohabitation rate.

Whether these trends will continue to offset each other in the future is unclear. The compensating effect of cohabitation has been weakening over time. More broadly, there has been considerable debate over the relationships between cohabitation and marriage (Bianchi and Casper 2000; Brown and Booth 1996; Bumpass et al. 1991; Clarkberg, Stolzenberg and Waite 1995; Manning 1993, 1995; Rindfuss and VandeHeuvel 1990; Thornton 1989). Some argue that cohabitation is typically a prelude to marriage, while others maintain that cohabitation is an alternative or substitution to marriage. In Scandinavian countries and some Western European countries, cohabitation has become more a substitution given that an increasing number of cohabitors remain in consensual unions without marrying. In contrast, studies of the marital status transition in the US indicate that cohabiting unmarried people have a much higher propensity of marriage than do non-cohabiting unmarried people. In a 1987-1988 survey, 46 percent of cohabitors characterized their living arrangement as a precursor to marriage, while another 15 percent classified the arrangement as a trial marriage and 10 percent as a substitute for marriage. About 40 percent of all unmarried couples in this survey were married within five to seven years. More than 50% of couples who characterized their living arrangement as a precursor did marry within five to seven years, compared to 25% of unmarried couples in “trial marriage” or “substitute marriage” (Casper and Sayer 2000).

Thus, there is historical experience in the U.S. of much more stable unions than currently exist – higher marriage rates and lower divorce rates. European countries provide many examples of societies with substantially lower marriage rates and higher cohabitation rates than currently observed in the U.S. And finally, based on international experience, a range of possible relationships exist between marriage and cohabitation, including cohabitation as either a precursor to marriage (in which case changes in marriage and cohabitation rates would move in similar directions) or a substitute for marriage (in which case marriage and cohabitation rates would be more independent, or even anti-correlated).

Divorce and cohabitation dissolution

Measured as a crude rate, the U.S. divorce rate has been approximately double the rate for many Western European countries (Ahlburg and De Vita, 1992), and witnessed a substantial increase up to about 1980, and a decline thereafter (Figure 8). However, measured as a general rate (which accounts for the population at risk, i.e., married), recent U.S. divorce rates are not much different from those of Western Europe, and has recently been stable or even declining. The leveling off of divorce in the U.S. appears to be real even considering the effect of increasing cohabitation, and taking into account other compositional factors (Goldstein 1999). At the same time, rates in Europe continue to increase, and the general divorce rate of Sweden has recently even become higher than that of the US. Given trends in Europe, it is not implausible that the US general divorce rate could increase in the future. However, it is also possible that divorce will continue to decrease, with recent trends signaling a fundamental change in marriage patterns.

Figure 8a Comparison of crude divorce rate (per 1000 population)

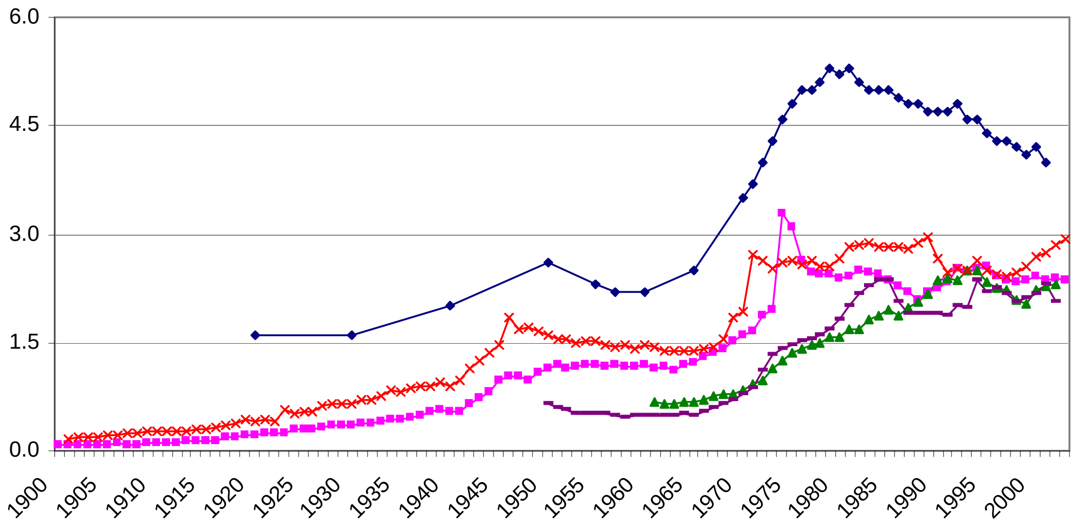
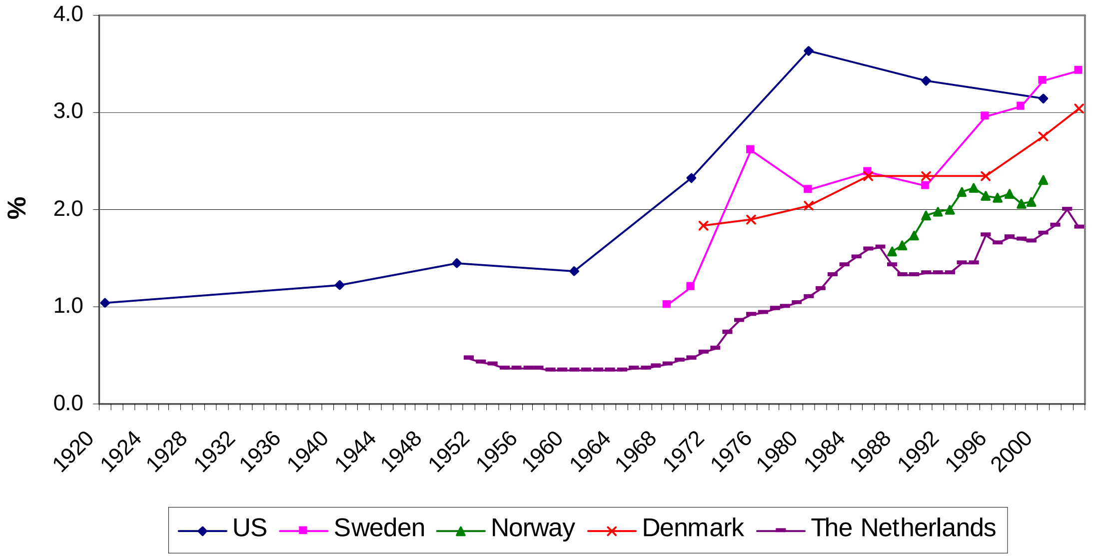


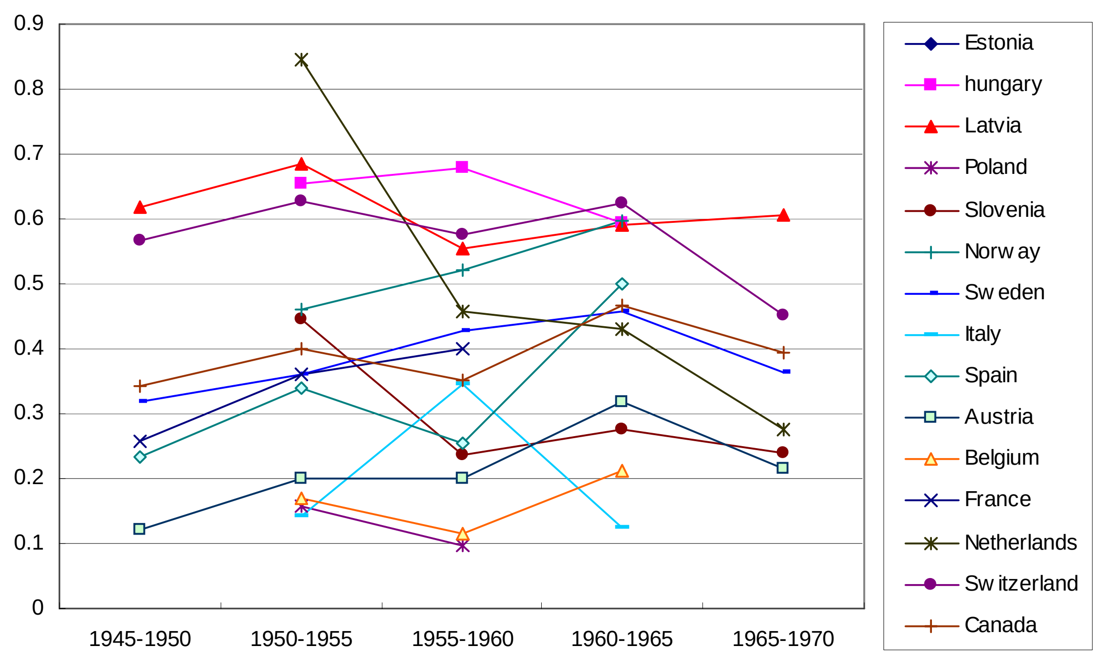
Figure 8b Comparison of general divorce rate



Source: same as in Figure 6

Turning to cohabitation dissolution rates, our calculations indicate that the general rate is currently 38% in the U.S., significantly higher than the general divorce rate. Comparison to past trends for cohorts in low fertility countries (Figure 9) shows that the general cohabitation dissolution rate has become stable in East European countries and some other part of Europe, such as Switzerland, the Netherlands, and Italy, at levels that are both higher and lower than the U.S. rate (note that women of cohort 1965-1970 were still too young to complete union formation process, so these estimates are less reliable than for earlier cohorts)

Figure 9 Estimated general cohabitation dissolution rate



Source: Same as in Figure 6.

Considering the joint effect of divorce and cohabitation dissolution shows that there has been a substantial increase in the instability of unions in the U.S. (increasing from 30 to 38% dissolution over ten years) despite the plateau in the US divorce rate of the last two decades. This decreasing stability results from a decline in the proportion of cohabiters who marry their cohabiting partner (from 60 to 53 percent over this period). Similarly, unions begun by cohabitation have become less stable: ignoring whether or not the couple married, the proportion of cohabitators who had separated by one year increased from 45% to 54%. (Bumpass et al. 2000). Data from Sweden (Bennett, Blanc, and Bloom, 1988) and Canada (Balakrishnan et al., 1987) also suggest that marriages preceded by cohabitation are more, rather than less, likely to end in divorce.

Future scenarios

Using historical trends in union formation and dissolution as a basis for future scenarios is difficult. The extent to which cohabitation will become a substitute for marriage or will be a new form of courtship is uncertain, and our understanding of the factors which lead individual couples today to cohabit, marry, or to live apart is incomplete. Nonetheless, history and experience in other countries gives us some guide to plausible trends toward more (or less) pervasive, and more (or less) stable unions in the future.

We define one scenario in which union formation is common and unions are stable; that is, high general union formation rates and low general union dissolution rates. This defines one end of a range of possible outcomes that would lead in general to larger households. Specifically, we assume by 2050, the general marriage rate will double from 6.7% in 2000, returning to its highest historical value which occurred around 1950. At the same time, we assume the general cohabitation rate will increase by 50%, from 12.3% in 2000 to 18.5%, about the current level in Sweden. Cohabitation in this scenario serves more as a precursor to than a substitute for marriage. We assume the general divorce rate will decrease from 3.2% in 2000 to 1.5% in 2050, about the level in 1950. We do not assume a decline in the cohabitation dissolution rate as well, but rather keep it constant, judging a decline to be less plausible in a scenario in which cohabitation is a pre-cursor to marriage (dissolution includes the transition to marriage). After 2050, all the union formation and dissolution rate are assumed to be constant.

We define a second scenario in which union formation is less common and unions are unstable; that is, low general union formation rates and high general union dissolution rates, leading to smaller household sizes. Specifically, we assume that by 2050 the general marriage rate will drop from 6.7% in 2000 to 3% in 2005, about the current level in Sweden, while the general cohabitation rate remains constant. In this scenario, cohabitation acts more as a substitute to marriage. We assume that the general divorce rate increases from 3.2% in 2000 to 4%, close to its highest level in 1980, while the general cohabitation dissolution rate will increase from 38% in 2000 to 48%, close to the current Swedish level. After 2050, all the rates are assumed to be constant.

US household projection

Based on the analysis of future perspectives on TFR, life expectancy at birth, net migration, and union formation and dissolution, we construct a set of scenarios for the US: a mid-range projection and two projections intended to span a wide range of plausible outcomes in composition by household age and household size. Table 1 summarizes the input assumptions defined in the previous section.

Table 1: Summary of input assumptions for U.S. household projections

	Small/Old	Medium	Large/Young
TFR (2100)	1.5	2.0	2.5
Life Expectancy (2100)	103 yrs	91 yrs	83 yrs
Migration (2100)	0.7 mill.	1.3 mill.	2.7 mill.
Marriage (2050)	-55% to level of Sweden	constant	Double to 1950 level
Cohabitation (2050)	constant	constant	+50% to level of Sweden
Divorce (2050)	+25% to 1980 level	constant	-50% to 1950 level
Cohabitation dissolution (2050)	+25% to level of Sweden	constant	constant

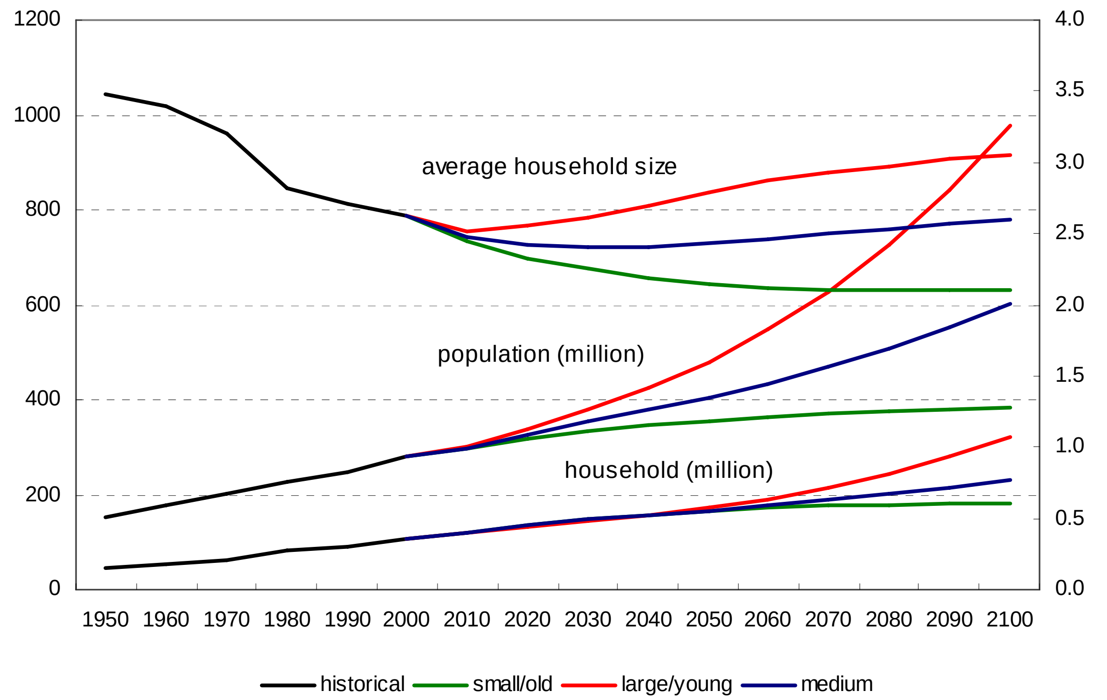
In our medium scenario, we adopt the medium scenarios for TFR, life expectancy at birth, and net migration derived from averaging the medium projections from major institutions. We assume constant levels for general union formation and dissolution rates and for other demographic parameters.

In the large and young scenario, we combine high TFR, low life expectancy, and high migration with the assumption of stable unions: high general union formation rates and low general union dissolution rates, as derived in section 4. This combination of assumptions is internally consistent given that fertility is higher within unions and among recent migrants. In the small and old scenario, we combine low TFR, high life expectancy, and low migration with low general union formation rates and high general union dissolution rates. The detailed values of the three scenarios are included in Appendix Table 2a-2c.

Results indicate that US population size and number of household will continue to grow under all the three scenarios (Figure 10). Population grows from 280 million at the start of the century to 390-980 million by 2100 – a factor of 2.6 uncertainty range. The number of households grows from 100 million to 190-310 million, a substantially smaller uncertainty range. In fact, through 2050 there is almost no uncertainty at all. However, this does not reflect the full range of uncertainty because the scenarios were designed to span a wide range of age and size compositions, a decision which has the effect of narrowing the range of numbers of households.

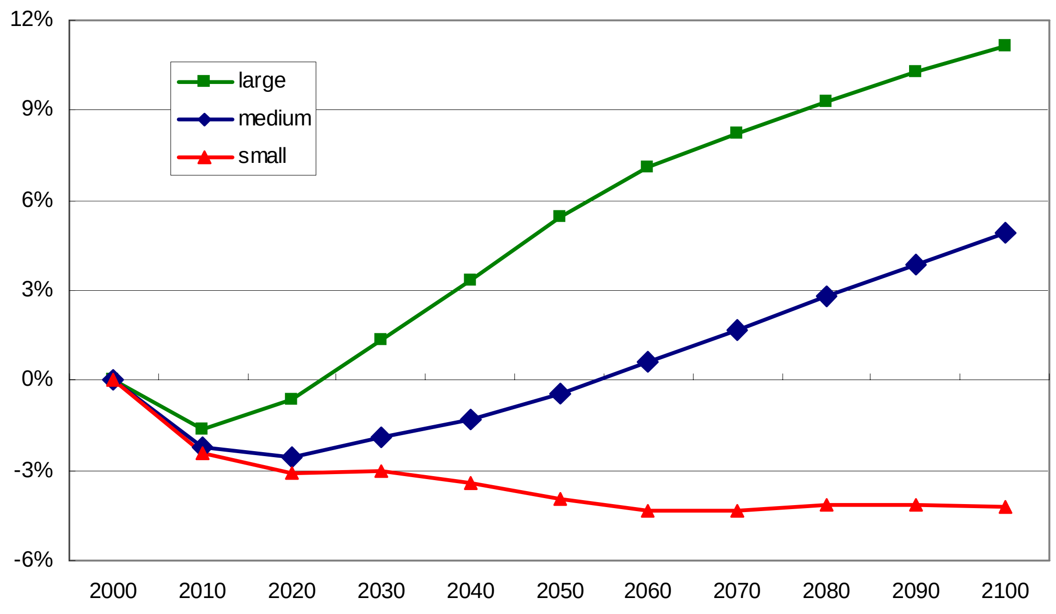
Average household size changes from 2.6 at the beginning of the century to 2.0-3.1 by 2100 (with most of the change occurring by 2050). In all scenarios average household size decreases over at least the first several decades, due mainly to the momentum in population age structure and family formation and dissolution, as discussed in the previous section. To test the difference in outcomes between a ProFamy projection and a vastly simpler headship rate approach, we combined our scenario outcomes for population age structure with age-specific household headship rates held constant at their levels in 2000 (figure 11). Differences in the projected number of households are generally only a few percent, except in the large/young scenario in which they reach 10% by the end of the century (differences in average household size are slightly smaller).

Figure 10 US historical and projected population, household and household size

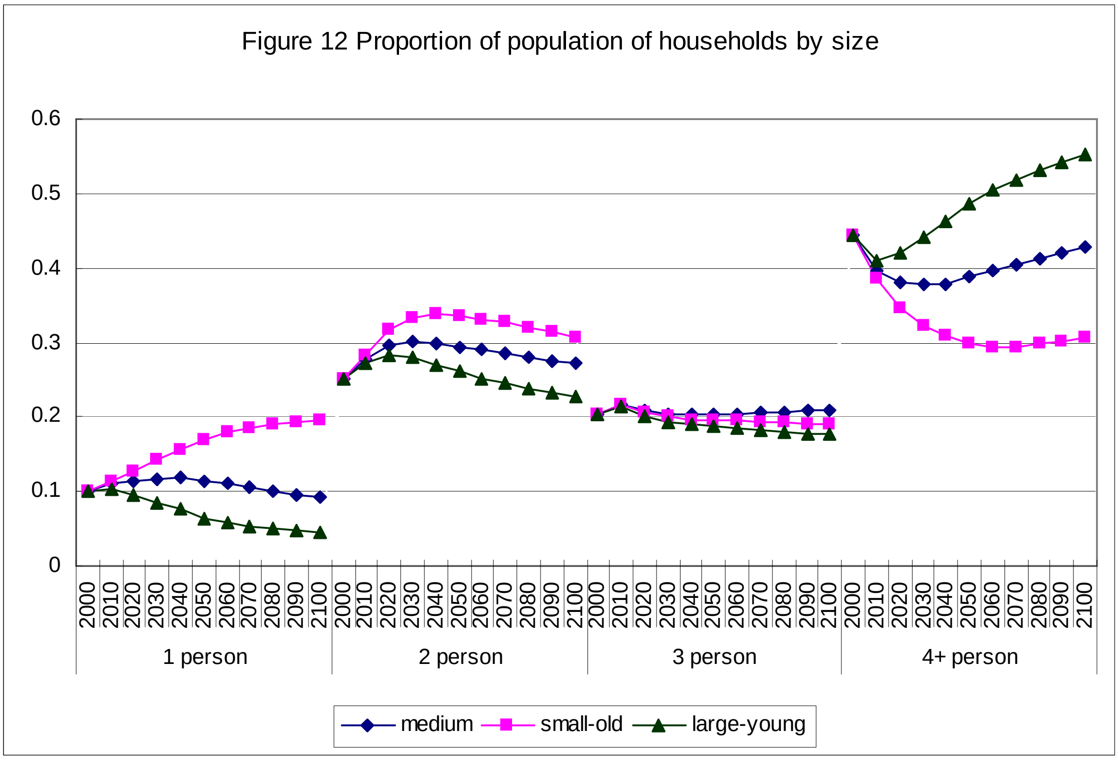


Source: Historical data from U.S. Census Bureau, Current Population Survey, March and Annual Social and Economic Supplements, 2004 and earlier. http://www.census.gov/population/socdemo/hh-fam/hh4.xls

Figure 11 Differences in number of household between ProFamy projection and projection using headship rate model

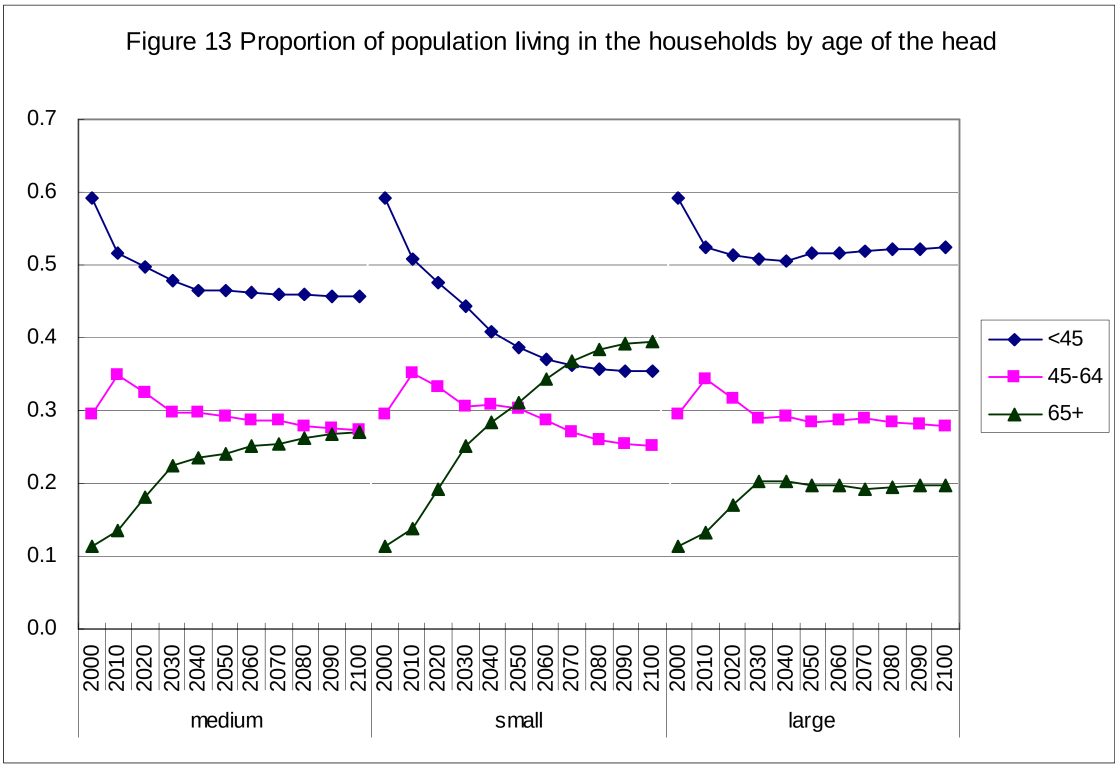


While this might be considered an approximation that is worth the reduction in complexity of the projection, the real advantage of carrying out a ProFamy projection is in the more disaggregated results for particular household types, which are not available from a simple headship rate projection. Results indicate, for example, that changes in average household size are driven primarily by a tradeoff between the proportions living in households of size 4+ and those living in households of size 1 and 2. There is little change in the proportion living in size 3 (Figure 12). Under the small-old scenario, the proportion of population living in 1-person households will more than double, and in 2-person households will increase by 50% in 2040 (then decline slightly afterwards). At the same time, the proportion living in 4+-person households will decrease by about one-third. Conversely, under the large-young scenario, the proportion of population living in 1- and 2-person households will be halved and decrease by about 15%, respectively, while the share in the 4+-person household will increase by one-third.



We also analyze changes in the proportion of population living in households headed by different age groups. In all scenarios there is little change in the proportion living in households headed by the middle aged, while elderly households gain, and young households decline, as a share of the population (Figure 13). This shift occurs to roughly equal degree across scenarios over the first 30 years (due to momentum), with the proportion living in elderly households doubling from 11% to 20% or more. This proportion continues to rise to nearly 40% by 2100 in the small/old scenario, while it remains essentially constant in the large/young scenario.

These results differ from the age structure of the population. For example, the population age 45-64 accounts for 18-20% of the total population in these scenarios by 2100, while the population living in households headed by 45-64 year olds accounts for 25-28%. Differences are smaller for the 65+ category (17-37% for the population, and 20-39% for population by household age) and the <45 category (29-39% for the population, and 35-52% for population by household age).



Discussion and conclusions

In our analysis, using the dynamic household projection model ProFamy, we assess the sensitivity of future living arrangements to various demographic events and develop a range of scenarios for composition of the population by household age structure and size. Our sensitivity analysis demonstrates that the most important determinants of household size composition of the population are fertility and union formation and dissolution rates. While the effect of other factors is small, we find some non-obvious results. For example, delayed childbearing interacts with the age structure of the population to produce first an increase in average household size, and later a decrease. In addition, we find that increased life expectancy acts in the direction of smaller households, which is not obvious *a priori* given the expectation of a decline in single person elderly households when mortality is reduced.

We assess the outlook for future changes in households by developing three scenarios aimed at exploring a wide range of outcomes for household size and age. These scenarios are based on new scenarios for fertility, life expectancy, and migration derived by averaging across existing scenarios in the literature, an approach that has been suggested (Sanderson, 1999) but that has not previously been used in long-term projections. We also produce the first long-term scenarios for household formation and dissolution rates that go beyond mechanical assumptions and are based on reasoning grounded in past trends, experience in other countries, and current theoretical perspectives. We anticipate that marriage rates could plausibly double, or decline by half; cohabitation rates could double; and divorce rates could increase by 25% or decline by half.

Results indicate that average household size declines over the next few decades in all scenarios, due mainly to changes in population age structure, and secondarily to momentum in household formation and dissolution processes. By the second half of the century, the range of plausible household size outcomes is 2.0 to 3.1, with this result being driven by tradeoffs in the proportion of the population living in one and two person households, on the one hand, and households of size 4+, on the other. The proportion living in households headed by the elderly (65+) doubles in the youngest scenarios, and nearly quadruples in the oldest scenario, to 40% of the population. Conversely, the proportion living in households headed by the young (<45) declines by nearly half, from 60% to 35%.

Taken together, these results give a first look at the range of plausible outcomes for living arrangements over the next 50-100 years. We have been relatively conservative in defining our high and low scenarios, by not choosing the most extreme scenarios in the literature for the components of population change, and by grounding our scenarios for union formation and dissolution rates in past experience in the U.S. and other countries. In this way, we argue that the range of outcomes presented here is a minimum plausible range of uncertainty. It is possible that unprecedented rates of demographic events could be experienced in the future, in which case this range would be expanded even further.

References

Ahlburg D., and C. De Vita. 1992. New realities of the American family. *Population Bulletin* 47: 1-50.

Arias, E., et al. 2003. PLEASE FOLLOW THIS LINK AND TAKE THE CITATION INFORMATION FROM THIS REPORT – IT SHOULD BE IN THE SAME FORM AS THE INFORMATION FROM THE CITATIONS FOR THE PREVIOUS FIGURE, SINCE IT IS THE SAME SERIES OF REPORTS. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_03.pdf

Balakrishnan T. R., K. Vaninadha Rao, E. Lapierre-Damcyk, and K.J. Krotki. 1987. A hazard model analysis of the covariates of marriage dissolution in Canada. *Demography* 24(3): 395-406.

Baughman, R., S. Dickert-Conlin, and S. Houser. 2002. How well can we track cohabitation using the SIPP? A consideration of direct and inferred measures. *Demography* 39(3): 455-465.

Bennett N. G., A. K. Blank, and D. E. Bloom. 1998. Commitment and the modern union: Assessing the link between premarital cohabitation and subsequent marital stability. *American Sociological Review* 53(1): 127-138.

Bianchi, S.M., and L. Casper. 2000. American families. *Population Bulletin* 55(4).

Bongaarts, J. 1987. The projection of family composition over the life course with family status life tables. In J. Bongaarts, T. Burch, and K.W. Wachter (eds.), *Family Demography: Methods and Applications.* Oxford: Calrendon Press.

Brown, S. L., and A. Booth. 1996. Cohabitation versus marriage: A comparison of relationship quality. *Journal of Marriage and the Family* 58: 668-678.

Bumpass, L., and H.-H. Lu. 2000. Trends in cohabitation and implications for children's family contexts in the United States. *Population Studies* 54(1): 29-41.

Bumpass, L., and J. Sweet. 1989. National estimates of cohabitation. *Demography* 26: 615-625.

Bumpass, L., J. A. Sweet, and A. Cherlin. 1991. The role of cohabitation in declining rates of marriage. *Journal of Marriage and the Family*, 53: 913-927.

Burch, T. K. 1970. Some demographic determinants of average household size: An analytic approach. *Demography* 7(1): 61-69.

Burch, T. K., and B. J. Mathews. 1987. Household formation in developed societies. *Population and Development Review* 13(3): 495-511.

Burr, J. A., and J. E. Mutchler. 1993. Ethnic living arrangements: Cultural covergency or cultural minifestation. *Social Forces* 72(1): 169-180.

Canada Depository Service Program. 1996. The long-term housing outlook: Household growth, 1991-2016. *Research and Development Highlights* 28.

Carliner, G. 1975. Determinants of household headship. J*ournal of Marriage and the Family* 37(1): 28-38.

Carlsson-Kanyama A., and A. L. Linden. 1999. Travel patterns and environmental effects now and in the future: implications of differences in energy consumption among socio-economic groups. *Ecological Economics*, 30: 405-417.

Casper, L., and S. M. Bianchi. 2002. C*ontinuity and change in the American family*. CA: Sage.

Casper, L., and P. N. Cohen. 2000. How does POSSLQ measure up? Historical estimates of cohabitation. *Demography* 37: 237-245.

Casper, L., and L. C. Sayer. 2000. Cohabitation transitions: different attitudes and purposes, different paths. Presented at annual meeting of the Population Association of America, March 2000, Los Angeles.

Clarkberg, M. E., R. M. Stolzenberg, and L. J. Waite. 1995. Attitudes, values, and entrance into cohabitation versus marital union. S*ocial Forces* 77: 945-968.

Curtin, P. 1969. *The Atlantic Slave Trade: A Census*. Madison. WI: University of Wisconsin Press.

Dalaker, J. 1999. Poverty in the United States: 1998. Table 2, U.S. Census Bureau, Current Population Reports P60-207. Washington, DC: U.S. Government Printing Office.

Dalton, M., O'Neill, B. C., Prskawetz, A., Jiang, L., and J. Pitkin. 2006. Population aging and future carbon emissions in the United States. Review at *Energy Economics*.

Deaton, A., and C. Paxson. 2000. Growth and saving among individuals and households. *Review of Economics and Statistics*, 82 (2): 212-225.

Ermisch, J. F., and E. Overton. 1985. Minimal household units: A new approach to the analysis of household formation. *Population Studies* 39: 35-54.

Gemery, H. A. 1984. European Emigration to North America: Numbers and quasi-numbers perspectives in American history. *New Series* 1.

Gokhale, J., L. J. Kotlikoff, and J. Sabelhaus. 1996. Understanding the post- war decline in U.S. saving: A cohort analysis. *BPEA* 1:1996, 315-407.

Goldstein, J. R. 1999. The leveling of divorce in the United States. *Demography* 36(3): 409-414.

Goldstein, J. R., and C. T. Kenney. 2001. Marriage delayed or marriage forgone? New cohort forcasts of first marriage for US women. *American Sociological Review* 66(4): 506-519.

Hauser, R. 1976 Fertility tables for birth cohorts by color: United States 1901-1973. Rockville, MD: National Center for Health Statistics.

Heuveline, P., and J. M. Timeberlake. 2004. The role of cohabitation in family formation: the United States in comparative perspective. *Journal of Marriage and the Family* 66(5): 1-21.

Hollmann, F. W., T. J. Mulder, et al. 2000. Methodology and assumptions for the population projections of the United States: 1999 to 2100. Working Paper No. 38. Washington, DC.: Population Division, U. S. Census Bureau.

Holmberg, I. 1987. Household change and housing needs: A forecasting model. In J. Bongaarts, T. Burch, and K. Watchter (eds.), *Family Demography - Methods and Their Application.* Oxford: Clarendon Press.

Hullen, G. 2003. Living arrangements and households - methods and results of demographic projections. Issue 109. Federal Institute of Population Research. http://www.bib-demographie.de/publikat/materialien/Heft109.pdf.

Hunton, L. 1998. Growth in Mexican-immigrant and Mexican-American households: The implication for planning. Working paper. Indiana University: School of Public and Environmental Affairs.

Jiang, L. 1999. P*opulation and Sustainable Development in China: Scenarios for Two Regions.* Amsterdam: Thela Thesis.

King, D. 1999. Official household projections in England: Methodology, usage and sensitivity tests. Paper presented at Joint ECE-EUROSTAT work session on Demographic Projections, Perugia, Italy, 3-7 May 1999.

Kobrin, F. E. 1973. Household headship and its changes in the United States, 1940-1960, 1970. *Journal of the American Statistical Association* 68(344): 793-800.

Kobrin, F. E. 1976. The fall in household size and the rise of the primary individual in the United States. D*emography* 13(1): 127-138.

Kuznets, S. 1958. Long swings in the growth of population and related economic variables. *Proceedings of the American Philosophical Society* 102(1): 25-52.

Lee, R. 1999. Probabilistic approaches to population forecasting, in W. Lutz, J. Vaupel and D. Ahlburg, (eds)., supplement to volume 24 of *Population and Development Review*, *Rethinking Population Projections*, 156-190.

Liu, J., C. C. Dally, P. R. Ehrlich, and G. W. Luck. 2003. Effects of household dynamics on resource consumption and biodiversity. *Nature* 421: 530-533.

Lutz, W., W. Sanderson, et al. 2001. The end of world population growth. *Nature* 412(6846): 490-491.

MacCracken, M. S. D., E. S. Brondizio, D. Nelson, E. F. Moran, A. D. Siqueira, and C. Rodriguez-Pedraza. 1999. Remote sensing and GIS at farm property level: Demography and deforestation in the Brazilian Amazon, *Photogrammetric Engineering and Remote Sensing* 65: 1311–1320.

Manning, W. D. 1993. Marriage and cohabitation following premarital conception. *Journal of Marriage and the Family 5*5: 839-850.

Manning, W. D. 1995. Cohabitation, marriage, and entry into motherhood. *Journal of Marriage and the Family 55*: 839-850.

Martin, N. 1999. Population, households and domestic water use in countries of the Mediterranean Middle East. Interim Report IR -99-032. Laxenburg, Austria: IIASA.

Martin, J. et al. 2001. Births: Final Data for 2000. National Vital Statistics Reports 50(5). Hyattsville, MD: National Center for Health Statistics.

Martin, J. et al.2002. Births: Final Data for 2001. National Vital Statistics Reports 51(2). Hyattsville, MD: National Center for Health Statistics.

Martin, P., and E. Midgley. 2003. Immigration: Shaping and reshaping America. *Population Bulletin* 58(2).

McClelland, P. D. and R. J. Zeckhauser. 1982. *Demographic Dimensions of the New Republic: American Interregional Migration, Vital Statistics and Manumissions, 1800-1860.* New York: Cambridge University Press.

Muller, C., K. S. Gnanasekaran, and K. Knapp. 1999. *Housing and Living Arrangements of the Elderly, An International Comparison Study*. New York: International Longevity Center – USA, Ltd. Almanac Phase 4.

National Center for Health Statistics. 1974. Vital statistics of the United States, 1969, Volume I, Natality. Rockville, MD: U.S. Department of Health and Human Services.

National Center for Health Statistics. 1995. Monthly Vital Statistics Report 43(12), Supplement, July 14.

Oeppen, J. and J. Vaupel. 2002. Broken limits to life expectancy. *Science* 296: 1029-1031.

O'Neill, B. C. and B. Chen. 2002. Demographic determinants of household energy use in the United States. In W. Lutz, A. Prskawetz and W. Sanderson (eds.), *Population and Environment: Methods and Analysis*, *A Supplement to Population and Development Review*, Volume 28, 2002.

O’Neill, B. C., F. L. MacKellar, and W. Lutz. 2001. *Population and Climate Change*, Cambridge, UK: Cambridge University Press.

Perz, S. G. 2001. Household demographic factors as life cycle determinants of land use in the Amazon. *Population Research and Policy Review* 20: 159–186.

Prskawetz, A., L. Jiang, and B. C. O'Neill. 2004. Demographic composition and projections of car use in Austria. *Vienna Yearbook of Population Research*, 2004: 247-326.

Raley, R. K. 2001. Increasing fertility in cohabiting unions: Evidences for the second demographic transition in the United States? *Demography* 38: 59-66.

Richards, T., M. J. White, and A. O. Tsui. 1987. Changing living arrangements: A hazard model of transitions among household types. *Demography* 24(1): 77-97.

Rindfuss, R. R.and A. van de Heuvel. 1990. Cohabitation: A precursor to marriage or an alternative to being single? *Population and Development Review* 16: 703-726.

Sanderson, W. 1999. Knowledge can improve forecasts: A review of selected socioeconomic population projection models. In Lutz, W., J. Vaupel, and D. Ahlburg (eds.), *Frontiers of Population Forecasting.* New York: The Population Council.

Sanderson, W., and S. Scherbov. 2004. Putting Oeppen and Vaupel to work: On the road to new stochastic mortality forecasts. Interim Report IR-04-049. Laxenburg, Austria: IIASA.

Santi, L. L. 1987. Change in the structure and size of American households: 1970 to 1985. *Journal of Marriage and the Family 49(*4): 833-837.

Santi, L. L. 1988. The demographic context of recent change in the structure of American households. Demog*raphy* 25(4): 509-519.

Scottish Executive. 2000. 1998-Based Household Projections for Scotland. *Scottish Executive Statistical Bulletin Housing Series*: HSG/2000/4.

Social Security Advisory Board. 2003. 2003 Technical Panel on Assumptions and Methods. Washington, DC.

Sweet, J. A. 1984. Components of change in the number of households: 1970-1980. *Demography* 21(2): 129-140.

Teachmen, J. D. 1982. Methodological issues in the analysis of family formation and dissolution. *Journal of Marriage and the Family* 44(4): 1037-1053.

Thornton, A. 1989. Changing attitudes toward family issues in the United States. *Journal of Marriage and the Family* 51*:* 873-893.

Toulemon, L. 1997. Cohabitation is here to stay. *Population: An English Selection* 9: 11-56.

Tsai I. J, C. Y. C. Chu, and C. F. Chung. 2000. Demographic transition and household saving in Taiwan. *Population and Development Review*, Supplement, S174-193.

UNPD. 2003b. Partnership and reproductive behavior in low-fertility countries. In ESA/P/*WP.177.*

UNPD. 2004. World population to 2300. ST/ESA/SER.A/236. New York.

UNPD. 2005. World population prospects: The 2004 revision. New York.

U.S. Census Bureau. 1975. Historical statistics of The United States. Washington, D.C.: GPO.

U.S. Census Bureau. 1990. Statistical abstract of The United States. Washington, DC.: GPO.

U.S. Census Bureau. Annual in-migration, out-migration, net migration, and movers from abroad for regions: 1980-2003. Internet release date: July 12, 2000, last revised: March 23, 2004.

U.S Census Bureau. 2003. Statistical abstract of the United States 83: 72. Live births, deaths, marriages and divorces.

U.S. Census Bureau. 2004. Interim projections of the US population by age, sex, race, and Hispanic origin: Summary, methodology, and assumptions. Washington, D.C.: U.G.P. Office.

Van Diepen., A. 1995. Population, land use and housing trends in the Netherlands since 1950. Working Paper WP-95-063. Laxenburg, Austria: IIASA.

Ventura, S. et al. 2000. Births: Final data for 1998. National vital statistics reports 48(3). Hyattsville, MD: National Center for Health Statistics.

Ventura, S. et al. 2001. Births: Final data for 1999. National vital statistics reports 49(1). Hyattsville, MD: National Center for Health Statistics.

Watkins, S. C., J. A. Menken, and J. Bongaarts. 1987. Demographic foundation of family change. *American Sociological Review* 52(3): 346-358.

White, M. J., and A. O. Tsui. 1986. A panel study of family-level structural change. *Journal of Marriage and the Family* 48(2): 435-446.

Wilkes, R. E. 1995. Household life-cycle stages, transitions, and product expenditures, *The Journal of Consumer Research* 22 (1): 27-42.

World Bank. 2004. World development indicators 2004 CD-ROM. Washington, DC.

Zeng, Y. 1986. Changes in family structure in China: a simulation study. *Population and Development Review* 12(4): 675-703.

Zeng, Y. 1988. Changing demographic characteristics and the family status of Chinese women. *Population Studies* 42: 183-203.

Zeng, Y. 1991. *Family* D*ynamics in China: A life Table Analysis.* Wisconsin: The University of Wisconsin Press.

Zeng, Y., K. C. Land, Z. Wang, and D. Gu. 2003. How many demographic changes affect future households. Presented at Annual Meeting of Population Association of America, May 1-3, 2003, Minnenapolis.

Zeng, Y., J. Vaupel, and Z. Wang. 1997. A multidimensional model for projecting family households - with an illustrative numerical application. *Mathematical Population Studies* 6(3): 187-216.

Zeng, Y., J. Vaupel, and Z. Wang. 1998. Household projection using conventional demographic data. *Population and Development Review, Supplementary Issue: Frontiers of Population Forecasting* 24: 59-87.

Zeng, Y., Z. Wang, L. Jiang, and D. Gu. 2005. Projection of family households and elderly living arrangement in the context of rapid population aging in China – A demographic window of opportunity until 2030 and serious challenges thereafter. Review at *Genus*.

Appendix:

Table 1 (continued on next page). Sensitivity of the population composition by household type to demographic events (% of total population).

		one person	one couple	couple with child	single parent with child	three generation
Constant	2000	25.8	26.8	31.7	8.5	3.5
	2030	28.6	28.8	26.4	10.2	1.2
	2050	28.4	27.3	27.0	10.9	1.4
	2100	24.4	26.9	30.0	11.6	1.8
LE+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-1.0	2.0	-0.4	-0.5	0.0
	2050	-1.6	3.8	-1.0	-0.9	0.0
	2100	-1.6	3.6	-0.6	-1.0	0.1
TFR+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.5	-1.6	1.5	0.5	0.1
	2050	-1.3	-3.5	3.4	1.4	0.3
	2100	-3.4	-6.7	6.9	3.4	0.5
NM+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.9	-3.1	2.9	0.9	0.2
	2050	-1.5	-3.7	4.0	1.2	0.2
	2100	-0.8	-2.6	2.8	0.9	0.1
UF+25% & UD-25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-2.6	2.7	1.7	-1.3	-0.1
	2050	-5.1	5.4	3.1	-2.2	-0.2
	2100	-6.4	7.5	3.7	-2.8	-0.5
GM&CR+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-1.7	1.8	0.9	-0.8	-0.1
	2050	-3.3	3.7	1.7	-1.4	-0.2
	2100	-4.3	5.4	1.9	-1.8	-0.5
GD&CDR-25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-1.0	0.9	0.8	-0.5	0.0
	2050	-1.9	1.7	1.5	-1.0	0.0
	2100	-2.6	2.5	2.1	-1.4	0.0
M&Bage+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.5	-0.8	1.2	0.9	-0.7
	2050	-0.3	-1.3	1.3	1.2	-0.9
	2100	0.6	0.4	-0.6	0.9	-1.3

		one person	one couple	couple with child	single parent with child	three generation
Mage+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.1	0.9	-1.1	0.5	-0.2
	2050	-0.3	1.4	-2.4	1.5	-0.2
	2100	-0.5	1.7	-2.8	2.1	-0.4
Bage+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.6	-1.7	2.0	0.9	-0.5
	2050	-0.8	-2.4	2.6	1.5	-0.7
	2100	0.1	-1.3	1.2	1.1	-1.0
LWC+25%	2000	0.0	0.0	0.0	0.0	0.0
	2030	-0.6	-1.2	1.3	0.6	0.1
	2050	-1.1	-1.7	1.8	1.2	0.1
	2100	-1.1	-2.1	2.2	1.1	0.2

Table 2a. Medium scenarios for US household projection

	TFR	LE	NM	GMR	GCR	GDR	GCDR
2000	2.03	76.8	1110218	0.07	0.12	0.03	0.38
2005	2.03	78.0	1079723	0.07	0.12	0.03	0.38
2010	2.02	78.8	1015892	0.07	0.12	0.03	0.38
2015	2.00	79.6	1041495	0.07	0.12	0.03	0.38
2020	2.00	80.4	1065476	0.07	0.12	0.03	0.38
2025	1.99	81.2	1161428	0.07	0.12	0.03	0.38
2030	1.99	81.9	1249481	0.07	0.12	0.03	0.38
2035	1.99	82.6	1248439	0.07	0.12	0.03	0.38
2040	1.99	83.2	1251699	0.07	0.12	0.03	0.38
2045	1.99	83.9	1257617	0.07	0.12	0.03	0.38
2050	1.99	84.5	1265059	0.07	0.12	0.03	0.38
2055	1.99	85.2	1268905	0.07	0.12	0.03	0.38
2060	2.00	85.9	1273475	0.07	0.12	0.03	0.38
2065	2.00	86.5	1278413	0.07	0.12	0.03	0.38
2070	2.00	87.3	1283659	0.07	0.12	0.03	0.38
2075	2.01	87.9	1289325	0.07	0.12	0.03	0.38
2080	2.01	88.5	1295321	0.07	0.12	0.03	0.38
2085	2.01	89.1	1301590	0.07	0.12	0.03	0.38
2090	2.01	89.8	1308251	0.07	0.12	0.03	0.38
2095	2.01	90.4	1315133	0.07	0.12	0.03	0.38
2100	2.01	90.8	1322396	0.07	0.12	0.03	0.38

Table 2b. Small household size and old age structure scenario for US household projection.

	TFR	LE	NM	GMR	GCR	GDR	GCDR
2000	2.00	76.9	935069	0.07	0.12	0.03	0.38
2005	1.83	78.3	777587	0.06	0.12	0.03	0.39
2010	1.75	79.7	692334	0.06	0.12	0.03	0.40
2015	1.67	81.2	681905	0.06	0.12	0.03	0.41
2020	1.61	82.6	676296	0.05	0.12	0.04	0.42
2025	1.59	84.0	707074	0.05	0.12	0.04	0.43
2030	1.57	85.2	732446	0.04	0.12	0.04	0.44
2035	1.57	86.4	717331	0.04	0.12	0.04	0.45
2040	1.57	87.7	708322	0.04	0.12	0.04	0.46
2045	1.57	89.1	702724	0.03	0.12	0.04	0.47
2050	1.57	90.4	698602	0.03	0.123	0.04	0.48
2055	1.57	91.8	695466	0.03	0.123	0.04	0.48
2060	1.56	93.0	692651	0.03	0.123	0.04	0.48
2065	1.56	94.6	689804	0.03	0.123	0.04	0.48
2070	1.56	95.7	686816	0.03	0.123	0.04	0.48
2075	1.56	97.4	683906	0.03	0.123	0.04	0.48
2080	1.56	98.6	681180	0.03	0.123	0.04	0.48
2085	1.56	100.1	678498	0.03	0.123	0.04	0.48
2090	1.55	101.5	676080	0.03	0.123	0.04	0.48
2095	1.55	102.5	673772	0.03	0.123	0.04	0.48
2100	1.55	103.5	671704	0.03	0.123	0.04	0.48

Table 2c. Large household size and young age structure scenario for US household projection.

	TFR	LE	NM	GMR	GCR	GDR	GCDR
2000	2.02	76.47	1316348	0.07	0.12	0.03	0.38
2005	2.2	76.99	1494753	0.07	0.13	0.03	0.38
2010	2.28	77.54	1491751	0.08	0.14	0.03	0.38
2015	2.32	78.05	1601934	0.09	0.14	0.03	0.38
2020	2.35	78.64	1697708	0.10	0.15	0.03	0.38
2025	2.36	79.17	1936451	0.10	0.15	0.02	0.38
2030	2.37	79.56	2169402	0.11	0.16	0.02	0.38
2035	2.38	79.81	2214463	0.12	0.17	0.02	0.38
2040	2.37	80.16	2258698	0.13	0.17	0.02	0.38
2045	2.38	80.36	2301723	0.13	0.18	0.02	0.38
2050	2.39	80.78	2343678	0.14	0.18	0.02	0.38
2055	2.4	80.98	2386430	0.14	0.18	0.02	0.38
2060	2.41	81.27	2428252	0.14	0.18	0.02	0.38
2065	2.42	81.52	2469008	0.14	0.18	0.02	0.38
2070	2.42	82.01	2508931	0.14	0.18	0.02	0.38
2075	2.43	82.15	2548442	0.14	0.18	0.02	0.38
2080	2.44	82.27	2587483	0.14	0.18	0.02	0.38
2085	2.44	82.42	2626136	0.14	0.18	0.02	0.38
2090	2.44	82.67	2664467	0.14	0.18	0.02	0.38
2095	2.44	82.68	2702588	0.14	0.18	0.02	0.38
2100	2.44	82.72	2740520	0.14	0.18	0.02	0.38

Note:

1. General rate is defined as the proportion of the events to the total number of persons at risk. For example, general cohabitation rate is the total number of new cohabitants divided by the number of non-cohabited never married, widowed and divorced people in the previous year.