Aging, Family Support Systems, Saving and Wealth: Is Decline on the Horizon for Japan?

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In many industrialized nations, fertility rates are now below the level of replacement, and life expectancy at birth has reached 80 years in a few select countries. As a result, population age distributions are changing markedly, with a relative increase in the numbers of elderly and a relative decrease in the numbers of young.

Demographic developments in Japan are similar in important respects to those occurring among industrialized countries of the West. Japan's demographic transition began more recently and has proceeded more rapidly. The total fertility rate is currently below 1.3 births per woman, and life expectancy at birth is higher than in any other country. Although a number of Western European populations are older, the percentage of Japan's population 65 or older is increasing rapidly and is expected to accelerate towards the early part of the next century (Ogawa, 1996). UN projections anticipate that 36% of Japan's population will be 65 or older by 2050 as compared with 20% of the U.S. population (United Nations, 2003).

An overwhelming majority of the Japanese people believe that a variety of social and economic changes will be necessary to accommodate rapid aging. In business circles, for instance, there has been concern about the implications of a slower-growing and older labor force (Clark and Ogawa, 1993, 1996). Government officials are concerned about the future viability of old-age pension schemes and the growing burden

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of medical services for the elderly (Ogawa and Retherford, 1997). In addition, although Japan's saving rate is currently relatively high as compared with other industrialized nations, there is widespread concern that population aging will depress national savings and, along with other aging consequences, undermine economic growth (Ogawa and Matsukura, 1995).

Studies of the impact of aging on national saving in Japan, reviewed in more detail below, reach widely divergent conclusions. Studies based on the analysis of aggregate saving data often conclude that population aging will lead to very low or even negative saving rates. In contrast, studies based on the analysis of household survey data typically find that population aging will have relatively little impact on saving. Efforts to reconcile these approaches have to this point been unsuccessful.

This paper addresses the relationship between saving and population aging using household survey data. The novel feature of this paper is its attention to extended living arrangements and intergenerational transfers. In societies where support for the elderly is achieved primarily through transfers from adult children, the lifecycle incentives for saving are diminished. Population aging would not lead to a substantial reduction in saving rates if the elderly were not financing their consumption by dis-accumulating personal wealth.

In Japan, however, the situation is very dynamic. Although many elderly live with and rely on their children in Japan, the importance of the extended household and intergenerational transfers has declined markedly in the last few decades. Young adults of today expect to receive old age support from their children to a much lesser extent than

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was the case in the past. Thus, the importance of life cycle saving may be increasing as elderly retirees become more independent of their children and dependent on personal wealth to meet their material needs. Moreover, strong aging effects may emerge as the family support system erodes. In a recent simulation analysis, Lee, Mason and Miller (2003) show that rapid demographic transition combined with a shift from a family-based support system to a lifecycle saving approach generates large swings in aggregate saving – large increases followed by large declines. During the transition wealth grows rapidly relative to income and stabilizes at a much higher level than prior to the transition. In this paper, we present empirical evidence from Japan that is broadly consistent with the simulation analysis in the Lee, Mason, and Miller paper. We do not find evidence that saving rates will drop to alarmingly low levels in Japan.

In the next section, we review the literature on aging and saving in Japan and the standard lifecycle saving model. We show, in theory, how saving and wealth are influenced by the existence of family support for the elderly and we discuss how household saving in nuclear and extended households vary during transition away from a family support system.

In the following section, we use household data from the National Survey of Family Income and Expenditure conducted in 1994 by the Statistics Bureau of Japan to estimate how demographic characteristics of the household influence saving and wealth. The results are consistent to an extent with the lifecycle model. Saving rates are higher at the working ages and lower when there are more young and elderly in the household. Wealth rises with age, particularly in the later working ages and declines at older ages.

The effect of changing living arrangements on saving are incorporated into the analysis by distinguishing nuclear from extended households. In addition, we use constructed measures of the number of non-coresident family members to assess whether coresident and non-coresident family members are substitutes. It may be that as extended living arrangements decline, inter-family transfers substitute for intra-family transfers either fully or partially maintaining family support for the elderly. Indeed, we do find that increases in the number of non-coresident family members partially offset the decline in coresident family members that results with the shift away from extended households.

The final section of the paper considers the future. Although our focus is on changes in saving and wealth, we also consider living arrangements and the employment status of households. The projections we present anticipate a continued decline in extended living arrangements. By 2050, only 10 percent of the population 65 and older is projected to be living in extended households as compared with 60 percent in 2000. We also anticipate a large increase in the proportion of households that are jobless because a larger percentage of the population will be elderly retirees who are not living with employed children. The percentage of jobless households is projected to rise from 15% in 1994 to 37% in 2050.

We find that the demographic changes that are occurring in Japan will lead to lower rates of saving, but our projections are for more gradual declines that anticipated by many other studies of saving in Japan. The household saving rate is projected to drop from 25.6% of disposable income in 2000 to 19.2% of disposable income in 2050. Most of that decline is concentrated in the second quarter of the 21st Century. The drop in the saving rate is sufficiently small, that projected wealth continues to rise during the first half of this century. Total household wealth rises from 9.1 times disposable income in 2000 to 11.4 times disposable income in 2050. Our assessment, then, is that alarmist views about the impact of aging on saving and wealth are unwarranted.

Recent studies of aging and saving

Gross national saving rates averaged around ten to fifteen percent of GNP at the beginning of the 20th Century. An upward trend is apparent starting from the mid-1930s, and very high rates of saving began during the early 1960s. Saving rates have recently declined but are still well above the level that persisted a century ago (Figure 1).

Figure 1. Trends in net saving rates, 1885-1996.

The trend in aggregate saving rates is broadly consistent with the lifecycle saving model that figures so prominently in most discussions of the connection between population aging and saving.   Reduced fertility, increased life expectancy, and accompanying changes in age structure, particularly when they are rapid as they have been in Japan, produce a rapid increase in the demand for lifecycle wealth and the saving rates necessary to produce that wealth. (See Higgins [1994] or Lee, Mason and Miller [2001]) for a more detailed discussion of the implications of demographic transition for lifecycle saving.)

Many studies have investigated directly the issue of whether or not high saving rates are likely to persist in Japan. Most studies take one of two alternative approaches. One approach is based on the analysis of aggregate saving data for Japan, OECD countries, or a larger group of countries of the world. These studies typically conclude that population aging will lead to a substantial decline in saving rates.

Yashiro and Oishi (1997) provide a recent example of this approach. They estimate saving equations similar to one first employed by Leff (1966). For their baseline simulation, gross national saving as a percent of GNP is regressed on the ratio of the old population to the working age population, the ratio of the young population to the working age population, and the rate of growth of per capita GNP. They use annual data for Japan for the period 1958-92 and estimate the saving relation using ordinary least squares methods. In their simulation, saving rates are depressed by the increased old-age dependency ratio and by the slow-down in the rate of growth of per capita income. They present four simulations with gross saving rates that vary from 5.8 percent of GNP to 9.1 percent of GNP by 2020-2025. Given depreciation that averages 15 percent of GNP, the average for the early 1990s in Japan, net saving as a percentage of net national product would range from -11.2 to -7.4 percent of net national product. These forecasts imply that Japan would be entering a new period of dis-equilibrium during which wealth would decline substantially relative to income.

The finding that net national saving rates will decline to low or negative levels as economies and populations mature is a robust one so long as the analysis is based on aggregate saving data. A number of such studies are summarized in Table 1. As can be seen, nearly all conclude that saving rates will drop substantially in the coming decades. There is, however, a wide range in just how substantial the decline is likely to be. Horioka (1991) for example forecasts a drop of the net private saving rate to -10 percent. A more optimistic assessment is provided by Masson and Tryon (1990) who anticipate a decline to 7 percent. Several recent studies based on international aggregate data reinforce the conclusion that saving rates will drop substantially. Higgins and Williamson (1997), for example, forecast a decline in Japan's gross national saving to 16.3 percent of GNP, a value consistent with a net saving rate close to zero, in 2025. Analysis by Kelley and Schmidt (1996) also supports the conclusion that saving rates will drop precipitously as population aging continues and economic growth slows.

Table 1. Summary of Saving Forecasts

The second method for forecasting saving relies on household survey data rather than aggregate data. Typically, a household saving function is estimated which includes demographic determinants, e.g., the age and sex of the household head and the number of household members in each age group. The simplest version constructs a saving profile that varies with the age of the household head. Projected household income by age of head is combined with the age-saving profile to construct a forecast of the aggregate household saving rate.

Mason et al. (1994) provides a recent example of a saving forecast based on micro data. This forecast of saving employs a saving equation estimated by Ando (1995) using the 1979 and 1984 the National Family Income and Expenditure Surveys. In his model, consumption as a fraction of labor income depends on the age of the household head and the number of household members in specified age-categories. Forecast household saving as a fraction of disposable income is relatively constant between 1995 and 2005 and then rises by two percentage points by 2025! Other micro-based studies forecast that saving rates will continue at relatively high levels or decline much more modestly than found by macro based studies. Deaton and Paxson (1997) reach similar conclusions in their analysis of survey data for Taiwan, Thailand, England, and the United States.

How can such extraordinarily different forecasts and such different conclusions about the implications of aging be reconciled? There are a number of possible explanations. The studies use different measures of saving—typically, gross national saving rates by aggregate studies and household saving rates by micro-based studies. However, the differences in forecasts are so great that they cannot be reconciled by differences in measurement.

In some respects, the forecasts based on aggregate data are flawed. Many of the causal factors are endogenous and identification problems have proved to be vexing. The saving-demography models have tended to be very parsimonious increasing the possibility that the strong relationship to demographic factors is spurious. Questions can be raised about the adequacy with which aggregate models have captured the complex dynamics that underlay the saving relationship.

Forecasts based on microdata also face daunting problems. The idea behind the approach is that the behavior of one age group can be used to predict future behavior of a younger age group. However, this approach will fail if there are substantial cohort effects or time effects that are not factored into the analysis. Consider the possible cohort effects. Those who are currently young in Japan may follow a different path than those who are currently old because their lifetime experiences are so different. Members of young cohorts married later, spent more time in school, have fewer siblings and are raising fewer children than members of old cohorts. Members of more recent cohorts can expect to live longer. Their lifetime income will be greater but they may experience slower earnings growth. They may expect more old-age support from the state but less support from their children. Each of these factors has a potentially important bearing on saving. Macro-based forecasts may prove to be more reliable than micro-based forecasts if they capture, even inadvertently, some of the cohort effects that are not modeled in micro-based forecasts.

The Lifecycle saving model

In the conventional lifecycle saving model consumption and earning both vary systematically with age. The age profile of consumption is determined by preferences and, in some formulations, physiological needs. The age profile of earning reflects variations in productivity. Saving is a means by which households can achieve their preferred consumption age profile irrespective of the age profile of earning they face. Because humans have extended period of youth dependency and increasingly significant periods of old-age dependency, there are extended periods during which preferred consumption may differ substantially earning. If the conventional lifecycle model is correct, rates of saving will vary over the lifecycle of individuals and aggregate saving will vary with the age structure of the population.

That consumption varies systematically with age but is constrained by available resources is represented by:

$$C(a) = f(a)PV[Y^l], \qquad (1)$$

where C(a) is consumption at age a, $PV[Y^l]$ is the present value of earnings ($Y^l(a)$) received over the lifetime, and *f(a)* is the fraction of lifetime resources consumed at age a. The household's lifetime budget constraint is satisfied if $\sum e^{-ra} f(a) = 1$.

Because households follow the same age earnings profile over their lives by assumption, the fraction of lifetime resources earned at each age, *g(a),* is fixed.[2] Under these conditions

$$Y(a) = g(a) PV[Y^l]. \tag{2}$$

The fraction of earnings consumed at each age, $c(a) = C(a)/Y^l(a)$, is obtained by dividing equation (1) by equation (2). Taking the natural log of both sides yields:

$$\ln c(a) = \ln f(a)/g(a) \tag{3}$$

Equation (3) gives the age profile of the consumption ratio at any point in time under the simplifying assumptions of the standard lifecycle model.

The aggregate consumption rate, consumption as a fraction of income, is calculated by:

$$c = C/Y = \sum_a c(a) N(a) Y^l(a)/Y, \tag{4}$$

where *N(a)* is the current population age a and *Y* is aggregate income. The influence of age structure on the consumption ratio is readily apparent as is its influence on the saving ratio, $s = 1 - c$.[3]

[2] Several studies take exception to this assumption with important implications for the relationship between saving and economic growth. See Lee, Mason and Miller (2000), for example.

[3] Although most aggregate saving models assume that saving rates depend on age-structure, it is clear from equation (4) that it is the share of income, not the population, of each age group that matters. Consequently, the effect of changes in age structure depend on the age-profile of income, which is influenced in turn by rate of economic growth (see Mason [1987]).

How are consumption and saving rates affected when societies rely on family transfers rather than saving to meet lifecycle needs? To provide a general answer to this question it is helpful to consider a special case. First, we assume that the economy is in long-run equilibrium. The interest rate r is constant; the rate of economic growth g is constant and equal to the rate of growth of technological progress plus population growth, both of which are constant. The age structure of the population is fixed. The aggregate saving rate is constant as is the ratio of wealth (W) to total earnings or total income.

Second, we assume that the population consists of families, each of which has the same demographic composition as the entire population. The individuals in these families can rely on saving to satisfy lifecycle needs as described by the lifecycle model. Or individuals can rely on intra-family transfers to solve their lifecycle problems. Individuals within families would pool their earnings and finance consumption of family members in accordance with preferences as defined by *f(a)*. Under these conditions, there would be no lifecycle saving nor any wealth. Each family would consume all of its earnings and, because it had neither wealth nor interest income, all of its income.

How do the saving and consumption rates of families relying on intra-family transfers compare with those relying on lifecycle saving? To answer this question we make use of some of the properties of a steady-state equilibrium. In steady-state, saving is just sufficient to maintain the ratio of wealth to income, a condition that is satisfied only when $S = gW$.[4] By definition, household income is equal to $Y^l + rW$, and it follows that consumption as a fraction of labor income must equal:

$$C / Y^l = 1 + (r - g) W / Y^l. \tag{5}$$

[4] See Tobin (1967) for a more extensive elaboration on the steady state lifecycle saving model.

If $g = r,$ the golden rule case, consumption will equal earnings. Thus, consumption as a fraction of labor income is equal to 1.0 whether families rely on transfers or saving.[5]

If the rate of return on capital exceeds the rate of economic growth, the more typical case, then consumption will exceed labor earnings by $(r-g)W$ under lifecycle saving. Thus, consumption as a fraction of labor earnings is higher under lifecycle saving. Another way to think about this is that the lifecycle saving family can support higher consumption than the transfer family if the rate of return to savings, *r*, is greater than the rate of return that can be achieved through transfer systems, *g*.

Under most circumstances, lifecycle saving families will consumer a smaller fraction of *total* income than families that rely on transfers. Consumption as a fraction of total income is given by:

$$C/Y = 1 - gW/Y. \tag{6}$$

If the rate of economic growth is positive, $C/Y < 1,$ while for transfer reliant families $C/Y = 1.$

In principle, states can implement transfer programs identical to the complete transfer system described above, but multi-generation extended family experiences age-related fluctuations in income and consumption needs that cannot be smoothed entirely through intra-family transfers (Chanayov, 1966; Lee, Mason and Miller, 2000). Thus, even in a setting where family support systems are pervasive, the demand for lifecycle saving may still be substantial. Thus, the existence of family support systems will lead to

[5] Total consumption will be higher under life cycle saving because of general equilibrium effects, however. Higher equilibrium wealth will lead to a higher capital-labor ratio and greater total earnings. In an economy in which some households are lifecycle savers and some rely on family transfers, both groups of households will benefit in the form of higher earnings from the wealth and capital held by lifecycle savers.

attenuation, not elimination, of the effects of age-structure on aggregate saving (Lee, Mason and Miller, 2003) .

As discussed above, the Japanese approach to old-age security is a mixed approach not characterized by either of the two extremes presented above. Some families rely on intergenerational transfers, while other families rely on pensions and personal savings. Nearly all elderly receive partial support from public transfer programs. Further complicating the picture is that the support system is in transition. Some adults are supporting their parents, have done so, or are expecting to do so in the future, but anticipate receiving much less support or no support at all from their own children.

How will saving in transition households be influenced by the decline in family support systems? This is an issue addressed using simulation techniques by Lee, Mason, and Miller (2003). They show that saving rates will rise in response to a decline in the transfer system. If the transition is relatively smooth and anticipated by those experiencing it, saving rates will rise to levels consistent with lifecycle saving households. If, however, the transition is rapid and unexpected, households may engage in "super-saving", saving that is higher than life cycle saving, as they reduce their current and planned consumption in response to the decline in expected transfers.

To summarize, the lifecycle model implies that in steady-state equilibrium, with $r>g$, the ratio of consumption to labor income is lower among households that rely on family support systems, and the ratio of consumption to total income is higher among households that rely on family support systems. During periods of transition, however, the ratio of consumption to total income may be lower among households that rely on family support systems. Thus, whether extended households have lower or higher saving than nuclear households is an empirical issue.

Even if the theoretical implications of the lifecycle model were unambiguous, obtaining reliable tests of these hypotheses would be difficult. Most household surveys, including the NSFIE, provide only a partial accounting of saving and income because they do not include accumulations in employment based pension funds. In addition, a relatively high percentage of Japanese are own-account workers for whom separating labor income from returns to business assets is very difficult. Adding to the complexities are problems with measuring income specific to the NSFIE that are discussed below.

Analysis of the Survey Data

The Data

The empirical work is based primarily on the 1994 round of the National Survey of Family Income and Expenditure (NSFIE). (The 1989 round is used for very limited purposes.) The Statistics Bureau of the Japanese Government has been conducting the NSFIE every five years since 1959. One of the primary objectives of this survey is to shed light on the structure of the household economy and regional differences therein emphasizing three aspects: (i) family income and expenditure, (ii) consumer durables, and (iii) assets and liabilities.

The sample size of the NSFIE is approximately 55,000 private households with two or more members and about 4,700 one-person households, but our analysis does not include one-person households. For each household type, the selection procedure is a stratified random sampling based on geographical location. Because it is difficult to design the stratified random sampling procedure based upon geographical locations without creating some variability in sampling ratios over the regions, NSFIE is subject to regional variability in sampling ratios. For this reason, each observation is weighted so as to obtain a representative sample. Private households with two or more members were surveyed for the period of three months from September to November.

The survey data are used to construct measures of disposable income, consumption, wealth, and demographic characteristics of the household. In defining each of these variables, there is an inevitable tension between designing a measure that is comparable to national income statistics, that is consistent with the underlying theoretical model of household behavior, and that is practical given the limitations of any survey as complex as the NSFIE. Thus, the measures used are a compromise between these different considerations.

Household income is measured as disposable household income. Income is net of all taxes and includes wage and salaries, interest income, property income, profits, public and private transfers, and the flow of imputed rent from owner-occupied dwellings. We exclude transfer expenditures.

Consumption is measured as the NSFIE variable living expenditure plus the imputed value of owner-occupied dwellings. There are some technical issues that arise with respect to measuring consumption and income that we describe in more detail below.

We distinguish three forms of wealth: financial wealth, housing wealth, and consumer durables. Financial wealth includes the value of stocks and bonds, savings accounts, cash, the value of life insurance policies, and other financial assets less all debt including mortgages against housing and land. Housing wealth is the gross value of real property.

Demographic characteristics of the household are measured by the number of male and female household members in five-year age groups from 0-4 to 85 and older. We distinguish extended from nuclear households using information about the relationship to head of household members. Extended households as defined here are multi-generation households, households in which there is a parent of the head, a grandchild of the head, or a child of the head over the age of 30 is counted as extended. The analysis also distinguishes households by their employment status (worker households, independent proprietors, and jobless households).

Table 2 provides the 1994 joint distribution of households by type. About two-thirds of all households are worker households, but there are substantial numbers of individual proprietors (21.7%) and jobless households (11.5%). Over 70 percent of all households are nuclear; nuclear households dominate both worker households and jobless households (about 60%).

Table 2. Distribution of Households, 1994 NSFIE

Worker households, particularly nuclear worker households, tend to be relatively young as compared with the others. Extended worker households are dominated by prime-age adults with one or more co-resident elderly member. Members of independent proprietor households are older, on average, than are the members of worker households.

This is true particularly of nuclear independent proprietor households. Jobless households consist mostly of elderly couples.

Adjustments to income and consumption

The NSFIE collects detailed income and expenditure data for a three-month period (September – November). However, the detailed income data are collected only for worker households. Our measure of income is based on *annual income*, a question asked of all households. Annual income refers to income received during the twelve-month period ending in November of the survey year. The measure is net of taxes and transfer expenditures.

The analysis is based on disposable income, which excludes transfer expenditures and non-living expenditures, consisting primarily of taxes and which includes the imputed rent of owner-occupied dwelling. A number of adjustments are necessary. First, transfer expenditure is available only for the three-month period rather than on an annual basis. Thus, we adjust transfer expenditure to account for seasonality in this variable. The adjustment is based on monthly data for the 12-month reference period for annual income collected by the Family Income and Expenditure Survey (FIES). These data are available only for worker households. We assume that worker and non-worker households experience the same seasonality in transfer expenditure.

Second, non-living expenditure, consisting primarily of taxes, are also adjusted for seasonality for worker households employing the same method as used for adjusting transfer expenditure. Non-living expenditure are not collected for non-worker households. Hence, we reduce annual income by a constant fraction for all non-worker households based on a crude estimate of the tax rate (non-living expenditure/income) paid by these households. Several studies of Japanese taxes indicate that the tax rate paid by worker households exceeds the tax rate paid by non-worker households. Consequently we assume that the tax rate paid by non-worker households is 80% of the tax rate paid by worker households. The average tax rate paid by worker households was 0.1560 according to the 1994 NSFIE.

Third, consumption expenditure, collected for the 3-month period, is adjusted for seasonality using the FIES. Estimates are available for both worker and non-worker households. Japan does not collect monthly data on imputed rents using the FIES and, hence, no adjustment for seasonality is possible. There is little reason to expect seasonality in imputed rent in any case.

Incorporating all of these adjustments, disposable income for worker households is:

YD = Annual income/12 – 1.047*Transfer expenditures – 1.186*non-living expenditures + imputed rent

Disposable income for non-worker households is:

YD = 0.875*annual income/12 – 1.047*transfer expenditures + imputed rent

Consumption is calculated as:

C = a1*consumption + imputed rents

Where a1 equals 1.058 for worker households and 1.044 for non-worker households.

Non-coresident family members

Two variables are constructed that measure, in crude form, the availability of non-coresident family members. NC2064 is an estimate of the number of non-coresident surviving family members (children or parents) between the ages of 20 and 64. NC65+ is an estimate of the number of surviving no-coresident parents aged 65 and older.

The methods for constructing these measures are described in detail in the appendix to the paper. Essentially we impute values to each of the households in the survey based on the age and sex of the household's members and whether or not the household is extended or nuclear. The values are averages that do not reflect many characteristics of the respondent households, e.g., whether or not their parents are still alive, their childbearing pattern, and the economic characteristics of their particular parents and children.

We assume that NC65+ equals zero for extended households. This assumption may at first appear to be unreasonable and it no doubt would be for many countries. In Japan, however, relatively few older adults are divorced. Moreover, given the patrilineal nature of Japanese society, the son's parents figure much more prominently than do the daughter's. Essentially, we are assuming that the wife's non-coresident parents have no effect on the household's behavior.

Variable names and definitions are provided in Table 3. Descriptive statistics are provided in Table 4.

Table 3. Variable names.

Table 4. Descriptive statistics.

The Results

Regression results (estimated coefficients and standard errors) for the natural log of consumption and disposable income are presented in Table 5. The final column is the estimated partial effect on $\ln C/Yd$, calculated as the difference between the ln *C* and the ln *Yd* coefficients. The values in the last column are also approximately equal to the negative of the partial effect on saving of each of the independent variables. The estimates are obtained using ordinary least-squares regression.

Table 5. Parameters estimates, consumption and income, NSFIE, Japan, 1994.

The standard errors are generally quite small. This is not surprising given the large sample size of the NSFIE. The coefficients are all significantly different than zero at conventional significance levels except for *NC65P* in the ln *Yd* regression.

The estimated age profiles of ln *C* and ln *Yd* both have an inverted U shape. The age profiles for both ln *C* and ln *Yd* peak at ages 50-54. Increases in the dependent population lead to a rise in the consumption ratio and a decline in the saving ratio, a conclusion that follows from the positive values in the final column of Table 5 for households members aged 0-19 and 75 and older. The magnitudes of the coefficients are relatively small, however, and changes in age structure may have a relatively modest impact on aggregate saving judging from these values. However, the estimates control for the employment status of the household, and jobless households tend to be concentrated among the elderly.

A puzzling feature of these estimates is that the largest positive impact on saving comes from additional young adults in the household, while the effect of middle-aged adults is very small. This seems contrary to conventional wisdom, but note that these estimates control for the number of children. The saving rate of a household headed by a middle-aged adult and no children is similar to a household headed a young adult and two children.

The employment status of the household has a relatively modest effect on consumption and a relatively substantial effect on income and saving. Worker households and entrepreneurial households have similar levels of disposable income, but substantially higher disposable income than jobless households (the excluded category). Worker households have somewhat higher consumption than jobless households or entrepreneurial households. Entrepreneurial and worker households have much higher saving rates than jobless households.

Being an extended family has a significant positive impact on disposable income and a much smaller positive impact on consumption. Thus, an increase in the proportion of extended households has a positive impact on saving. Note that we have controlled for family size so that the effect does not reflect the fact that extended households have more members (and more earners) than nuclear household, nor does it reflect differences in employment status that are correlated with living arrangements.

An increase in the number of non-coresident family members also leads to higher income and higher saving. These effects partially offset the impact of being in an extended family, because nuclear households have higher numbers of non-coresident family members. The combined effect of NC2064, NC65P, and EXFAM given the mean values for 1994 is that ln *C/Yd* is reduced by –0.079 by living in an extended household. Saving rates are approximately 8 percent higher in extended than in nuclear households controlling for the demographic composition and the employment status of the household.

Table 6 presents wealth regressions. Several measures of wealth relative to disposable income are regressed on the same set of regressors used in the consumption and income analysis. The age profile of wealth is consistent to some extent with the lifecycle model. Wealth increases substantially with age with the greatest wealth is concentrated among those in their 50s and 60s. The peak wealth/income ratio varies with the form of wealth. Total wealth and housing wealth reach a peak among those in the early 70s. Financial wealth reaches a peak in the early 60s. The age profile for consumer durables is quite distinctive with the peak occurring in the late 20s.

Table 6. Parameter estimates, wealth equations, NSFIE, Japan, 1994.

Jobless households have the highest wealth-income ratio followed by entrepreneurial households and worker households. The effect of employment status is very substantial. Although part of the explanation is that jobless households have lower income, i.e., a smaller denominator, they have substantially more wealth. A plausible explanation for this pattern is that higher wealth households are more likely to retire (become jobless).

Except for consumer durables, the effects of living in an extended family and the effects of non-coresident family members on wealth are consistent, at least in sign, with their effects on saving rates. Living in an extended family and having more non-coresident family members leads to greater wealth irrespective of whether the family members are elderly or of working age. As discussed above, these variables offset each other because those living in extended families have fewer non-coresident family members. Given the mean values for 1994, the net effect of living in an extended household is to raise wealth by 1.12 times disposable income. Almost all of this gain is in housing wealth. The gain in financial wealth is very small – only 0.04 times disposable income.

Projections

Japan has experienced a rapid decline in the prevalence of extended households in recent years. Whether the trend will continue is to difficult to say, but our look into the future is premised on the assumption that the downward trend will continue and that by 2050 a relatively small percentage will live in multi-generation, extended households. The great majority of elderly will live independently. If these changes do occur, many of the variables in the model estimated above will be affected. The average number of members per household will decline because multi-generation households will be less prevalent. The average number of non-coresident family members will be higher than would otherwise be the case because fewer family members will be living with each other. The proportion of households classified as "jobless" will increase because many more retired elderly will be living independently rather than with their working children. These changes in living arrangements will interact with changes in population age structure to produce changes in the demographic and economic characteristics of Japanese households.

Projections of population and living arrangements

The population projections used here are the medium scenario recently released by the United Nations (2001). Projections of the number of extended and nuclear households, the average number of members in each age group, the number of non-coresident family members, and the distribution of households by their employment status are not available. There are several general purpose models that can be used to project families or households[6] and household projections available for Japan (Mason et al, 1996; IPSSR, 1998), but these models do not meet the specific needs of this effort.

The details of the formal model used to project living arrangements are presented in the appendix and in Mason and Lee (2002). Here we provide a general overview and some of the key results obtained by estimating the model using the 1989 and 1994 NSFIE.

The model distinguishes three age groups or generations within the population–older adults, younger adults, and children. Those under age 30 are children, those 30 years or older but younger than 60 are younger adults, and those 60 or older are older adults. Although age 30 is an unusually late age for classifying individuals as adults, the singulate mean age at first marriage is currently nearly 30 for women and just over 30 for men. Thus, for considering living arrangements using 30 is appropriate and convenient.

The proportion of older adults living in extended households is determined by an age effect and a cohort effect. The age effect captures the influences of infirmity or financial hardship that may increase with age. The cohort effect captures the shift in living arrangements that are occurring over time or, to be more explicit, the shift away from extended families. We assume that the effect of age on the log-odds of living in an extended household is unchanging over time and that the log-odds for a cohort is linear in time (or year of birth).

Analysis of the NSFIE for 1989 and 1994 supports two tentative conclusions. First, later born cohorts are much less likely to live in extended households than earlier born cohorts. The percentage of those 60-64 living in extended households is estimated to be in excess of 80 percent for 1969 as compared to the observed values of 52 percent in 1989 and 45 percent in 1994. Second, age per se appears to have an important effect on living arrangements only among the older old. Controlling for the cohort effect, the odds that an individual aged 65-69 or 70-74 lives in an extended household are no greater than the odds for an individual aged 60-64. However, the odds for individuals aged 75-79 are 1.3 times as great, for individuals aged 80-84 2.2 times as great, and for individuals aged 85+ 3.5 times as great as the odds for individuals aged 60-64.

The proportion of those 65-69 living in extended households is projected to decline to only 20 percent in 2015 and further, thereafter (Figure 2). Similar declines are projected for other age groups. This dramatic projected decline is an extrapolation based on data for only two years and is very tentative in nature. It is no more rapid, however, than expectations regarding the decline in family support for the elderly expressed in attitudinal surveys (Ogawa and Retherford, 1997).

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[6] Examples include SOCSIM (Hammel et al., 1981) and HOMES (Mason et al, 1996).

Figure 2. Estimated and projected proportion of those 60-64 living in extended households.

The projections of the proportions of younger adults and children living in extended households are tied to the projections for older adults. An extended household as defined here requires at least one adult member from two generations. Consequently, the trend for older adults and younger adults are clearly not independent. The details of the method for modeling this interdependency are relegated to the appendix. The outcome of that effort is that the proportions of younger adults and children living in extended households are projected to decline, as well. The overall change is that the percentage of the population living in extended households is projected to decline from 33% in 1994 to 6% in 2050. The percentage of households that are extended is projected to decline from 25% to 4% during the same period.

As we shall see, one of the most important implications of the decline in extended households is that it leads to a rise in the proportion of households that are jobless. The reason for this is easy to imagine. The great majority of jobless *individuals* are retired elderly, but in current day Japan most live with their employed children. As independent living becomes the norm, retired elderly will maintain separate households in which no members are working. Hence, the proportion of jobless households will rise. This intuition is born out by the facts as is evident in Figure 3, which shows the proportion of each age group living in jobless households separately for extended and nuclear households. Fewer than 20 percent of the elderly living in extended households live in jobless households. Between 50 and 80 percent of those 65 and older living in nuclear households live in jobless households.

Figure 3. Jobless households and the elderly.

The final methodological issue with respect to our projections is the procedure used to project the number of non-coresident family members. The methods used our identical to the methods used to construct the measures used in the statistical analysis presented above and are described in the appendix.

Projection Results

Rapid aging in Japan is reflected at the household level in changes in the average numbers of household members at each age. Aging is so dramatic in Japan that the average numbers of members at all ages below age 70 are projected to decline between 2000 and 2025. Between 2000 and 2025 there are large increases in the numbers aged 75 and older. Between 2025 and 2050, the increase is concentrated among those 85 and older (Figure 4).

Figure 4. Average members per households, projected, 2000-2025.

Projected changes in age structure and projected changes in living arrangements combine to produce enormous changes in the demographic characteristics of the family support system. Between 2000 and 2025, the number of non-coresident prime age adults

(NC2064) is relatively stable at about two persons per household. By 2050, however, the number has dropped to only one person per household (Table 7). This change reflects the substantial decline in childbearing (or the age structure) and occurs even though a larger percentage of prime age adults are living away from their parents in 2050 than in 2000.

Table 7. Projected Household Characteristics, 2000-2050

The changes in the number of non-coresident elderly (NC65P) are similar in magnitude to the changes in non-coresident prime age adults. Between 2000 and 2050, the number of elderly living elsewhere more than doubles from 0.40 per household to 0.86 per household. The increased reflects both the increased survival of the elderly and the passing of older cohorts of high fertility Japanese.[7]

Multi-generation extended households are in substantial decline and the projection anticipates that only 4 percent of households will be extended in 2050 as compared with about 25 percent in 2000. The employment status of households is also projected to change substantially. In particular, worker households will decline and jobless households will increase while self-employed households (other) will remain relatively stable. Between 2000 and 2050, the proportion of households that are jobless increases from 15 percent to 37 percent. This dramatic change reflects the complementary effects of aging and the shift towards nuclear households. A much higher percentage of Japan's population will be concentrated at older ages where rates of

[7] NC65P is measured in such a way as to reflect sharing among siblings. Hence, a value of 1 would correspond to 2 siblings with 2 surviving parents.

employment are low and a much lower percentage of those elderly will be living in households with their working adult children.

If the assumptions that underlie these projections hold, the demographic changes outlined above will lead to a decline in the rate of saving and a rise in wealth relative to income. Total wealth is projected to increase to 11.4 times household disposable income in 2050 from 9.1 times household disposable income in 2000. In percentage terms, the greatest increase is in financial wealth; in absolute term, in housing wealth. Saving as a percent of disposable income is projected to decline from 25.6 percent in 2000 to 23.1 percent in 2025 and 19.2 percent in 2050 (Table 8).

Table 8. Projected Economic Variables, 2000-2050.

The bottom rows in Table 8 show the equilibrium saving rates that would sustain the projected wealth-income ratios given the current growth in the number of households and the rate of growth of output per worker, assumed to 1.5 percent per annum for the purposes of these calculations.[8] Given this assumption, growth in household disposable income would decline from 3.0 percent in 2000 to 1.6 percent in 2025 and 1.0 percent in 2050.[9]

The equilibrium saving rate in 2000 for total wealth is quite similar to the projected saving rate, 27.5 percent versus 25.6 percent. In 2025 and 2050, however, the equilibrium rate has dropped to values substantially below the projected value. Thus, the

[8] Wealth/household income will remain constant only if the saving rate is equal to the rate of growth of household income times the ratio of wealth to household income.
[9] These values do not include the impact of changing demographic characteristics on household disposable income, which have a negligible impact on the calculations.

projected saving and wealth values for 2025 and 2050 are clearly inconsistent with equilibria. Thus, wealth relative to income will continue to rise after 2050 until the current saving rate and the equilibrium saving rate are equal. Exactly how this outcome would be achieved can not be determined without extending the projections beyond 2050.

What accounts for the decline in saving and the rise in wealth? Although the partial effect of the changes over the projection period in mean values of individual variables can be readily calculated, interpretation requires caution because of the inter-connections among the explanatory variables. Changes in age structure have a direct influence on saving and wealth, but an indirect influence on the number of non-coresident family members, the employment status of households, and the prevalence of extended households. Likewise, the decline in the extended family slows the decline in the number of non-coresident family members and contributes to the rise in the number of jobless households. Thus, we cannot readily partition the rise in the wealth ratio or the decline in the saving ratio into additive components that capture the full effects of changes in age structure or living arrangements.

The direct effects are as follows. Between 2000 and 2050, changes in age structure led to a direct increase in the consumption ratio of 4.3 percent. Changes in employment status, i.e., the rise in the number of jobless workers, and the decline in extended living arrangements led to increases in the consumption ratio by 4.1 and 4.2 percent, respectively. Changes in the number of non-coresident family members led to a decline in the consumption ratio by 4.2 percent.

Age and employment status also had large positive direct effects on wealth. The changes in age structure between 2000 and 2050 led to an increase in the wealth-income ratio by 1.9. Changes in employment status led to an increase in the wealth-income ratio by 1.1 while the decline in the extended family directly reduced the wealth-income ratio by 0.7. Changes in the number of non-coresident family members had a relatively negligible effect.

The shift away from extended living arrangements is playing a somewhat ambiguous role in the determination of saving and wealth. The direct effect of the decline in the proportion of extended households is to lower saving rates and to reduce wealth. This runs counter to the intuition that those living in nuclear households should save more to satisfy lifecycle needs that are no longer provided through family transfers. As shown above, this intuition may be incorrect during transition periods. Extended households may be unusually high saving rates if young adults living in these households anticipate that they will not be able to rely on support from their own children. If this phenomenon is operating, then the methodology employed here may not successfully capture these dynamic effects.

If we look more broadly at the changes that accompany the decline in the extended family, however, the full effect may be to raise saving rates. The direct effect of a decline in the extended family is entirely offset by changes in the number of non-coresident family members. The rise in the number of jobless households, due in large part to a rise in the number of extended households, has a large positive effect on saving. Under these circumstances, we cannot reach any firm conclusion about the changing role in living arrangements.

These results support the view that demographic change in Japan may lead to a significant decline in aggregate saving over a very extended period, but a decline that is much smaller than suggested by analysis of aggregate data. The decline projected here is not alarming. It is sufficiently small that wealth will continue to rise relative to income throughout the next five decades. This conclusion is supported either by computing the equilibrium wealth-income ratio implied by the projected saving rates or by the direct projection of the wealth-income ratio.

Conclusions

The results from this analysis paint a somewhat optimistic view about one aspect of Japan's future. Even though aging is more rapid in Japan than in any other country, our analysis suggests that saving rates will decline only modestly over the long-term. The decline is sufficiently modest that wealth will continue to rise relative to income if our projections hold. If one believes the standard neo-classical model, the further rise in the capital intensity of the Japanese economy will yield additional economic growth.

Whether high rates of saving are good for the Japanese economy or not is a debatable point. One cannot count on demographics to push domestic consumption to higher levels. Thus, if the Japanese economy needs substantially higher domestic consumption in order to recover and to sustain higher rates of economic growth, then our analysis is bad news. Of course, no one has ever suggested relying on demographics to stimulate consumer demand.

The results do point to the importance of achieving higher rates of return to domestic capital or foreign investment. As Japan ages an increasingly large percentage of its population will depend, not on earnings, but on returns to capital. The economic status of the elderly will suffer if the rise in wealth depresses returns to capital to even lower levels than those that prevail today.

The importance of personal savings to Japanese elderly will be all the greater if the decline in the family support system continues. Our projections anticipate that only 10% of Japan's elderly will be living with their children by 2050. Of course, many who are living independently may be able to count on their children for support for their instrumental and financial needs. Given the persistence of low fertility and increased life expectancy, however, the potential burden of family support systems on the children of the elderly will be much greater than in the past. Family support has a role to play, but perhaps a less important one in the future.

Many questions can be raised about the analysis presented and additional research should provide results in which we can place greater confidence. One of the major short-comings of this study is its reliance on a single cross-section. This is an especially serious problem when the processes being studied are so dynamic in nature. Making use of repeated cross-sections or panel data to study how saving and wealth are responding to changing demographic conditions should prove very instructive. This is a step we intend to take next.

Appendix

Surviving offspring per woman

Surviving offspring per woman, o'(x,s,a), is an estimate of the average number of offspring by age (x) and sex (s) per woman aged a. The values are calculated using historical data on the distribution of births by age of mother under several simplifying assumptions: (1) that the population is closed to migration; (2) that survival rates of offspring and mothers are independent of the birth age of mothers and the total numbers of births. If we let B(a,t) be the number of births to woman aged a in year t and s(x,t) be the probability of surviving from birth to age x in year t, the total number of surviving offspring (or population) aged x with a mother aged a in year t is given by:

$$O(x, a, t) = B(a - x, t - x)\, s(x, t) \quad (1)$$

Summing over mother's age a and dividing equation (1) by the results yields:

$$O(x, a, t)/O(x, t) = B(a - x, t - x)/B(t - x) \quad (2)$$

If survival is independent of the age of one's mother at time of birth, then the distribution of offspring by age of mother is determined solely by the distribution of births.

The number of surviving offspring in year t is calculated multiplying the birth distribution in equation (2) by the population aged x in year t, N(x,t). The number of offspring includes those whose mothers are deceased. The number of offspring with living mothers is given by:

$$O'(x, a, t) = [B(a - x, t - x)/B(t - x)]\, N(x, t)\, s'(a, t) \quad (3)$$

where s'(a,t) is the proportion of women belonging to the cohort aged a in year t who survived to the current age from their childbearing years. This value is approximated here as the proportion who survived from age 50-54.

Offspring per woman is given by:

$$o'(x, a, t) = [B(a - x, t - x)/B(t - x)]\, N(x, t)\, s'(a, t)/W(a, t) \quad (4)$$

where W(a,t) is the number of women aged a in year t.

The birth distribution is taken from vital statistics records for Japan. Single year of age distributions are available for 1947 and later; five-year age distributions are used for earlier years except for a few years during World War II. All values are calculated separately by sex of offspring. We assume that male and female births have the same age of mother distribution. Population data are from the population census. For the projections, the distribution of births by age of mother and the joint age distribution of husbands and wives are assumed to remain constant at the most recently available values. Population and survival data are from the UN Population Division's most recent projections ([United Nations, 2000 #406]).

Surviving offspring per man

Given a birth distribution by age of father, surviving offspring per man could be calculated in a fashion that parallels the calculation of surviving offspring per woman. These data are not available for most countries. For Japan a five-year age distribution is available, but we do not employ this. Rather, we use an estimate of the joint-distribution of husbands and wives while assuming that given the age of mother, the number of births is independent of the age of father. Let H(w,x) be the number of couples with a husband aged x and a wife aged w, then B*(x,t), the number of births in year t to men aged x, is calculated by:

$$B^*(x, t) = \sum_w B(w, t)\ H(w, x, t)/H(w, t) \qquad (5)$$

where H(w) is the number of childbearing couples consisting of a man of any age and a woman aged w.

The proportion of women aged w married to a man aged x is approximated using the joint age-distribution of households heads and their spouse tabulated from 1 percent samples of the population census of Japan. The joint age distribution, tabulated for another purpose, is available at five-year intervals from 1970 to 1995.

Surviving parents per offspring

The number of surviving women and men per offspring are calculated separately. Letting o(a,x,t) be the number of surviving offspring aged x per woman a in year t, then the number of surviving women aged x per offspring, p(x,a,t), is given by:

$$p(x, a, t) = [1/o(a, t)]\,[o(a, x, t)/o(x, t)] \qquad (6)$$

Note that o(a,x,t) includes offspring who do not have a surviving mother. Surviving parents per offspring is consequently reduced by mortality among parents. Note further that the measure constructed in this fashion also includes women in the numerator who have no surviving offspring including those who never gave birth. There is no attempt to assess the extent to which family links have been severed by mortality or celibacy. Surviving fathers per offspring are calculated in parallel fashion.

Modeling extended living arrangements

Assume that individuals in a one-sex population live for 3g periods where g is the length of a generation. Individuals give birth at age g, become grandparents at age 2g, and die at age 3g. There are two types of households: extended households, consisting of at least one member belonging to each generation; or, nuclear households that consist of members of the oldest generation or members of the middle generation and their children.

Further we assume that some unspecified optimizing process leads to a number of adults per household, which we designate by m^x for extended households and by m^n for nuclear households.

Proportion living in extended households

Let $x(a,t)$ be the proportion of persons age *a* living in extended households in year *t* and let $o(a,t) = x(a,t)/(1 - x(a,t))$ be the corresponding odds ratio. The odds that members of the oldest generation will live in an extended household is determined by a cohort and an age effect:

$$\begin{aligned} o(a,t) &= o(2g,t)\,b(a) \\ \ln o(a,t) &= \ln o(2g,t) + \ln b(a) \quad \text{for } a \geq 2g. \end{aligned} \tag{1}$$

The log-odds of living in an extended household for individuals aged *2g* is estimated as a linear function of *t*. The model employed and estimated to project the proportion 60 and older living in extended households is:

$$\ln o(a,t) = \alpha_0 + \alpha_1 t + \ln b(a) \quad \text{for } a \geq 2g. \tag{2}$$

Estimation procedures are described below.

The proportion middle-generation adults living in extended household can be obtained directly given the old-age dependency ratio and the proportion of older-generation adults living in extended households. It is straightforward to show that:

$$x(a,t) = (d(a,t)/d^x(a,t))\,x(a+g,t) \quad \text{for a<2g.} \tag{3}$$

where the old-age dependency ratio for extended households is defined as:

$$d^x(a) = N^x(a+g)/N^x(a) \quad \text{for } g \leq a < 2g. \tag{4}$$

$N^x(x)$ is the population of age x living in extended households. The support ratio for the general population is defined in similar fashion.

The dependency ratio for extended households is influenced by the social conventions that determine the form of extended households and by differential rates of survival among the members of extended households. In Japan, where the traditional form of the extended family is for parents to live with the eldest son and his spouse, a dependency ratio of approximately one would be expected at younger ages where survival rates are high for both generations. At older ages, however, the dependency ratio will be reduced due to the higher rate of mortality experienced by members of the older generation. The dependency ratio for extended households is given by:

$$\begin{aligned} d^x(a,t) &= \frac{N^x(a+g-5,t-5)}{N^x(a-5,t-5)}\frac{s^x(a+g,t)}{s^x(a,t)} \\ &= d^x(a-5,t-5)\frac{s^x(a+g,t)}{s^x(a,t)} \end{aligned} \tag{5}$$

where $s^x(a,t)$ is the proportion aged *a-5* in year *t-5* surviving as members of the extended household to age *a* in year *t*.[10] The dependency ratio for the general population could be represented in similar fashion, and the ratio of the two dependency ratios is given by:

$$\frac{d(g,t)}{d^x(g,t)} = \frac{d(g,t)}{k}$$

$$\frac{d(a,t)}{d^x(a,t)} = \frac{d(a-5,t-5)}{d^x(a-5,t-5)} \frac{s(a+g,t) \big/ s(a,t)}{s^x(a+g,t) \big/ s^x(a,t)} \tag{6}$$

$$= \frac{d(a-5,t-5)}{d^x(a-5,t-5)} d(a) \quad \text{for } a \geq g.$$

These two equations can be employed to project the ratio of dependency ratios for the middle generation and, hence, the proportion living in extended households. The dependency ratio for the population at age *g* is calculated directly using the population projection and the value k is estimated as discussed below. If survival rates are independent of living arrangements, the ratio of survival rates reduces to one. However, here we assume that age-schedule of the ratio of survival rates, $d(a)$, is constant over time, but not necessarily equal to one.

The number of children (*a*<*g*) living in extended and nuclear households is projected assuming that the ratio of dependency ratios does not change over time and employing equation (3). Note that all children live with their parents so that this simplifying assumption is not violated on its face.

Proportion of households that are extended; number of members per household

Let $\hat{N}(a,t)$ be the projected population aged *a*, and $\hat{x}(a,t)$ be the projected proportion living in extended households. $\hat{N}^x(a,t)$, the projected population living in extended households, and $\hat{N}^n(a,t)$, the projected population living in nuclear households are given by:

$$\begin{aligned} \hat{N}^x(a,t) &= \hat{x}(a,t)\hat{N}(a,t) \\ \hat{N}^n(a,t) &= (1-\hat{x}(a,t))\hat{N}(a,t) \end{aligned} \tag{7}$$

The projected number of extended households, $\hat{H}^x(t)$, and nuclear households, $\hat{H}^n(t)$, are given by:

[10] Strictly speaking s is not a survival rate as individuals within the population could join extended households. Given the late age at marriage in Japan this might occur with some frequency if older unmarried sons were living with their parents and married.

$$\hat{H}^x(t) = \sum_{a \geq g} \hat{N}^x(a,t)/m^x$$
$$\hat{H}^n(t) = \sum_{a \geq g} \hat{N}^n(a,t)/m^n \qquad (8)$$

The average number of members aged *a* per extended household is:

$$\hat{n}^x(a,t) = \hat{N}^x(a,t)/\hat{H}^x(t) \qquad (9)$$

and the average number of members per nuclear household is calculated in similar fashion.

Proportion of worker, other, and jobless households

Assuming that the average number of adults per nuclear household and extended household do not vary by household type, z, then:

$$\hat{h}^x(z,t) = \sum_{a=g}^{3g} h^x(z,a)\hat{N}^x(a,t) / \sum_{a=g}^{3g} \hat{N}^x(a,t)$$
$$\hat{h}^n(z,t) = \sum_{a=g}^{3g} h^n(z,a)\hat{N}^n(a,t) / \sum_{a=g}^{3g} \hat{N}^n(a,t) \qquad (10)$$

where the index z distinguishes worker, jobless, and other households and $h^x(z,a)$ is the proportion of persons aged *a* and living in extended households who live in a household of type *z*. $h^n(z,a)$ is defined in similar fashion.

Estimation

Model parameters are estimated using data for five-year age groups, 85 and older being the upper age group, using the 1989 and 1994 NSFIE for Japan. We assume that the generation length *g* is 30 years. (The singulate mean age at first marriage is currently over 28 years for women and 30 years for men.) Thus, individuals who are 60-64 have children 30-34 and grandchildren 0-4 by assumption.

The age effect in equation (1) is estimated directly[11] in the following manner:

$$\ln b(60) = 0$$
$$\ln b(a) = \sum_{x=60}^{a} \Delta \ln b(x) \quad \text{for a>60, where} \qquad (11)$$
$$\Delta \ln b(x) = \ln o(x+5, t+5) - \ln o(x,t)$$

[11] A regression approach would be employed were estimates available for more than two years.

and *a* denotes the lower limit of the five-year age group.

Using the estimated age effects and the observed odds-ratios for *t* and *t+5* we construct a time series of values for the log-odds ratio for individuals 60-64.

$$\ln \hat{o}(60, t - x) = \ln o(60 + x, t) + \ln \hat{b}(x) \quad \text{for } x = (5, 20) \qquad (12)$$

The estimated values are combined with the observed values for *t* and *t+5* and fitted using a logistic, i.e.,

$$\ln \hat{o}(60, t) = a_0 + a_1 t. \qquad (13)$$

The estimated age effects and the estimated cohort effect, obtained using the logistic, are used to project proportion living in extended households as in equation (2).

The other parameters in the model (the average number of adults per household, the dependency ratios, and the relative survival schedule $d(a)$) are estimated as the average of the values observed in 1989 and 1994 from the NSFIE.

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