Are extended living arrangements on their way out?
A simple empirical model based on Taiwan

Andrew Mason and Sang-Hyop Lee[1]

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Living arrangements in Asia are quite distinctive from those found in Western societies. The great majority of Asia's elderly live with their adult children. Even in Japan and Singapore, two countries that by any measure are as advanced as the richest countries in the West, about half of all seniors live with their children. Living arrangements are beginning to change, however, and in some countries quite rapidly. In South Korea and in Japan the proportion of seniors living with their children has dropped substantially in recent years. The situation in Taiwan is somewhat distinctive. Apparently, the proportion of seniors living with their children is well below historical levels, but in recent years there has been little obvious change. As the analysis presented below will show, stability in the aggregate values masks important underlying changes that will lead to further decline in extended living arrangements. Further decline is on the horizon, but the evidence does not point to a precipitous decline. At least in Taiwan, extended living arrangements do not appear to be on their way out.

To many, the decline of the extended family is a matter of concern particularly when many Asian countries face rapid population aging. The extended family has been the primary system of support for the elderly. Their children have provided both financial support and personal care to their aging parents. Some Asian governments have gone so far as to mandate that children support their elderly parents.

Others have noted, however, that the traditional family support system may be ill-suited to a society with large numbers of dependent elderly. Middle-aged women, in particular, may face a heavy burden as the sole care-giver for their parents, the parents of their husband, and in some cases grandparents. Alternative support systems can spread the costs of caring for the elderly. The family support system is also an unattractive way of financing retirement in an aging society for exactly the same reason as PAYGO pension programs. In slowly growing or declining populations, the rate of return that can be sustained from intergenerational transfers are much lower than the rate of return available from financial markets or real investment ((Lee, Mason et al. 2000)).

The objective of this paper, however, is not to address whether the decline in the extended family is a welcome development or not. The purpose is to model a specific feature of living arrangements – the choice by individuals to live in multi-

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[1] The authors are Professor of Economics, University of Hawaii at Manoa and Senior Fellow, East-West Center and Assistant Professor of Economics, University of Hawaii at Manoa, respectively. This paper was presented at the Workshop on Future Seniors and their Kin in honor of Gene Hammel, 5-7 April 2002, Marconi Conference Center, Marshall, California. The suggestions of participants in the workshop are gratefully acknowledged. Our thanks to Turro Wongkaren for his assistance. For additional information please contact amason@hawaii.edu. The authors gratefully acknowledge the support of the Rockefeller Foundation.

generation extended households – and to make some assessment about the future course of extended living arrangements.[2]

The approach employed here is macro-analytic and has more in common with other macro approaches than with the microsimulation methods pioneered by Gene Hammel, Ken Wachter and their collaborators (Hammell et al., 1981, 1991). Some of the important underlying issues – the availability of kin, for example - are much more readily addressed through microsimulation approaches, although the implications for macrosimulation are obvious and important. Lin's (1994) application of SOCSIM is of interest, for example, because he provides simulated values for the proportion of Chinese elderly with surviving children.

Our approach is similar in some respects to household projection research (Kono, 1987; Pitkin and Masnick, 1987; Holmberg; 1987; (Mason, Racelis et al. 1996)) that attempts to devise a model that can be used to project or forecast a key aggregate characteristic of households, e.g., a headship rate. The extent to which the underlying processes are analyzed varies among these models, but they do not rival the detailed treatment found in SOCSIM and other microsimulation methods. The model analyzed in this paper is very simple, abstracts from many of the important demographic processes, and is heavily driven by the available data.

We are unaware of other efforts to develop a model for projecting the proportion of individuals living in extended households, although Freedman et als. (1991) projection of the percentage of US women 85 and older living with children confronts similar issues to the ones addressed in this study. Household projection models often distinguish different types of households or the age and sex of household members, but it is difficult to infer characteristics of individuals from the limited set of characteristics of households that are typically available from household projections. For many purposes, including a description of the extent of family support available to seniors, the individual (the senior) is the analytic unit of interest.

In this paper we analyze changes in living arrangements by seniors and by prime age adults. The two are connected, of course, because extended households as we have defined them here are created when seniors and their adult children choose to live together. Thus, an increase in the proportion of seniors leads to an increase in the proportion of working-age adults living in extended households, *ceteris paribus.* The relationship is not an entirely simple one, however. The proportion of working-age adults living in extended households will depend on the extent to which the "dependency burden" that arises from co-residence is equally shared across the population. Two illustrate the point one could imagine two highly unrealistic extremes. All seniors could live in a single household with only one non-senior adult present. In this case, the proportion of seniors in extended households would be 100 and the proportion of non-seniors would be close to zero. In an entirely egalitarian world, seniors could spread themselves evenly among all non-senior members of the population. In this case, all seniors and all non-seniors would live in extended

[2] In this paper extended households consist of households with adult members who belong to two different generations. Adults are defined as those who are 30 years of age or older for reasons discussed more fully below. This definition excludes joint households, e.g., those consisting of two married brothers. These are relatively unusual in Taiwan. In 1986 only 1 percent of households with married couples 20-39 were joint extended households (Weinstein et al., 1994).

households. The key point here is that the connection between the proportion of seniors and non-seniors living in extended households is not a mechanistic one. Rather it is a flexible one that will differ among countries and over time depending on how the dependency burden of senior co-residents is distributed among the non-senior members of the population.

There are important demographic/social constraints that preclude the unrealistic outcomes described above. An important one is that extended households typically consist of kin and, hence, that availability of kin influences whether or not the burden of supporting seniors is widely shared or not. Many non-senior adults may not live with elderly parents because their parents are deceased or because one of their siblings is living with their parents. Thus, given the proportion of seniors living in extended households, changes in fertility and mortality may have a large affect on the proportion of non-seniors living in extended households. Freedman et al. (1991) provide a formal treatment of the relationship between fertility, kin availability, and living arrangements.

This issue is addressed in a simple but more formal way below. In the empirical analysis, we find that the distribution of the dependency burden has changed over time so that the proportion of non-seniors living in extended households has increased relative to the proportion of seniors living in households. There are some indications, however, that this phenomenon will not continue in the future and that the proportion of seniors and non-seniors living in extended households will both decline.

Extended Living Arrangements: What Drives the Decision?

The family offers an efficient institution for producing, consuming, and redistributing resources among family members and across generations. In all societies, the family is the primary institution through which resources are transferred to children from productive members of the population (parents). As children age and become productive, resources may begin to flow from children to their parents ((Lee 2000)). The extent and direction of resource flows between prime-age adults and their elderly parents is perhaps more complex. Decisions by the family may be governed by altruism (Becker 1981). The extended family may offer an efficient institution for exchange. Elderly parents may care for their grandchildren in exchange for financial support. Or, adult children may care for the elderly parents in return for a bequest. Or, the family may provide a system by which family members pool risks that they face in various aspects of their daily lives (Kotlikoff and Spivak (1981)). The extended family may offer scale economies in consumption that allows members to achieve a higher standard of living (McElroy and Horney (1981)). Of course, the roles are not mutually exclusive nor is the list provided here exhaustive.

Fulfilling these roles does not require co-residence. Family members can live in independent households and exchange goods and services (money or time), but co-residence provides an efficient means for carrying out these transactions. If the transactions are large and frequent and if they involve time, family members may choose to live together throughout their lives. If the transfers tend to episodic or confined to a particular period during the lifecycle, family members may choose to vary their living arrangements depending on the current circumstances.

One of the empirical features of living arrangements in Taiwan is that for many seniors co-residence is not a permanent feature. The proportion of seniors living with their adult children increases with the age of those seniors. In the absence of panel data, however, we cannot tell whether the decision by seniors to live with their children is a permanent one or whether it is common for seniors to change living arrangements frequently. Some seniors may rotate their residence from one child to another so that they are permanently in an extended household, but their children are not. In any event, the rise among seniors in extended living arrangements as they age is consistent with the view that the formation of extended families is a response to changing circumstances associated with aging, i.e., the risks associated with growing old.

The risks faced by the elderly take a number of forms. Older adults face substantial financial risks. Three that directly affect financial wealth seem particularly important: premature forced retirement, investment risk due to fluctuations in financial markets, and longevity risk (the risk of living longer than expected and, hence, outliving one's resources). Older adults also face risks on the consumption side of which unanticipated health care expenditure looms large.

As older adults age, they experience a succession of shocks that reduce their financial resources, and for some, to unexpectedly low levels. The financial hardship they experience may induce transfers from their children and ultimately lead to co-residence.[3] In the absence of uncertainty, there is no obvious reason why the economic situation of the elderly would decline as they age, so long as the elderly were effective lifecycle planners.

Financial risk is not the only uncertainty faced by the elderly. Indeed, it may not be the most important factor that leads to increased co-residence. The elderly face risks that may also greatly affect the value they attach to personal attention or time inputs from their children. Two aspects seem particularly important – the first is health risks. The elderly face health crises that influence the need for personal care. Because personal care from strangers is a poor substitute for personal care from children and because personal care requires direct contact, the efficiency gains from co-residence may be especially large. The second event faced by the elderly that influences their demand for attention from their children is the death of their spouse. A spouse may be a source of companionship and a source of personal care. The loss then will lead to increased demand for companionship and personal care from children. In addition, the loss of a spouse may also influence other calculations of the cost and benefits of co-residence. The economies to be gained may be substantially larger when a single person households is absorbed rather than a two-person household.

The family is not the only means of insuring against these risks. Both commercial and social insurance can play an important role. Wealth can be annuitized by participating in employer-based defined benefit retirement programs, by

[3] Not all risks are downside risks. Investment risk may lead to an increase as well as to a decline in financial resources in any period. Even here, however, if elderly face repeated shocks the proportion whose wealth drops below any given level (say the level for independent living) will increase over time (with age).

purchasing commercial annuities, or by participating in public pension programs. These programs protect the elderly from both investment risk and longevity risk. Health insurance, either private insurance or the public provision of health care, reduces the financial risks associated with illness. Moreover, individuals can self-insure by accumulating more wealth during their working years.

The availability of risk-sharing alternatives to the family increases as societies develop and as growth in the number of elderly increases the demand for commercial and social insurance. Pension programs develop and are extended to growing numbers of workers employed in the public sector and by larger private firms. Comprehensive health insurance becomes increasingly available and may be extended to retirees. Publicly funded health programs meet the health care needs of the elderly. But even in the most economically advanced economies, the elderly face risks that are difficult or impossible to insure. The market for annuities is thin and the price is so high that few elderly can protect themselves against investment and longevity risk in the absence of comprehensive social insurance.[4] Many of the other risks described are essentially uninsurable. Thus, there is little reason to think that the role of the family, and intergenerational co-residence, will shrink to nothing as Asian societies develop.

The theory of co-residence implicates a number of factors that may account for changes in the extent to which adult children and their parents co-reside. The effects of kin availability, per capita income, education, and disability have all been explored in empirical studies (Bachrach, 1980; Chevan and Korson, 1975; Kobrin 1976; Macunovich et al., 1995; Michael, Fuchs, and Scott, 1980; Soldo, 1981; Wister and Burch, 1983; and Wolf, 1995). The development of social and commercial insurance may lead to a decline in the importance of the family support system and to a decline in co-residence. But as will be seen below, the analysis presented here does not attempt to identify which specific aspects of social and economic development influence changes in living arrangements.

[4] Annuities are subject to adverse selection, i.e., only those who expect to live a long life purchase annuities. This drives up the price to levels that are unattractive to individuals who do not expect to live to an unusually old age.

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 become adults, marry, give birth, and consider establishing separate households at age g. At age 2g they become seniors, experience declining productivity, begin considering retirement, and face elevated health risks. There are two types of households: extended households, consisting of at least one member belonging to each generation; and, nuclear households that consist of members of the oldest generation or members of the middle generation and their children.

Let $n(a,t)$ for be the proportion of persons aged *a* living in nuclear households in year *t* and $x(a,t)$ be the proportion living in extended households. The proportion of seniors ($a \geq 2g$) living in a nuclear household depends on a cohort effect, $k(b)$, which captures persistent, lifetime characteristics of members of any birth cohort and an age effect, $h(a)$, which captures the effects of year-to-year changes that each birth cohort experiences as it ages:

$$n(a,b) = 1 - x(a,t) = k(b)h(a) \tag{1.1}$$

where $b = t - a.$

The proportion of middle-generation adults $(g \leq a < 2g)$ living in extended households depends on two factors. First, the middle-generation provides the members that co-reside with the elderly in extended households. Thus, the proportion of middle-generation adults living in extended households varies directly with the proportion of older generation adults living in extended households.

A second factor is the extent to which the dependency structure of extended households mirrors the dependency structure of the general population. If the age structure of extended households is identical to the age structure of the general population, then the proportion of generation 3 and generation 2 living in extended households will be identical. If the number of elderly per prime-age adult is greater in extended households than in the general population, then the proportion of prime-age adults living in extended households will be less than the proportion of seniors living in extended households. It is straightforward to show that:

$$x(a,t) = ddx(a,t)x(a+g,t) \text{ for a<2g.} \tag{1.2}$$

where:

$$\begin{aligned} &ddx(a,t) = (d(a,t)/d^x(a,t)), \text{ and} \\ &d^x(a,t) = N^x(a+g,t)/N^x(a,t) \text{ for } g \leq a < 2g. \end{aligned} \tag{1.3}$$

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

The identity, equation (1.2), suggests a strategy of modeling the relative dependency structure of the population *ddx* and calculating the proportion of *2g* adults living in extended households using equation (1.2). That is the strategy that we pursue in this paper.

The dependency ratio for extended households may differ from the dependency ratio for the general population for a variety of reasons. First, seniors living in extended households may have more surviving children. Of course, to live in an extended household requires at least one surviving child.[5] Those with more surviving children are more likely to have a child that is a suitable candidate for co-residence (male, rich, generous). Moreover, childbearing may be influenced by the taste for or expectations about living arrangements. If so, those who expect to live in extended households may choose to bear more children. If those living in extended households have more surviving children, the dependency ratio for the general population relative to the dependency ratio for the extended household population (*ddx*) will be higher.

Second, the structure of dependency within extended households will depend on the extent to which the co-residence "burden" is spread across all offspring or concentrated on a subset. In societies where the norm is for parents and all of their married children (sons) to live together, the dependency ratio within extended households will more closely mirror the dependency ratio in the general population. In East Asia, however, seniors often live "permanently" with only one of their adult child, typically a son and his wife. As their other children marry and bear children, they establish separate households, although they may live a few years with their parents. Thus, the dependency ratio within extended households is influenced by the age at which young adults marry, bear children, and establish separate households. Given the practice in East Asia, the dependency ratio within extended households will be greater than one for the general population and *ddx* will be less than one. The difference will be particularly large in populations where seniors have many surviving children, but would disappear in populations where seniors have exactly two surviving children.

Third, the relative structure of dependency is influenced by mortality among seniors and its effect on living arrangements. As members of the generation 2 population age, mortality among their parents leads to a decline in the dependency ratio of both the general and the extended population. If mortality is influenced by living arrangements, either because one household form provides a healthier environment or because health status influences choice of living arrangements, then the dependency ratio will decline more rapidly for the population that experiences higher generation 3 mortality rates, given living arrangements. The impact of mortality on dependency structure is more complex than this, however, because of its effect on living arrangements. As noted above, the death of the first parent may increase the chances that the surviving parent will move into an extended household. Such an event will generally reduce the dependency ratio within extended households by establishing a new household with only one generation 3 member. The dependency ratio of the general population will also be reduced, but it is unclear

[5] In our definition of extended families below, we include individuals living with their grandchildren irrespective of whether or not the children are surviving. Thus, to live in an extended family requires only that seniors had at least one child survive long enough to produce children.

whether the decline is necessarily smaller or greater than the decline in the dependency ratio in the extended household population. The death of a second parent has a very clear effect. The dependency ratio in the general population will decline. If the parent lived in an extended household, the household will be transformed from extended to nuclear. This will lead to a rise in the average dependency ratio of the remaining extended households because extended households that lose their last generation 3 member have low dependency ratios relative to the mean.

The aggregate data on which the analysis presented below is insufficient to analyze the complex influences of mortality and decisions about living arrangements by both the young and the old. However, we can conclude that the relative dependency structure of the population will be subject to strong age effects that capture the influences of age-specific mortality and changes in living arrangements that are associated with age. Moreover, these age effects may be shifting because of changes in fertility and mortality, decisions about living arrangements, and interactions with the dependency ratio.

Cohort effects may also be important. In the empirical implementation below the cohort effect is captured by changes in the relative dependency ratio at age g, the age at which individuals become adults. The relative dependency ratio will vary among cohorts because of differences in the age at which cohort members leave home, persistent differences in the form that extended households take, and because the correlation between sibset size and living arrangements may vary by cohort.

Taiwan – Is the Extended Family on the Way Out?

In some respects Taiwan is an ideal subject for this research. Demographic and economic changes there have been very rapid. In the early 1950s, Taiwan had barely begun its demographic transition and its people were quite poor. By 1999, per capita GNP had reached $13,250, life expectancy at birth was 78 for females and 72 for males and the total fertility rate 1.6 births per woman. The population is beginning to experience significant aging. In 2000 an estimated 8.6 percent of the population was 65 and older. Income is very equally distributed – the Gini coefficient is 0.33. Its levels of educational attainment are very high – gross enrollment ratios for secondary school are 101 for females and 98 for males. About 60% of the population levels in urban areas (ADB 2001). Thus, in five decades Taiwan has transformed itself into one of Asia’s most advanced economies. Only Japan, Hong Kong, and Singapore can boast of a higher standard of living.

One idiosyncratic feature of Taiwan’s demography is relevant to the analysis. Around 1950, a large group of mainland Chinese migrated to Taiwan. The group was about 15% of Taiwan’s population at the time. About two-thirds were men and they were heavily concentrated in the young adult ages. The great majority were not accompanied by their parents and, hence, could not establish extended households with their parents. Moreover, many never married nor bore any children. As a consequence they cannot form extended households by living with children.

The remarkable transformation of Taiwan’s economy and demography has not led to a transformation in living arrangements. More than half of those 60 and older live in a multi-generation extended family. Of those 85 and older in 1998, threequarters lived in a multi-generation extended family. The proportion 60 and older living in an extended household has changed very little during the last 20 years – varying between 57 percent and 52 percent with no clear trend. A simple extrapolation of the proportion in extended households would not lead one to believe that the extended household is on the way out in Taiwan or even in decline.

The aggregate data aside, there are indications, however, that change is occurring in Taiwan. Weinstein et al. (1994) report that the percentage of married couples aged 20-39 who reported living with their parents at least one month after marriage declined from 90 percent in 1967 to 70 percent in 1986. They also report that the percentage of parents with a married son who lived with a married son declined from 82 percent in 1973 to 70 percent in 1986.

Data

We use the Survey of Family Income and Expenditure in Taiwan (FIES, also known as the Survey of Personal Income Distribution in Taiwan until 1993). The FIES was first conducted in 1964 and, then, every other year until 1970. Since then, the survey has been conducted annually and data are available for the 1976 and subsequent surveys. For technical reasons, we have confined our analysis to surveys conducted in 1978 and later until 1998. The number of household surveyed has varied over time, but the sample size is more than sufficient for our purposes. In 1998, about 0.4 percent of all households (14,031 households and 52,610 individuals) were covered. These are not panel data, but repeated cross-sections.

The survey data are used to calculate mean values of the proportion living in nuclear households and other relevant data by current age (single years of age; 85 and older is the upper bracket) and birth cohort. Generation 3 consists of all those who are 60 or older.[6] The data set yields 546 observations. The oldest birth cohort was born in 1893 and the youngest birth cohort was born in 1938. For these two birth cohorts we have values for only one age – 85+ for the oldest cohort and 60 for the youngest cohort. For several birth cohorts we have values for 21 age groups, but no cohort can be followed over the entire aging period 60-85+. Generation 2 consists of all those who are 30-59, but we analyze only the 30-55 age groups, conforming with the twenty-five age groups analyzed for generation 3. The oldest cohort was born in 1923 and the youngest in 1968. Again we have only a single value for the youngest and oldest cohorts and values at 21 ages for those born around 1955.

A subset of the available data are plotted in Figure 1. Panel A shows the mean proportion of seniors living in nuclear households by age for selected birth cohorts. Panel B shows the mean value of *ddx* for the generation 2 population by age for selected birth cohorts.

Figure 1. Proportion nuclear and relative dependency burden by age and year of birth.

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[6] The generation length of 30 is based on the average differences in age found in extended households between prime-age adult members and their co-resident parents. Thirty-year-olds are 30 years younger than their parents for all birth cohorts. There is a gradual decline in the generation length measured in this way. By age 50 the generation length was about 21 years in 1978 and about 26 years in 1992 and 1998.

Empirical Specification

The simplest approach to estimating cohort and age effects is non-parametric. This is a feasible method given the data available for analysis if the age effects do not vary across cohorts. This represents a null hypothesis in the sense that the analysis presented below primarily addresses whether age effects interact with cohort effects and, in a more limited way, whether alternative representations of the age effects can reduce or eliminate the interaction that is found to exist. In the absence of interactions, however, the cohort and age effects for the proportions of seniors living in nuclear households are estimated by:

$$\ln n(a,b) = \sum_{a=60}^{85+} a_k A_a + \sum_{j=1893}^{1938} b_j B_j \qquad (1.4)$$

where A_a is a dummy variable that takes on the value of one for cohorts of age *a* and B_b is a dummy variable that takes on the value of one for cohorts born in year *b*. Similarly, the relative dependency structure can be estimated by:

$$\ln ddx(a,b) = \sum_{a=60}^{85+} g_k A_a + \sum_{j=1923}^{1968} h_j B_j . \qquad (1.5)$$

The age and cohort effects are presented in Figure 2. The cohort effect, an estimate of the proportion living in nuclear households at age 60, rises substantially among early birth cohorts. Over 70% of the 1922 birth cohort is estimated to have lived in nuclear households at age 60 as compared to under 30% of the 1900 birth cohort. The estimated proportion of recent birth cohorts living in nuclear households is much less than 70%. For the most recent birth cohort, those born in 1938, the estimated value has dropped to below 50%. The reversal in the cohort trend towards nuclear living arrangements is a surprising phenomenon, but the high proportions nuclear may simply reflect the large un-married immigrant population belonging to those cohorts. The sex ratio at age 60 is a convenient indicator of the magnitude of the immigrant population. The correlation with the proportion nuclear is very evident, as shown in Figure 2, and suggests that the proportion living in nuclear households was elevated to unusually high levels by the enormous surplus of males found in the 1912-1930 birth cohorts. The estimated age effects, the proportion nuclear at age *x* relative to the proportion nuclear at age 60 for any birth cohort, are substantial. An increase in age from 60 to 70 reduces the proportion nuclear by over 30 percent and to age 80 by another 20 percent. By age 85 and older, 30 percent of those living in nuclear households at age 60 are still doing so.

Figure 2. Estimated age and cohort effects, proportion nuclear and relative dependency ratios.

The dependency structure in Taiwan is also characterized by substantial cohort and age effects. The cohort effect is an estimate of the relative dependency ratio at age 30 by birth cohort. Among early birth cohorts the dependency ratio for the general population, at age 30, was only about 0.4 of the dependency ratio for extended households. Gradually, the dependency ratios have converged so that by the time the

1955 birth cohort turned 30, the dependency ratios for the general and the extended populations were the same. Among later birth cohorts, the 1968 cohort excepted, the general dependency ratio has been about 5 to 10 percent higher than the dependency ratio for extended households. The age effects are estimates of *ddx* at age *x* relative to the value at age 30 for each birth cohort. By age 35, the value of *ddx* has declined to only 0.6 of its age 30 level, i.e., the dependency ratio for the general population has declined by 40% relative to the dependency ratio for the extended household population. By age 50, *ddx* has declined to about one-third its age 30 level. During the last five years for which we have estimates (50-55) the dependency ratio of the general population rises relative to the dependency ratio within extended households. These last few years aside, the dependency burden becomes much more heavily concentrated on a sub-set of cohort members as they become middle-aged.

Are the age effects fixed?

The assumption that the age effects don't interact with cohort effects is convenient, but seems quite implausible. There have been substantial improvements in health and mortality and the development of alternative support systems (social systems provided by the government; market based systems that supply insurance and facilitate the accumulation of personal wealth) that would surely influence the effects of aging on co-residence. Likewise, the *ddx* age effects have surely changed over time in response to changes in age-specific survival rates, the age structure of the population, and other factors discussed in more detail above.

We explore whether or not age effects have shifted, whether the changes are large and whether they are relatively systematic by specifying a functional form for the age effect and estimating age effects separately for broad birth cohorts. For the proportion nuclear we assume that $\ln h(a)$ in equation (1.1) is linear in age, in which case we have:

$$\ln n(a,b) = \ln n(60,b) + b\,(a - 2g). \tag{1.6}$$

Given the non-linear, non-monotonic relationship between the dependency structure of the population and age exhibited in Figure 1, we estimate *ddx* using:

$$\ln ddx(a,b) = \ln ddx(30,b) + b_1(a-30) + b_2(a-30)^2. \tag{1.7}$$

Equations (1.6) and (1.7) are estimated using ordinary least squares. All estimates were obtained using the consistent variance-covariance matrix estimator of White (1980). The standard errors are thus robust to heteroscedasticity. Separate cohort effects are estimated by single year of birth for the proportion of seniors living in nuclear households and for four broad cohorts for the age structure of dependency. Separate age effects are estimated for four broad birth cohorts. The model is estimated using the pooled sample and interacting the age effects with dummy variables that correspond to the four birth cohorts that are distinguished. For the proportion of seniors living in nuclear households the broad birth cohorts are: 1893-1908, 1909-1915, 1916-1922, and 1923-1938. For estimating the dependency structure the available birth cohorts are 1923-1938, 1939-1945, 1946-1952, and 1953-1968. The birth cohorts were selected so that each groups contains a roughly equal number of observations. One of the difficulties encountered in estimating separate age effects for different cohorts is that for some cohorts we have no observations over a substantial portion of the age range of interest. This presents no apparent problem when the age effect is specified using a linear function or some other relatively inflexible functional form. The problem does arise, however, when using a flexible functional form such as the quadratic employed to estimate the age effect for *ddx*. In the empirical work the problem arises for the 1923-1938 birth cohort for which we have no observations for ages 30-39. When we fit the quadratic to this birth cohort the age effect rises very steeply at young ages in a manner quite inconsistent with the results obtained from younger birth cohorts. To deal with this problem, we estimate a second model that restricts the age effects for the 1923-38 birth cohort to equal the age effects for the 1939-45 birth cohort for the 30-39 ages using a quadratic spline. The functional form employed is:

$$\begin{aligned}\ln ddx(a,b) = \ln ddx(30,b) + B2345(b_1(a-40) + b_2(a-40)^2)(a>39) \\ +B3945(b_3(a-30) + b_4(a-30)^2).\end{aligned} \tag{1.8}$$

where *B2345* and *B3945* are dummy variables that take on the value of one for the 1923-45 and the 1939-45 birth cohorts and (a>39) is a dummy variable that take the value of one if age is greater than 39. Using the specification, the age effect for the 1923-38 birth cohort deviates from the age effect for the 1939-45 birth cohort at age 40, but the function is continuous at 40 as is its first derivate.

For the proportion of seniors living in nuclear households, the estimated cohort effects are charted in Figure 3 and the estimated age effects are provided in the second column of Table 1.

Figure 3. Estimated cohort effects, variable age effects, proportion nuclear.

Table 1. Estimates of age effects for proportion nuclear (60 and older) and the relative dependency structure.

The cohort effects are not greatly influenced by allowing for interaction between cohort and age effects. For 60-year-olds we find a rapid transition from extended to nuclear households followed by a substantial reversal. The peak is only slightly lower when we allow for variable age effects. The estimated age effects change becoming substantially weaker for later born cohorts than for earlier born cohorts. For the 1893-1908 birth cohort the effect of age is significantly more negative than for later born cohorts.

The estimates for *ddx* allowing for changing age effects provide a very different picture than the estimates presented above that assume a fixed age effect. First, the cohort effects are much weaker than above. For three of the broad birth cohorts, the estimated coefficients are not significantly different from zero. The corresponding values of *ddx(30),* the exponential of the estimated coefficients, range from 1.0 to 1.06. The only significant difference among cohorts is for the third birth cohort (1946-52) for which the estimated value of *ddx(30)* is 0.88. The strong and steady trend that is apparent in Figure 2 appears to be an artifact of the assumption of an unchanging age effect.

The changes in the age effect parameters are small but very systematic. The coefficient of the linear term increases from –0.175 for the 1923-38 cohort to –0.094 for the 1953-68 cohort. The coefficient of the squared term declines from 0.0053 to 0.0016. Both the cohort and age effects are incorporated into Figure 4, which shows the predicted value of *ddx* for four birth cohorts. Allowing for a changing age effect also leads to a very different picture than the constant age effect result. The rise in *ddx* at older ages is apparently much smaller than suggested by the fixed age effect model. For the most recent birth cohort there is no increase at all in the estimated age effects, however the "predicted" values at older ages for the youngest birth cohort are extrapolations. No member of that cohort was older than age 45 during the survey period.

Figure 4. Estimated age and cohort effects, variable age effects, dependency structure.

An Alternative Approach to Age Effects

If forecasting or projecting is the ultimate objective of modeling living arrangements, then changing age effects is an unwelcome complexity. One possibility is to project the age coefficients either by explicitly modeling the underlying processes or by some simple extrapolation. An alternative that is explored here is to identify one or more variables that captures the effects of aging, but are not subject to the shifts found with using years of age. An obvious candidate for estimating the proportion nuclear is the age-specific survival rate. The survival rate is closely related to many of the age-related phenomenon that influence living arrangements. Most directly it bears on the probability of losing a spouse, the health status of seniors, and the longevity risks that affect their economic status. (Those who survive the high-risk ages towards the end of life are most likely to outlive their financial resources.) Using survival rates rather than years of age is advantageous in that it may capture the underlying reason for the shift in aging – that people do not age as rapidly as in the past.

Substituting the survival rate at each age for each birth cohort for age, the proportion nuclear is given by:

$$\ln n(a,b) = \ln n(60,b) + b \ln s(a,b). \tag{1.9}$$

To estimate this equation we use four broad cohort dummy variables, as above, to capture the effect of birth cohort and the survival rates are interacted with the birth cohort dummies to assess whether or not survival effects are changing over time. In regression 1 we do not include the sex ratio of the birth cohort at age 60 to capture the surpls of immigrant males. In regression 2 the sex ratio is included.

Table 2. Estimates of survival effects for the proportion nuclear (60 and older) and the relative dependency structure.

The results, presented in Table 2, are somewhat mixed. In regression 1, the impact of the survival rate is much more stable across birth cohorts than the impact of age. With the exception of the third birth cohort, there is no discernible difference in the effect of survival rates on proportion nuclear. The estimated cohort effect is broadly similar to the estimates reported above – a non-monotonic pattern persists with the proportion nuclear declining from the third to the fourth birth cohort.

The sex ratio, introduced in regression 2, has a significant positive effect, as expected.[7] The cohort effect is monotonically increasing once the sex ratio is controlled, consistent with our hypothesis that the atypically high proportion nuclear for the third birth cohort was a reflection of the surplus of males that can be traced to Chinese mainland immigration. The estimated survival effects are sensitive to the inclusion of the sex ratio. The survival effect is much greater for the fourth birth cohort when the sex ratio is controlled than when it is not. In this formulation, then, the goal of finding a stable age affect has not been achieved.

Forecasts

In order to forecast the proportion of seniors living in extended households we employ a simpler specification that assumes a constant trend in the cohort effect and a survival effect that is independent of birth cohort. Moreover, we use the log-odds of the proportion nuclear as the dependent variable so as to constrain the projected values of the proportion nuclear to between 0 and 1. The estimated results are:

$$\begin{aligned}\ln(n/(1-n)) &= \underset{(3.77)}{-56.13} + \underset{(0.002)}{0.028}BYear + \underset{(0.58)}{8.16}\ln s + \underset{(0.076)}{1.46}SexRatio \\ N&=546 \quad \bar{R}^2 = 0.86\end{aligned} \tag{1.10}$$

The value of *ddx* is forecast using the estimated age effects for the 1953-68 birth cohort reported in Table 1 and assuming that *ddx(30)=1* for all future years. The proportion of adults aged 30-54 living in extended households is forecast as the product of the forecast values *ddx* and the proportion seniors living in extended households, equation (1.2). We do not have recent forecasts or projections of age-specific survival rates for Taiwan, which are not included in UN projections. In the forecasts presented below we used projected survival rates for Singapore lagged to account for the difference in life expectancy between Singapore and Taiwan (UN 2001).

The projections are presented in Figures 5 and Figure 6. The age-specific proportions living in extended households are projected to drop fairly significantly at all ages except where the residual effect of Taiwan's unusual sex ratio persists. For sixty year olds, the drop is by about twenty percentage points between 2000-05 and 2030-05. The changes are smaller at older ages – about ten percentage points among those 85 and older. For non-senior adults, the greatest decline in the proportion extended is also among the youngest adults. We forecast a drop of about 25 percentage points for 30 years olds and very little change for those in their late forties and early fifties.

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[7] A more appropriate general formulation might measure absolute deviations in the sex ratio from 1 as either a large surplus of men or women would affect the proportion nuclear. In this particular instance, however, the only large deviations are positive.

Figure 5. Forecast of the Proportion Living in Extended Households by Single Years of Age.

The overall forecast of extended living arrangements for seniors and for non-senior adults is shown in Figure 6. For seniors, we forecast a gradual decline in the proportion living in extended households. The proportion does not drop below 0.5 until 2010-15. By 2025-2030 the proportion is just below 0.4. The decline represents a departure from the trend of the last twenty years, but the extended family appears to be alive and well in Taiwan.

Figure 6. Forecast of the Proportion Living in Extended Households, Persons 60+ and 30-55.

The forecast of the proportion of non-senior adults living in extended families reverses the trend over the last twenty years. Between 1978 and 1998 the proportion 30-55 living in extended households has increased fairly steadily from a little less than 18 percent to almost 30 percent. Our forecast is that the proportion extended will begin to decline again and drop back below 20 percent by 2035. The proportions of seniors and non-seniors living in extended households are projected to be much more closely tied in the future than they have in the past. The change in the relationship occurs in our analysis because the large trend in the cohort effect for *ddx* shown in Figure 2 for the 1924 to 1960 birth cohorts does not persist after 1960, either in the data or in our projections.

Conclusions

Population aging changes the availability of kin with whom intergenerational exchange of any form can take place. Co-residence is one form of this exchange that is influenced by age structure. As the number of seniors increases relative to the number of non-senior adults, at least one of the three outcomes must occur: (1) the number of seniors living in extended households must decline; (2) the old-age dependency ratio within extended households must rise more rapidly than the old-age dependency ratio for the general population; and/or (3) the proportion of non-senior adults living in extended households must rise.

In Taiwan, no single outcome has dominated. Once we control for age effects and the effects of immigration on the availability of men, the proportion of seniors living in extended households is in gradual decline. The proportion of non-seniors living in extended households has increased fairly substantially. In recent years, the old-age dependency ratio in extended households has *declined* relative to the old-age dependency ratio in the general population.

An important feature of living arrangements in Taiwan is the affect of individual aging. As seniors age, the proportion living in extended households increases substantially. The effect of individual aging has moderated in recent years. Seniors are moving in with their children at a later age than previously. Although the analysis we undertake is only suggestive, improvements in the health of the elderly might explain the lower rates of co-residence at advanced ages. However, higher incomes, improvements in alternative support systems, or other factors may be responsible for the changes we document.

The most striking feature of the analysis is the resilience of extended living arrangements in Taiwan. The twenty-one year period spanned by our analysis, 1978 to 1998, was one of enormous social, economic, and demographic change in Taiwan. Those who reached their 60s in 1998 were much richer, more educated, more urbanized, and had substantially fewer surviving children than those who reached their 60s in 1978. Those who reached 60 in 1998 were somewhat less likely to live with their adult children than those who reached 60 in 1978, but the cohort trend is quite modest.

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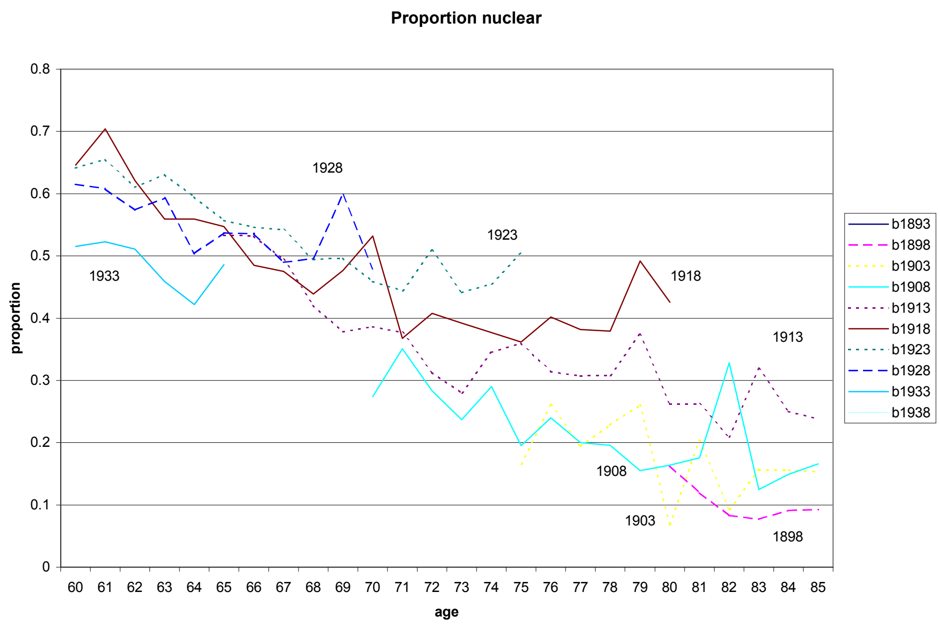
Figure 1 Proportion nuclear and the relative dependency structure by age and birth cohort



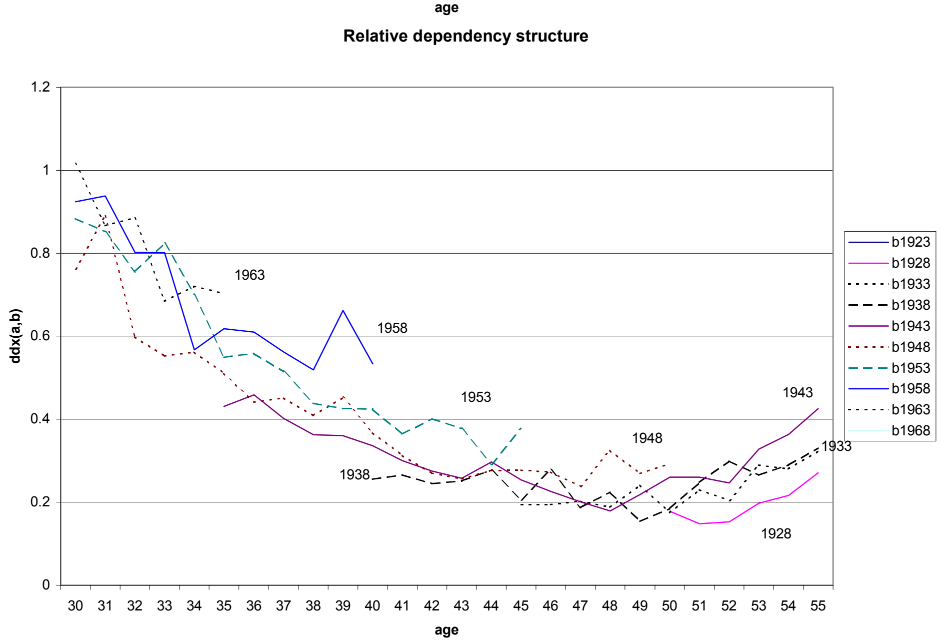


Figure 2
Estimated age and cohort effects, fixed age effects, proportion nuclear and dependency structures

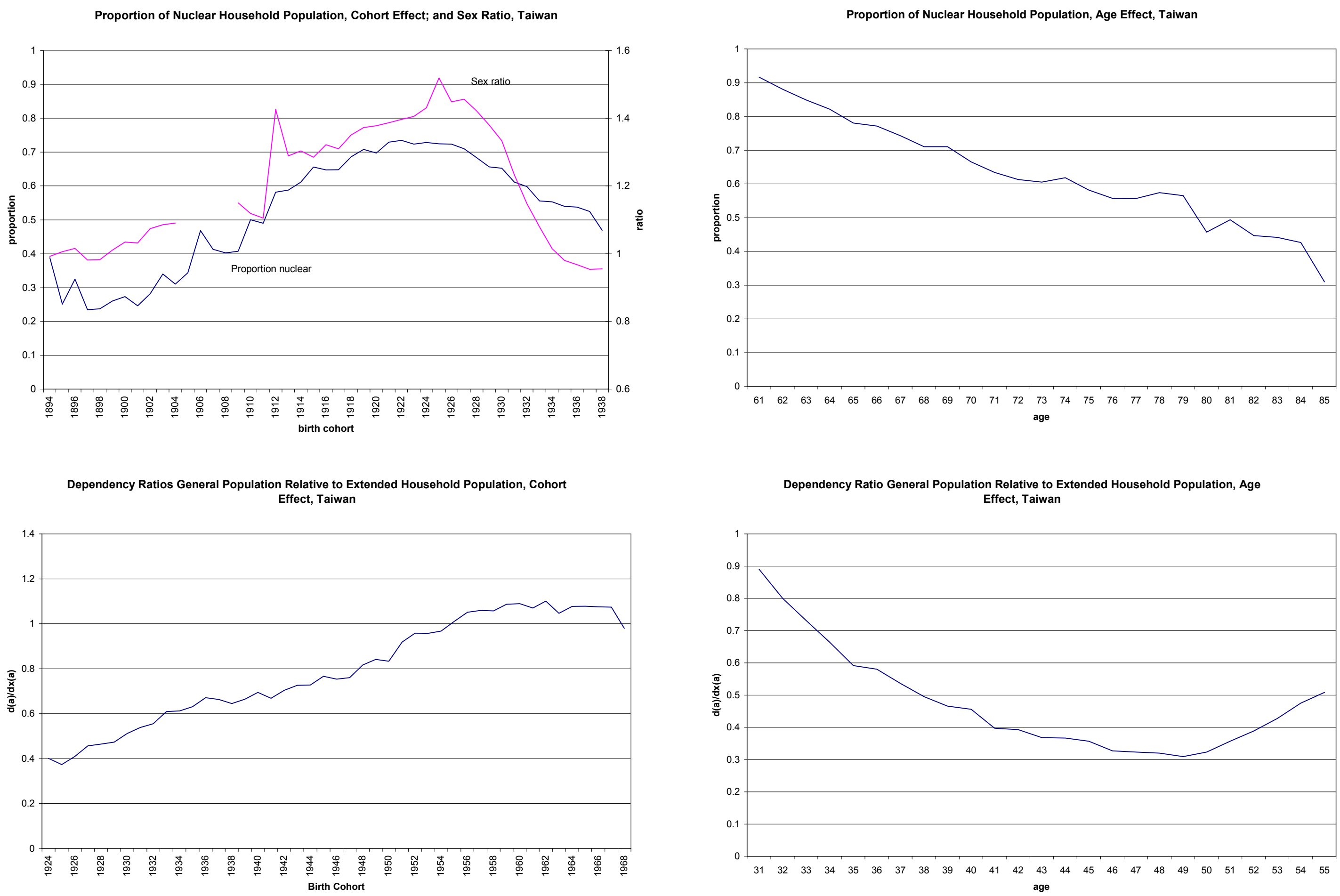


Figure 3 Estimated Cohort Effect, variable age effect, proportion nuclear

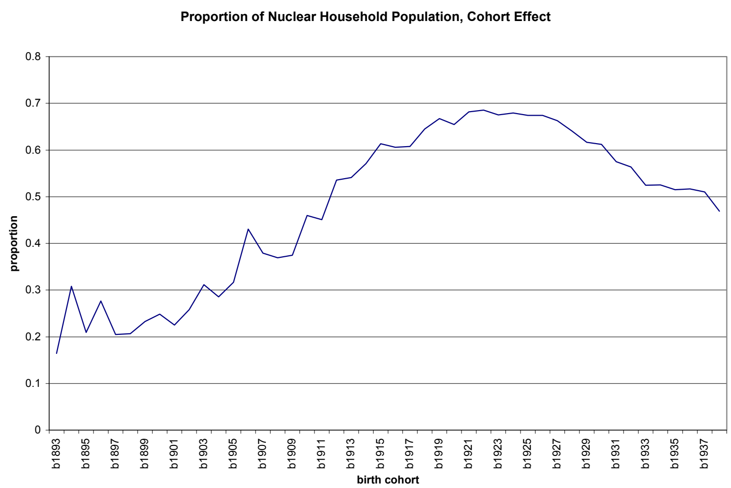


Figure 4 Ratio of General Dependency Ratio to Extended Household Dependency Ratio, Four Birth Cohorts by Age

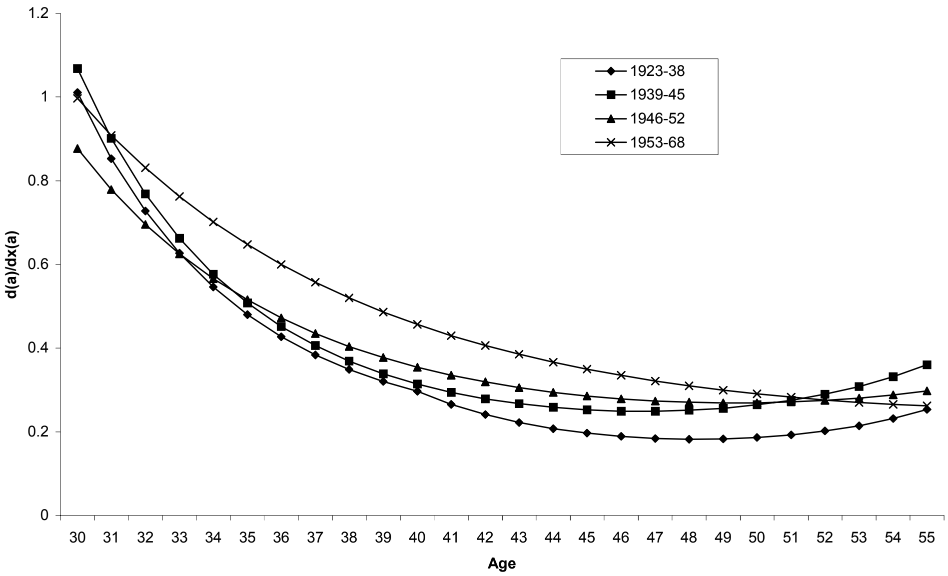
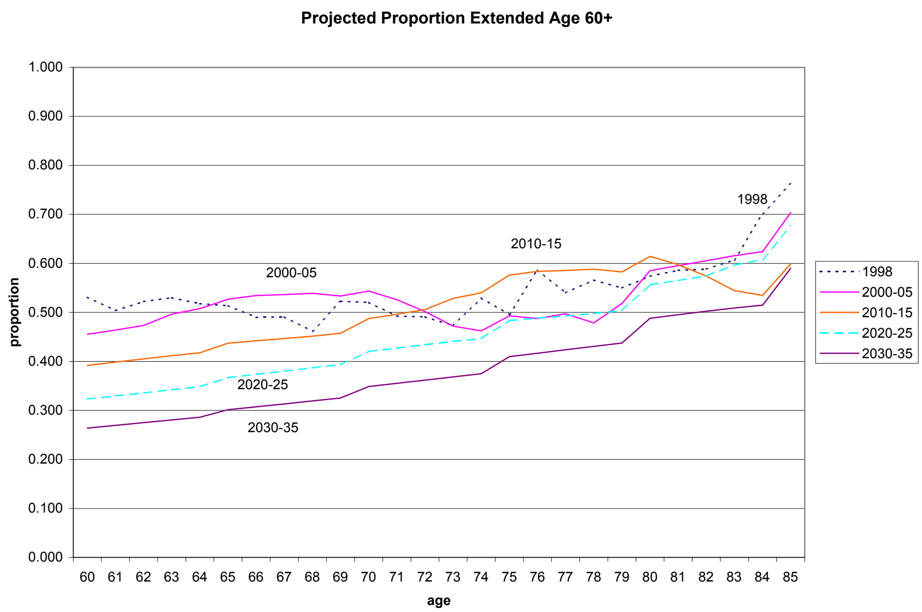


Figure 5 Projected Proportion Extended by Age, 2000-2035



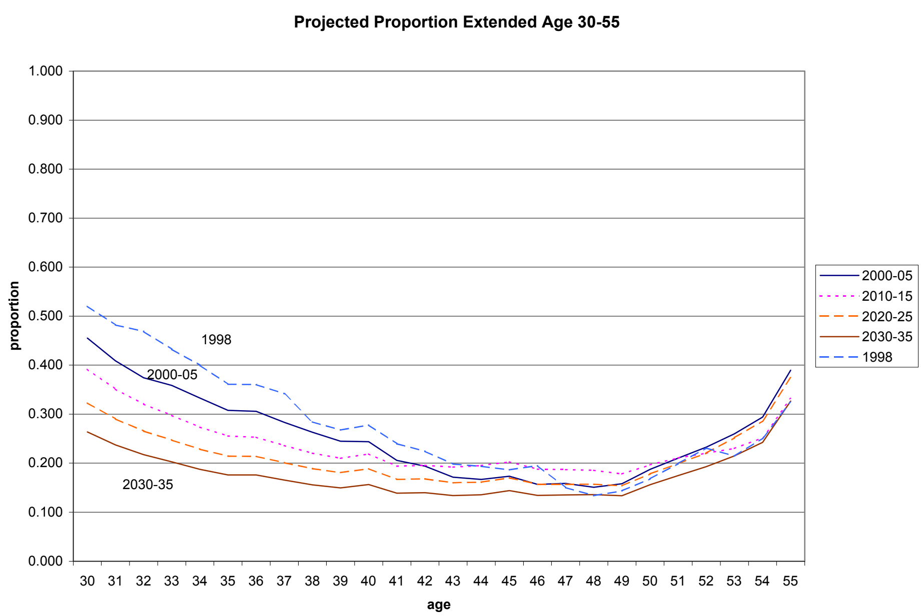


Figure 6 Projected Proportion Extended 30-55 and 60+

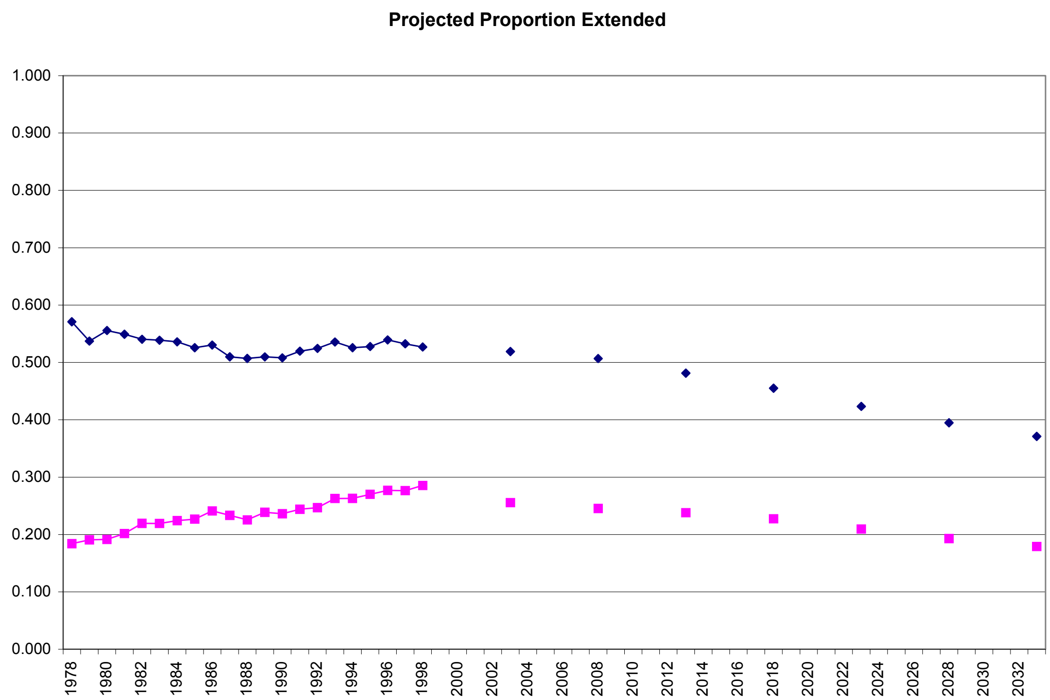


Table 1. Estimate of cohort and age effects for proportion nuclear (60 and older) and the relative dependency structure.

Variable &	Proportion Nuclear		Dependency Structure	
Birth Cohort	Coefficient	Standard Error	Coefficient	Standard Error
Cohort Effect				
1923-1945			0.112666	0.094977
1939-1945 (1)	see Figure 3		0.036532	0.062200
1946-1952			-0.130915	0.031114
1953-1968			-0.003065	0.013731
Age - 60				
1893-1908	-0.069028	0.118963	-	-
1909-1915	-0.031682	0.002572	-	-
1916-1922	-0.027036	0.001787	-	-
1923-1938	-0.024008	0.001464	-	-
Age - 30				
1923-1945	-	-	-0.179886	0.009540
1939-1945 (1)	-	-	-0.054433	0.018897
1946-1952	-	-	-0.122191	0.007871
1953-1968	-	-	-0.094437	0.007120
(Age-30)2				
1923-1945	-	-	0.005455	0.000329
1939-1945 (1)	-	-	0.002216	0.001129
1946-1952	-	-	0.003159	0.000408
1953-1968	-	-	0.001636	0.000595
R^2	0.98		0.98	
N	546		546	

1. Coefficients are the difference between 1923-38 cohort and the 1939-45 cohort for age>39

Table 2. Estimates of cohort and survival effects for the proportion nuclear (60 and older)

Variable & Birth Cohort	Regression 1 Coefficient	Regression 1 Standard Error	Regression 2 Coefficient	Regression 2 Standard Error
Cohorts				
1893-1908	-1.145124	0.0616824	-1.952457	0.100052
1909-1915	-0.7620756	0.0385685	-1.691282	0.0901655
1916-1922	-0.4298552	0.0273966	-1.430517	0.0981117
1923-1938	-0.5059747	0.0246451	-1.324926	0.0799782
Survival Rate				
1893-1908	6.617319	0.5916776	6.2697	0.583374
1909-1915	6.254623	0.6041052	5.87446	0.5318503
1916-1922	8.820706	0.7994179	8.4138	0.7963056
1923-1938	6.324669	1.00899	14.12053	1.510797
Sex Ratio	-	-	0.726349	0.0682659
R^2	0.97		0.96	
N	546		546	