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Swings in the Economic Support Ratio and Income Inequality
by
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When populations are young, income inequality depends on the distribution of earnings and wealth among working-age adults, marriage patterns, marital sorting, female labor force participation, and childbearing patterns. The income of the elderly and the systems that provide them with economic security are relatively unimportant. This is a simple matter of numbers. If only one in ten adults is elderly, overall levels of inequality are not much influenced by their economic circumstances. That is not to say that the elderly are economically disadvantaged in young (developing) societies. Most low-income countries do not have comprehensive, state-sponsored systems that provide support to the elderly. In many countries, financial systems are so under-developed that accumulating wealth for old age is not a realistic option. But in many developing countries, the extended family is an effective institution for providing support, financial and otherwise, to elderly who can no longer support themselves.

As populations have begun to age, overall levels of inequality depend to a much greater extent on the economic circumstances of the elderly and the support systems that exist to maintain their standards of living. Many of the existing systems that provide support to the elderly may not be sustainable when one in three adults, or more, are elderly instead of one in ten. The vulnerability of public pensions programs has received a great deal of attention in recent years, but the family support system is vulnerable to the same forces. Given the speed of aging in many relatively low-income countries, it is likely that the economic status of the elderly and the overall level of inequality will depend as much on how aging affects the family support system as how it effects formal, state-sponsored support systems.

The effect of aging on inequality has been the subject of a number of studies. Lam (1997) presents what has become the standard methodology for analyzing the effects on inequality of changes in age composition and discusses many of the issues that arise. The standard approach is to estimate age profiles of the mean and variance of income, the log of income, or consumption. The variance for the population is calculated holding the age profiles constant and varying the proportions of the population in each age group. In some cases, Lam and Levison (1992) for example, the method is applied to the earnings of individuals. In other instances, the method is applied to households using profiles and population weights estimated by the age of the household head. Two recent examples are

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Schultz' (1997) study of the variance of household income per adult in Taiwan, using the same data employed here and Deaton and Paxson's (1997) analysis of consumption for the US, Great Britain, Thailand, and Taiwan, using the same data for Taiwan as we employ here. In both the Schultz and the Deaton and Paxson studies, population aging is found to increase the level of inequality primarily because the variance of income or consumption for the elderly is greater than the variance of income or consumption for the non-elderly.

Analyses of the impact of changing age structure on household variables implicitly assume that changes in age structure will not affect the age profiles of the variables in question. In a population where multi-generation households are prevalent, however, changes in age structure may have a large effect on the demographic characteristics of households and the economic variables of interest. If the number of seniors increases relative to working-age adults, at least one of three important household characteristics must change: the proportion of seniors living in extended households, the proportion of working-age adults living in extended households, and/or the number of seniors per working-age adult within extended households.

Each of these changes has potentially important implications for income inequality. A rise in the proportion of seniors living in extended households would, other things equal, reduce inequality by increasing the extent to which incomes are pooled. A rise in the proportion of working-age adults living in extended households would have a similar effect. The impact of a change in the number of seniors per working-age adult on income inequality within extended families depends on the characteristics of the income distributions of working-age adults and seniors who form extended households. Changes in age structure have more than a compositional effect. They induce changes in the family support system with potentially important implications for income inequality.

In this paper we present a simple theoretical structure that The objective of this paper is to examine the impact of aging on income inequality when the extended family is an important part of the support system. We show that under a variety of circumstances population aging will lead to lower income inequality. . . . [add basic findings here]

BACKGROUND

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 be 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 ones 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.[2] 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.

[2] 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).

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 household 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 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.[3] 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.

Even if the world faced by the elderly were one of complete certainty, income differences across generations would exist and extended living arrangements would be an efficient way for family members to transfer resources from low to high income members. These transfer may be an altruistic response to income differences that inevitably arise within a family because of differences in natural ability, effort, or luck. They may be a systematic response to the lifecycle problem. As an alternative to saving,

[3] 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.

parents may invest in their children with the understanding that they will receive support in their old age. Or transfers and extended living arrangements may arise simply because macroeconomic forces have influenced rates of economic growth, creating large intergenerational differences in lifetime income. This latter phenomenon is certainly a feature of Taiwan, the subject of our empirical analysis and one of the fastest growing economies in the world since 1960.

MODEL

Assume that individuals in a one-sex population live for up to 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, face declining productivity, retirement, and elevated health risks. The focus of this analysis is entirely on the adult population, those aged g and older. We refer to members of the population g or older, but younger than 2g, as non-senior adults or non-seniors and to individuals aged 2g or older as seniors. Families consist of non-senior adults and their surviving parents.[4] A family cohort consists of all non-seniors born during the same period and their surviving parents.[5] There are two types of households: extended households, consisting of at least one member belonging to each generation; and nuclear households, consisting either of seniors or non-seniors, but not both.

The income of an individual is designated by Y and is exogenous. When individuals form households they are assumed to fully pool their income. Hence, we do not consider any intrahousehold distributional issues.

The population of non-seniors is designated as $K(a)$ where $g \leq a < 2g$ and the population aged $P(a+g)$ are the parents of those aged a. The total population (of adults) is given by $M = \sum_{a=g}^{2g}(K(a)+P(a+g))$. At any point in time, the old-age dependency ratio for non-senior adults aged a is given by:

$$D(a) = N(a+g)/N(a) = s(a+g)/(f(a+g)s(a)). \qquad (1.1)$$

where $f(a+g)$ is the fertility rate of parents aged $a+g$ and $s(a)$ and $s(a+g)$ are the survival rates for the populations aged a and $a+g$.[6] The dependency ratio within extended households $D_x(a)$ is equal to $P_x(a+g)/K_x(a)$, where the subscript x is used to distinguish extended households and n to distinguish nuclear households.

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[4] For simplicity we assume that children do not die before their parents and that the population is closed.
[5] Given the simplifying assumptions the adult population can be separated into family cohorts that are mutually exclusive and exhaustive.
[6] To define these concepts more precisely, f(a) is the mean number of children ever born, s(a) is the proportion surviving to age a, and s(a+g) is the proportion of seniors surviving from age g to age a+g. We assume that the fertility rate and survival rates are independent.

Let $x^k(a)$ be the proportion of non-seniors aged *a* living in extended households and $x^p(a+g)$ be the proportion of seniors aged *a+g* living in extended households. For each family cohort, the following relationship must hold:

$$x^p(a+g) = d_x(a)x^k(a) \text{ for a<2g.} \tag{1.2}$$

where:

$$d_x(a) = D_x(a)/D(a) \tag{1.3}$$

is the dependency ratio in extended households relative to the general dependency ratio.

Equation (1.2) represents a demographic constraint that captures the fundamental tradeoff between rates of co-residence among non-senior adults and the relative concentration of seniors within extended households faced by each family cohort. Given the proportion of seniors living with their adult children, $x^p(a+g)$, the proportion of non-senior adults living in extended households may be low (high), but only if those who live with their parents live with relatively many (few) of them. The "choice" that is made among these alternatives has clear implications for income inequality for each family cohort.

The demographic constraint and its general bearing on the relationship between living arrangements and inequality is illustrated by Figure 1. The demographic constraint is shown in the upper panel, with two cases considered. In one case, "x(a+g) high", a high proportion of seniors are living with their adult children. The proportion of non-senior adults living with their parents is X1 and d1 is the dependency ratio of extended households relative to the general population. The corresponding level of inequality is given by I1 in the lower panel of Figure 1. Note that the figure is drawn so that inequality increases as we move down the scale in the lower panel. Suppose that old-age burden were shared more equally among non-senior adults. This would be achieved by moving to the right along "x(a+g) high". Such a change in living arrangements would lead to a reduction in inequality, represented by the "x(a+g) high" line in the lower panel, as the proportion of individuals pooling resources in the population increased.[7]

Figure 1. A Model of Co-residence and Inequality

A downward shift in the proportion of seniors living with their children is represented by the shift to the "x(a+g) low" lines shown in both of the upper and lower panels. Inequality must be greater when the proportion of seniors living in extended households declines, given the proportion of non-senior adults living in extended

[7] This is an axiomatic property of measures of income inequality. If income is transferred from a higher income individual to a lower income individual, income is said to be more equally distributed. Assuming that income is fully pooled within extended households, any increase in membership involves a transfer from the higher income members to the lower income members and, thus, an decline in income inequality.

households, again because of the unambiguous effects of income pooling on income inequality.

Suppose that society experiences population aging, i.e., a rise in the dependency ratio for the general population, D(a). How is that reflected in Figure 1?[8] There is a range of possible outcomes, all of which involve different possible outcomes with respect to $d_x(a)$, $x^k(a)$, and $x^p(a+g)$. One possibility is that the dependency ratio within extended households increases by an equal percentage, leaving $d_x(a)$, $x^k(a)$, and $x^p(a+g)$ at their original level. Another possibility is that neither the dependency ratio within extended families nor does the proportion of seniors living with their children change, but $d_x(a)$ would then fall and the proportion of non-seniors living in extended households would rise. A third polar case is that the dependency ratio within extended families and the proportion of non-seniors living in extended families would remain constant, and the proportion of seniors living in extended families would decline. Of course, what we might expect is that some combination of all three would occur in response to aging, i.e., the dependency ratio in extended household would rise by less than the dependency ratio for the population, the proportion of seniors living in extended households would decline, and the proportion of non-seniors living in extended households would rise. Given these range of possibilities how will inequality be affected by aging when extended living arrangements constitute an important part of the economic support system?

A Primer on Aging, Extended Living Arrangements, and Inequality

Consider the simplest case. Suppose that a cohort[9] consists of *F* families and *M* members. The number of non-senior adults is designated as *K*, the number of seniors by *P*, and the members of the population and household *i* by *M* and M_i. Each family consists of one non-senior adult and one senior. Families may form *X* extended households consisting of one senior and one non-senior adult or *N* nuclear households consisting of either a single senior or a single non-senior. The income of a non-senior adults is designated by Y^k and the income of senior by Y^p. The per adult income of extended households is Y_x and of nuclear households is Y_n. The variance of any variable is represented using the operator *V( )*, for example, $V(Y^k)$ and $V(Y^p)$.

Given this information we can readily calculate inequality, as measured by the variance in income, in two polar cases. If the cohort consists entirely of nuclear households, the variance in per capita household income is given by:

[8] Figure 1 is constructed to illustrate the implications of alternative living arrangements given the population age structure, not the implications of changes in age structure. There is no reason to expect that relationship between demographics and inequality represented by the lower panel in Figure 1 would be invariant with respect to changes in age structure.
[9] We define the family cohort as consisting of all members of a single birth cohort (non-senior adults) and their parents (seniors). To ease analysis we assume that all siblings are members of the same birth cohort.

$$V(Y) = m^k V(Y^k) + m^p V(Y^p) + m^k m^p (\bar{Y}^k - \bar{Y}^p)^2 \qquad (1.4)$$

where m^k is the proportion of non-seniors in the (adult) population and m^p is the proportion of seniors in the population.

This can be contrasted with the case where all individuals live in extended households. This is possible only if the number of seniors and non-seniors are equal given our assumption that extended households consist of one senior and one non-senior. Under these restrictive assumptions, the variance in per capita household income is:

$$V(Y_x) = 0.5(1 + \tilde{r}_{Y^k Y^p}) V(Y), \text{ where}$$
$$\tilde{r}_{Y^k Y^p} = \frac{1}{M} \sum_i M_i (Y_i^k - \bar{Y})(Y_i^p - \bar{Y}) / V(Y). \qquad (1.5)$$

If the income of non-senior adults and their parents were independent, the variance of per capita income would be reduced by one-half if the extended family system entirely replaced the nuclear family system. If the covariance between the incomes of children and parents were negative, the impact of establishing an extended family system would be even greater. The covariance is undoubtedly positive, however, and the greater the covariance the smaller the impact of establishing an extended family system. In the extreme, i.e., the correlation between the income of parents and children were perfect ($\tilde{r}_{Y^k Y^p} = 1$), then the variance and covariance are equal, there is no reduction in inequality achieved by establishing extended households. Otherwise, populations consisting of extended household will always have lower variance than populations consisting entirely of nuclear households because of the effects of pooling.

This case is special and simple because the decision to live in extended households is not influenced by the incomes of parents and children. Likewise, the relationship between inequality and the proportion living in extended households is simple if the assignment of families to the extended status is random or independent of the incomes of seniors and non-seniors and there are equal numbers of seniors and non-seniors. In this case, if we take m_x as the proportion of persons living in extended households, then the variance of per capita household income is:

$$V(Y) = m_x V(Y_x) + (1 - m_x) V(Y_n). \qquad (1.6)$$

This case is simple, in part, because the simplifying assumptions insure that the per capita income for nuclear and extended households are identical and that the variance of per capita income in extended and nuclear households and the covariance of income for extended households are independent of the proportion of households that are extended. Under these conditions, the variance in income is linear in the proportion of persons living in extended households.

In the absence of extended households, the effect of changes in age structure is readily analyzed using equation (1.4) or more general formulation used by Lam (2001) and others. Changes in age structure influence the overall variance of income because both the variance of income and mean income vary with age. Thus, if the population is more heavily concentrated in age groups with high variance or with a mean income that differs substantially from the mean income of other age groups, overall inequality will be greater. The first two right-hand-side terms in equation (1.4) capture differences in the variance in income between senior and non-senior populations. If the variance in income of seniors is less than the variance in income of non-seniors, which is typically the case, a rise in the senior population will depress inequality. The third term captures the effect on inequality of the differences in the mean income of seniors and non-seniors. Any change in age structure that results in a more uniform distribution will lead to greater inequality. Given the current situation in any population, $m^k > m^p$, an increase in the proportion senior will increase the difference in means effect. Thus, in the absence of extended households, the impact of aging on inequality is uncertain and will depend on the specifics of the income distribution of the senior and non-senior populations.

One of the difficulties that must be confronted in analyzing the relationship between aging and inequality in the presence of extended households is that changes in age structure must influence either the proportion of the population living in extended households, the age composition of extended households, or both. Given our assumption that extended households consist of exactly one senior and one non-senior, changes in age structure must affect the proportion living in extended households.

We can consider the implications of changing age structure for inequality in the presence of extended living arrangements by relaxing our assumption that there are equal numbers of seniors and non-seniors, while retaining the assumption that co-residence decisions are independent of income. Under these conditions, the variance in per capita income is given by:

$$
\begin{aligned}
&V(Y) = b_1 V(Y^k) + b_2 V(Y^p) + b_3 (\bar{Y}^k - \bar{Y}^p)^2, \text{ where} \\
&b_1 = m_n^k (m_n + 0.5(1 + \tilde{r}_{Y^k Y^p}) m_x), \\
&b_2 = m_n^p (m_n + 0.5(1 + \tilde{r}_{Y^k Y^p}) m_x), \text{ and} \\
&b_3 = m_n^k m_n^p (m_n + 0.5(1 + \tilde{r}_{Y^k Y^p}) m_x) + m_n m_x (m_n^k - 0.5)^2.
\end{aligned}
\qquad (1.7)
$$

The variables m_n^k and m_n^p are the proportion of nuclear household members who are non-senior adults and seniors, respectively. The first two terms on the right-hand-side determine the weight of non-senior adults and seniors in the determination of overall inequality. In the extreme case of the proportion nuclear being 1, the weights are simply the proportion of the population that are seniors and non-seniors. But as the proportion nuclear declines and the proportion extended increases, the first two coefficients and inequality decline. The third term in equation (1.7) captures the impact on inequality of the differences in the mean income of senior and non-senior nuclear households.

Equation (1.7) is an incomplete characterization of the relationship between age structure and inequality. The coefficients vary with the proportion of seniors and non-seniors living in extended households. As the relative number of seniors and non-seniors changes, the proportion of one or both groups living in extended households must change.[10] Let's consider two polar cases. In the first we hold the proportion of seniors living in extended households constant; in the second case we hold the proportion of non-seniors living in extended households constant. If the proportion of seniors living in extended households is constant, a rise in the proportion of non-seniors in the population leads to a rise in the proportion of non-seniors in nuclear households and a rise in the proportion of the population living in nuclear households. Suppose, however, that the proportion of non-seniors living in extended households is fixed. Then a rise in the proportion of non-seniors leads to a rise in the proportion of seniors living in nuclear households, but a decline in the proportion of the population living in nuclear households.

In the first case, the proportion of the population living in extended households is equal to $m^x = 2x^p m^p$ where x^p is the proportion of seniors living in extended households and m^p is the proportion of seniors in the adult population. The proportion of the seniors in the nuclear household population is $m_n^p = (1-x^p)m^p/(1-2x^p m^p)$. If the proportion of non-seniors living in extended households is fixed, then the proportion of the adult population living in extended households is given by $m^x = 2x^k m^k$ and the proportion of nuclear household members who are non-senior adults is $m_n^k = (1-x^k)m^k/(1-2x^k m^k)$.

As is true in the absence of extended households, whether aging leads to an increase or a reduction in inequality cannot be determined on *a priori* grounds. Again, the relationship depends on the characteristics of the income distributions of seniors and non-seniors and the correlation between the incomes of extended family members. If the difference in mean incomes is sufficiently large, an increase in the proportion elderly can lead to a rise in income inequality. However, using observed values for Taiwan in 1992[11] for illustrative purposes and assuming that the correlation between the income of seniors and non-seniors is 0.25, an increase in the proportion seniors leads to a monotonic decline in income inequality, as measured by the variance, in either of the two polar cases (Figure 2). The effect of inequality on aging is greater if the proportion of seniors living in extended households does not decline in response to the increase in their numbers. This is the case because the proportion living in extended households necessarily increases under these circumstances. The relationship between age and inequality in Taiwan in 1992 is dominated by the fact that the variance of income for the senior population is much less than the variance of income for the non-senior population. This is more important than the decline in the proportion of the population living in extended households that occurs when the proportion of non-seniors is held constant and the reduction in overall inequality that occurs because seniors have substantially lower income than non-seniors.

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[10] Given our assumption that the age structure within extended households does not change.

[11] For non-senior adults the variance and mean income of all persons aged 30-59 are used. Values for seniors are based on those 60 and older.

Figure 2. Inequality and aging (combined two figures).

The effect of the proportion living in extended households is also illustrated in Figure 2. The level of inequality is consistently reduced by an increase in the proportion living in extended households given the proportion seniors. There is little interaction between the proportion living in extended households and aging in 1992 Taiwan. The effect of aging on inequality is essentially independent of the proportion of non-seniors living in extended households. There is a negative interaction between aging and the proportion of seniors living in extended households. An increase in the proportion of seniors leads to a greater reduction in inequality if a higher percentage of seniors are living in extended households.

To summarize, even given the exceedingly simple models employed here little can be said on *a priori* grounds about the effects of aging in the presence of extended living arrangements. We can say that (1) inequality is reduced if seniors live with their adult children and that (2) the impact is diminished if income is highly correlated across generations. Neither of these are startling conclusions. We cannot say with certainty how population aging will influence overall levels of inequality. Given one set of parameters based on Taiwan, aging leads to a decline in inequality irrespective of the extent of intergenerational co-residence. Also, given a particular set of parameters we find that the effects of population aging on inequality are greater if a high proportion of seniors live in extended households (and the proportion living in extended households does not change in response to the aging).

Two important considerations beyond those discussed above influence how changes in age structure and living arrangements will influence income inequality. The first is the manner in which changes in age structure influence living arrangements. The model presented above shows that the proportion can either rise or decline as populations age. An additional possibility that is not explicitly considered is that the age composition of households may change. The second consideration is that co-residence decisions are influenced by income. If, for example, altruism governs decision-making, then living arrangements will more effectively pool income and reduce inequality to a greater extent than suggested by the simple models considered here.[12]

Some Additional Complications: Variation in the Composition of Extended Households

Our primer on inequality imposed some simplifying assumptions so that we could focus on a few key issues. Here we relax these assumptions allowing the membership of nuclear and extended households to vary and making no assumptions about the relationship between income and co-residence decisions. This allows us to consider how income inequality will be influenced by changes in the support ratio within extended households, a demographic response to population aging. Extending the model comes at

[12] An additional consideration is that survival may be influenced by one's own income and the income of other family members. Thus the mean incomes of seniors and non-seniors living in extended households may differ systematically from the means incomes of those living in nuclear households.

a cost, however. Changes in the composition of extended households inevitably must influence the composition of nuclear households. A comprehensive assessment of the affect on inequality requires an understanding of the effects of changes in both nuclear and extended households. This is an issue we intend address further, but have not yet done so.

We continue with our focus on inequality within a cohort of families consisting of non-senior adults aged *a* and their parents.[13] For a family cohort aged *a* the variance of per adult household income is a weighted sum of the variance of the income of nuclear and extended households and the squared difference between the mean incomes of nuclear and extended households. The weights are the proportion of the family members living in extended and nuclear households:

$$V(Y) = m_x V(Y_x) + m_n V(Y_n) + m_x m_n (\overline{Y}_x - \overline{Y}_n)^2 \tag{1.8}$$

This is a simple extension of equation (1.6) above.

The variance in per adult income of nuclear families is given by:

$$V(Y_n) = m_n^k V(Y_n^k) + m_n^p V(Y_n^p) + m_n^k m_n^p (\overline{Y}_n^k - \overline{Y}_n^p)^2 \tag{1.9}$$

where:

$$V(Y_n^k) = \sum_i K_i (\overline{Y}_{ni} - \overline{Y}_n)^2, \text{ and}$$
$$V(Y_n^p) = \sum_i P_i (\overline{Y}_{ni} - \overline{Y}_n)^2.$$

where K_i and P_i are the number of non-seniors and seniors in nuclear household *i*, $\overline{Y}_i$ is the average income per adult in nuclear household *i*, and $\overline{\overline{Y}}_n$ is the mean income of all age *a* nuclear households. The weights in equation (1.9) are the proportions of nuclear household members who are non-seniors and seniors.

The variance in per adult income for extended households is:[14]

$$\begin{aligned} V(Y_x) &= m_x^k V(Y_x^k) + m_x^p V(Y_x^p) + (\overline{Y}_x^{k\,2} + \overline{Y}_x^{p\,2}) V(m_x^k) \\ &+ 2(m_x^k \overline{Y}_x^k C(m_x^k Y_x^k) + m_x^p \overline{Y}_x^p C(m_x^p Y_x^p) + C(Y_x^k Y_x^p)) \end{aligned} \tag{1.10}$$

where:

[13] To simplify notation we drop *a* from all notation.

$$V(Y_x^k) = \sum_i m_{xi}^k K_i (\bar{Y}_i^k - \bar{Y}^k)^2 / K$$

$$C(m_x^k Y_x^k) = \sum_i K_i (m_{xi}^k - m_x^k)(\bar{Y}_i^k - \bar{Y}^k)^2 / K$$

$$V(m_x^k) = \sum_i M_i (m_{xi}^k - m_x^k)^2 / M$$

$$C(Y_x^k Y_x^p) = \sum_i M_i (m_{xi}^k \bar{Y}_i^k - m_x^k \bar{Y}^k)(m_{xi}^p \bar{Y}_i^p - m_x^p \bar{Y}^p) / M, \text{ and}$$

$$m_{xi}^k = K_{xi} / M_{ix}.$$

The terms for seniors in equation (1.10) are obtained by replacing K with P and m_x^k with m_x^p, in the terms for non-seniors.

Much of the complexity in equation (1.10) arises because of variation in m_x^k, the support ratio, across households. We can abstract from this complexity for the moment by considering a special case in which the support ratio is the same for all extended households. Equation (1.10) simplifies to:

$$V(Y_x) = m_x^k V(Y_x^k) + m_x^p V(Y_x^p) + 2C(Y^k Y^p) \qquad (1.11)$$

where the variance and co-variance terms are weighted by the number of household members but not by the support ratio. As the support ratio ranges from 0 to 1, the variance in income for extended households ranges from the variance in income for the senior sub-unit to the variance in income for the non-senior sub-unit. For intermediate values of the support ratio, the variance of extended households will decline relative to a simple weighted average of the variances of the two sub-units. The effect of changes in the support ratio depends also on the covariance between the income of non-senior adults and their parents. The relationship is illustrated in Figure 3 using values obtained for all age groups combined in 1992. Given these values the variance in extended households reaches a minimum when there are about 0.3 non-senior adults per household member as compared with the actual value for 1992 of 0.63.

The variance in income for extended households is compared with the variance in income that we would observe if these households were to establish nuclear households. The gap between the two series reaches a maximum for a support ratio at 0.5 and is symmetric with respect to the support ratio. It is always the case that the greatest reduction in the variance of income occurs when there are equal numbers of non-senior adults and senior living in extended households.

Figure 3. Variance of income and the support ratio.

Once we abandon our simplifying assumption (that the old age support ratio is the same in all extended households), the variance in extended household income also depends on the variance in the support ratio, the third additive term in equation (1.10), and the covariance between the support ratio and the average income of non-senior adult members and the average income of the parents. In general, if the variance in the support ratio is large, the variance in household income in extended households will be greater. If the covariance between the support ratio and the income of non-senior adults is negative, the variance of income will be lower because higher income non-senior adults are bearing a heavier dependency burden. Likewise, if the covariance between m_x^p and the income of parents is negative, the variance of household income will be lower because low income adults are living in households where the support ratio is relatively high.

LIVING ARRANGEMENT, INEQUALITY, AND AGING IN TAIWAN

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 transformed itself into one of Asia's most advanced economies. Only Japan, Hong Kong, and Singapore can boast of a higher standard of living.

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.

There are two features of the FIES that are important to the analysis presented below. First, the FIES has a complete households roster with age, sex, relationship to head, and other individual characteristics of household members. The household roster is used to partition households into groups of individuals belonging to the same generation. For example, the head, spouse of the head, or sibling of the head would belong to one generation. The mother, father, aunt, or uncle of the head would belong to another generation. All individuals who are related to the head are assigned to a generation. Extended households are defined as households consisting of two or more generations in which at least one member is 30 years of age or older. The great majority of extended households consist of only two adult generations. If there are more, we collapse the oldest generations into a single group. Thus, all extended households consist of two generations of adults. Each of these generations is assigned a head, who is the individual with the greatest earnings within the generation. If no member has income or if two members are tied for the highest income, the youngest member is the head of the sub-unit. The age of this individual is used as the age of each generation within extended households.

The second feature of the FIES is that household income is assigned to members of the household. Although there is a residual category for income that cannot be assigned to an individual, this category is rarely used. Consequently, we can calculate income characteristics separately for the non-senior and senior generation within extended households. Income is measured by total current income excluding depreciation. We analyze income per adult. All means and variances are weighted by the number of adults in the household or sub-unit.[15]

Seniors consist of all those who are 60 years of age or older. Non-seniors consist of those who are 30-59. The generation length is assumed to be 30 years, which is very close to the average difference between generations in Taiwan that have not yet been subject to high rates of mortality.[16] Age 30 is used to measure adults for a variety of reasons. Marriage and childbearing are relatively late in Taiwan. Many of those who are in their 20s are still in school, have not yet married, have not yet entered the labor force or are working full-time. Given our focus on the family as a support system for seniors, we have used a very conservative definition of adult.

RESULTS

Presentation of the empirical results is organized around one key issue: Has aging led to greater income inequality in Taiwan? To answer this question requires that we explore a number of subsidiary issues:

1) the effect of aging on the dependency ratio within extended households and on the proportions of seniors, non-seniors, and adults living in extended households;

2) the effect of changes in the extended household dependency ratio on the variance of extended household income;

3) the effect of changes in the proportion of senior nuclear households on the variance on nuclear household income;

4) the effect of changes in the proportion of seniors on the gap between the mean incomes of seniors and non-seniors.

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[15] For a discussion of some of the issues that arise in measuring income inequality see Lam 1997 or Schultz 1997.

[16] The age difference between generations declines when older members of the senior generation are subject to higher mortality rates.

Answering these questions allows us to reach a more comprehensive answer to whether or not aging is a source of greater income inequality using equation (1.8).

Living arrangements and aging

Taiwan experienced substantial population aging between 1978 and 1998, although it is still early in the aging process as compared with Japan, for example. The senior population (60+) as a percentage of the adult population (30+) increased from 14.5 percent in 1978, to 20.5 percent in 1988, and 25.7 percent in 1998. For "family cohorts" the increase in the dependency ratio between 1978 and 1998 ranged from a rise of 67 percent for 30-34 year old to an increase of 234 percent for 50-54 year olds and 251 percent for 55-59 years.[17]

The dependency ratio within extended households increased during the same period, but by much less than the dependency ratio for the general population (Figure 4). For extended households the rise in the dependency ratio ranged from 1.4 percent for the 50-54-year-old group to a high of 11.7 percent for the 35-39-year-old group. The elasticity of the extended household dependency ratio with respect to the "family" dependency ratio ranged from a low of 0.001 to a high of 0.005, well below an elasticity of 1 – the value consistent with constant proportion of seniors and non-seniors living in extended households (see equation **(1.2)**).

Figure 4. Dependency ratios, extended household and general populations, by age groups, 1978 - 1998.

Because the dependency ratio in the general population increased so much more rapidly than within extended households, the proportion of seniors living in extended households must have declined and/or the proportion of non-seniors living in extended households must have increased between 1978 and 1998. Both happened, but the response of non-seniors was much stronger (Figure 5). The proportion of those aged 30-59 living in extended households increased from 19 percent to 30 percent between 1978 and 1998 while the proportion of seniors living in extended households dropped from 57 percent to 53 percent.

As noted above, the effect of aging on the proportion of the adult population living in extended households depends on the relative strength of the drop in the proportion of seniors living in extended households and the rise in the proportion of non-seniors living in extended households. In Taiwan, the rise in the proportion of non-seniors dominated producing a rise in the proportion of adults living in extended households of 11 percentage points, from 24.3 percent in 1978 to 35.5 percent in 1998.

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[17] The dependency ratio for a family cohort is calculated as $M(a+g)/M(a)$ using five-year age groups and a value of 30 for *g*.

[Figure 5. Proportion of seniors, non-seniors, and adults living in extended households, 1978-1998.]

It is unlikely that the changes in living arrangements experienced in Taiwan were a response entirely to changes in age structure. Taiwan was experiencing rapid social and economic development during much of this period, with potentially important implications for the response of living arrangements to changes in age structure.[18] Of course, we can not rule out that the proportion living in extended households would have risen even more in response to changes in age structure had other circumstances remained the same in Taiwan. It is a striking feature of Taiwan's demography that the proportion living in extended households increased so substantially.

The Effect of Aging on the Distribution of Income among Extended Households

The rise in the dependency ratio in Taiwan has led to an increase in the dependency ratio within extended households, albeit one that appears to be quite small. Nonetheless, inequality among extended households will change. To assess the effect we make several simplifying assumptions. We assume that the mean and variance of the incomes of seniors and non-seniors living in extended households is unaffected by the change in the extended households dependency ratio; that the covariance between the income of seniors and non-seniors living in extended households is unaffected; and that the variance of the dependency ratio and the covariance with the income and seniors and non-seniors is unaffected by changes in the dependency ratio. The only effect we assess is compositional, that the mean and variance in income will reflect the greater weight of seniors in extended households.

The compositional effect of the change is easily assessed by simulation. We increase the number of seniors living in extended households by 10 percent in every extended household in our samples and recalculate the variance of per capita income of extended households. The results of this exercise applied to data for 1978, 1988, and 1998 displayed in Table 1 show that an increase in the dependency ratio consistently led to a decline in the variance in per capita household income for extended households. The impact of a change in the dependency ratio is substantial. A ten percent increase in the dependency ratio produced a decline in the variance of income that ranged from 6.2 to 11.4 percent depending on the year and the age group.

Although the variance in income for extended households appears to be sensitive to aging, the changes in the dependency ratio in extended households was relatively modest as explained above. Between 1978 and 1998, the dependency ratio increased by roughly 10 percent for those aged 35-49, but by much less for the other groups.

Why does aging among extended households lead to a decline in the variance of per capita income? As discussed in more detail above, the effect of changes in age

[18] Lee and Mason (2002) we consider this issue in more detail.

Table 1. Effect on $V(Y_x)$ ten percent increase in M^p, Taiwan, 1978, 1988, and 1998.

Year	Age group	M^k	M^p	$\bar{Y}_x^p$	$\bar{Y}_x^k$	$\bar{Y}_x$	m_x^k	m_x^p	$V(Y_x)$	Percent change
Before										
1978	30-34	844	958	0.255	0.911	0.563	0.468	0.532	0.104	
1978	35-39	897	647	0.106	0.807	0.513	0.581	0.419	0.083	
1978	40-44	713	465	0.044	0.783	0.491	0.605	0.395	0.076	
1978	45-49	548	341	0.034	0.740	0.469	0.616	0.384	0.070	
1978	50-54	323	199	0.016	0.750	0.471	0.619	0.381	0.110	
1978	55-59	103	61	0.030	0.665	0.429	0.628	0.372	0.089	
After										
1978	30-34	844	1054	0.255	0.911	0.534	0.445	0.555	0.095	-9.4
1978	35-39	897	712	0.106	0.807	0.493	0.558	0.442	0.077	-7.7
1978	40-44	713	512	0.044	0.783	0.472	0.582	0.418	0.070	-7.2
1978	45-49	548	375	0.034	0.740	0.452	0.594	0.406	0.065	-7.1
1978	50-54	323	219	0.016	0.750	0.453	0.596	0.404	0.103	-6.6
1978	55-59	103	67	0.030	0.665	0.414	0.606	0.394	0.084	-6.2
Before										
1988	30-34	1651	1883	0.688	2.242	1.419	0.467	0.533	0.547	
1988	35-39	1358	1082	0.399	2.227	1.417	0.557	0.443	0.604	
1988	40-44	674	465	0.265	2.084	1.342	0.592	0.408	0.638	
1988	45-49	606	394	0.108	1.942	1.219	0.606	0.394	0.477	
1988	50-54	395	246	0.030	2.054	1.277	0.616	0.384	1.098	
1988	55-59	200	121	0.123	1.763	1.145	0.623	0.377	0.770	
After										
1988	30-34	1651	2070	0.688	2.242	1.343	0.444	0.556	0.485	-11.4
1988	35-39	1358	1190	0.399	2.227	1.357	0.533	0.467	0.557	-7.7
1988	40-44	674	512	0.265	2.084	1.289	0.569	0.431	0.591	-7.5
1988	45-49	606	433	0.108	1.942	1.173	0.583	0.417	0.447	-6.3
1988	50-54	395	271	0.030	2.054	1.230	0.593	0.407	1.024	-6.8
1988	55-59	200	133	0.123	1.763	1.104	0.600	0.400	0.716	-7.0
Before										
1998	30-34	1609	1902	1.899	4.742	3.202	0.458	0.542	2.835	
1998	35-39	1486	1308	1.051	4.774	3.031	0.532	0.468	2.448	
1998	40-44	1042	805	0.664	5.062	3.146	0.564	0.436	3.399	
1998	45-49	664	479	0.442	5.125	3.162	0.581	0.419	4.064	
1998	50-54	301	201	0.324	5.261	3.285	0.600	0.400	5.740	
1998	55-59	208	126	0.192	4.669	2.980	0.623	0.377	5.994	
After										
1998	30-34	1609	2092	1.899	4.742	3.037	0.435	0.565	2.562	-9.6
1998	35-39	1486	1439	1.051	4.774	2.895	0.508	0.492	2.256	-7.8
1998	40-44	1042	886	0.664	5.062	3.014	0.541	0.459	3.151	-7.3
1998	45-49	664	527	0.442	5.125	3.035	0.558	0.442	3.782	-6.9
1998	50-54	301	221	0.324	5.261	3.158	0.577	0.423	5.323	-7.3
1998	55-59	208	139	0.192	4.669	2.872	0.600	0.400	5.589	-6.8

composition depend on the mean and variance of income for seniors and non-seniors within the family cohort. The mean incomes of seniors living in extended households were only about twenty percent of the mean incomes of non-seniors, but the variance in the income of seniors was also substantially lower than the variance in the income of non-seniors (Figure 6). The lower variance dominates in Taiwan, and the net effect of a rise in dependency ratio is to reduce income inequality.

[Figure 6. The Mean and Variance of Income, Ratio of Senior to Non-senior Members of Extended Households, Taiwan, 1978-1998.]

The Effect of Aging on the Distribution of Income among Nuclear Households

Aging also has compositional effects on the distribution of income among nuclear households, again because of differences in the means and variances of income associated with the age of the individuals who reside in those households. The means and variances of income for nuclear households are compared in Figure 7. The mean income differentials for nuclear households are smaller than the mean income differentials for extended households. Seniors nuclear households had an average income that was about 60 percent of the average income of non-seniors nuclear households. Note that the gap increased over the twenty year period and by 1998 the per-adult income of seniors was only about half of the per-adult income of non-seniors living in nuclear households. The variance of income for non-seniors and seniors were similar through the early 1980s, and under these conditions an increase in the proportion of seniors in nuclear households must increase the variance in nuclear household income. But since that time, the variance of senior income has declined dramatically relative to the variance in non-senior income. As a result, the changes in age composition, i.e., the aging of nuclear households has reduced inequality among nuclear households since 1984 (Figure 8).

[Figure 7. The Mean and Variance of Income, Ratio of Senior to Non-senior Members of Nuclear Households, Taiwan, 1978-1998.]

[Figure 8. The Impact of Aging on Inequality among Nuclear Households.]

Although we do not explore the issue here, it is possible that the mean and variance of nuclear households has been influenced by aging. In particular, improving survival rates lead to a delay in the age at which individuals become widowed and, other considerations aside, will lead to a decline in the proportion of one-person households and an increase in the proportion of couples living in nuclear households. Whether this has happened and the implications for income inequality are issues that we do not explore here.

The Effect of Aging on the Mean Incomes of Extended and Nuclear Households

The income per adult in nuclear households is consistently greater than the income per adult in extended households in Taiwan – per-adult income in extended households is only about two-thirds of the per-adult income in nuclear households. This gap is a source of greater inequality in a population where the proportion living in extended households is increasing, but has not reached 0.5. Aging will reduce the mean incomes of both household types, and the sizes of the gap, because the mean incomes of seniors are exceeded by the mean incomes of non-seniors. The proportion of nuclear household members who are seniors has increased much more rapidly than the proportion of extended households who are seniors. For nuclear households the proportion senior increased from 8.2 percent to 18.8 percent between 1978 and 1998. For extended households the proportion senior increased from 34.0 percent to 38.1 percent. This has the effect of reducing the average income of nuclear households by more than the average income of extended households and reducing the gap between the two types of households. However, the gap in average income between seniors and non-seniors is much larger in extended households than in nuclear households. Thus, the effect of aging on the gap between the mean income of nuclear and extended households is unclear. In fact, the changes in age structure resulted in a reduction in the age gap by a little under 3% for the entire 21-year period of analysis.

The Bottom Line

To this point, aging appears to have reduced adult income inequality in Taiwan. First, population aging has resulted in an increase in the proportion of adults living in extended households. Second, the rise in the dependency ratio in extended households has led to a small decline in income inequality among extended households. Third, the rise in the proportion of nuclear households consisting of elderly members has led to a reduction in inequality among nuclear households beginning in the early 1980s. Although the rise in the proportion of persons in extended households has had a dis-equalizing effect because of the difference between the mean incomes of extended and nuclear households, the magnitude of this effect has been relatively small. Our estimate is that the net effect of aging has been to reduce the variance in per adult household income by just over 1 percent per year.

SOME OUTSTANDING ISSUES

There are, however, important features of aging that are beyond our purview. First, the elderly are not only living longer, but they are living longer healthier lives. Hence, the proportion of prime-age adults with disabled parents, who are perhaps more financially burdensome, is not rising as rapidly as the proportion of prime-age adults with healthy parents. Second, alternative support mechanisms are becoming more important as life expectancy increases and the need for retirement wealth becomes evident. Workers are now faced with the near certainty of an extended period of retirement and substantial incentives to accumulate pension wealth on which they can rely in their old age. The reduced uncertainty about the age at death essentially makes it more feasible for individuals to self-insure against longevity risk by accumulating personal wealth. Interestingly, the mean income of seniors has changed little relative to the mean income of non-seniors in Taiwan during the last 20 years, suggesting little change in the extent to which seniors are relying on their own resources in old-age.

One of the difficulties that limits our analysis is that we have no information about non-coresident family members. In part, we deal with this difficulty by assuming that all members of a cohort give birth at age *g*. The estimate of the generation length is based on the generation length within extended households. To the extent that co-residence decisions are conditioned on age, the generation length for the family will differ from the generation length for the household. Perhaps a more serious problem is that we have no information about the covariance of the incomes of family members living in nuclear households. In general, we know that the incomes of parents and children are positively correlated because genetic traits that influence earnings are transmitted from parent to child and because higher income parents invest more in human capital of their children.

We consider any of the determinants of income inequality within generations, such as those related to marital sorting.

CONCLUSIONS

The evidence marshaled here suggests that the view that aging will lead to greater income inequality needs careful scrutiny. Aging not only has important compositional effects, but it also influences the economic support system on which many elderly depend. In Taiwan we find that to this point aging has probably led to a reduction in income inequality rather than an increase – a finding that is contrary to previous research on Taiwan based on the same survey data as used here.

It is difficult to generalize studies of income inequality. There are great differences in the characteristics of income distributions around the world and equally great differences in the support system. In many countries in the West, the family support system is much less important than in Taiwan or many other countries. However, public support systems are also subject to the same kinds of demographic effects as highlighted here. As populations age, benefits to the elderly must decline and/or taxes on workers must rise. This simple truth cannot be neglected in assessments of how aging will influence income inequality in the coming years.

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Figure 1. Co-residence and inequality

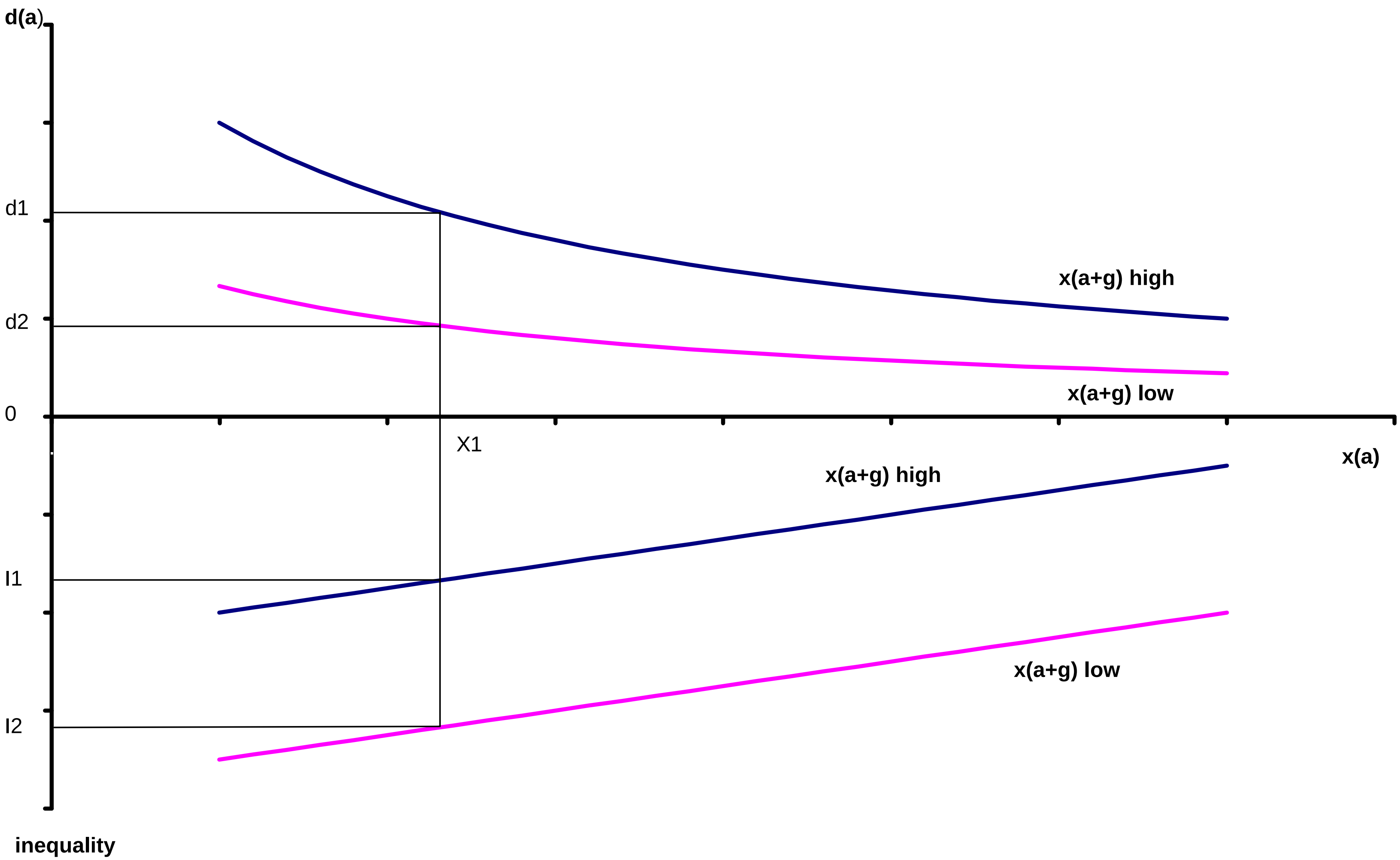


Figure 2a. Inequality and aging
rho=.25, based on 1992 parameters for extended households

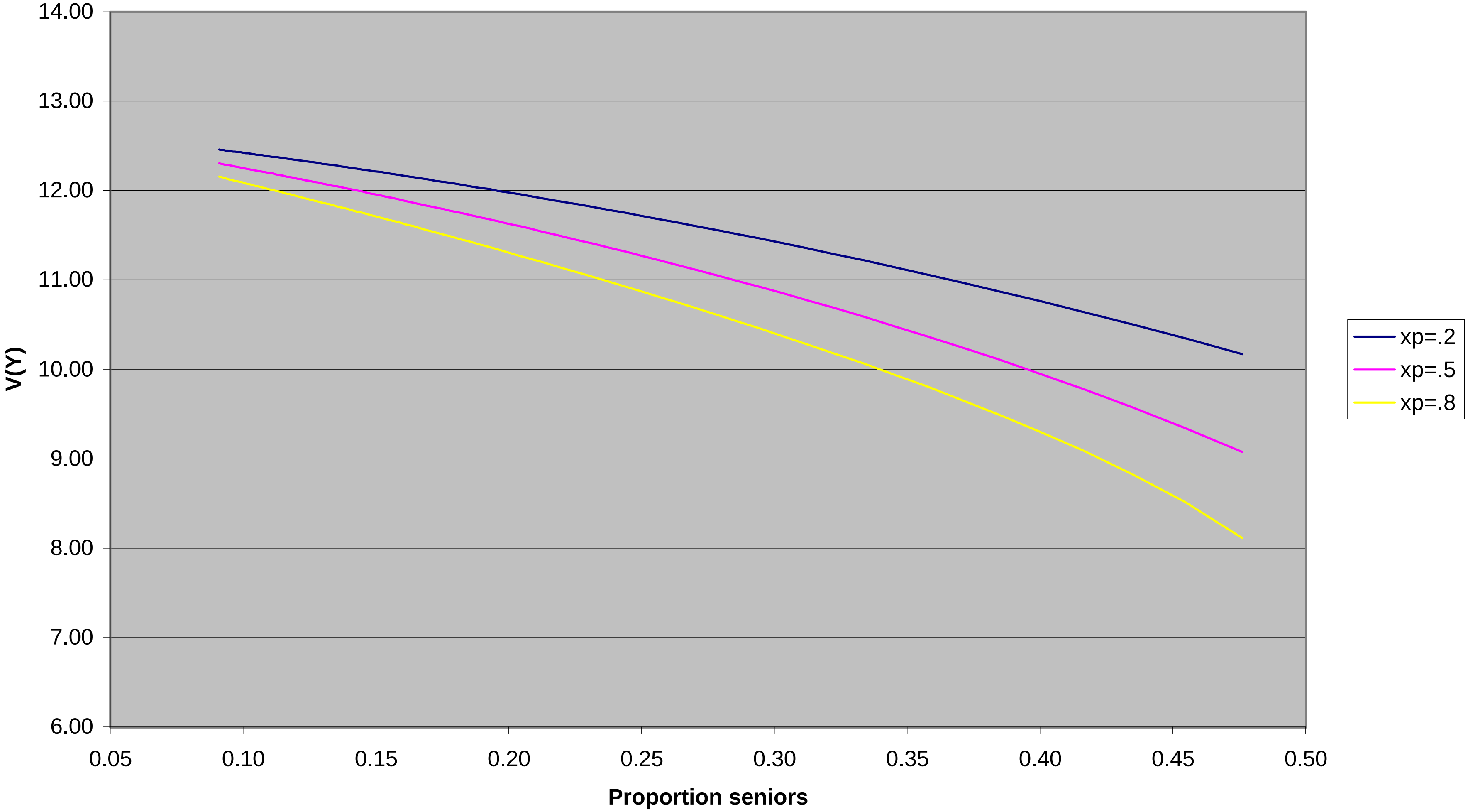


Figure 2b. Inequality and Aging, Selected values of xk held constant

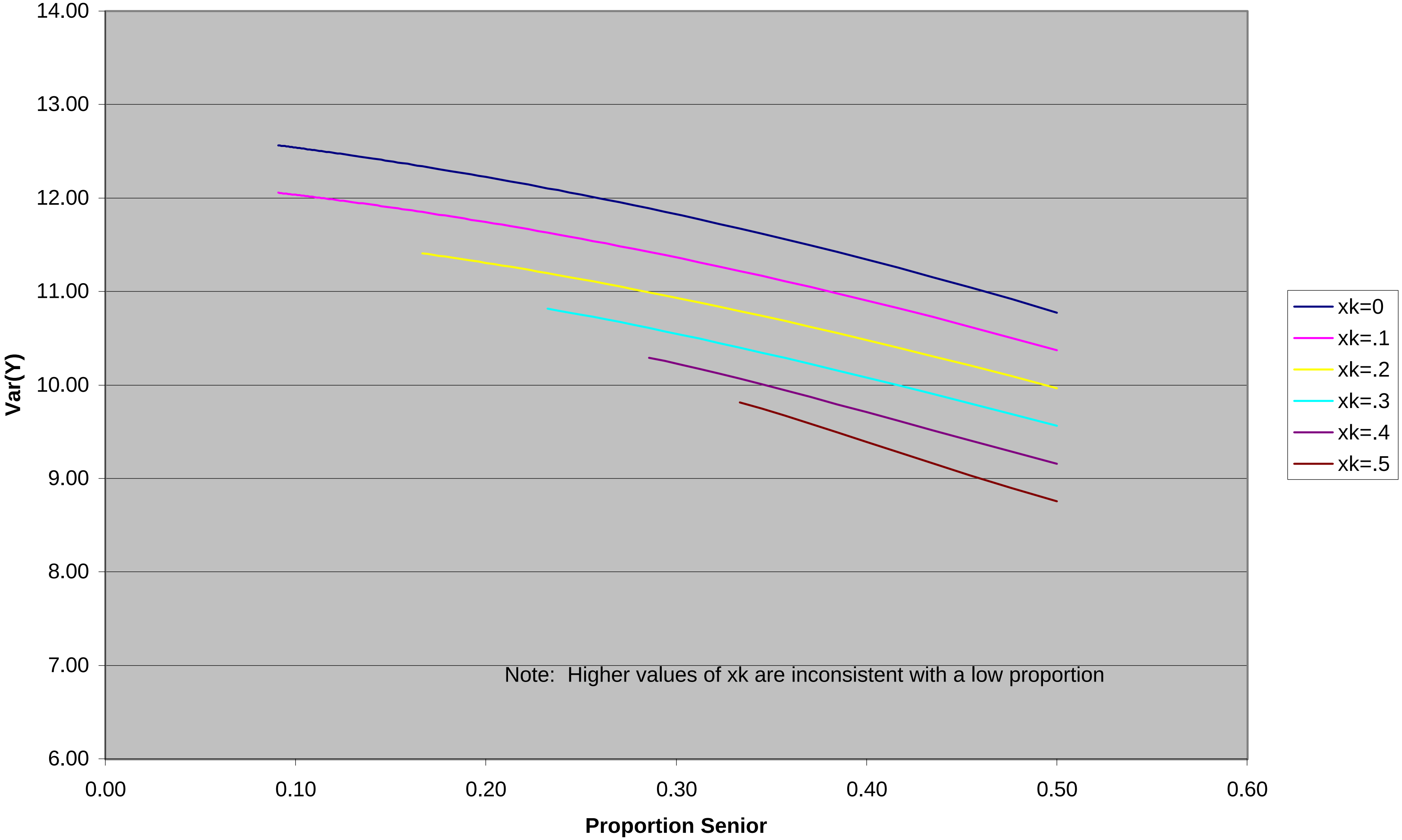


Figure 3. Variance of income and the support ratio

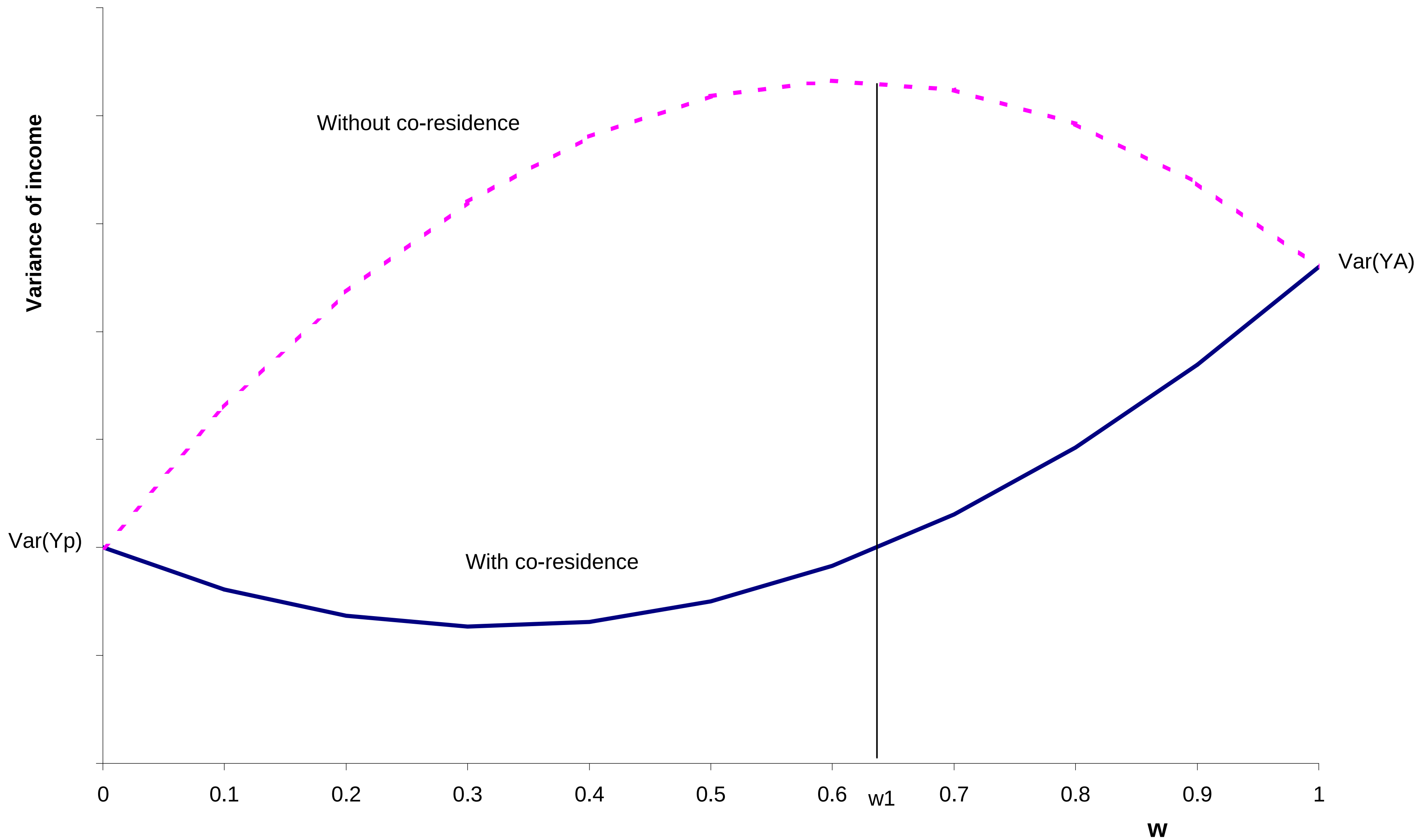


**Figure 4. Dependency ratios, extended households vs. general population
Taiwan, 1978-1998**

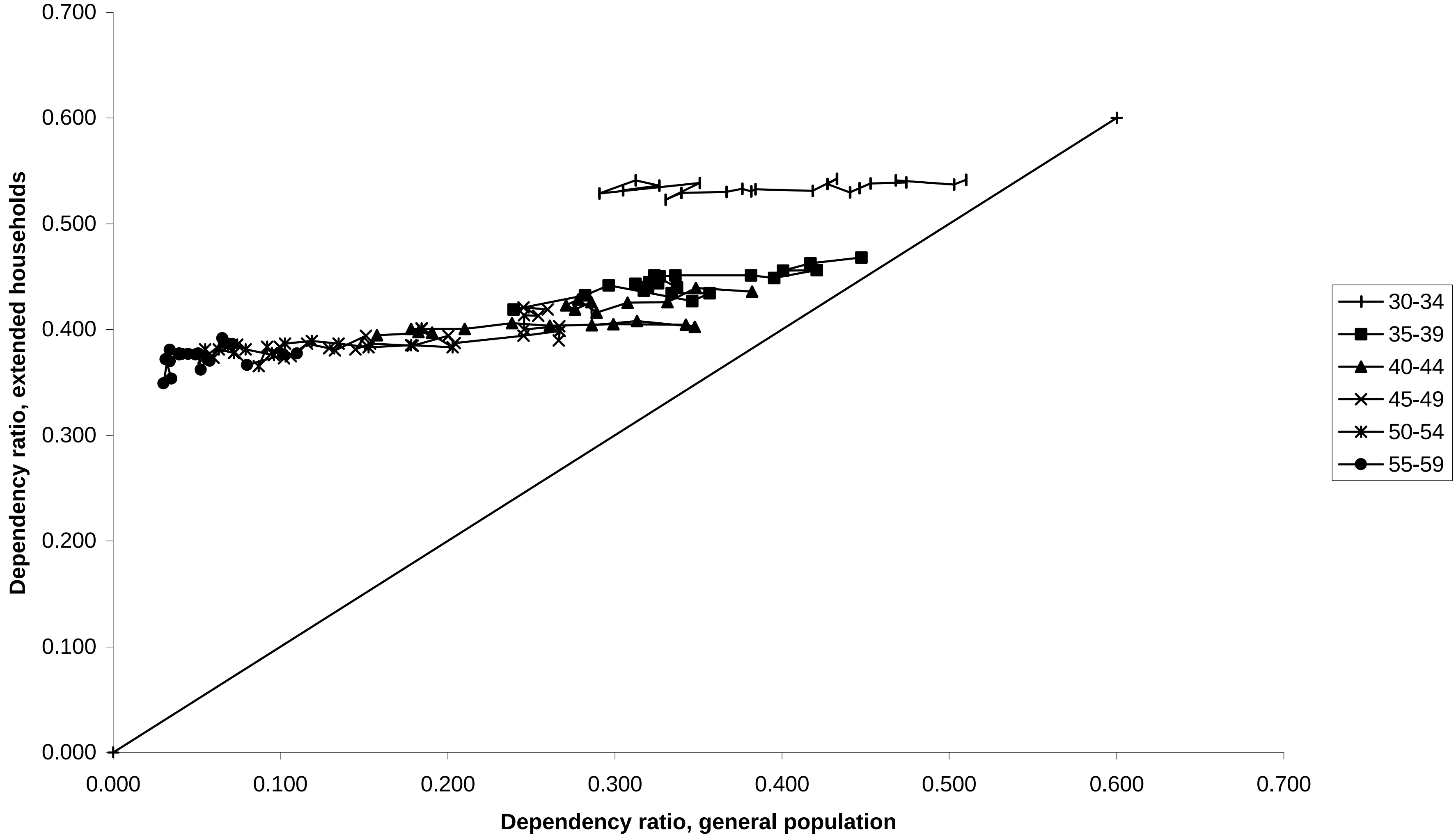
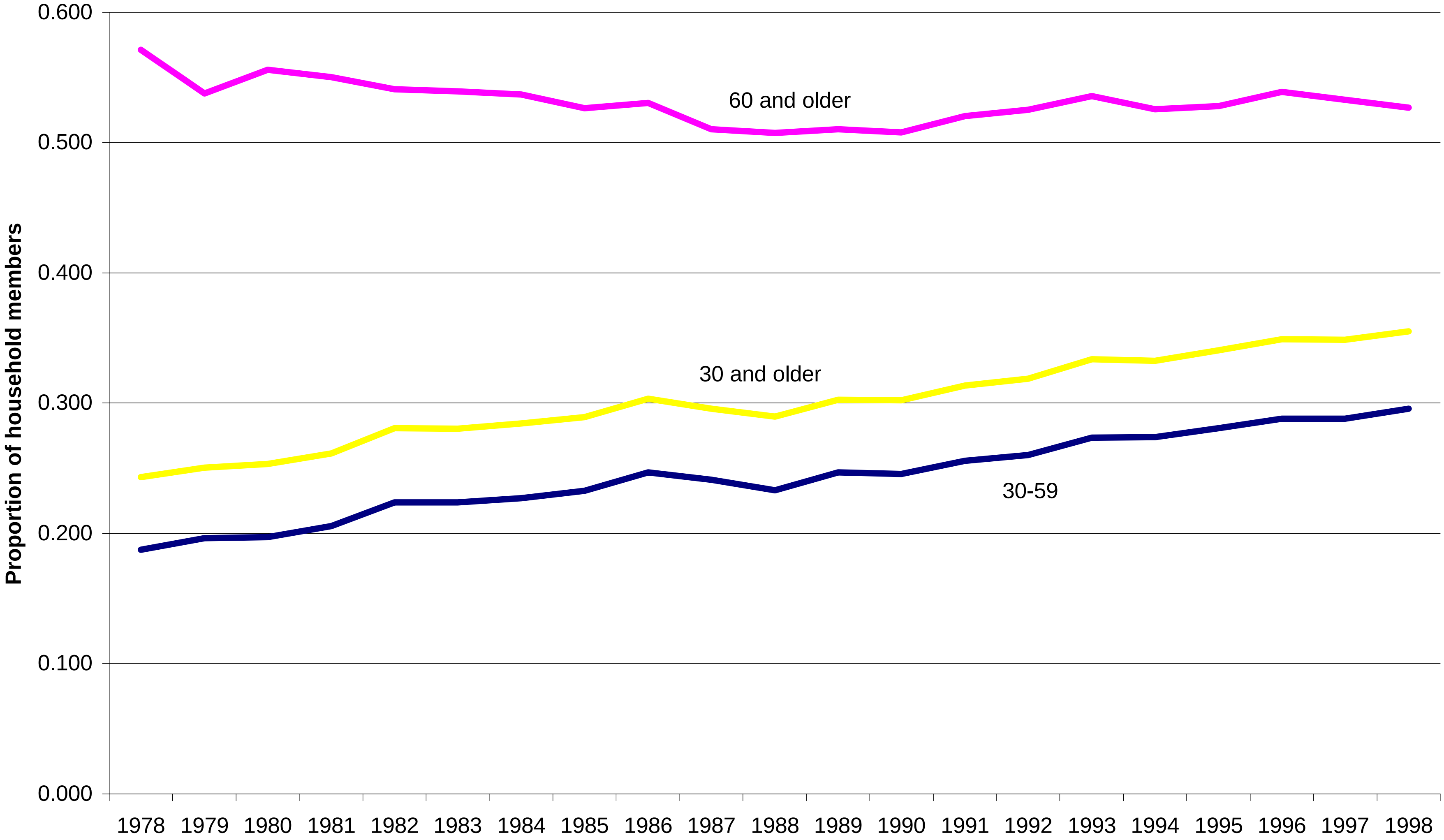


Figure 5. Proportion Living in Extended Households
Taiwan, 1978-1998



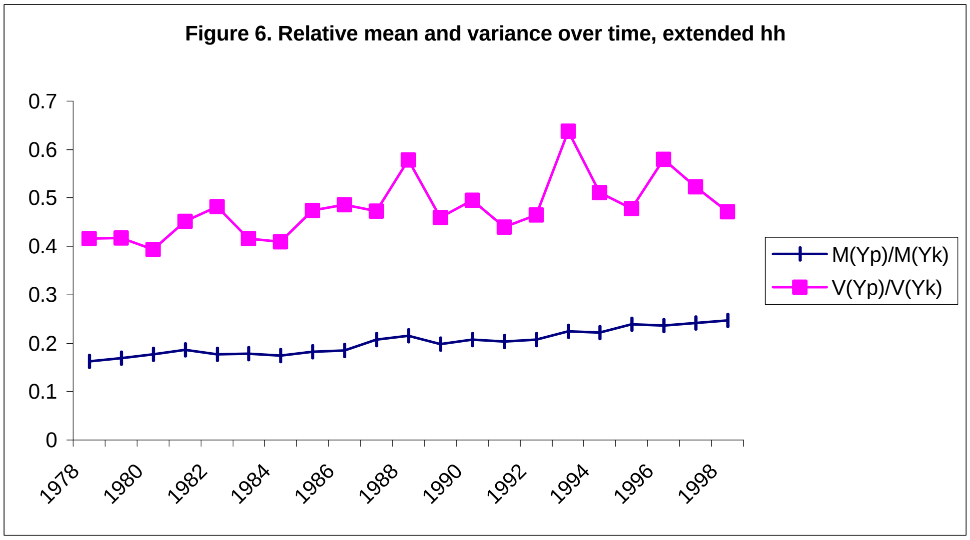


Figure 6. Relative mean and variance over time, extended hh
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
M(Yp)/M(Yk)
V(Yp)/V(Yk)

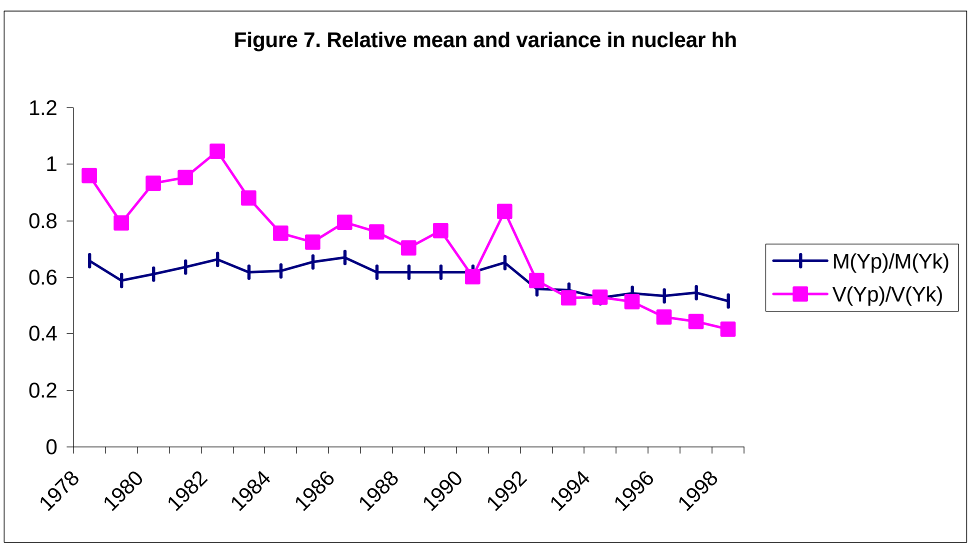


Figure 7. Relative mean and variance in nuclear hh
1.2
1
0.8
0.6
0.4
0.2
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
M(Yp)/M(Yk)
V(Yp)/V(Yk)

Figure 8. Percentage Change in V(Yn) from a 10% Increase in Percentage Senior Taiwan, 1978-1998