Growth, demographic structure, and national saving in Taiwan

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1. Introduction

This paper is concerned with the effects that changes in demographic structure have had on Taiwan's national saving rate, and how coming changes in its age structure—notably population aging—will affect the future saving rate. We examine this topic within the framework of the life-cycle hypothesis (LCH). Life-cycle theory is a natural starting place, since it implies that changes in demographic structure can exert potentially large effects on national saving: increases in the number of people who save (presumably those in middle age) relative to those who save little or dissave (the very young and the elderly) will increase the aggregate saving rate. A related implication of the LCH is that changes in the rate of growth of per capita income affect saving: higher rates of economic growth increase the life-time wealth of the young relative to the old, and the effects on saving of higher growth are much the same as the effects of increasing the numbers of young relative to the old. The LCH also delivers a rich set of predictions about interactions between economic growth and the age structure. As is emphasized in the "variable rate-of-growth" models of Fry and Mason (1982) and Mason (1987, 1988), the effects of changes in age structure on the saving rate will depend on the life-time wealth of individuals in different age groups, something determined by economic growth. These interactions are important for understanding how the Taiwanese saving rate has evolved over time, and how it may change in the future.

There is a large empirical literature that examines the relationships between demographic structure, economic growth, and saving. Early international comparisons of saving rates by Leff (1969) and Modigliani (1970) provided empirical support both for a positive association between growth and saving rates and for a negative effect of dependency rates—the ratio of young and old to the middle—on aggregate saving. Subsequent empirical analysis has been less positive. The demographic effects were shown not to be robust to improvements in data and econometric technique, see for example the review in Gersovitz (1988, 415–17). While the correlation between per capita growth and saving rates remains robust in the aggregate data, there is strong and accumulating evidence from the analysis of microeconomic data in individual countries that the life-cycle saving is not the cause, see Carroll and Summers (1988), Paxson (1996) and Deaton and Paxson (1997).

An older literature implicates dependency rates, not only in decreasing saving rates, but in hindering growth. Under the presumption that saving drives growth, not the other way round, Coale and Hoover (1958) argued that with high population growth the burden of children would decrease workers ability to save and so limit growth. More recently, Higgins and Williamson (1997) use pooled cross-section and time-series data from a number of Asian countries, find strong negative effects of the dependency rate on saving, and conclude that "Coale and Hoover were right." Indeed Bloom and Williamson (1997), and in Asian Development Bank (1997), attribute about a third of East Asia's recent growth performance to the increases in saving and in labor supply relative to population provided by the "demographic gift" of low fractions of children and the elderly associated with post-war baby booms and the rapid subsequent drops in fertility. Since the "gift" will have to be repaid as the baby-boomers age, once again there are concerns for the future, not only for saving rates, but also for growth.

Taiwan's saving, growth, and demographic structure conform to the broad patterns of East Asia. High rates of economic growth have accompanied an increase in private saving rates from five percent of disposable income in 1950 to around a quarter in the early 1990s. A postwar baby boom was succeeded by a sharp drop in fertility, so that the dependency ratios became low when the baby boomers entered the labor force around 1970, and will remain low until they leave around 2010. In 1950, 43 percent of the population were under 20, and 52 percent were between 20 and 60; by 1995, the corresponding fractions were 33 percent and 56 percent, see Table 1. The results of Bloom and Williamson (and Coale and Hoover) imply that Taiwan's future may look quite different from its recent experience. Lee, Mason and Miller (1996) have simulation results for Taiwan that point in the same direction.

Our own recent work has been on the determinants of saving in Taiwan, in Asia and elsewhere, with a primary focus on the effects of economic growth on saving and a good deal less attention to the effects of demographic structure and saving. Working with repeated cross-sectional surveys, our approach has been to estimate age and cohort effects in income and consumption in order to derive the age profiles of saving that are the fundamental determinants of the relationship between growth and aggregate saving in the LCH. If saving rates are negatively correlated with age—as in the simplest saving for retirement model—higher growth redistributes resources towards high savers, and will increase saving. In Paxson (1996) and Deaton and Paxson (1997, 1998), we find that age-saving profiles for Taiwan, Thailand, Indonesia, the United States, and Britain show little negative correlation with age, which implies little effect of growth on aggregate household saving. These results also have implications for the relationship between demographic structure and saving. Because our estimated age profiles of saving are uncorrelated with age, changes in the rate of population growth have little or no effect on aggregate saving, at least for comparisons between demographic equilibria. The absence of such equilibrium effects for Taiwan (and other countries) is documented in Deaton and Paxson (1997). However, the changes in demographic structure that take place during a demographic transition are quite distinct from differences in structure across demographic equilibria with different fertility rates, so that the absence of an effect of population growth rates on aggregate savings does not imply that there will be no effects of demographic structure on saving during a transition. In consequence, our earlier results are not necessarily inconsistent with either those of Higgins and Williamson's (from macroeconomic cross-country evidence) or those of Lee, Mason, and Miller (from simulations.)

In this paper, we use improved techniques and updated data from Taiwan to see if, after all, it is possible to tell a story in which demographic change has large effects on saving. We do this not because we have any reason to revise our previous empirical results—indeed they are replicated on the most recent data—but because our previous work paid too little explicit attention to demographic factors, and because our results looked only at demographic structures in equilibrium, rather than at the actual transition. Furthermore, our previous work relied on information about *households*, and on how saving rates vary over the household life-cycle, where the latter is defined by the age of the household head. This approach, which is dictated by the data, poses problems when we try to translate demographic change, which makes predictions about people, into predictions about households, whose saving is what we know about from the data. It is far from obvious how changes in the age structure of population translate into changes in the age structure of household heads, and whether the age-profiles of saving by head's age can be expected to be invariant to changes in demographic structure. In consequence, results about growth and saving are determined as much by assumptions about household structure as by our measurements of the age profiles of saving.

In this paper, we follow the more recent approach of Deaton and Paxson (1998), and construct life-cycle saving profiles for *individuals*, not households. This new approach, like the household approach, makes its own assumptions, and requires its own suspensions of disbelief. But the assumptions and suspensions are different, and it turns out that the new approach gives different results. Specifically, our estimated life-cycle saving profile for Taiwan has a pronounced "hump" shape that is consistent with the hypothesis that greater old-age and youth dependency rates depress saving. These negative effects of children and the elderly on saving are masked when working at the level of the household, since few elderly and virtually no children live in independent households.

Given the hump-shaped age-saving profile we estimate, the LCH implies that increases in the rate of population growth can either increase or reduce the aggregate saving rate. At higher rates of population growth, there will be fewer elderly dissavers relative to middle-aged savers, and this will cause the saving rate to rise. However, children will make up a greater fraction of the population, and this will depress the saving rate. Which effect dominates depends on the rate of economic growth. At very high rates of per capita income growth—in excess of six percent per annum—the life-time wealth of the elderly is small relative to those who are younger, and their dissaving contributes little to the aggregate saving rate. In this case, the depressing effect on saving of relatively more children predominates, and increases in the rate of population growth are predicted to reduce the aggregate saving rate. Conversely, at slow rates of economic growth—in the range of zero to three percent per annum—the life-time wealth of the elderly is relatively large, as is their (negative) contribution to aggregate saving. Increases in the rate of population growth that reduce the fraction of the population that is elderly increase the aggregate saving rate.

Although these positive or negative effects of population growth on saving are possible at high or low rates of economic growth, the growth rates that have characterized recent Taiwanese history fall between these two extremes. We show that at growth rates in the range of five or six percent per annum, increases in the rate of population growth produce almost no change in the aggregate saving rate. The effects of having relatively fewer elderly are almost exactly offset by the effects of having relatively more children. The same is true for the Taiwanese demographic transition: given Taiwan's economic performance, actual changes in demographic structure account for a very small fraction of the increase in the private saving ratio since 1950. Likewise, the aging of the baby boom generation will not adversely affect saving rates provided growth rates are maintained. However, if growth rates of income were to fall, the aging of Taiwan could indeed drive saving rates back to their levels in 1950.

The paper is laid out as follows. Section 2 begins with a summary of the life-cycle model and its estimation using the "household" method. We lay out the basic implications of the life-cycle hypothesis for the relationship between age structure and saving, and provide an explanation of the general methodology for parsing consumption and income into age and cohort effects, and for estimating the age-profiles of saving. The presentation is verbal and brief, and mathematical statements are given in the appendix. Section 3 moves to an approach in which the family is seen "as a veil concealing purely individualistic behavior," Gersovitz (1988, 401). This "individual" life-cycle model allows a reinterpretation of the household data, permits a much cleaner link between population structure and aggregate saving, and shows much clearer demographic effects on age-profiles of saving. Section 4 uses the individual results to construct counterfactuals for the past, running Taiwan's demographic transition through the estimated age profiles to assess the contribution of demographics to the rise in the saving rate, and to estimate the likely future effects of the aging of Taiwan's baby boom generation. Section 5 concludes, and provides a discussion of the some of the more important and controversial assumptions on which the work is based.

2. Life-cycle and aggregate saving in Taiwan: households

The life-cycle hypothesis of consumption asserts that consumption over the life-cycle follows an *age-profile*, the shape of which is determined by preferences (or needs, or incentives to postpone consumption), and whose level—but not shape—is set by lifetime resources. The age profile of earnings or of income has no effect on the shape of the age profile of consumption, but serves only to determine its level. The budget must balance over the lifetime, but in any given period, borrowing and lending make up the difference between consumption and income. The life-cycle hypothesis rests on the questionable assumption that capital markets are sufficiently developed to allow people to borrow against future earnings, and empirical evidence on its validity is mixed. Despite its shortcomings, however, the model provides a coherent framework for the analysis of life-cycle saving patterns. (See Deaton (1992) for a thorough discussion and assessment of the life-cycle hypothesis.)

In a growing economy like Taiwan, successive birth cohorts are each richer over their lifetimes than were their predecessors, so that according to the hypothesis, the age profiles of consumption, earnings, and income will be higher for later-born cohorts. Although the *levels* of these profiles differ across cohorts, their *shapes* will be the same, assuming there are no changes in tastes or in incentives to postpone consumption, and that earnings profiles retain a characteristic age profile that does not change shape across cohorts. Given these assumptions (which are not trivial, and will be discussed further below), the ratio of consumption to income or, equivalently, its complement, the ratio of saving to income, can be described by an age profile that has the same shape for all cohorts. A final assumption, that bequests are either zero or an unchanging fraction of life-time wealth, implies that the level of age profile of the saving ratio will be the same for all cohorts.

The shape of the age profile of saving determines how the aggregate saving rate responds to changes in economic growth and in demographic structure. In what Modigliani calls the “stripped-down” model, income is constant until retirement, and consumption is constant throughout life, so that there is positive saving until retirement, and negative saving (dissaving) from retirement until death. This negative association between age and the rate of saving implies that aggregate saving will be larger the larger is the rate of per capita economic growth (because the young, who are saving, have higher lifetime resources than the old, who are dissaving), and will be larger the larger is the ratio of young to old (by exactly the same scale effect.) Faster economic growth drives higher aggregate saving rates, as does faster population growth; by this argument, saving in Taiwan is threatened by the “greying” of the population, as it would be by a reduction in the rate of per capita income growth.

The stripped-down model needs to be modified to recognize the existence of children and their likely effects on the age profiles of consumption, earnings, and saving. While there is no lack of theoretical models, it is unclear from theory alone how these effects will work. The most popular view is that child-ren act as a substitute for retirement saving. Children are costly to rear and to educate, and require parental time and attention that lowers family earnings, so that saving of the families with children will be lower, at least when the children are in the household. But children help care for their elderly parents, which reduces the need for parents to save when their children are young, and lowers dissaving in retirement. But there are other possibilities. If bequests are an important motive for saving, the presence of children may raise their parents saving throughout the life-cycle, for example to provide housing or small businesses for their children and grandchildren. Or, if parents have strategic bequest motives, they may accumulate assets so as to ensure their children’s attention and good behavior.

Whatever the nature of the effects, it is clear that the presence and age structure of children are potentially important "taste and need" factors that shape the age-profile of family saving. In aggregate, changes in the ratio of children to adults in the population will also affect the aggregate saving ratio. Further, as emphasized by Fry and Mason (1982), these effects of demographic structure can be expected to interact with the effects of economic growth in determining national savings. For example, suppose that children lower saving for young families enough to cause dissaving at the beginning of the family life-cycle, with saving in middle age and perhaps some dissaving in old age. An increase in the number of children relative to middle-aged adults (holding the fraction of elderly fixed) will depress the saving rate—this is the familiar "youth dependency" effect. In addition, at higher rates of economic growth, young families will have greater life-time resources than middle-aged families, the scale of their dissaving will be larger, and the depressing effects of additional children on the saving rate will be bigger—this is the interaction effect. A similar story, which is more relevant to Taiwan's future, can be told about the effects of population aging. Shifts in the population from middle-aged savers to older dissavers will depress saving. The slower the rate of economic growth, the greater the life-time wealth of the older dissavers relative to middle-aged savers, and the larger the decline in the saving rate.

Taiwan is well-endowed with the kind of data required to investigate life-cycle saving behavior. The annual *Survey of Personal Income Distribution* has gathered annual data on income and consumption from 1976 on around 14,000 households (fewer in the first two years), and this time series of cross-sectional surveys can be used to track birth cohorts of Taiwanese over time. At the time of writing, we have data through 1995, so that we can track the cohort of individuals born in 1945 (for example) through their randomly sampled representatives in 20 surveys, from age 31 to age 50. Although we do not have enough years to track any one cohort through its whole life course, we can take the 20-year segments for many overlapping birth cohorts and infer from them both the cohort effects—the position of the segment for each birth cohort—and the age profiles which are taken to be common across cohorts.

The techniques are straightforward, and are described in full detail in our earlier work, Deaton and

Paxson (1994a, 1994b, 1997, 1998), and Paxson (1996), and the main equations are summarized in the Appendix, equations (1) through (6). Since consumption for each household is an age profile scaled by a lifetime wealth effect, the logarithm of consumption is the sum of a logarithmic age profile and a logarithmic wealth effect. For a birth cohort observed in a specific year, say the cohort of 1945 observed at age 40 in 1985, the average of the logarithm of consumption is therefore the sum of an age effect (that for age 40) and a cohort effect (that for those born in 1945). To estimate these effects, we go through each survey, calculate the average of the logarithm of consumption for each cohort in that year, and then pool the data across the 20 survey years. Since the data are for households rather than individuals, we must define age and cohort in terms of a characteristic of the household, and we take the age of the household head as that characteristic, a decision to which we return at some length in the next section. For each survey we include only observations for which the head is aged between 25 and 75; there are too few heads outside this range to allow useful inference. These calculations give us averaged data on 70 cohorts, born from 1901 to 1970, who are observed as household heads for up to 20 years each. These averages of the logarithm of consumption are the observations on our dependent variable which is regressed on a set of age and cohort dummy variables, thus allowing the shape of the age and cohort profiles to be determined by the data; there is no need to assume any particular parametric form. The procedure is then repeated for the logarithms of income, to get age and cohort effects for log income. The difference between the logarithm of income and the logarithm of consumption is approximately the saving ratio, which can also be decomposed into age and cohort effects.

The results are shown in Figure 1, which is an updated version of Figure 9.9 in Deaton and Paxson (1994a). Cohort effects in log consumption, income, and the saving ratio are shown in the two left-hand panels, and the corresponding age effects in the two right-hand panels. Because cohorts are defined here by age in 1995, we move from later to earlier born cohorts as we move from left to right, and because earlier born cohorts are lifetime poorer, the cohort effects decline from left to right. The age profiles of income and consumption do not have the “hump-shape” that is often used to illustrate life-cycle models. Instead, both consumption and income appear to increase steadily throughout the life course. Of greatest interest here are the associated age and cohort profiles of saving, neither of which conforms very well to the standard expectations of life-cycle theory. In particular, the estimated income and consumption cohort effects do not cancel out (i.e. they are not proportional in levels), and the left-hand panel shows higher *lifetime* saving rates out of *lifetime* resources for younger Taiwanese households. Taken at face value, this finding implies that bequest motives are becoming more and more important over time, with later born households leaving larger fractions of their lifetime wealth to their descendants. The age-effects are even more contrary to standard theory. Instead of savings rates being negatively correlated with age, with saving among young households and dissaving among the elderly, saving rates simply rise with age; households with the oldest heads are saving around thirty percentage points more of their incomes than households with the youngest heads.

How can we explain these patterns? The life-cycle explanation remains possible, but we would have to assign a great deal of importance to bequests, and we must accept quite unconventional age-patterns in saving. When we first began this work, this was the explanation that we adopted. However, when these methods were applied to the United States and Britain in Paxson (1996), the difficulties of interpretation became even more extreme, and it became necessary to think of other explanations. Suppose that for reasons we do not understand, everyone in Taiwan decides that it is more important to save, so that all cohorts, at all ages, slowly raise their saving ratios over time. (In the United States, the supposition runs the other way, with everyone deciding to decrease their saving rates over time.) We do not know what causes this change, except that, by assumption, it has nothing to do with the life-cycle hypothesis. Suppose then we look for a life-cycle interpretation, and fit cohort and age effects to these data. For any given cohort, we can fit the facts by choosing a rising age profile for saving; as people move through time, they will save more because the age-profile is rising with age. But to match the assumption, we also want the 40 year olds today to be saving more than the 40 year olds yesterday, and to make this happen, we need to choose cohort effects that are higher for later born cohorts or, equivalently, are falling with cohort age in the base year. Offsetting time trends in age and cohort effects are just a complicated way of matching a time trend in the data, and this is what we see in Figure 1, see also Appendix equations (9) through (11). When the same calculations are done for the US, we find the same phenomenon in reverse, with saving showing falling age and rising cohort effects, thus matching the secular fall in the saving ratio. For both Taiwan and the US, the changes in saving ratios have taken place for all households and are synchronized in calendar time.

These results tell us something of great importance: over the periods of our data, the rise in the aggregate saving rate in Taiwan (and the decline in the aggregate saving rate in the US) cannot be explained by the life-cycle hypothesis, which attributes the trend to changing relative lifetime incomes and sizes of different age groups each with a different saving rate. Instead, individual households at all ages and from all birth cohorts have been saving more in Taiwan, just as they have been saving less in the US.

Because the LCH cannot explain the trends does not mean that life-cycle motives are not operative, nor that changes in demographic structure and economic growth would not affect aggregate saving rates. We can find out how much by conceding the time trend to “forces unknown,” and then examining the cohort and age effects that remain. One way to do this is to force the cohort effects in the consumption and income regressions to be identical, so that there are no cohort effects in the estimated saving ratios, or equivalently, to regress the age/cohort average saving ratios on age dummies, without including cohort effects. More generally, this last regression can be estimated allowing year effects in addition to the age effects. Although the year effects are significant, their inclusion or exclusion has little effect on the estimated age effects which are shown (from the regressions with year effects excluded) in Figure 2.

The age profile of saving in Figure 2 makes a good deal more sense than that in Figure 1, though it is still very far from the “hump-shape” of standard life-cycle theory. Saving rates are highest for very young households, with heads in their mid twenties. The saving rate then declines with age, until families with heads in their early 40s are saving 7 percentage points less than those in their mid-20s. Saving rates then rise until late middle age, declining once again thereafter. That saving should be lower for heads aged in their 60s and 70s is consistent with life-cycle theory, though that they should save *positive* amounts is not what would should expect from dissaving in retirement. The obvious candidate for explaining the low saving trough earlier in the life-cycle is the presence in the household of children, and possibly of elderly adults. Figure 3 shows age and cohort effects in the average number of children (left panel) and average number of people aged 60 and over (right panel), by the age of the head. The cohort effects in the number of children (left panel) show the decline in fertility, while those in the right panel are dominated by the increasing ratio of the elderly to the middle-aged, an effect that more than offsets the increasing tendency of the elderly to live alone. Both sets of age effects peak at around age forty, which coincides with the trough in the age-profile of saving in Figure 2, giving some support to the idea that children and dependent elderly depress saving.

The “twin trough” pattern of lifetime saving in Figure 2 implies that, in general, aggregate saving will respond to changes in both demographic structure and the distribution of lifetime income across birth cohorts. Even so, Paxson (1996, Table 3) and Deaton and Paxson (1998, Table 1) show that the effects are small. Indeed, at a rate of population growth of two percent, the results in Figure 2 give a small *negative* effect on aggregate saving of increases in the rate of per capita income growth. In steady state income growth at 2 percent per annum, the predicted saving rate is 20.3 percent; this falls to 20.1 percent at 4 percent, and 20.0 percent at 6 percent. These are quite different from the large positive effects predicted by stripped-down models, in which a rise in the growth rate of a percentage point increases the saving rate by about two percentage points. The reason for the small effects is clear from the Figure; changes in the rate of growth smoothly redistributes lifetime resources across age groups, so that the effect of growth on saving depends on the correlation over the life-cycle of saving and age. Because of the twin troughs in the age profile of saving, this correlation is close to zero, so that changes in the equilibrium rate of income growth have little effect on aggregate saving. Of course, these conclusions concern changes in the equilibrium rate of growth; patterns of growth that enrich particular cohorts at the expense of others could exert large temporary effects on the aggregate saving rates as those cohorts moved through the relevant age ranges. We return to the issue in Section 4.

The effects on aggregate savings of changes in demographic structure are a good deal harder to deal with than those of income growth. It is straightforward to redistribute population mass across the ages in Figure 2, which would be the effect of changes in the equilibrium rate of population growth, and to calculate the effects on aggregate saving. And for the same reason as before—the low correlation between saving rates and age over the life-cycle—the effects are small. However, changes in the rate of population growth not only change the weights of the age profile in aggregate saving, they must also change the age profile itself. Recall that the age profile relates to *households*, not individuals, and that the ages are ages of household heads, not ages of individuals. When fertility falls, there are fewer children per adult, fewer children per head at each age, so that if the first trough in Figure 2 is associated with children, we might reasonably expect it to flatten out. Similarly, there are now relatively more elderly people, only some of whom live by themselves. Others live with their children, and the higher ratio of elderly to adults in each household is likely to reduce household saving in the age group of the household head.

In our previous work, particularly Deaton and Paxson (1997), we made allowance for these effects as best we could. There are two steps in making the adjustment. First, the age profiles need to be explicitly linked to the demographic composition of the household, which is done by adding variables for average household composition to the age dummies in the consumption, income and saving regressions. Second, when we make projections with different rates of population growth, it is necessary to "repackage" the numbers of people at different age into numbers and compositions of households by the age of the head. Neither step is straightforward. The estimation of demographic effects on saving, unlike the age and cohort effects, is done parametrically, and an inappropriate functional form or unfortunate selection of age groups could compromise the results. But the second step is the more difficult. We use headship probabilities by age from recent surveys to turn population predictions into household predictions, but we have little confidence in these essentially mechanical projections. In consequence, when we find that changes in the rate of population growth have little effect on aggregate savings, it is possible that our results are driven as much by our auxiliary assumptions to get from people to households, as by the age profile in Figure 2, about which we are relatively confident.

Figure 2 suggests that different results might be possible under different assumptions. If the first trough in the age profile were to be raised by lower fertility, the negative correlation between saving and age would be increased, so that aggregate saving would become more responsive to changes in the rate of economic growth. This is exactly the sort of effect emphasized by the “variable rate of growth” model.

3. Life-cycle and aggregate saving in Taiwan: individuals

It is difficult to move from population projections to their consequences for saving because the projections are about the numbers of *individuals* at different ages, while our theory and our data about saving relate to *households* indexed by the age of the household head. In our work to date, we have solved this disjunction in favor of the households, transforming population projections into household projections. In this section we discuss the alternative, which is to turn the life-cycle theory and its empirical implementation into a theory of individual behavior together with estimates of age profiles for individuals. The idea is to think of each person as following his or her own life-cycle trajectory from birth, each endowed with an age-specific consumption and income profile, and each satisfying a lifetime budget constraint tying lifetime income to lifetime consumption. Using Gersovitz’s (1988) term, households are veils for the individuals within, behind which individual consumption, income, and saving take place unobserved, with only the household totals revealed to the investigator. As Gersovitz emphasizes, such households permit individuals to consume more or less than their income without the household necessarily having to save or dissave, and by removing credit constraints, may allow household members to conform more closely to the theory than would be the case on their own. Young children and many of the elderly have no earnings, and their consumption can be supported from the earnings of other family members without the transfer of assets or liabilities. It would be possible to extend this model to allow household consumption to be different from the aggregate of the consumptions of each of its members, thus recognizing joint consumption, public goods in the household, and economies of scale. But in the current analysis, which can be thought of as a first cut, we adopt the simplest version, that household income, consumption, and income are the sums of income, consumption, and saving of each household member.

There are other good reasons for moving away from households, to do with being forced to define a household by the age of its head. When we track cohorts of households from one survey to another, the 40-year olds in one survey followed by the 41-year olds in the next, any changes in headship from one year to another will mean that we are not truly observing the same cohort through time. In Taiwan, the head is defined as the main earner in the household. For example, in a household consisting of a working couple, children, and the husband's father, the older man will be head as long as he earns more than his son. But if, from one year to the next, the son's earnings overtake those of his father, the "age" of the household head will drop by perhaps 25 years, even though household composition has not changed. Equally problematic is the treatment of the elderly. Because many elderly people in Taiwan live with their children, where they may not be recorded as household heads, households headed by people in their sixties and seventies are a selected sample that is likely to become less and less representative with age. When we look at the savings behavior of those households, and how it changes with age, we have no way of separating out the changes that come from behavior, and those that come from selection.

That selection is important can be demonstrated in a number of ways. For example, the education of male heads relative to the education level of all males of the same age increases with age from age 40, see Deaton and Paxson (1998). The heads that survive as such are more highly educated than those who do not. Figure 4 illustrates the selection more directly. It shows the average age of the household head (on the vertical axis) in relation to the age of individuals (on the horizontal axis), so that the graph shows the average age of people's household heads (including themselves) as a function of age. If it were true that once a household head, always a household head, the graph would coincide with the 45-degree line, at least after the age at which people become heads. Instead, the graph falls at first, because people in their 20s often live in their parents' house. Once we are beyond the age at which people have set up independent households, head's age rises more or less one for one with age; this is the area where there is no selection. But after about age 50, head's age ceases to rise with individual age, either because the earnings of a younger person in the household exceed that of the previous head, so that the household becomes "younger," or because a previous head moves in with his or her children or relatives. (Note the increase in the slope in the last few years as more elderly Taiwanese are living alone.) But the deviation of these lines from the 45-degree slope shows that it is dangerous to base a research strategy on the assumption that heads remain heads until they die. If instead of following households, we follow cohorts of individuals, we avoid most of these problems. Emigration, immigration, and death apart, the cohort of 41-year old individuals is the same as the cohort of 40-year old individuals a year before.

Our empirical procedures are explained in detail in Deaton and Paxson (1998) and the main equations are given in the Appendix, equations (7) and (8); here we present a non-technical summary. As before, our starting point is the set of 20 cross-sectional surveys on household income, consumption, and saving. For each cross-section in turn, we regress household consumption on the numbers of people of each age in the household, with age running from 0 to 99; there are thus 100 right-hand side variables in each regression (most of which are zero for any given household) which is estimated without a constant. Suppose we write the coefficient on age *a* from the survey in year *t* as $\beta(t, a)$. This quantity is the average consumption in year *t* of people of age *a*, which, according to the theory, is the product of an age effect (preferences) and a cohort wealth effect (the lifetime budget constraint). We can therefore treat each $\beta(t, a)$ in exactly the same way as we treated the household consumption data in the household approach in Section 1, *viz*. we take logarithms, and regress on a set of age and cohort dummies. The resulting coefficients are the estimated age and cohort effects for individual consumption, not household consumption. As before, the procedure is replicated for income and for the saving ratio, or at least its approximation, the difference between the logarithm of income and the logarithm of consumption.

There are two main differences between this approach and that outlined in Section 2. First, allowing for all ages separately allows needs to vary with age in a very flexible way; this is something like including very general controls for household demographic structure in the household regressions. Second, we are tracking individuals, not households through the successive cross-sections, thus avoiding the problem of selection into and out of household headship.

Where there are only a few observations for an age group, particularly among the elderly, the estimates of the β's are imprecise and occasionally are negative. We deal with these by smoothing the estimates over adjacent age groups, essentially by taking moving averages. We impose *a priori* that incomes are zero for those aged 16 or less; since these numbers are small in any case, and occasionally negative if children take a parent out of the labor force, we would risk obtaining many negative numbers by attempting to estimate these effects. We also impose the restriction that income is zero for those aged 80 and older. An alternative procedure for estimating age and cohort effects, that does not require taking logarithms and so can accommodate zero or negative values, is described in Deaton and Paxson (1998). This method yields results very similar to those shown here.

Figure 5 shows the resulting age profiles for the logarithms of income and consumption for both the individual (left panels) and household (right panel) approaches, together with the saving profiles for both approaches (bottom row: the bottom right panel reproduces Figure 2.) The issue of time trends in saving rates is the same for the household and individual approaches so that, as before, we restrict the cohort effects in income and consumption to be identical in the top row. The saving profiles in the bottom row are obtained simply by regressing the "saving rate," defined as the difference between the average logarithm of income and the average logarithm of consumption, on a set of age dummies. No cohort effects are included because these are restricted to be equal in income and consumption. A set of year effects can be included (but are not in these results); their inclusion makes little difference to the age profile of saving. In the household approach, we must restrict age to the range where there are household heads, here 25 to 75. In the individual approach, we cover the full age range, from 0 to 99, for consumption, and from 17 to 79 for income. We graph the saving rate for the age range 17 to 79, for which income is positive. Note that we are *not* assuming that saving is zero for individuals either older than 79 or younger than 17; since income is assumed to be zero for these groups, and consumption is positive, saving is negative, and the saving rate is not defined.

The two graphs in the top row are reassuringly similar; after all, we are looking at the same data. Over the common age range, the two pairs of age profiles are quite similar, with log income lying above log consumption. The main difference lies in the range of ages not covered by the household approach; partly by construction, and partly by measurement, consumption exceeds income at low and at high ages. As a result, the two saving rate profiles in the bottom row look much more different than do the two profiles for either consumption or income (but note the different scales). In the individual model, saving rates are negative at the beginning and end of the life-cycle. At intermediate ages, saving rates are similar to those from the household data— indeed there is still a trough around age 40—but higher, as must be the case to compensate for the dissaving of children and the elderly.

It is straightforward to use the age profiles of consumption and income shown in Figure 5 to examine the effects of population growth on the national saving rate. The consumption and income levels of a cohort of individuals at each age is simply the product of life-time wealth, which is assumed to grow at a constant rate across cohorts, and the exponents of the age effects of the logarithm of income and of consumption shown in Figure 5. (Income is assumed to be zero for those younger than 17 and older than 79.) Different rates of population growth imply different distributions of the population across ages; for any rate of population growth, the aggregate saving rate can be calculated as the ratio of the population-weighted sum of saving (income minus consumption) to the population-weighted sum of income. (See Appendix equation 12.) This aggregate rate can be calculated using either the "household" or "individual" results in Figure 5, although when working with households it is necessary to make assumptions about the fractions of each age group that are household heads, see Deaton and Paxson (1997). Another difference is that, when working with households, the sums are computed only over the age range 25 to 75 for which we have estimates; for individuals, we use the full age range from 1 to 99.

Figure 6 shows aggregate saving rates as a function of the rate of population growth, with each panel calculated at a different rate of economic growth across cohorts. These results confirm the calculations in Deaton and Paxson (1997), that at the high growth rates of per capita income that Taiwan has enjoyed for much of the last quarter century, changes in the rate of population growth have little effect on national saving, see the bottom-left panel. Higher population growth increases the numbers of middle-aged savers relative to elderly dissavers, but it also increases, by even more, the numbers of the young who are dis-saving, and the net effect is small. However, the results are different at lower and higher rates of income growth. In the top left panel, we have assumed a growth rate of zero, so that life-time wealth is identical across cohorts. Because the youngest dissavers are not wealthy relative to middle-aged savers, the dominant effect of a decline in equilibrium population growth is through the increase in the numbers of the elderly relative to the middle aged—the young have insufficient resources to count for much—and the aggregate saving rate falls. Fertility decline can have strong negative effects on aggregate saving in

Taiwan, but only when per capita incomes are growing slowly. The bottom right panel shows the other extreme where the growth rate of per capita income is very high, illustrated here at nine percent per annum. Because young people are now so much richer than the old—at nine percent growth, a 5 year old is 8.6 times richer than her 30 year old father, 74 times richer than her 55 year old grandfather, and 640 times richer than her 80 year old great-grandfather—the dissaving associated with children is large enough to become the dominant effect when the young are made more plentiful. At high enough growth rates of per capita income, saving declines with increases in the rate of growth of the population.

4. Demographic structure and the past and future of saving

The calculations in Figure 6 are of saving rates in demographic and economic growth equilibrium, when the rates of growth of income and population have been the same for an indefinite period of time. Because these equilibria take so long to be established—we have to wait for the whole population to be replaced before the new patterns of age groups and lifetime wealth effects are established—it is possible that they are not relevant or useful for interpreting history over a few decades, or for projecting forward except into the very distant future. Indeed, as Higgins and Williamson (1997) argue, the effects that arise from a baby boom generation working through the population are unlikely to captured by a model that can only handle equilibrium demographic structures. Figure 7 and Table 1 shows the actual structure of the Taiwanese population at fifteen year intervals from 1950 through to 1995, and the progress of the post-war baby boom is clearly visible. (The “missing” 20 year-olds in the 1965 data were in the military, who were not included in the data until 1969.)

It is straightforward to calculate the effects of the *actual* demographic structure on saving using the results that we have already obtained. The procedure is essentially the same as for the results in Figure 6, except instead of using the steady-state age distribution of the population implied by different rates of population growth, we use the actual age distribution of the Taiwanese population from 1947 to the present. As before, consumption and income at each age for each cohort is the product of the life-time wealth of cohort members, and the exponents of the age effects in Figure 5 (with income set to zero for the youngest and oldest individuals.) The cohort-specific life-time wealth terms can be obtained up to scale—and the scale factor cancels in the aggregate saving rate—in one of two ways: (i) by using the actual estimated cohort effects from the regressions shown in Figure 5, or (ii) by assuming that cohort effects grow from year to year at a constant rate equal to the average growth in our estimated cohort effects. This latter approach, which yields a growth rate of life-time wealth across cohorts of 6.08% per year, has the attraction of allowing us to project backward as far as we like, while the former, although more realistic, confines us to cohorts alive during our data period of 1976 through to 1995. (Since the estimated cohort effects grow fairly steadily, the difference is not large, as we shall see.) Note that these calculations are not intended to capture year to year fluctuations in saving rates, for example those associated with oil shocks or other unanticipated events. But they should give us a good guide to trends and of the contribution of demographic changes to those trends.

Figure 8 and Table 2 present the results graphically and numerically. It is important to start by establishing that the data from the surveys on which our analysis rests are consistent with the aggregate data. The first three columns of Table 2, the first two of which are illustrated in Figure 8, show the aggregate private saving from the national accounts, the private saving rate from the survey documentation, and the private saving rate as calculated by us from the survey data. The first two series differ somewhat, which is not surprising given that the former is private saving (including not-for-profit institutions) and the latter is household saving out of disposable income. However, both series follow similar trends. Our own calculations are a point or two lower than the published survey tables, again because of the precise definitions of consumption and income (we include transfers made to others in consumption, whereas the survey publications net transfers out of income,) not because our calculations differ from those of the government statisticians. The micro data are consistent with the aggregate behavior in the national accounts.

The Table and the Figure also show the two hypothetical saving figures that come from applying the actual age structure of the population to our estimates of age effects. Neither set of counterfactuals explains more than a very small fraction of the growth in the aggregate saving rate, and none at all before the 1970s. None of this should be surprising in the light of the results in earlier sections. From the first household estimates it was clear that, in order to fit the data, the age profile of saving had to be supplemented by a set of year dummies to capture the secular rise in the saving rate. As we saw then, and as reappears now, the life-cycle hypothesis cannot explain the rising saving rate in Taiwan. That rise comes from a secular trend in saving rates among all cohorts at all ages; it cannot be attributed to changes in the distribution of population or of spending power over an unchanging but age-varying profile of saving.

What then of the future? The baby-boom generation is aging, and according to our estimates, the elderly save less. Does this mean that aggregate saving rates will fall? The answers are given in Figures 9 and 10 based on population projections taken from Bos, Vu, Massiah and Bulatao (1994). The differences in the three figures come from differences in assumptions about the rate of per capita income growth, and from differences in the way we handle the cohort effects. In both parts of Figure 9, cohort effects are set according to their equilibrium pattern for the relevant rate of economic growth. In the left-hand panel, the rate of growth is set at six percent, close its historical value, and is held constant as the population is aged; this can be taken as our central projection. The growth in saving rates still has some way to go, but will reverse after 2010. Even so, the effects are modest, and the aggregate household saving rate in 2030 will be only a point or two lower than it is now. The right hand panel repeats the calculation, but with the cohort wealth effects growing at three percent and nine percent in addition to the original six percent, which is shown for comparison (note the change in scale from left to right panel.) In the case where the growth rate of income is halved, from six to three percent, the fall in saving rates is large, and by 2030, the saving rate is below ten percent.

These last calculations can be criticized on the grounds that, although we are using actual demographics and the best available demographic projections, the cohort wealth effects are set at their equilibrium values so that, when income growth is three percent, not only do we assume that it will be three percent in the future, but that it was three percent in the past. We correct this problem in Figure 10. In these calculations, we assume that growth changes from 6.08 percent to its new value in 1998, and calculate new wealth figures for each cohort assuming that everyone knows immediately that the change will be permanent. For those beyond age 65, we assume that lifetime resources are set and are unaffected by the change in growth. For those who are in the middle of their working careers, their lifetime wealth is adjusted down according to age, with the youngest suffering the largest change because they have the largest number of years to work at the new, lower growth rate.

With these modifications, the drop in saving rates with lower growth is less severe than previously; compare the three percent line with the three percent line in the right-hand panel of Figure 9. However, the same general effect is present. If Taiwan's economic growth rate falters, the combination of lower growth and the aging of the baby boom generation is capable of sharply reducing the rate of saving. If economic performance is maintained, likely changes are small enough to be of little concern, and in that circumstance, there is no reason to see the greying of Taiwan as a threat to its rate of saving.

5. Summary and conclusions

The life-cycle hypothesis of saving supposes that the profile of consumption over the life-cycle is set by preferences, including demographic choices and outcomes, while the position of the profile is set by lifetime resources. As a result, the average consumption, income, and saving of a birth cohort in any given year can be decomposed into the product of an age-effect, which is the same for all cohorts, and a cohort effect that summarizes the average lifetime resources of the cohort. In this paper, we have used time-series of cross-sectional household surveys from Taiwan to estimate these age profiles for consumption, income, and saving, and we have used the results to investigate the extent to which demographic change and economic growth can account for the increase in Taiwan's saving rate within a life-cycle story of saving. The methodological advance of this paper, apart from an updated and extended data base, consists in the use of an "individual" version of the life-cycle model in which we apply the life-cycle hypothesis to the complete life-cycle of individuals, and trace cohorts of individuals through the various surveys, rather than the more conventional treatment where households are the unit of analysis, and we track households as identified by the age of the household head. The new approach allows us to recognize that people regroup from one household to another over time, for example as the elderly move in with their children, and requires no arbitrary assumptions about how changes in population structure affect household formation and structure.

There are a number of important results from the analysis. First, and as in previous work, we find that the increase in Taiwan's saving rate, like the decline in the saving rate in the United States, cannot be explained by the life-cycle mechanism, which attributes changes in aggregate saving to changes in relative population and relative resource weights over an unchanging age-profile of saving. As in our own and others' previous work, we find that the upward trend in saving is not an aggregation effect, but an individual effect. Young Taiwanese now save a larger fraction of their resources than did their parents at the same age.

Once this is admitted, and the main part of the change in saving attributed to unexplained time trends, more modest effects can be attributed to the changing structure of population and changing patterns of lifetime resources. In particular, we find an age profile of saving with "two troughs," one associated with children, and one associated with old age. There is no *overall* correlation between age and saving rates, so that there are no large differences in aggregate saving rates across populations in demographic equilibrium at different population growth rates. Nevertheless, because of the "two trough" pattern, changes in population structure through a demographic transition can have temporary effects on saving rates, where "temporary" is understood relative to demographic equilibrium. We use the model to assess the historical evidence in Taiwan, and to see how much of the actual increase in saving can be attributed to its actual demography and economic growth. Between 1970 and 1990, Taiwan's household saving rate rose from around 10 percent to around 30 percent; of this 20 percentage point increase, only about 4 percentage points can be attributed to life-cycle effects generated by economic growth and population change. Nor does the demographic future of Taiwan, and in particular its rapid aging, threaten its saving rate, at least if economic growth is maintained. It is only in the most pessimistic scenarios, in which very much slower growth interacts with aging, that saving rates are predicted to fall sharply.

Our results are rather different from those in the two related papers in this special issue, by Lee, Mason, and Miller (1999), who attribute a substantial share of the increase in Taiwan's saving rate to demographic change over the transition, and by Tsai, Chu and Chang (1999), who find that the higher saving rates of successive cohorts of Taiwanese can be tied to their own rising life expectancy, and to the enhanced probabilities of survival for their children. Perhaps the most fundamental difference between our work and that of the others is the extent to which we believe that the life-cycle hypothesis provided as adequate account of household saving in Taiwan, or indeed elsewhere. In Deaton and Paxson (1994), which is the platform on which Tsai, Chu, and Chang build, we assume that the life-cycle hypothesis is valid, and estimate parameters conditional on its truth. In our subsequent work, particularly Paxson (1996), Deaton and Paxson (1997, 1998), and in the current paper, the anomalies that seemed minor in our first paper reappeared in much more serious forms, not only for Taiwan, but for other countries including the United States. In consequence, we were forced to the conclusion that time trends in saving ratios—upward in Taiwan and downward in the United States—cannot be well explained within the life-cycle framework, a conclusion that has also been reached by other researchers, and is increasingly accepted in much of the recent consumption literature, see in particular Bosworth, Burtless and

Sabelhaus (1991) and the papers in Poterba (1994). If this conclusion is denied, and an attempt is made to fit the life-cycle hypothesis to the Taiwanese data, the result is an upward trend of saving rates with age in the age-profile, and an offsetting upward trend with date of birth in the cohort profile. This latter can be linked to other trending variables, such as the declining force of mortality, as in Tsai, Chu, and Chang. The question then arises as to whether other trending variables might not do the same job as well or better, or indeed whether cohort effects are not simply a label for the time-trend in Taiwanese saving for which we have no explanation. Lee, Mason, and Miller's simulations, like our own earlier work, take the truth of the life-cycle model for granted. As we know, such a model can be used to make demographics affect saving rates, but the validity of the simulations depends on denying the central empirical anomaly that is revealed by our work and by other research in the literature.

Like all analyses and predictions, our results rest on a number of assumptions, and we conclude by noting the most important and most controversial. In particular, we assume the constancy of various age-profiles over time. Like most of the work on life-cycle saving, and following Modigliani's original lead, we assume that the age-profile of earnings is not changed by economic growth, so that economic growth affects earnings only across cohorts and not the age pattern of earnings for any given cohort. That this assumption may not be true has been pointed out many times in the past, as has the fact that the prediction that economic growth increases saving depends on it. Unfortunately, examination of how growth changes age profiles requires more than the twenty years of data that are currently available, and we have maintained the standard (Modigliani) assumption, on the grounds that it gives the growth-to-saving link the best chance of accounting for the data. Similar considerations prevent us from examining the effects of changes in female labor force participation on the age-profiles of earnings; our attempts to allow for it were frustrated by the brevity of the time-series, at least for this purpose. We are also conscious of the absence of any treatment of decreases in the force of mortality. In a world where retirement ages are legislated and fixed, increases in the retirement span can be expected to increase the rate of individual saving, if retirement saving is important. In an economy as flexible as Taiwan's, and without state mandated retirement, we would expect an increase in life-expectancy to increase the work span as well as the retirement span, with no obvious predictions for the rate of saving. If this were to be the case, the age-profile of earnings would change in response to decreases in mortality rates, and for the same reasons as before, we have made no attempt to take this into account.

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6. Mathematical Appendix

In the LCH with perfect certainty, consumption at any age is proportional to lifetime resources. Hence, for individual *i,* (household or person) born at date *b*, and observed at age *a* (i.e. at date $b + a$), consumption c_{iab} is given by

$$c_{iab} = f_i(a)\, W_{ib} \tag{1}$$

where $f_i(a)$ is the age profile of consumption, and W_{ib} is a measure of lifetime resources. Note that while the age-profile is indexed on i, and so varies over individuals, it is independent of birth date b, so that the distribution of age profiles over individuals within each cohort is the same for all cohorts, while the measure of resources W_{ib} is invariant with respect to age. Taking logarithms of (1) and averaging over all members of the same cohort at the same age, we obtain

$$\overline{\ln c_{ab}} = \overline{\ln f(a)} + \overline{\ln W_b} \tag{2}$$

where the lines over the variables denote means. Equation (2) can be estimated by regressing the average of the logarithm of consumption for those born in b and observed in $b+a$ on a set of age and cohort dummies, i.e. from the regression

$$\overline{\ln c} = \boldsymbol{D}^{\boldsymbol{a}}\beta_c + \boldsymbol{D}^{\boldsymbol{c}}\gamma_c + u_c \tag{3}$$

where $\overline{\ln c}$ is a stacked vector of log consumption with elements corresponding to each cohort in each year, $\boldsymbol{D}^{\boldsymbol{a}}$ is a matrix of age dummies, and $\boldsymbol{D}^{\boldsymbol{c}}$ is a matrix of cohort dummies. The coefficients β_c and γ_c are the age-effects and cohorts effects in consumption (c subscripts stand for consumption, superscripts for cohorts), and u_c is the sampling (or equivalently measurement) error that comes from the fact that $\overline{\ln c_{ab}}$ is a sample estimate of the average log consumption of all individuals born at b and observed at $b+a$.

Earnings, like consumption, is assumed to follow an invariant age-profile over the life-cycle, but to shift up with growth. Income is earnings plus the interest income on accumulated wealth, so that, given that (log) consumption and (log) earnings can both be decomposed into cohort and age effects, so can income y_{iab}, so that we can write, corresponding to (4),

$$\overline{\ln y} = \boldsymbol{D}^{\boldsymbol{a}}\beta_y + \boldsymbol{D}^{\boldsymbol{c}}\gamma_y + u_y \tag{4}$$

where β_y and γ_y are the age and cohort effects in income. The difference between (3) and (4) is, if consumption is close to income, approximately the saving ratio, so that

$$s/y \approx \overline{\ln y} - \overline{\ln c} = \boldsymbol{D}^{\boldsymbol{a}}(\beta_y - \beta_c) + \boldsymbol{D}^{\boldsymbol{c}}(\gamma_y - \gamma_c) + (u_y - u_c). \tag{5}$$

The age and cohort effects in Figure 1 are from estimates of equations (3), (4) and (5), where averages of the logarithm of income and consumption are computed over household heads of the same age in the same year.

Under the usual assumption that there are no bequests, and that lifetime consumption exhausts lifetime resources, the cohort effects in income and consumption will be the same, so that (5) will have only age effects and can therefore be rewritten as

$$s/y \approx \boldsymbol{D}^{\boldsymbol{a}}(\beta_y - \beta_c) + (u_y - u_c). \tag{6}$$

Figure 2 graphs the age effects from this equation.

In the "household" version of the model, the subscript *i* in the foregoing is interpreted to refer to a household, whose age is given by the age of the household head. In the "individual" version, *i* is taken to be an individual, and (1) is modified to read

$$c_{iab} = c_{ab} + \varepsilon_{iab} = f(a)W_b + \varepsilon_{iab} \tag{7}$$

where ε_{iab} is a mean zero error, and we are now decomposing the mean cohort consumption into an age effect $f(a)$ and a cohort effect W_b, interpretable as cohort average lifetime resources. For a household *h*, included in the survey at time *t*, we observe household consumption c_{ht} which is the sum of individual consumption, so that

$$c_{ht} = \sum_{a=1}^{N} n_{aht} f(a) W_{t-a} + \sum_{i \in h} \varepsilon_{iat-a} \tag{8}$$

where n_{aht} is the number of people aged *a* in household *h* at time *t*, where *N* is the maximum age in the population, and where we have used the fact that someone aged *a* and observed in *t* was born in $t-a.$ In the main text, we refer to coefficients $\beta(t,a)$ which are defined as the product $f(a)W_{t-a}$ in (8) above. These coefficients are calculated from (8), which is estimated from regressions, one per survey year, of household consumption on the numbers of people of each age in the household. The estimated $\beta(t,a)$ are then "smoothed" as described in Deaton and Paxson (1998), and then treated as estimates of individual consumption that are further decomposed into age and cohort effects by taking logs, and regressing on age and cohort dummies as in the household version of the model. These age effects are shown in Figure 5.

An alternative procedure for estimating age and cohort effects, that does not require taking logarithms and so avoids having to "smooth" out non-positive values, is described in Deaton and Paxson (1998). This procedure involves stacking the coefficients $\beta(t,a)$ into a B × A matrix, where B is the number of birth cohorts and A is the number of ages. This matrix can be expressed as the product of a B×1 vector of cohort effects and a 1×A vector of ages effects. These vectors are estimated using an iterative principal components technique. This paper reports results based on the log-linear decomposition, but results using the alternative technique are similar.

The fact that time trends in saving rates show up as offsetting cohort and age effects can be demonstrated as follows. Suppose that the saving rate for age *a* at time *t* is σ_{at}, and that, for "reasons unknown," these rates are increasing over time at rate θ, i.e.

$$\sigma_{at} = \alpha_a + \theta t \tag{9}$$

Cohort *c* is measured as age in a base year, 1976, say, so that year of birth *b* is $1976 - c$, and we have the identity

$$t = 1976 - c + a. \tag{10}$$

Substituting (10) into (9) gives

$$\sigma_{at} = (\alpha_a + 1976\theta) + \theta a - \theta c \tag{11}$$

so that the time trend appears as offsetting age and cohort effects in the saving ratio. When there are "genuine" age and cohort effects, the time trend will be added to one and subtracted from the other.

The aggregate saving ratios in any given year are calculated from formulas of the form

$$\left(\frac{S}{Y}\right)_t = \frac{\sum_{a=1}^{A} \eta_{at}\gamma_{t-a}[\exp(\beta_{ay}) - \exp(\beta_{ac})]}{\sum_{a=1}^{A} \eta_{at}\gamma_{t-a}\exp(\beta_{ay})} \tag{12}$$

where *S* and *Y* are aggregate saving and aggregate income, η_{at} is the number of people aged *a* at time *t*,

γ_{t-a} is the cohort wealth level for people born in $t - a$, and β_{ay} and β_{ac} are the age effects in the logarithmic income and consumption profiles respectively. These β's are estimated as described above, as are the γ's in the case where the estimated profiles are used. Otherwise, when we assume that cohort effects are generated by an equilibrium economic growth path along which per capita income is growing at rate *g*, γ's are set to be $(1+g)^{t-a}$. Similarly, the η's are either the actual numbers of people, or in equilibrium population growth are taken to be $(1+n)^{t-a} p_a$, where *n* is the rate of population growth and p_a is the probability of living to age *a*. In the household model, p_a must be replaced by p_a^h, the probability of surviving to age *a* and being a household head at that age.

Table 1: Percent of the population by 10-year age groups

age group	1950	1965	1980	1995
0-9	29.08	30.95	21.34	14.94
10-19	23.26	23.42	21.99	18.23
20-29	17.44	13.24	20.49	17.14
30-39	12.36	12.61	11.66	17.87
40-49	8.56	9.13	9.54	13.07
50-59	5.11	6.15	8.16	7.77
60-69	2.99	3.07	4.51	6.46
70+	1.19	1.42	2.31	4.53

Note: From Taiwan-Fukien Demographic Factbook. Data for 1991 to 1995 were obtained from Table 1 in the annual volumes. Data for earlier years were obtained on a diskette from DGBAS. Before 1969, professional servicemen, conscripts and prison inmates were not included in the population numbers.

Table 2: Actual and projected saving rates

Year	National Private saving rate (1)	Published saving rate, Survey of Personal Income Distribution (2)	Calculated saving rate, Survey of Personal Income Distribution (3)	Projected saving rate, actual cohort effects (4)	Projected saving rate, constant growth in cohort effects (5)
1952	2.55	.	.	.	20.41
1954	2.75	.	.	.	20.47
1956	3.95	.	.	.	20.59
1958	4.79	.	.	.	20.46
1960	6.52	.	.	.	20.56
1962	7.93	.	.	.	20.18
1964	13.34	11.23	.	.	19.88
1966	14.84	10.61	.	.	19.63
1968	12.55	8.87	.	.	19.63
1970	16.27	8.00	.	20.73	20.01
1972	20.62	13.12	.	21.26	20.30
1974	19.65	12.96	.	21.82	20.64
1976	18.03	17.92	16.53	22.47	21.09
1978	20.73	21.73	20.06	23.05	21.56
1980	17.86	23.17	21.43	23.54	22.03
1982	20.13	23.76	21.62	23.91	22.44
1984	22.90	22.96	20.38	24.14	22.75
1986	28.53	24.36	22.16	24.25	23.06
1988	23.57	26.38	23.80	24.07	23.25
1990	20.17	28.80	25.75	23.48	23.37
1992	.	.	26.43	22.55	23.48
1994	.	.	25.07	21.35	23.54

Note: Column (1) is based on data from "National Income in Taiwan Area of the Republic of China: 1991." The saving rate is calculated as the saving of households and private non-profit institutions (Table 16) divided by saving plus final private consumption expenditure (Table 18). Column (2) is from Table 9 of "Report on the Survey of Personal Income Distribution in Taiwan Area," 1991. Column (3) is based on our calculations of the household saving rate using the Survey of Personal Income Distribution. Columns (4) and (5) are projected saving rates that are based on actual population figures and our estimates of expenditure and income by age, and estimates of cohort-specific life-time wealth. See text.

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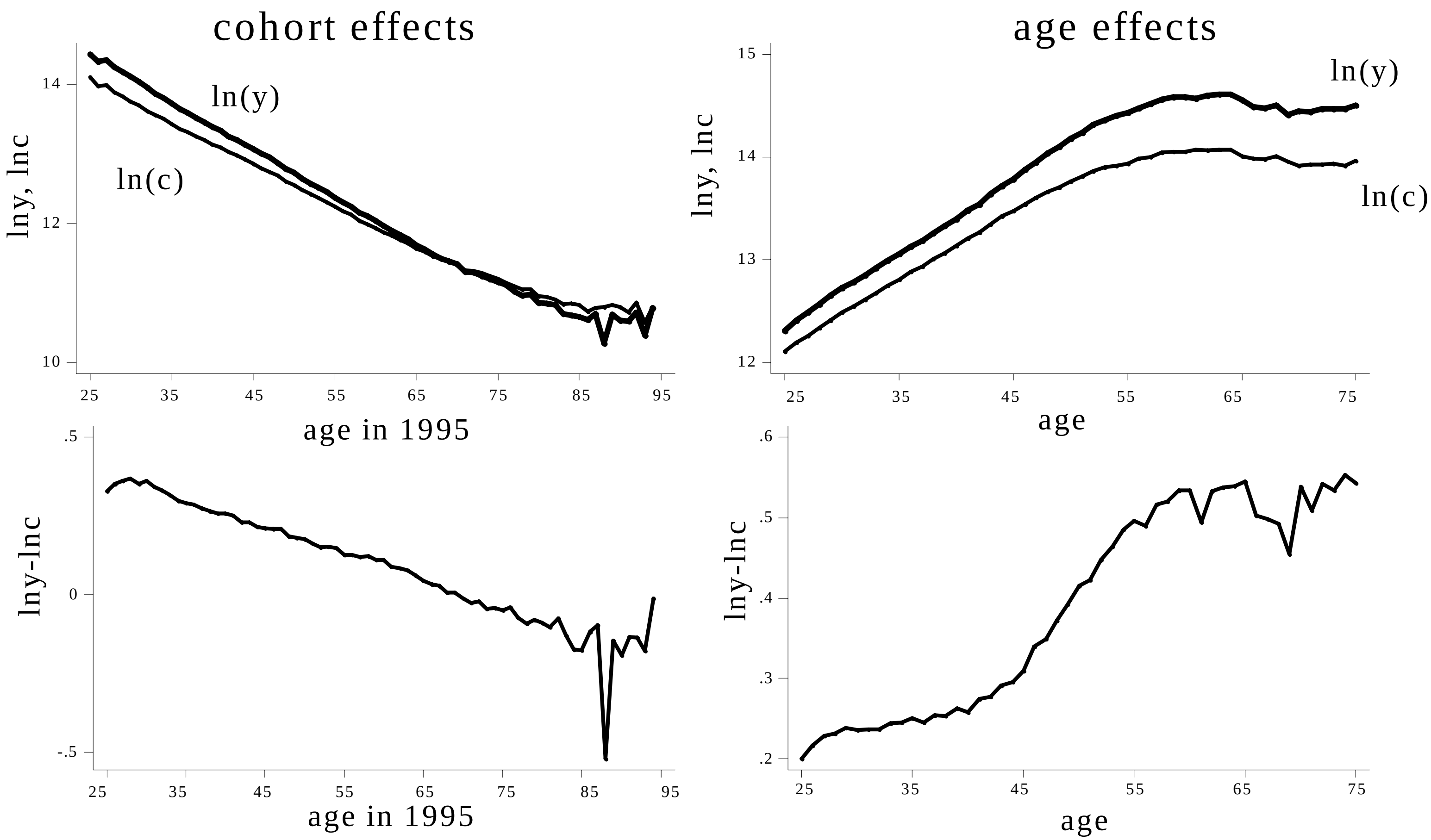

Figure 1: Cohort and age effects in log consumption, log income and the saving ratio: household model

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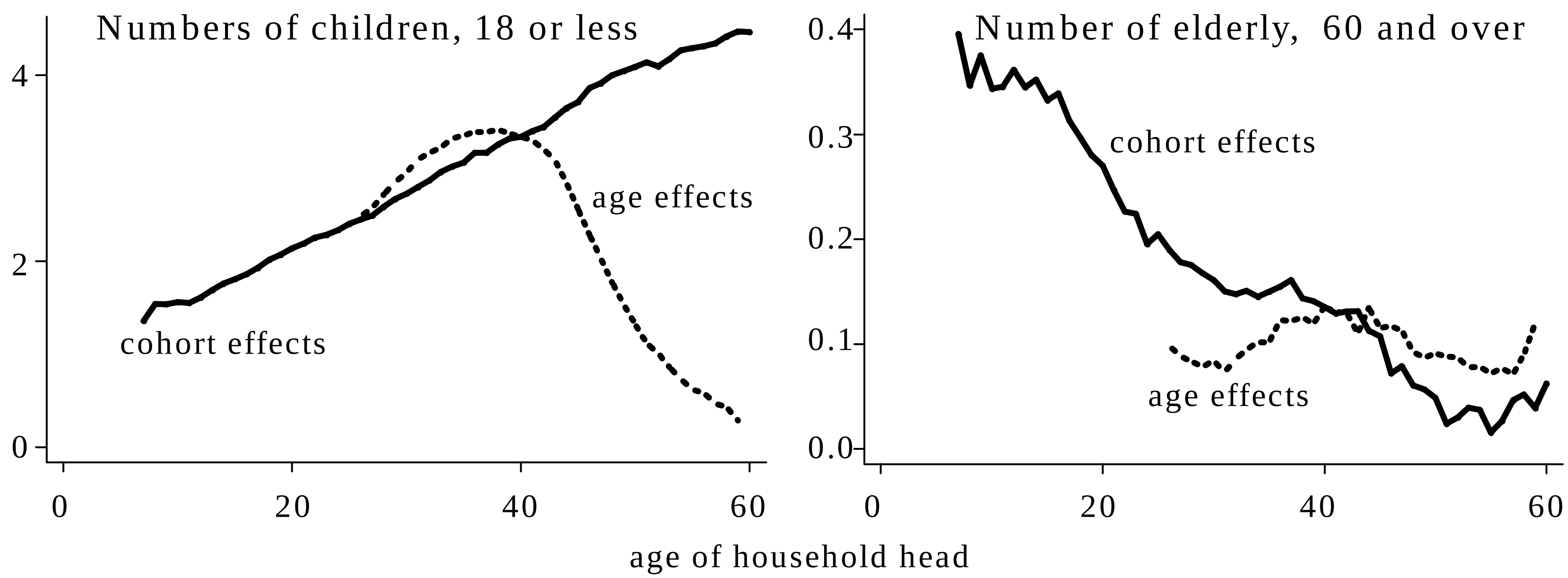

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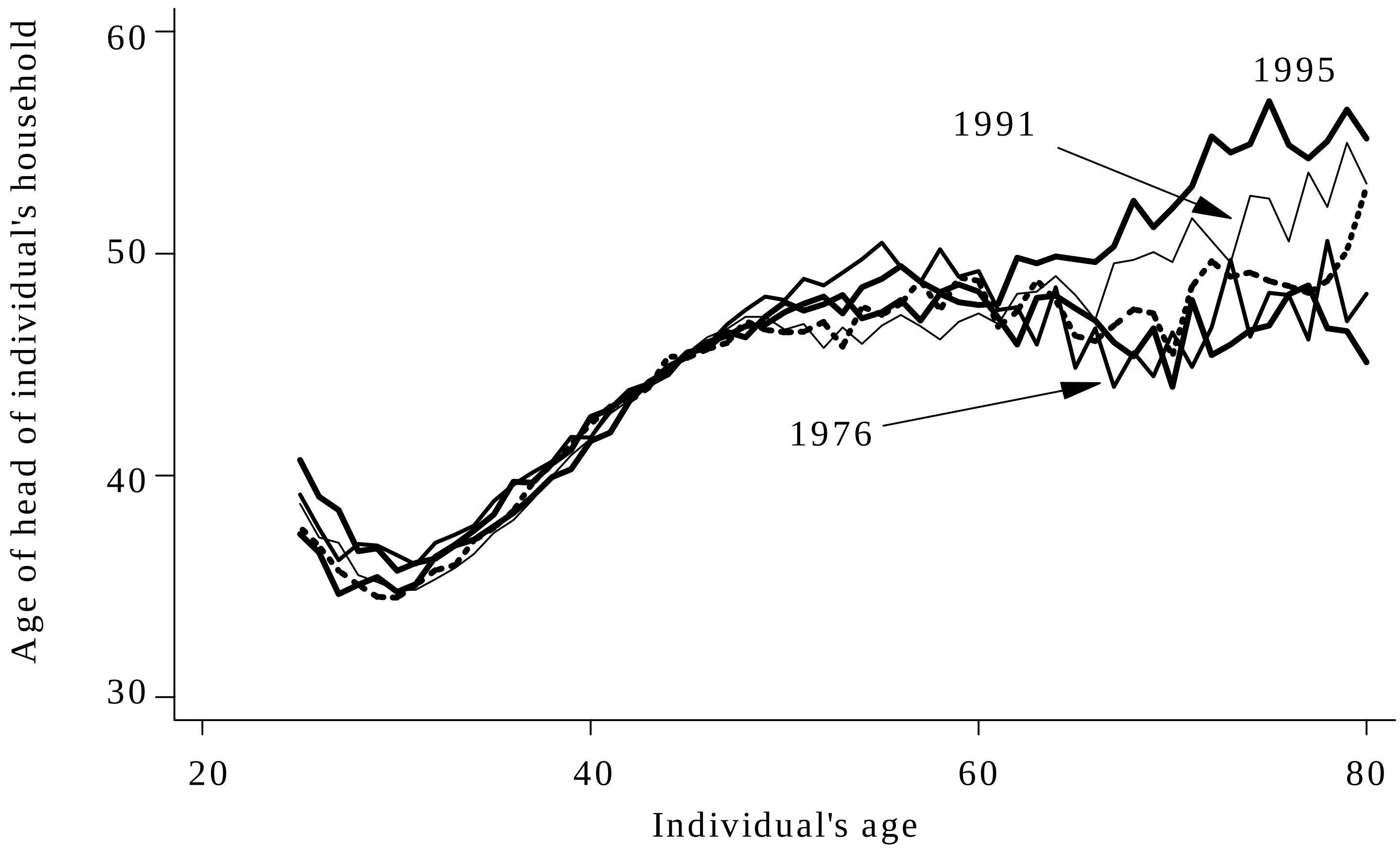

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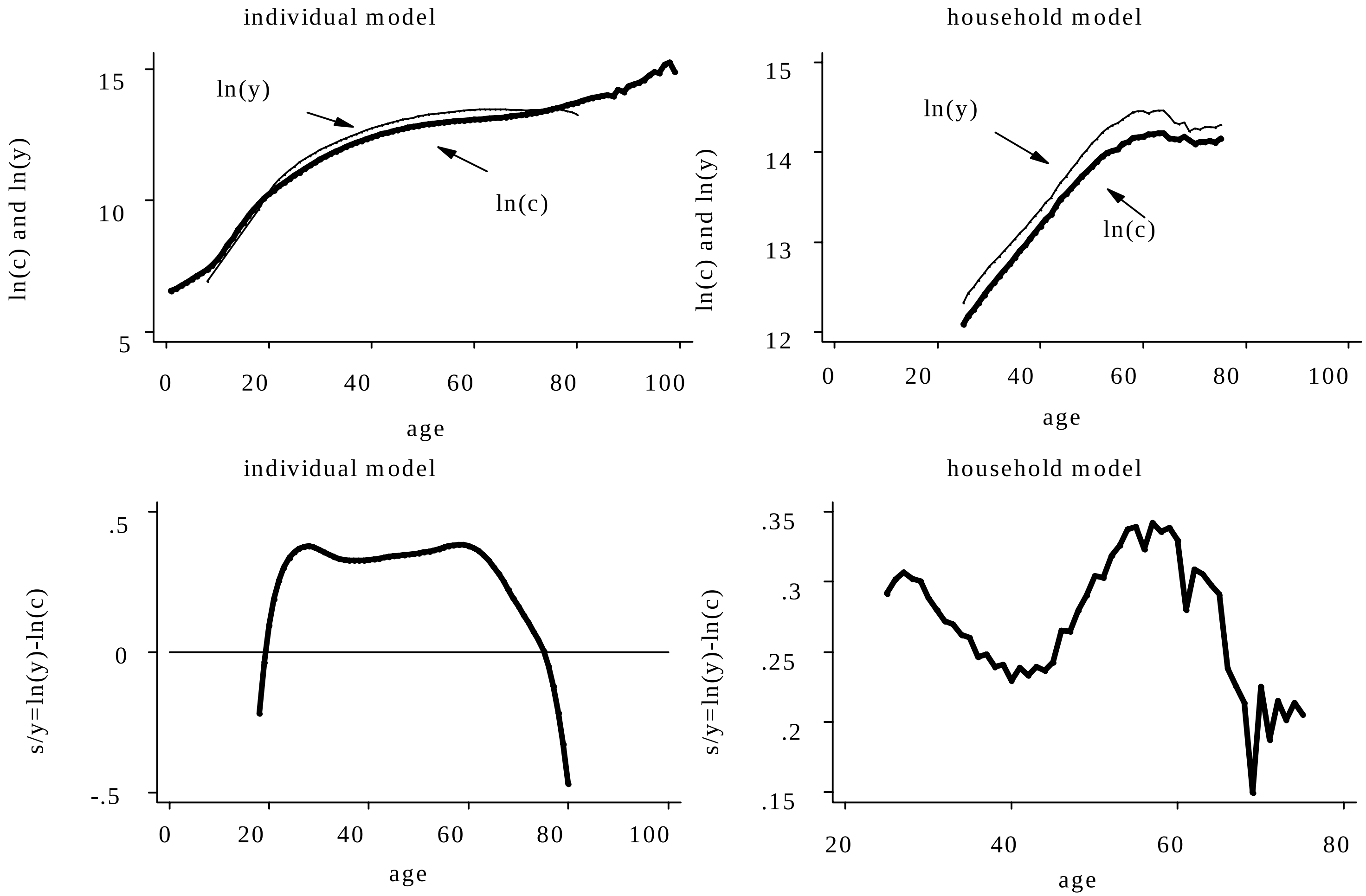

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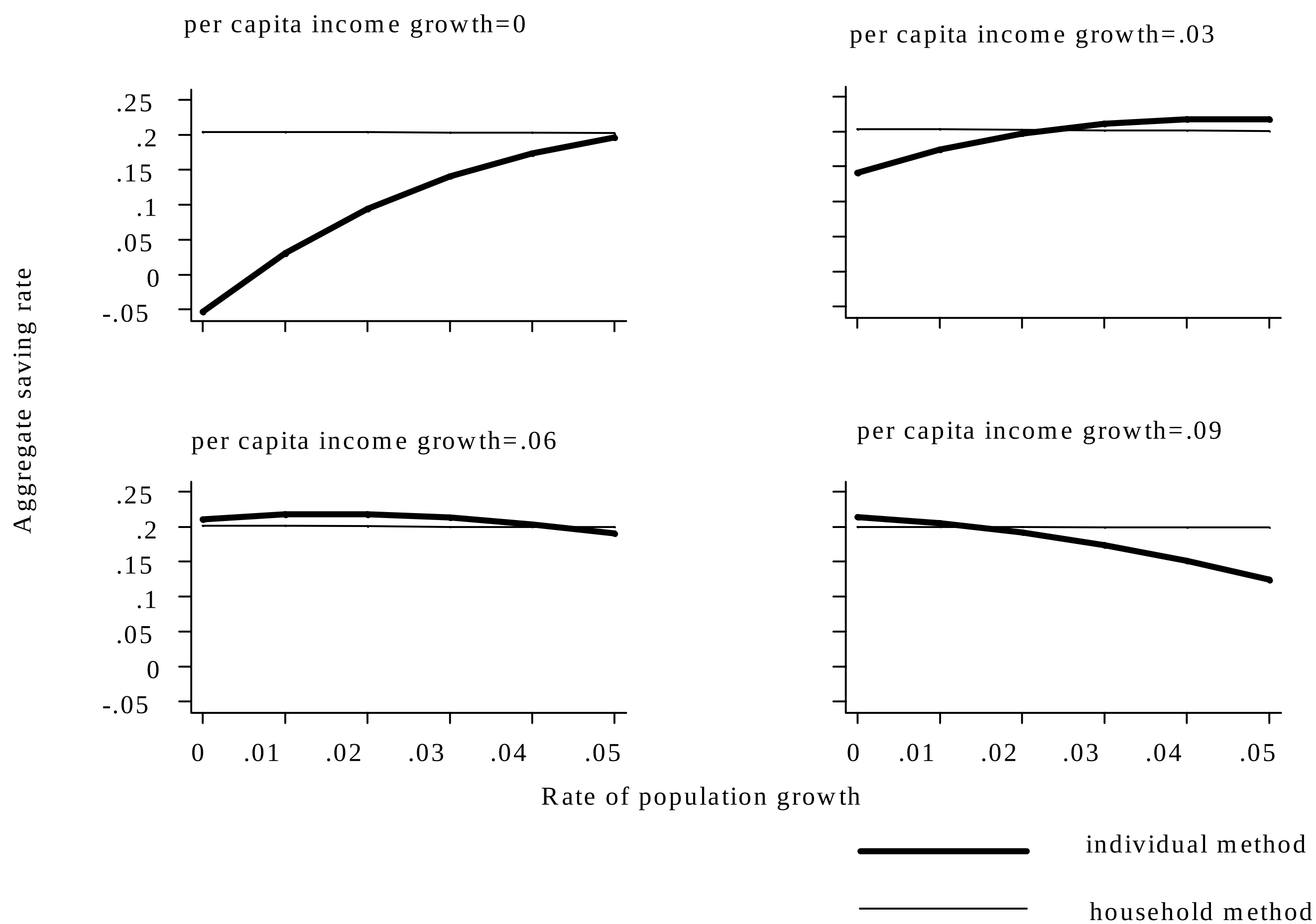

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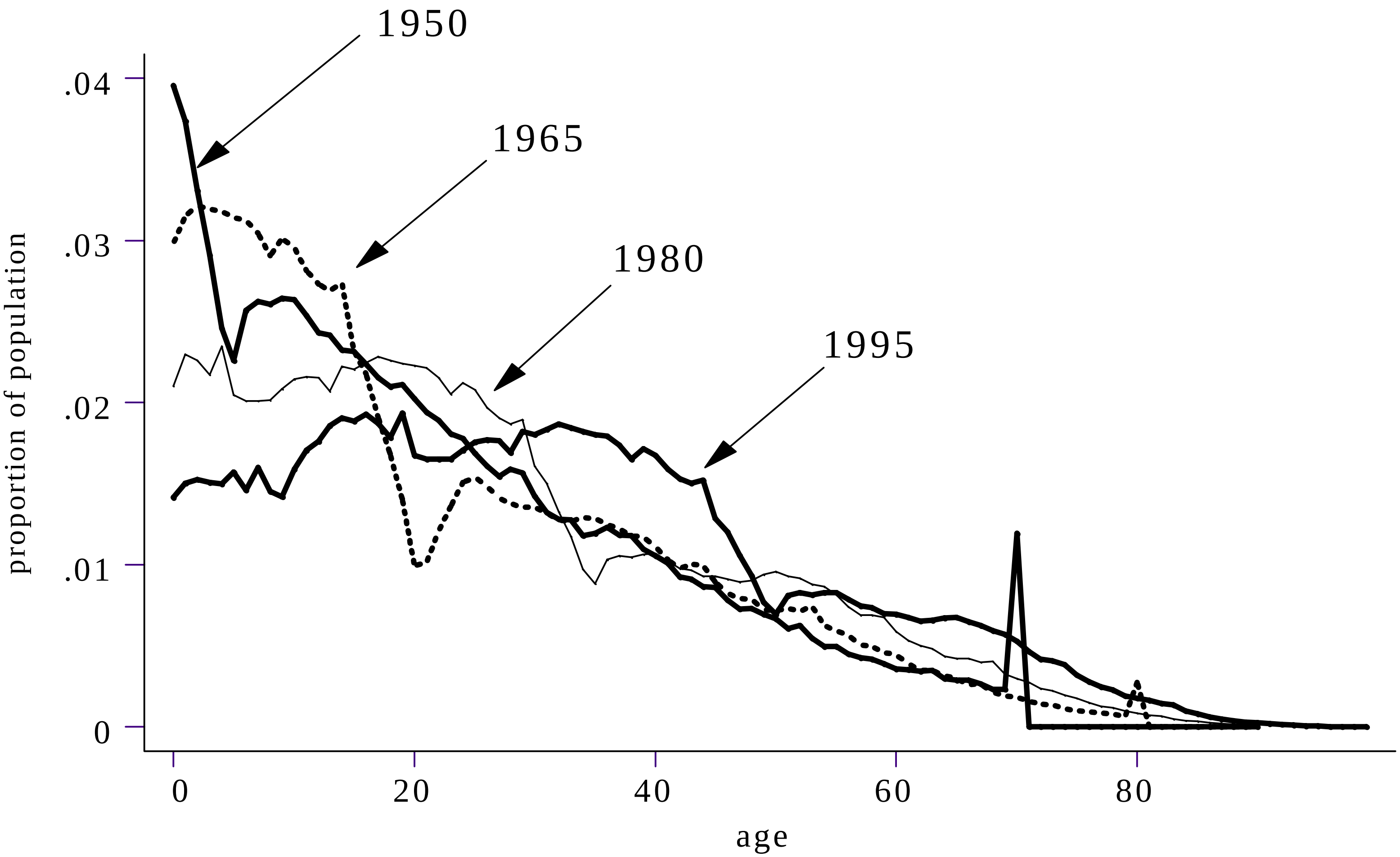

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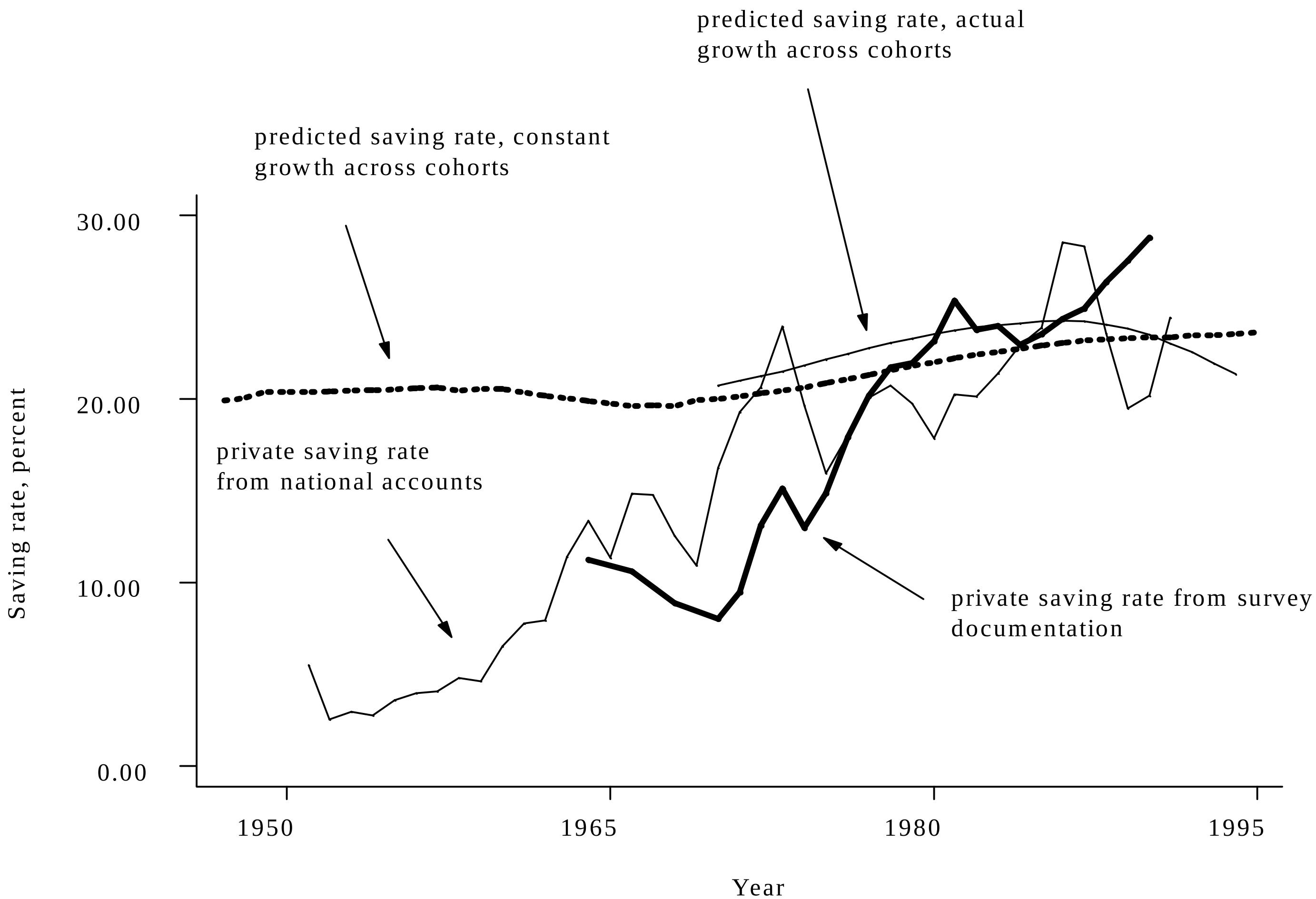

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