September 28, 1999
date last saved: 09/27/99 5:01 PM
date last printed: 10/04/99 12:13 PM
Draft: twnpdr8.doc

Life Cycle Saving and the Demographic Transition in East Asia

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The authors acknowledge the assistance of Jeff Brown and Noreen Tanouye at the Program on Population of the East-West Center and Bryan Lincoln at the NIA supported Center for Economics and Demography of Aging at Berkeley. Angus Deaton, Christina Paxson and an anonymous referee provided many helpful suggestions. Lee and Miller's research for this paper was funded by NIA grant AG11761. Mason's support for this paper was provided by the Agency for International Development, the Rockefeller Foundation, the William and Flora Hewlett Foundation, and the Ministry of Foreign Affairs of Japan.

Might the demographic transition from high fertility and mortality to low fertility and mortality cause an increase in savings rates and a rise in capital per worker? A long literature addresses this important question, and after a period of neglect, there has been new but contradictory research on the topic. Here we return to this issue, extending our earlier work, and attempting to reconcile it with findings from household level data.

We will argue that demographic change over the transition leads to a substantial increase in the demand for life cycle wealth –that is, a desire for claims on future output to support consumption in old age—held either in the form of capital or in the form of transfer wealth. This increase comes in part from the expectation of longer life, in part from fewer children, and in part from an older population age distribution. Before the transition, old age support was largely provided by families, and the expectation of such support was a form of transfer wealth. The elderly were also supported in part from their holdings of property (capital), and savings flows would have been partly an attempt to acquire such holdings of capital. A full account of demographic influences on saving behavior would have to take explicit account of the system of familial transfers, and its changes over time. Here, however, we give a partial account, for a hypothetical situation in which there are no transfers to the elderly.

In this paper, we simulate the effect of the demographic transition on saving rates and the demand for capital if all savings were for the purpose of spreading consumption smoothly over the life cycle, and if there were no transfers for this purpose other than to children. We assume that people correctly foresee all demographic change, but that expectations about future rates of interest and productivity growth are based on recent experience, using an ad hoc procedure, and that these expectations are typically incorrect. Actual interest rates and productivity growth are treated as exogenous, and are unaffected by savings behavior or demographic change. Future work will determine these within the model. We find that under the assumption of pure life cycle saving, aggregate saving rates would decline modestly during early stages of the transition, then rise quite substantially during a long middle period, and then decline again as the population ages rapidly in the last stage of the transition. Our simulated age patterns of income, consumption, and savings rates for Taiwan agree in some respects, but not all, with aggregate savings data and with survey data from Taiwan. Comparisons with other approaches show general qualitative agreement that the demographic transition should boost savings rates for a number of decades, but disagreement about the magnitude of this effect. We believe that our results are of general relevance for countries passing through the demographic transition, provided that life cycle saving, and the financial institutions necessary to sustain it, are present at least in the later stages of the transition.

Research on Population and Saving

Fisher (1930), among many others, recognized that life-cycle variation in individual productivity would lead individuals to vary their saving over their lifetime in order to smooth their consumption. Changes in population age-structure weight differently the different stages of the life cycle, and thus affect aggregate saving. If lifecycle saving is dominated by pension motives, slower population growth leads to reduced saving

(Modigliani and Ando (1957)). If lifecycle saving is dominated by childrearing costs, slower population growth leads to increased saving (Coale and Hoover (1958)).

Most theoretical analyses of aggregate saving based on the lifecycle model have been comparative static, examining the impact of different steady-state population age structures. Mason, 1981, 1987 and Fry and Mason, 1982 consider the impact of demography on the age-schedules of consumption and earning, as well as on the age structure of the population, but within a comparative-static framework. Higgins (1994) uses a simple overlapping generations model to examine the impact of changes in the number of children on saving in transition between steady-states.

Several recent empirical studies based on international time series of cross-sections have found an important link between demographic change and saving (Mason 1981, 1987, 1988; Fry and Mason, 1982; Kelley and Schmidt, 1996; Williamson and Higgins, 1997). Analyses at the microlevel are less supportive. While household saving rates do vary with the demographic characteristics of the household, the age-variation is sufficiently small that changes in age-structure have only a modest impact on aggregate saving or no impact at all (Deaton and Paxson, 1997; Mason et al., 1993). Deaton and Paxson find a more substantial impact of demographic change over the transition on household saving in the micro-level analysis in this volume, but the impact is much smaller than found by Williamson and Higgins (1997) or Kelley and Schmidt (1996) from cross-national analysis.

A consensus about the importance of demographic factors requires a reconciliation of these micro and macro approaches. Our micro-based macro simulations in this paper offer a first step towards such a reconciliation.

Demographic Change and the Demand for Wealth Over the Life Cycle

During childhood and old age, people on average consume more than they produce through their labor. During the middle years, people produce in excess of their consumption. Consumption in childhood is generally provided by transfers from the child's parents, with whom the child co-resides. Children are not generally financially independent, and they can be treated as part of their parents' planning problem. Support in old age, however, is another matter. Working age people must develop claims on future output beyond their own expected future production; without such claims, they could not consume once they ceased working. Such claims are called "wealth", or sometimes "life cycle wealth". This wealth can be held in the form of expected future net transfers, or in the form of property (capital).

The accumulation of wealth by households is illustrated in a stylized manner in Figure 1. Adults enter the workforce and begin to accumulate wealth. They continue do so until they retire. During retirement they draw down their wealth to support themselves in the absence of labor income. (Note that wealth need not actually begin to decline until some years after retirement). Lifecycle models frequently assume that wealth is accumulated only to support consumption during retirement and declines to zero at death. However, there are many reasons why this may not be the case. Uncertainty about time of death may lead people to over-accumulate wealth on average. People may hold additional wealth as a buffer against uncertain income streams or consumption needs, and people may save to provide bequests for their children. The need to provide for old age consumption is only one of a number of factors that motivates accumulation. Irrespective of the motivation, wealth profiles typically increase with age. The extent to which wealth declines among the elderly is an empirical issue about which there is considerable debate (Hurd, 1997).

{Figure 1}

In Taiwan, as in many Third World countries, "retirement" as an abrupt cessation of labor near some conventional age such as 65 is rare. Instead, there is a gradual diminution of labor after age 50, with substantial proportions still working at age 70. Nonetheless, it will be convenient to discuss the problem of providing for old age in terms of some conventional marker for retirement age, which we will here take to be 65.

The retirement motive for wealth accumulation is a relatively weak force in a pre-transition population because due to high mortality, the expected number of years spent in old age are few. For the pre-transition mortality rates used to characterize Taiwan below, a typical individual could expect to live only 0.078 years after age 65 for every year lived between the ages of 20-64. A modest level of wealth (Figure 1) is sufficient to finance average retirement needs in such a population. In a post-transition population, the number of years lived after age 65 per year lived in working ages is greater by a factor of 4 or 5. To provide the same measure of economic support in old age, saving rates and average wealth also must be substantially greater (Figure 1).

The age-wealth profile also should be influenced by the number of children. If children are costly, an increase in the number of children reduces consumption by adults. If parents smooth consumption over the life-cycle, then an increase in the number of children leads to an increase in consumption, by less than the cost of children, during years in which children are being reared. Consumption during years in which no childrearing costs are being incurred, including retirement years, is lower. Thus, the wealth profile is more bowed and peaks at a lower level. The impact of the number of children is attenuated because there are substantial economies of scale to childrearing and parents may reduce spending on their other children. Also, parents may limit their fertility specifically because they choose to spend more on each child. Changes in the number of children may also influence other saving motives, such as bequests or uncertainty, affecting the wealth profile in ways that cannot be determined a priori.

Non-demographic factors also influence the wealth profile. If people desire to leave larger bequests, the demand for wealth shifts upwards. A higher rate of interest may lead people to postpone consumption, thereby increasing holdings of wealth. However, with higher interest rates the wealth necessary to support a given level of consumption in old age is reduced. Consequently, interest rates have an ambiguous impact on wealth profiles. Productivity growth also has an ambiguous impact on wealth profiles. A higher rate of productivity growth means that younger households will have higher lifetime earning than older households and will consequently accumulate more wealth. However, a higher rate of productivity growth also means that households earn a smaller share of life time earnings at young ages. This will lead them to accumulate less wealth when young and their earnings are low and more wealth when they are older and their earnings are high. Earnings that are sufficiently low at young ages might lead individuals to go into debt if that were institutionally possible. The net impact on the wealth profile can not be determined a priori.

Total wealth is determined by the wealth profile and the number of adults at each age. If pre- and post-transition populations were stationary and everyone lived to the same age of death, wealth per person would be given by the area under the life cycle wealth profile, divided by the number of years of life. From inspection of the figure, we can conclude that because life expectancy is greater, wealth per adult will be greater in a post-transition population (provided that increases in the age at retirement do not offset increases in years lived); and that because families have fewer children, wealth per adult will be greater in a post-transition population (provided that greater expenditures per child do not completely compensate for the decline in the number of children).

The population age composition reinforces these life cycle effects, since a pre-transition population has a relatively large proportion of its population concentrated at younger ages where the demand for wealth is relatively low. Table 1, based on the experience of Taiwan, illustrates the sharp difference between pre- and post transition demography. The ratio of the expected number of years lived at old ages to working ages is much greater in a post-transition population. The average number of children reared is smaller, and the percentage of the population concentrated at older ages is greater. Each of these demographic factors pushes the demand for wealth higher and, in concert, dramatically so.

{Table 1}

The hypotheses advanced above and those obtained from most lifecycle saving models apply to comparative steady states. Demographic conditions prevailing before and after a demographic transition may be approximated as steady-states, but transitional populations cannot. During a typical transition, the number of surviving children per family first increases substantially and growth rates rise as mortality declines, and then these drop only after fertility decline sets in some decades later. The population age distribution initially grows younger early in the transition, and the total dependency ratio rises, depressing the demand for wealth. Then growth slows and the dependency burden declines over a long period of 50 or 60 years, before population aging sets in. This is the period of the so-called “demographic gift”, when demographic conditions may be particularly favorable for the economy. A further complexity is that during the transition, each cohort experiences different fertility and mortality. This is particularly important in East Asia where demographic change has been so rapid. Thus, no simple generalizations about the relationship between population, wealth, and saving during transition can be obtained.

Nonetheless, once we realize that under life cycle savings, equilibrium wealth holdings per capita must be greater after the transition than before, and that aggregate saving rates will be low both before and after the transition, then there are two implications. First, saving rates must temporarily rise during the transition, to generate the increased wealth.[1] Second, the height to which saving rates rise during the transition will depend on the speed of the transition. Populations that reach their post-transition wealth level more quickly can do so only if saving rates are higher during the transition. (The effects of the pace of transition on savings rates are explored in Lee, Mason, and Miller, 1998). Of course, the effects of changes in transfer behavior will be superimposed on these effects, or interact with them. We will see below that patterns may be quite complex, and that saving rates may both decline and rise at different points during the transition.

Despite the complexities of the life cycle model applied to the transition, note that if the increased demand for wealth per capita were not satisfied, then old people would experience sharp discontinuities in consumption when they no longer worked; possibly they would starve. In fact we do not observe that elders in societies nearing the end of the demographic transition consume at or below subsistence levels. In Taiwan, cross-sectional age profiles of consumption for recent years (to be displayed later) do not show such discontinuities. Household consumption per capita is very flat across age of individuals in cross sections (Mason and Miller, 1998). It follows that per capita wealth holdings must have increased substantially over the course of the transition. In one way or another, the elderly have acquired the claims on resources that permit them to consume increasing amounts per year during increasingly long periods of retirement.

Lifecycle Wealth: Transfer Wealth or Capital

Wealth as we have defined it above is quite general, consisting at the societal level of both transfer wealth and capital. Either form of wealth can be used by the elderly to sustain their consumption. However, transfer wealth has no direct impact on economic production nor on total income, although transfer systems alter incentives and thereby may generate indirect effects. The accumulation of capital, in contrast, is central to modern economic growth.

In traditional societies, the elderly are supported primarily by transfers within the extended family, either through co-residence with adult children or through transfers between households. Lifecycle wealth is largely transfer wealth, taking the form of expected net transfers in the future, not of holdings of productive property (although livestock, structures and land are also common forms of wealth). If family transfers continued to dominate throughout the demographic transition, the transition would have little impact on capital accumulation, although anticipation of the obligation to make transfers to elderly parents might affect savings of the non-elderly.

Economic development typically, perhaps always, erodes the system of family transfers. If the system is replaced by a pay-as-you-go public pension system with transfer income from those who are currently working to those who are currently retired, one form of transfer wealth (public) is simply substituted for another form (private). Under these circumstances, the demographic transition increases transfer wealth (or the size of the public pension system) and may have a fiscal impact (raising taxes on earnings), but has no direct impact on capital formation. It simply leads to a heavier support burden on the working age population.

However, if the family transfer system is replaced by a prefunded system, in which real wealth supports retirement, then a demographic transition leads to increased holdings of capital, fueling economic growth. Institutional forms of prefunded systems vary from country to country. Farmers and small businessmen may save by investing directly in productive enterprises. Workers may save directly through a variety of financial instruments or by participating in funded company-sponsored pension programs. Fully funded public pensions would have the same effect. Some countries, Singapore and Malaysia, for example, have now institutionalized such individual "life cycle saving" through large mandatory saving/retirement programs.

The transition from a transfer system to a prefunded system for supporting the elderly must create a transitory increase in aggregate savings which will be superimposed on, and reinforce, the demographically induced temporary increase in savings. These dynamic effects of the movement from a familial support system to a system of individual responsibility or funded pensions are not reflected in the simulations we report below, which assume that life cycle savings (individual responsibility) has prevailed throughout.

There is ample evidence of a shift away from familial support in East Asia, although family transfers are still considerably more important than is true of the West. The proportion of Japanese elderly living with their children declined from 80 to 50 percent between 1950 and 1990 (Feeney and Mason, 1998). In 1973, more than 80 percent of Taiwan's elderly lived with their children (Weinstein et al., 1994), but by 1993, only sixty percent of elderly men and seventy percent of elderly women were living with their children (calculated from the Family Income and Expenditure Survey).

The planned accumulation of wealth should depend more on expectations about support by those who are currently working than on the current arrangements of those who have already retired, and these expectations are changing rapidly. In 1950, 65% of Japanese women of childbearing age expected to rely on their children in old age. By 1990, only 18% expected to turn to their children for support in the future (Ogawa and Retherford, 1993).

The following table illustrates how the demographic transition and institutional arrangements for old age support interact to determine saving behavior and capital holdings. The biggest effect on saving rates and on capital formation occurs when the demographic transition is combined with a transition to individual responsibility for old age support.

	Transfers	**Prefunded (Indiv. Resp.)**
Pre-Demog Transition	Initial Situation	Small increase in savings and K
Post-Demog Transition	Small increase in savings and K	Big increase in savings and K

In this paper, we analyze the effect of the demographic transition on savings and capital accumulation only under the assumption that the system of individual responsibility has existed throughout. This will exaggerate the effect of a movement down the left hand column, passing through the transition while maintaining the system of transfers. It will understate the effect of a movement diagonally from the upper left to the lower right. We believe that this diagonal movement is the most appropriate representation of the changes taking place in East Asia and eventually in other Third World countries. In a number of countries of Latin America, currently switching to mandatory private savings for retirement, the movement to the lower right cell has already taken place or is in process.

THE DYNAMIC SIMULATION MODEL

The simulation model used in this paper determines how aggregate saving rates and wealth change during demographic transition if saving by members of the population is determined entirely by lifecycle considerations (individual responsibility) before, during and after the transition. The model takes the approach of Tobin (1967), and is very similar to the one used in Lee, Mason, and Miller (1997), wherein further details can be found.

While the population composition in Lee, Mason and Miller (1997) reflected actual census data, here we instead generate the population from the historical and projected trajectories of mortality and fertility (see the appendix for details). Consequently, the demography does not reflect the massive immigration from mainland China that occurred around 1950. We refer to the resulting transition as "Pseudo-Taiwan." Comparison to results in Lee, Mason and Miller (1997) indicates that this treatment of immigration does not alter the conclusions reached here in any important respect. The trajectories for life-expectancy at birth and the TFR for Taiwan, as well as the implied population growth rates, are shown in Figure 2. The TFR is assumed to move slowly to replacement level in future decades, and life-expectancy at birth is assumed to rise to about 80 years by 2050.

{ Figure 2 }

Based on empirical household headship rates, we set the age of economic independence at 25 in this paper, a change from our previous paper where it was 21. Until this age, we assume that children remain in the parental home, pooling their income with that of their parents, although some marry and begin childbearing at an earlier age. Until then, their income is treated as income of their parents, and its disposition is governed by the parents' life cycle budget constraint and consumption plan. In fact, in 1980 only about a quarter of males aged 25-29 were household heads, so the actual age of males leaving home is typically later than 25. However, we expect (with no direct evidence) that co-resident children would increasingly have control over their earnings as they grow older, whether or not they remain co-resident. Once children leave home and set up their own households, we assume they remain in their own households for the remainder of their lives. In reality, the current elderly often co-reside with their adult children, but we anticipate that this will become less common as time passes, as discussed earlier. We do not know the extent to which the co-resident elderly are financially dependent on their children.

Household consumption behavior is governed by a utility maximization model. In each period, adults decide how much of their income to consume and how much to save based on their current wealth, and family size, and expectations about future childbearing, mortality conditions, interest rates and earnings. We make no allowance for intergenerational transfers: parents make no bequests to their children and adult children provide no support to their parents. (Lee, Mason, and Miller (1997) analyzes the impact of transfers in steady states.) While children are present in the home, they are supported by their parents, who give children half of their own weight, on average, in setting household consumption levels. The mechanics of this calculation are such that each child in a two child family is allocated 70% more resources than in a six child family, when household income is the same. Thus our model does entail some tradeoff between child quality and number.

Each householder calculates the present value of expected life time earnings, including the earnings of co-resident children. The present value of expected lifetime household consumption is constrained to equal this amount. Couples distribute household consumption over time so as to maximize their life time utility. Given the life time utility function employed, household consumption per equivalent adult consumer is planned to rise at a rate equal to $(r-\rho)(1/\gamma)$, where r is the real rate of interest, ρ is the rate of subjective time preference, and $(1/\gamma)$ is the intertemporal elasticity of substitution. In our simulations, we take ρ to be 0. For $(1/\gamma)$ we use an estimate of .6 for Taiwan by Ogaki, Ostry, and Reinhart (1996).[2] We assume that the weight of children in consumption calculations by their parents rises with the children's age, and averages 0.5. Additional elements of the simulation model are described in the appendix to this paper, and in greater detail in Lee, Mason and Miller (1997).

For life cycle planning, it is the anticipated future values of the demographic and economic variables that matter. We assume that couples correctly anticipate their fertility and the survival probabilities of all family members. Mortality expectations take the form of proportions or probabilities, but we assume that all the uncertainty around these average rates is absorbed by institutions, whose exact nature we do not consider. Plans are formulated on the basis of the expected person-years of life at each future date. Householders who die bequeath their wealth to all other householders of the same age, and likewise the orphans created by death are shared out among all surviving households of the same age.

Earnings in each year are determined by changes in the general wage level, the productivity growth rate, and a fixed cross-sectional age-earnings profile. The profile is equal to the average shape over the years 1976 to 1990 in Taiwan calculated from the Family Income and Expenditure Survey. The level of this profile shifts according to the assumed time path of productivity growth. We depart here from the standard implementation of the life cycle model, which has assumed that the longitudinal earnings profile has a fixed shape. We believe our specification to be preferable on both theoretical and empirical grounds as discussed in Lee, Mason and Miller (forthcoming).

For the interest rate and productivity growth rate, we do not assume perfect foresight. We instead make the ad hoc assumption that people base their expectations on the average experience of the past five years. Then, rather than assuming this rate to continue for the rest of their lives, they expect the rate to tend exponentially toward a long run target rate, which is their long run future expectation. These we have taken in our baseline simulation to be interest rate =.03, and productivity growth = .015. Our thought is that long-term interest rates will converge to international levels as global capital markets are increasingly integrated and that productivity growth will depend only on technological advance at a rate similar to those experienced in mature economies once the economy reaches equilibrium. Since r has averaged 7.4% since 1950, and productivity growth has averaged 5.5%, we assume that people have been constantly surprised by continuing high rates. Our analysis is inconsistent, because although people are repeatedly surprised by economic outcomes, they continue to believe that they know the future with certainty. It would be preferable to develop a model incorporating both uncertainty and demographic factors (see Attanasio, et al. 1997), but that is beyond the scope of this paper.

We start the simulations in 1800, to permit convergence to the steady state before the transition begins. Results are presented either for 1900 to 2050 or, occasionally, from 1950 to 2050. We have not tried to take into account the massive immigration of the 1950s, or the loss of capital during the war. For our baseline scenario, the productivity growth rate conforms to our best guess at historical and future trends. Thus it rises from a pre-transition level of 1% per year, peaks at 5.5% over the period 1950-99, and then declines to a long-run average of 1.5%. (see the note to Figure 3, scenario 1). The real interest rate is set at 1.5 percentage points above the productivity growth rate. People's expectations about eventual long run values remain unchanged at 3% for the interest rate and 1.5% for the productivity growth rate. We assume a zero rate of time preference throughout.

Results of Simulations

Figures 3 and 4 chart the trend in saving and wealth from 1950 to 2050 for the baseline simulation and several alternatives. The most prominent feature of the baseline simulation is the very substantial swing in saving that begins about 1973. The saving rate increases by almost 14 percentage points, doubling the 1973 rate by the time it peaks in 2005. This is followed by an even greater decline in the saving rate. The large swing in saving is a phenomenon that is missed entirely by comparative static analyses but was noted above as an outcome of rapid demographic transition under life cycle savings. The swing in saving rates is accompanied by a rapid increase in W/Y (see Figure 4). A second important feature of the saving simulation is the dip that occurs in the 1960s and early 1970s.This dip in savings is related in complex ways to the changing numbers of surviving children in households.

{ Figure 3 }
{ Figure 4 }

In the baseline simulation, demography, interest rates, and productivity growth rates are all changing and influencing the outcome. The direct impact of demography is isolated by an additional simulation which holds the interest rate and productivity growth rate constant at 3 and 1.5 percent, respectively, throughout the simulation (scenario 2). If only demographic factors change, the saving rate reaches a higher peak and declines more modestly than in the baseline. Note, however, the artificial nature of assuming a constant rate of interest (return to capital) and a constant productivity growth rate in light of the large increase in capital. In a more complete model of the economy, currently being developed, interest rates and growth would be determined in large part by the changes in capital induced by demographic factors. As W/Y approaches its equilibrium level, productivity growth would decline to a lower long-term growth governed solely by technological innovation.

Figure 3 also plots the time path of the actual net national savings rate for the available years, and there are important dissimilarities. The short-term fluctuations need not concern us; persistent differences are more relevant. As compared with the lifecycle simulation, Taiwan was saving too little during the 1950s and early 1960s, too much between 1964 and1988, and too little during the most recent years. There was no obvious medium-term downturn in the saving rate prior to 1975. The recent decline in saving occurred several decades before the simulated decline and seems not to be associated with demographic factors. On the positive side, the dynamic lifecycle model does predict a large increase in saving rates (about 14 percentage points) and the level of the simulated saving rate is fairly consistent with actual saving rates.

At least two difficult aspects of the lifecycle model require more careful attention and could account for some differences between the simulated and actual saving rates observed. The first is the formation of expectations. Our treatment of economic expectations is problematic since we assume that people repeatedly under-predict the future productivity growth rate and interest rate. The second issue is the erosion of the family support system discussed extensively above. Low saving rates are sufficient to satisfy lifecycle needs when the elderly rely heavily on their children for economic support. Hence, the rapid increase in saving is very consistent with a shift from a transfer based system to a system of self-reliance combined with purely demographic changes, and as discussed earlier, during such a shift savings rates could easily rise above their normal life cycle level. In a similar vein, the development of public transfer systems in Taiwan in recent years might account for the downturn in national saving.

Sensitivity Tests

The baseline simulation is based on Taiwan's experience, to the extent that it is documented, with the exception of the massive, immigration and disruption of the war years. In order to assess the robustness of our results we have investigated a) different parameter values; b) different economic input time series; and c) different formation of expectations.[3] For parameter values, we set the elasticity of substitution at .3 and at 1.0, in contrast to .6 in the baseline. The resulting level of the saving rate is much lower for .3, and higher for 1.0, but the shape, timing, and magnitudes of the resulting swings in the saving rate remain very similar to the baseline case. There are similar results when we vary the EAC weights. For the assumptions about productivity growth and interest rates, we have sometimes held these constant, and sometimes varied them independently of one another. Other things equal, a higher interest rate raises savings rates, and higher productivity growth rates reduce savings, but the impact of demography on the saving rate remains qualitatively similar.[4] For expectations, results are largely unchanged if actors expect that each period's age specific mortality will persist instead of having perfect foresight about future mortality. We conclude that the effects of demographic change on aggregate savings rates are quite robust to these kinds of variations in the details of the model.

Simulated Saving at the Household Level

The simulation model also provides detailed age data that can be used to construct cross-sectional or longitudinal profiles of income, consumption, and saving, by age of household head. Comparing these profiles to household data provides another check on the realism of the simulations, once we take into account some issues of non-comparability. First, household surveys provide a narrow measure of saving and wealth which excludes, for example, employers' contributions to employee pension funds. Second, household headship is highly selective at younger and older ages, when only a small fraction of the population are heads or spouses of heads. The age at which young adults establish a separate household may be influenced by unobserved factors that also influence the accumulation of wealth. Likewise, the age at which older adults become members of households headed by their offspring may be influenced by conditions that also bear on wealth. Under these circumstances, the saving and wealth of younger and older household heads may differ substantially from the saving and wealth of the average individuals at those ages.

Figure 5 compares household saving by age of household head from survey data for 1976-90 to the simulated age-saving profile for the same period. The actual and the simulated profiles both have a distinctive M shape. The dip in the middle-ages corresponds to a rise in dependency relative to household income at those same ages (Mason and Miller, 1998). Saving rates in the survey are higher than in the simulation among young households, and first lower, then higher, among older households. The apparent failure of the elderly to dissave during retirement is a common point of criticism of the lifecycle model. However, the selectivity of headship and of survival makes it difficult to interpret survey data on the age-patterns of saving at both the younger and older ages. Thus, the high rate of saving among households with young and old household heads does not provide clear evidence about the applicability of the lifecycle model to Taiwan. (See Hurd, 1997 for a recent review of these issues.)

{ Figure 5 }

Results presented in Figure 6 address a recent criticism of the lifecycle saving model. Empirical studies show that consumption tracks income quite closely (Carroll and Summers, 1991; Paxson, 1996) while the standard lifecycle model implies that the path of consumption should depend only on total life time income, and be independent of current income. Attanasio, et al. (1997) consider this issue in their research and show that demographic factors and uncertainty can also lead to tracking. We examine this issue with respect to our simulation model by duplicating a figure in Deaton and Paxson's work (1997: Figure 2 and 1999: Figure1), except that theirs is based on an analysis of survey data, and ours is based on an analysis of simulated data, for the same period. The plot shows the estimated "age effects" from regressions of the logarithm of consumption and of income on age and cohort.[5] The two plots are very similar, although not identical. The plots show the logarithm of income rising by the same amount (no surprise there; that's in the data), and consumption rising by less, and leveling out well below income in the later years. In the simulation, this leveling of consumption occurs in the mid to late 40's, reflecting declines in household size, while in the survey data it occurs a few years later. Given that the simulations do not include co-resident elderly, this difference is not surprising. Deaton and Paxson interpret their plot (together with others for other countries) as showing that "consumption 'tracks' income over the life cycle" which they say is "difficult to reconcile with the simple life cycle model, but it may be explained by more complicated versions…such as those that include precautionary motives for saving and borrowing constraints…." (1997:103). In the case of Taiwan, our life cycle model, although "simple" in the sense of including neither precautionary motives nor borrowing constraints, generates very similar trajectories due to the demographic structure.[6]

{ Figure 6 }

Despite some success in duplicating certain key patterns observed in survey data, we have important reservations about the life cycle saving model, particularly the steep rise in consumption with age in our simulations in response to high interest rates. This is why the young, with much higher life time earnings, consume about the same amount as the concurrent elderly, who have much lower life time earnings. The longitudinal and cross-sectional implications of the simulation are empirically realistic (see above). However, it is doubtful that consumption and saving behavior are so strongly influenced by interest rates, since the empirical literature suggests that behavior is relatively insensitive to interest rate variations. We would like to experiment with non-standard models that contain elements of life cycle saving, but which build on simpler "rule of thumb" specifications, modified by demographic factors. One such model we have examined assumes that households save a fixed proportion of income throughout their lives until "retirement", with the amount set to provide a retirement income equal to 70% of their average income in the preceding five years. In this setup, the presence of children has no effect on saving behavior (contrary to reality), but there is still a substantial effect of the demographic transition on saving rates and wealth due to longer life and the changing age distribution of household heads.

Demographic Influences on Savings Implied by Different Approaches

We are now in a position to compare the implications of savings derived from three very different methods: cross national regressions, regressions on household level survey data, and simulations based on assumed behaviors. The implications of each for aggregate savings over the transition can be expressed in comparable terms.

The first kind of study analyzes a time series of international cross-sectional data. Figure 7 simulates results from two studies: Williamson and Higgins (1997) and Kelley and Schmidt (1996). These simulations show gross savings rates. The main effect to note is the very large upswing in saving rates followed by a down swing as population aging sets in; the magnitude of the upswing ranges from 25 to 43 percentage points. A secondary point is the much smaller early downswing in savings rates due to deteriorating child dependency ratios in earlier stages of the transition.

{ Figure 7 }

Deaton and Paxson (this volume) employ a very different approach. Relying on the National Family Income and Expenditure survey they construct longitudinal, individual age profiles of consumption, income, and saving. They hold these profiles constant and determine how changes in age-structure will influence aggregate household saving. In an earlier analysis, Deaton and Paxson (1997) found that demographic change essentially had no impact. The more recent analysis presented here accounts for the effects of coresidency of older and younger adults on household age profiles and examines the effects of transitional changes in population age distributions, concluding that demographic change has a modest effect on saving. Although the changes are substantially smaller than in the Williamson and Higgins simulations or ours, the pattern over time is quite similar. They find that demographic change leads to a dip in saving in the late 1960s, a few years earlier than in Williamson and Higgins (1998) or our simulations. Saving rises subsequently, reaching a peak in about the same year as the simulations. The swing from trough to peak is 6-7 percentage points (depending on the scenario), much smaller than the rise in the other two analyses, but far from inconsequential. For the future, they find a very slight decrease in saving if Taiwan’s current productivity growth rates persist (6%/year). With lower productivity growth (0% or 3%), they find large declines in saving.

Our own macro-simulations show swings intermediate between those based on cross-national estimates and those based on household data, with the timing very similar to both. The magnitude of our swing is about 14 percentage points for net savings and 24 for gross savings (the measure used in cross national studies). Reconciling the macro and micro studies would greatly increase confidence about the size of the impact of demography on saving. Our simulations show that under a particular set of circumstances the impact of demography on gross savings could be as large as in Kelley and Schmidt, although not as large as estimated by Williamson and Higgins. But given a sufficiently strong transfer system, either family or public, demographic changes would have a considerably smaller impact than in our simulations. Thus, one could not conclude that the more modest swing in savings based on Deaton and Paxson's results is inconsistent with our analysis here.

Assumptions about economic growth are similar in the scenarios we compare in Figure 7. Our baseline model uses Taiwan’s historical growth and assumes future economic growth will slowly decline to a long-run average of 1.5%. We chose two of Deaton and Paxson’s scenarios (0% and 3%) which bracket that figure. The Kelley and Schmidt simulation uses the same economic growth rates as our baseline model. Differences among these models cannot be attributed to assumptions about economic growth. The Williamson and Higgins simulation examines only the effect of changes in demographic structure on savings, holding economic growth constant.

In part, the results can be reconciled by taking definitional differences into account. Williamson and Higgins analyzes a very broad measure of saving, gross national saving rates, that takes on larger values and might be expected to vary more, in percentage point terms, than net saving or household saving. Deaton and Paxson's measure of saving is narrower and excludes some components of retirement saving making it less sensitive to demographic changes. However, definitional differences almost surely do not account for all of the differences apparent in Figure 7.

An additional feature of the Deaton and Paxson analysis may have a particularly important bearing on the difference between their results and those in our simulation. Their estimates of the effects of demographic change do not incorporate any effect of increasing life-expectancy across cohorts or periods on saving profiles. Our simulated saving rates rise much more rapidly than those in Deaton and Paxson in part because of these cohort longevity effects. In short, we believe that a more complete accounting that included longevity might suggest that demographic factors have a greater impact on saving.

Conclusions

We have considered how the demographic transition in Taiwan would affect aggregate savings under the assumption of pure life cycle saving. Comparing pre- and post-transition stationary states, the demand for wealth would increase substantially and permanently over the transition. Under life cycle saving, this increase in the demand for wealth would be met by a transitory but substantial increase in the saving rate during the stage in the transition when the total dependency rate is falling. In the presence of productivity growth, savings would be higher after the transition than before, but otherwise not. Realistically, pretransitional old age was largely supported by familial transfers. Over the demographic transition, a concurrent move from familial transfers to individual responsibility for old age (or funded pension systems) would itself generate a larger increase in savings and a higher level than there would have been had life cycle savings always been the rule.

People now live two or three times as long as in the past, but the role of mortality decline for savings has been largely ignored. Declining mortality could explain a large part of increased savings even with no change in population age distribution, and even with no age-variation in saving rates. It is possible, of course, that instead of saving more, people faced with longer life would choose to postpone retirement, in which case mortality decline would have less if any effect on saving. But to this point in the history of the industrial populations, the trend in retirement age has been strongly downward even as longevity has increased.

It is striking that the simulated effects of demographic transition on saving rates for Taiwan are similar in timing and direction when based on several completely different methods: micro analysis of survey data, macro analysis of cross-national data, and our micro-based macro simulation. However, the simulation based on analysis of survey data shows swings of very much smaller magnitude than the other approaches.

We have shown that the demographic transition, operating through the life cycle saving motive, is capable of accounting for a substantial rise in saving rates, and for very high levels of savings rates, in Taiwan. Our simulations do not fit the timing of changes particularly well, and they predict a modest early decline in savings rates in the 1950s and 1960s that was not observed. The levels and expected changes in familial transfers must surely play an important role in the explanation of savings in Taiwan, and we have not yet examined this possibility systematically. Other influences on saving, such as buffering against uncertainty of income streams, preparing for intended bequests, or slowly changing consumption habits, must also play a role. We do believe, however, that life cycle saving is an important part of this picture, and that through life cycle saving, the massive demographic changes over the course of the demographic transition have influenced savings behavior and wealth accumulation, and will continue to do so in the future.

Appendix

A. Demography: Time paths of life expectancy at birth (e0) and the total fertility rate (TFR) are specified. We then derive age specific rates from these summary measures by assuming that rates for age x, time t, are described by: $m_{x,t} = a_x + b_x k_t$, where a and b are age specific parameters that do not change over time, and k is an index of the level of mortality or fertility (see Lee and Carter, 1992; Lee, 1993). $m_{x,t}$ in the case of mortality is the log of the age specific death rate for age x at time t, and for fertility is age specific birth rate. The trajectory of k then determines the trajectory of mortality or fertility, and the time path of k can be chosen to match the time path of e0 or TFR. The vectors a and b are chosen (for each of fertility and mortality) to provide a good fit to Taiwanese historical experience, but the same vectors can also fit the experience of other populations reasonably well. This setup makes it easy to experiment with alternative demographic scenarios. In this paper (unlike our previous) we assume that the population is closed to migration. This means that we ignore the demographic effects of the migration from the mainland to Taiwan, which is an unfortunate implication of the greater generality of our current approach. We refer to the resulting transition as "Pseudo-Taiwan."

B. Economic Behavior.

Details of this model can be found in the appendices to Lee, Mason and Miller (1997). Here we begin by describing a few elements of the model for the static case. When a household is formed, the heads seek to maximize life time utility V:

$$V = \int_z^{\omega} e^{-\rho x} u[C(x), H(x)]dx$$

where z is the age of forming a household; ω is oldest age with non-zero survival probability; C(x) is total household consumption at age x; H(x) is the expected (survival weighted) total household size measured in equivalent adult consumer units (EAC); and ρ is the discount rate.

The instantaneous household utility function in V is specified as:

$$u[H(x), C(x)] = H(x)\left(\left(\left[\frac{C(x)}{H(x)}\right]^{1-\gamma} - 1\right) \Big/ (1-\gamma)\right)$$

where γ is the inverse of the intertemporal elasticity of substitution.

In this specification, household utility is proportional to the number of Equivalent Adult Consumers (EACs) in the household, denoted *H(x)*, times a standard constant relative risk aversion utility function, with consumption per EAC as its argument. If H(x) were instead replaced by the simple number of household members, giving children the same unitary weight as adults, then optimization would lead parents to squeeze higher consumption per EAC into years in which children were present, since children become super-efficient producers of household utility, contrary to empirical reality.

Life cycle utility is maximized subject to the constraint that the present value of expected future life time earnings of householders, and their children while co-resident (PV(Yl)), evaluated when the heads are age z), equals the present value of expected future household consumption. Both expectations are survival weighted. The maximization yields the following planned age-time path for household consumption:

$$C(x)=\frac{H(x)PV[Y_l]e^{(r-\rho)x/\gamma}}{\int_z^{\omega} e^{-ra}H(a)e^{(r-\rho)a/\gamma}da}$$

It follows that the life cycle trajectory of consumption per EAC rises at the rate (r-ρ)/γ, where γ is the inverse of the intertemporal elasticity of substitution. Bearing in mind that C(x)/H(x) is consumption per surviving EAC, this is readily shown to be consistent with the well known analysis by Yaari (1965, Case C) for consumption paths under uncertain life times, given the presence of fair annuities.

The extension to a context of economic and demographic change is based on rules for formulating expectations as circumstances change, and then on reoptimization at each age, taking as given the situation that has resulted from earlier decisions. We assume that every decision is made as if actors were completely certainty about the future (except that survival is a probability, albeit a fully insured one), despite the fact that householders are repeatedly surprised as the future unfolds, which is an inconsistency in our model.

In our main implementation of the dynamic model, actors have full and correct knowledge of future fertility and mortality probabilities, so the only source of uncertainty concerns future economic change as reflected in productivity rates and interest rates. Actors form their life cycle plans based on their expectation of future productivity rates and interest rates, which turn out to be incorrect. Each year, they must form new life cycle plans since their current circumstances are different than what they had foreseen.

The dynamic version of the age-time path of consumption is given below. It differs from the static version in that optimization occurs at all ages $x \geq z$ rather than solely at age $x = z$ and that these optimizations are based on expectations about future interest rate [$r^*(t)$] and productivity growth rates [which are reflected in Y^*_l]; these expectations are described in the text. Consumption is optimized at age x looking forward a years ($a \geq 0$) into the future when the household head will be aged $x+a$ in year $t+a$. In the dynamic equation, the value of future life time wealth must include both expected future earnings (as in the static model) and current wealth that reflects the accumulation of past savings. Wealth [$W(x,t)$] is defined so that cohort wealth is maintained. That is, there are lateral, not vertical, bequests – wealth saved by last year's households aged x-1 is shared among this year's surviving heads aged x.

$$C(x,a,t)=\frac{H(x,a,t)\left[W(x,t)+PV\left[Y_l^*(x,a,t)\right]\right]e^{\left(r^*(t)-\rho\right)a/\gamma}}{\int_0^{\omega-x} e^{-r^*(t)g}H(x,g,t)e^{\left(r^*(t)-\rho\right)g/\gamma}dg}$$

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Table 1. Demographic characteristics of a pre-transition and post-transition population.

Variable	Pre-transition	Post-transition	Ratio
Population growth rate	1.1%	0.0%	----
Life expectancy at birth	28.3	78.8	2.8
Total Fertility Rate	6.0	2.0	0.3
Average number of surviving children [l20*TFR]	3.1	2.0	0.7
Retirement years/ Working years	.078	.361	4.6
Proportion of population under age 20	.49	.26	0.5
Proportion of adult population over age 50	.21	.50	2.4
Wealth/Income	1.6	5.4	3.5
Savings/Income	4.0%	8.3%	2.1

[1] Unless population growth rates are reduced below their pre-transition levels, which ordinarily occurs only late in the transition if it occurs at all.

[2] Because cohort wealth is never negative in the simulations presented here, we have not imposed a non-negative wealth constraint in our model.

[3] Given the many parameters of the model, it would be possible to tailor the assumptions to improve the fit to the observed results. For example, raising the long run expected interest rate from .03 to .04 makes the simulations fit the survey data considerably better, by raising saving rates at younger ages. We have avoided doing this, however, preferring to see whether our best guesses at parameter values would produce a rise in saving during the transition.

[4] The reason that higher productivity growth rates reduce savings is that in our model, productivity growth operates across all age groups in a given year, rather than operating only on the cohort entering the labor force in that year. Therefore, life cycle earnings profiles rise more rapidly in our simulations when productivity growth is more rapid, unlike in the usual formulation.

[5] Theirs included restricted year effects to capture short-term fluctuations. We do not include these restrictions as our simulations are not influenced by short-term fluctuations. In addition, theirs includes the effects of co-resident elderly whereas ours does not.

[6] Note, however, that after age 69, when the last 25 year old child has left home, our simulated trajectory resumes its increase at an exponential rate equal to the interest rate times the elasticity of substitution, or in our case .6*.075 = .045; we truncated the plot at age 70. It appears from the Deaton and Paxson panel in the figure that consumption in their estimates would decline rather than rise. Also, we simulate single adult households rather than adult couples. With couples, mortality would continue to reduce household size after children’s departure.

Figure 1: Schematic Wealth Profiles

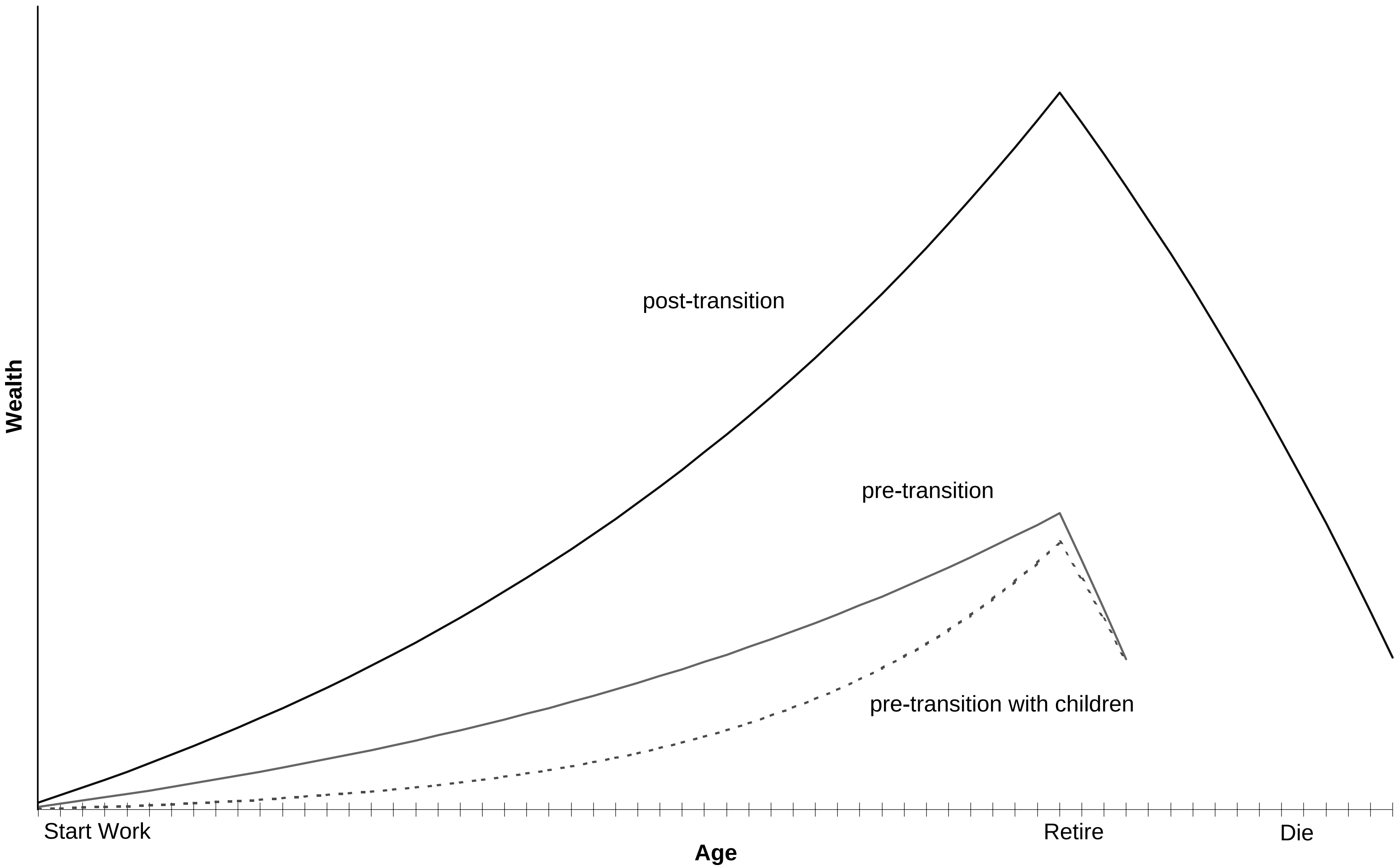


Figure 2. Life Expectancy at Birth and the Total Fertility Rate, Taiwan, 1900-2050

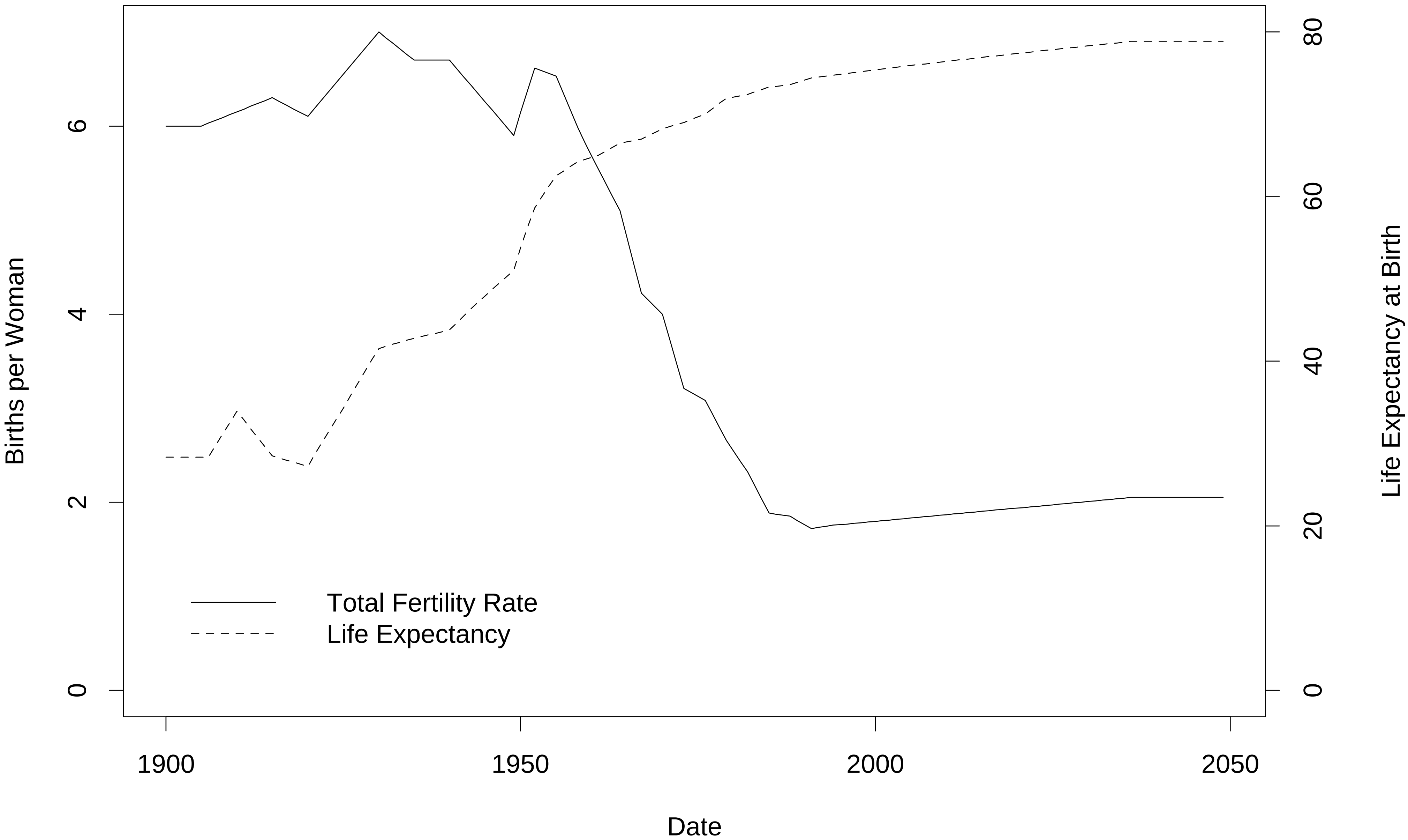


Figure 3. Simulated Savings Rate: Pseudo-Taiwan, 1950-2050

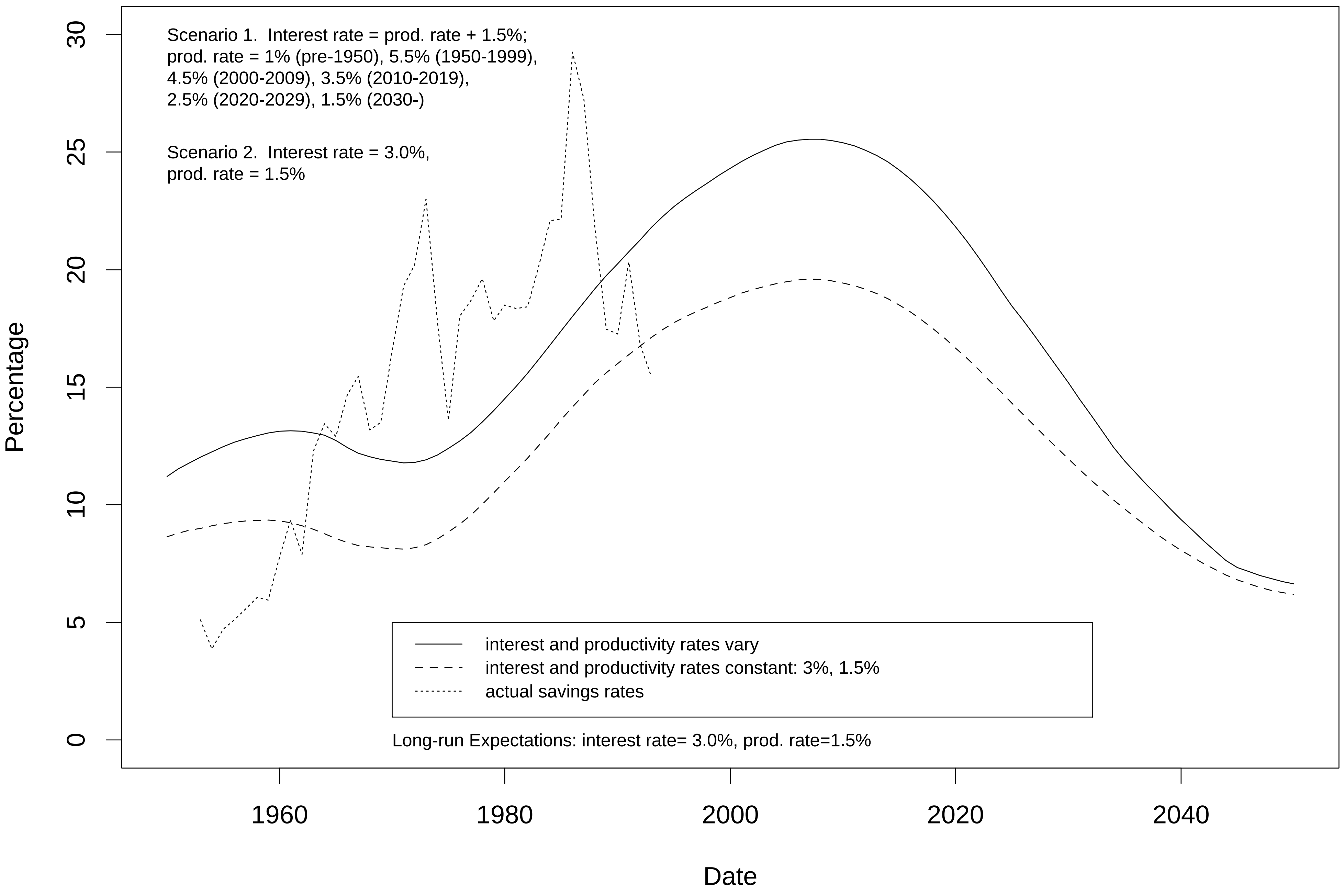


Figure 4. Simulated Wealth/Output Ratio: Pseudo-Taiwan, 1950-2050

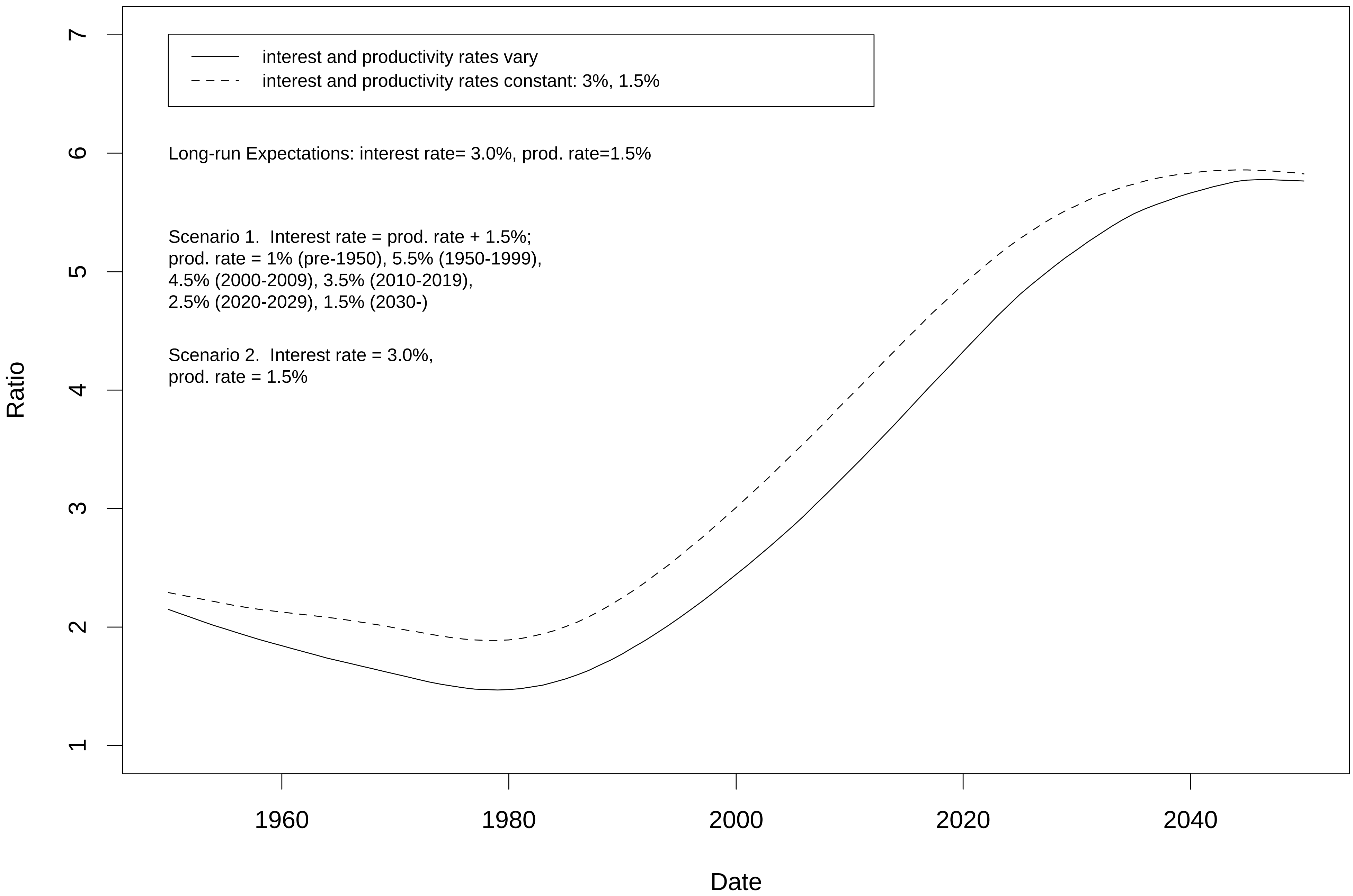


Figure 5. Household Age-specific Savings Rates: Actual and Baseline Simulation

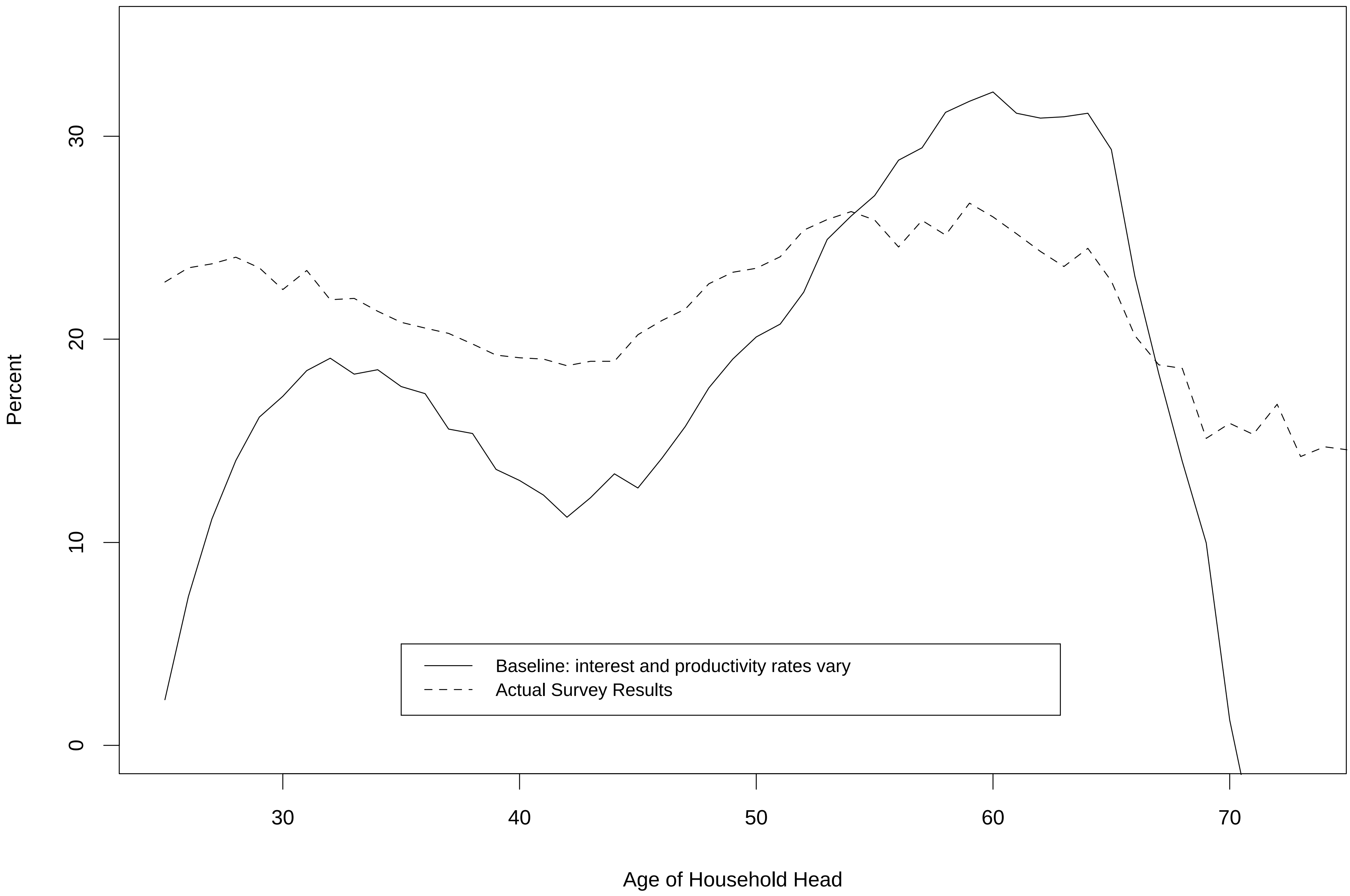
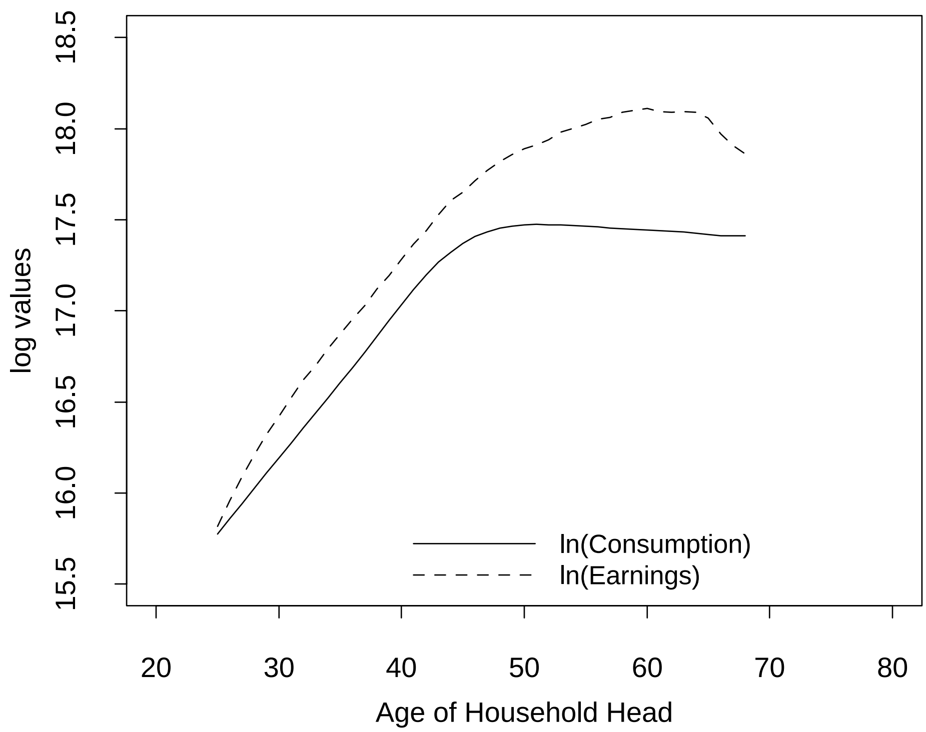


Figure 6. Household Consumption and Earnings by Age in Simulations and in Deaton and Paxson's Estimates from Survey Data

(a) Simulated Data from Lee, Mason, and Miller (1999)



(b) Estimates from Survey Data from Deaton and Paxson (1999)

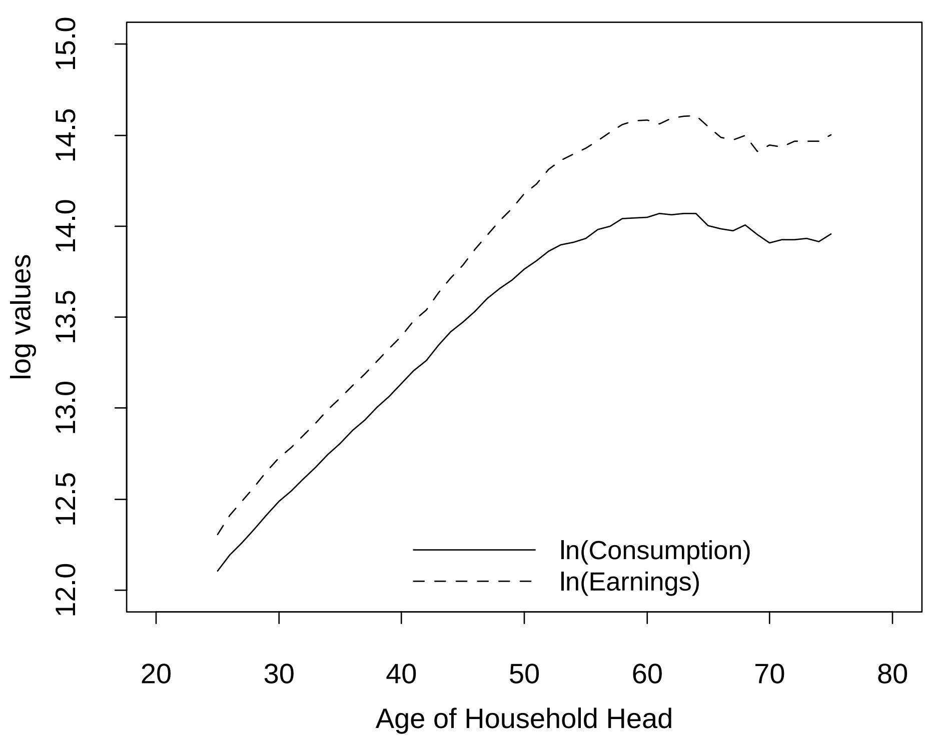


Figure 7. Simulated Demographic Effects on Aggregate Savings Based on Four Methods