Life Cycle Saving and the Demographic Transition: The Case of Taiwan

RONALD LEE
ANDREW MASON
TIMOTHY MILLER

MIGHT THE DEMOGRAPHIC transition from high fertility and mortality to low fertility and mortality cause an increase in saving rates and a rise in capital per worker? A large literature addresses this important question; and after a period of neglect, new but contradictory research has focused 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 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 in the form of either capital or 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 is provided largely by families, and the expectation of such support is a form of transfer wealth. The elderly are also supported in part from their holdings of property (capital), and savings flows will be 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 family 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.

We simulate the effect of the demographic transition on saving rates and the demand for capital, assuming that all savings are for the purpose of spreading consumption smoothly over the life cycle, and that there are no transfers for this purpose other than to children. We assume further that individuals correctly foresee all demographic changes, but that they base their expectations about future rates of interest and productivity growth on recent experience, using an ad hoc procedure, and that those expectations are typically incorrect. We treat actual interest rates and productivity growth as exogenous variables that are unaffected by saving 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 demographic transition, then rise quite substantially during a long middle period, and then decline again as the population aged rapidly in the last stage of the transition. Our simulated age patterns of income, consumption, and saving 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 saving 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 life time in order to smooth their consumption. Changes in a population's age structure weight differently the various stages of the life cycle and thus affect aggregate saving. If pension motives dominate life cycle saving, slower population growth leads to reduced saving (Modigliani and Ando 1957). If, however, childrearing costs dominate life cycle saving, slower population growth leads to increased saving (Coale and Hoover 1958).

Most theoretical analyses of aggregate saving based on the life cycle model have used comparative statics, examining the impact of different steady-state population age structures. Mason (1981 and 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 during the transition between steady states.

Several recent empirical studies based on international time series of cross-sections have found a close link between demographic change and saving (Fry and Mason 1982; Kelley and Schmidt 1996; Mason 1981, 1987, and 1988; Higgins and Williamson 1997). Analyses at the microlevel are less supportive. Although 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 modest effects on aggregate saving or no effect at all (Deaton and Paxson 1997; Mason, Woramontri, and Kleinbaum 1993). Deaton and Paxson find a substantial impact of demographic change on household saving over the transition in their microlevel analysis in this volume, but the impact is much smaller than that found by Kelley and Schmidt (1996) or Higgins and Williamson (1997) from cross-national analyses.

A consensus about the importance of demographic factors requires a reconciliation of these micro and macro approaches. Our microdata-based macrosimulations in this chapter offer a first step toward such a reconciliation.

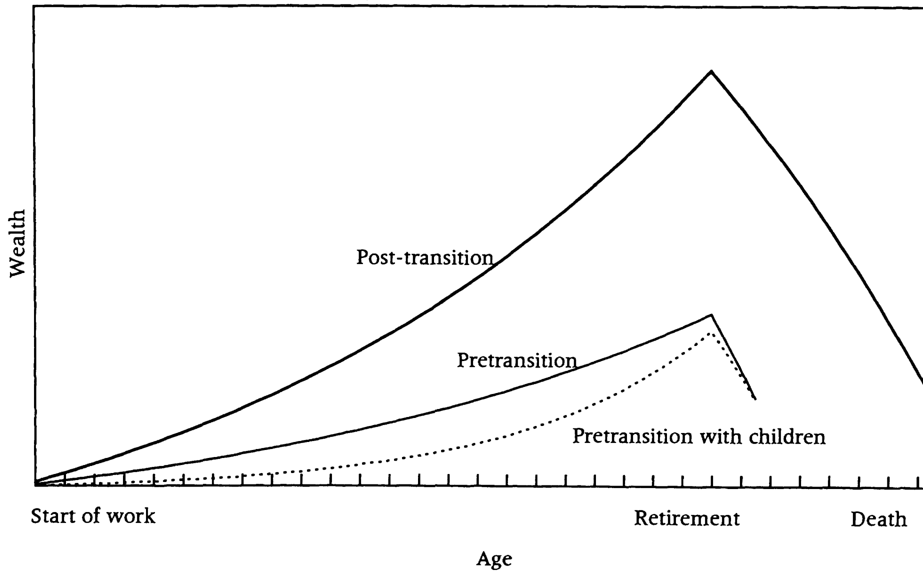
Demographic change and the demand for wealth over the life cycle

During childhood and old age, people on average consume more than they produce through their labor. During their middle years they produce in excess of their consumption. Consumption in childhood is generally supported by transfers from parents, with whom a child co-resides. Children, being financially dependent, 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).

Figure 1 illustrates the accumulation of wealth by households in a stylized manner. Adults enter the work force 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. (Wealth need not actually begin to decline until some years after retirement.) Life cycle models frequently assume that wealth is accumulated only to support consumption during retirement and declines to zero at death. There are many reasons why this may not be the case, however. Uncertainty about time of death may lead people to overaccumulate wealth. People may hold additional wealth as a buffer against uncertain income streams or consumption needs, and they 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 motivate 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).

In Taiwan, as in many countries, "retirement," conceived as an abrupt cessation of labor that takes place at some conventional age, such as 65, is

FIGURE 1 Schematic wealth profiles



rare. Instead, there is a gradual diminution of labor after age 50, but substantial proportions of people still work at age 70. Nonetheless, in discussing the problem of providing for old age, it is convenient to use some conventional marker for retirement age, which here we take to be 65.

The retirement motive for wealth accumulation is a relatively weak force in a pretransition population because, as a result of high mortality, the expected number of years spent in old age are few. For the pretransition mortality rates used here to characterize Taiwan, a typical individual could expect to live only 0.078 years after age 65 for every year lived between ages 20 and 64. As illustrated in Figure 1, a modest level of wealth is sufficient to finance average retirement needs in such a population. In a post-transition population, the number of years lived after age 65 for every year lived during 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.

The age-wealth profile also should be influenced by the number of children in a family. If children are costly, an increase in the number of children reduces consumption by their parents. If parents smooth consumption over their 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 the parents incur no childrearing costs, including their 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 individual children. Parents may also limit their fertility because they choose to spend more on each child. Changes in the number of children may influence other saving motives, such as bequests or uncertainty, affecting the wealth profile in ways that cannot be determined a priori.

Nondemographic factors also influence the wealth profile. If people desire to leave larger bequests, the demand for wealth shifts upward. A higher rate of interest may lead people to postpone consumption, thereby increasing their holdings of wealth. With higher interest rates, however, the wealth necessary to support a given level of consumption in old age is reduced. Interest rates consequently have an ambiguous effect on wealth profiles. Productivity growth also has an ambiguous effect on wealth profiles. A higher rate of productivity growth means that younger households will have higher lifetime earnings than older households and will consequently accumulate more wealth. But a higher rate of productivity growth means that households earn a smaller share of lifetime earnings at young ages. This will lead them to accumulate less wealth when they are 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 may lead individuals to go into debt if that is institutionally possible. The net impact on the wealth profile cannot 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 died at the same age, 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 Figure 1, we can conclude that because life expectancy is greater in a post-transition population, wealth per adult will be greater (provided that increases in the age at retirement do not offset increases in years lived), and that because post-transition families have fewer children, wealth per adult will be greater (provided that greater expenditures per child do not completely compensate for the decline in the number of children).

The age composition of a population reinforces these life cycle effects, given that a pretransition population has a large proportion of its population concentrated at younger ages, in which 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 expected number of years lived at old ages to the number of years lived during working ages is much greater in a post-transition population. The average number of children reared is smaller, and the proportion of the population concentrated at older ages is greater. Individually these demographic factors push the demand for wealth higher, and together they do so significantly.

TABLE 1 Characteristics of a population before and after demographic transition

Characteristic	Pre-transition	Post-transition	Ratio (post/pre)
Population growth rate (per year)	1.1%	0.0%	
Life expectancy at birth (years)	28.3	78.8	2.8
Total fertility rate (TFR), births per woman	6.0	2.0	0.3
Number of children surviving to age 20 (= TFR x l_{20})	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 per year	1.6	5.4	3.5
Savings/income (per year)	4.0%	8.3%	2.1

The hypotheses advanced above and those derived from most life cycle saving models apply to comparatively steady states. Demographic conditions prevailing before and after a demographic transition may be approximated as steady states, but conditions prevailing in transitional populations cannot. During a typical transition the number of surviving children per family first increases substantially and population growth rates rise as mortality declines, and then drop 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 to the economy. A further complexity is that during the transition, different cohorts experience different rates of fertility and mortality. This is particularly the case in East Asia, where demographic change has been very rapid. Thus no simple generalizations about the relationship between population, wealth, and saving during transition can be made.

Nonetheless, once we realize that under conditions of 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. That is so unless population growth rates are reduced below their pretransition levels, which ordinarily occurs only late in the transition if it occurs at all. Second, the level to which saving rates rise during the transition will depend on the speed of the transition. Populations that reach their post-transition wealth level quickly can do so only if saving rates are higher during the transition. (We explore the effects of the pace of transition on saving rates 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 shall see below that patterns may be quite complex, and that saving rates may both decline and rise at different times during the transition.

Despite the complexities of the life cycle model applied to the transition, 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; they might even 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 do not show such discontinuities; rather, household consumption per capita is flat across ages of individuals (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 claims on resources that permit them to consume increasing amounts per year during increasingly long periods of retirement.

Life cycle wealth as transfer wealth or capital

Wealth as we have defined it 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 or 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. Life cycle 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, but the anticipation of an obligation to make transfers to elderly parents might affect saving by their children.

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.

If, however, the family transfer system is replaced by a prefunded system, in which real wealth supports retirement, then the demographic transition leads to increased holdings of capital, fueling economic growth. Institutional forms of prefunded systems vary from country to country. Farmers and owners of small businesses 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 institutionalized such individual "life cycle saving" through large, mandatory saving and retirement programs.

The transition from a transfer system to a prefunded system for supporting the elderly must create a transitory increase in aggregate savings that will be superimposed on, and reinforce, the demographically induced temporary increase in savings. These dynamic effects of the movement from a family 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 saving (individual responsibility) has prevailed throughout.

There is ample evidence of a shift away from family support in East Asia, although family transfers are still considerably more common there than in the West. The proportion of Japanese elderly living with their children declined from about 70 percent to about 50 percent between 1970 and 1990 (Feeney and Mason 1998: 17). In 1973 more than 80 percent of Taiwan's elderly lived with their children (Weinstein et al. 1994: Table 12.6), but by 1993 only 60 percent of elderly men and 70 percent of elderly women were living with their children (calculated from the Family Income and Expenditure Survey; see Taiwan, Directorate-General of Budget, Accounting and Statistics 1993).

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 percent of Japanese women of childbearing age expected to rely on their children in old age. By 1990, only 18 percent expected to turn to their children for support in the future (Ogawa and Retherford 1993: 590, Table 2).

The following matrix 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 capital formation occurs when the demographic transition is combined with a transition to individual responsibility for old-age support.

Demographic stage	Private or public transfers	Prefunded system (individual responsibility)
Pretransition	Initial situation	Small increase in savings and capital
Post-transition	Small increase in savings and capital	Large increase in savings and capital

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

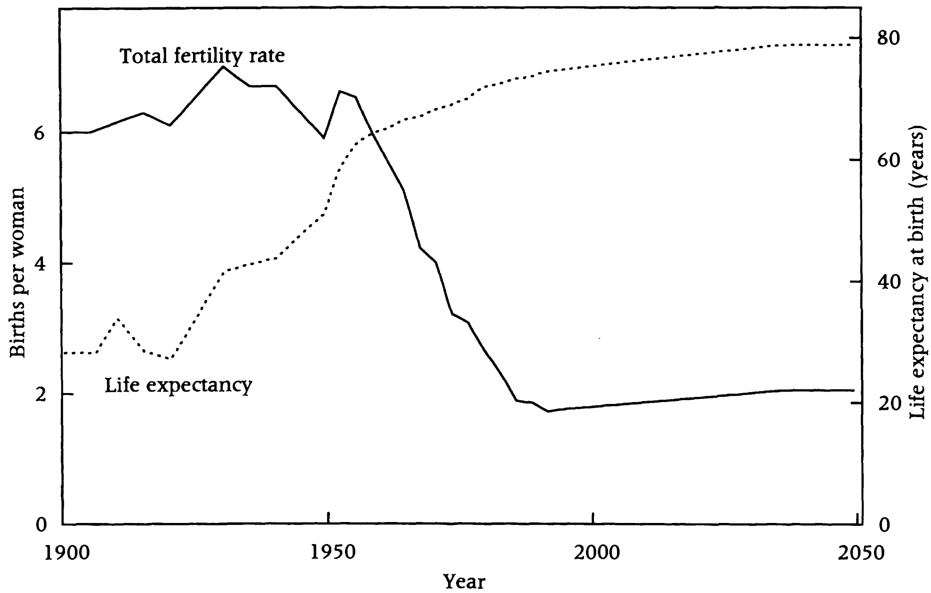
The dynamic simulation model

Our simulation model shows how aggregate saving rates and wealth change during the demographic transition if life cycle considerations (individual responsibility) before, during, and after the transition entirely determine saving by members of the population. The model takes the approach of Tobin (1967) and is similar to the one we used in Lee, Mason, and Miller (1997), wherein further details about it can be found.

The population composition in our 1997 study reflected actual census data, but here we generate the population from the historical and projected trajectories of mortality and fertility. (See the Appendix for details.) Consequently the population composition does not reflect the massive immigration from mainland China that occurred around 1950. We refer to the resulting transition as "pseudo-Taiwan." A comparison with the results in our previous study 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 total fertility rate for Taiwan, as well as the implied population growth rates, are shown in Figure 2. The total fertility rate is assumed to move slowly up to replacement level in future decades, and life expectancy at birth is assumed to rise to about 80 years by 2050.

On the basis of actual household headship rates, we set the age of an individual's economic independence at 25, a change from our previous

FIGURE 2 Actual and projected total fertility rate and life expectancy at birth: Taiwan, 1900–2050



study, in which it was 21. We assume that until this age, 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 the 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 Taiwanese males aged 25–29 were household heads, and so the actual age at which males leave home is typically later than 25. However, we assume (with no direct evidence) that adult children have increasing control over their earnings as they grow older, whether or not they continue to reside with their parents. Once they leave home and set up their own households, we assume they remain in their own households for the remainder of their lives. In reality many elderly currently reside with their adult children, but we anticipate that this arrangement will become less common as time passes. We do not know the extent to which the co-resident elderly are financially dependent on their children.

Consumption behavior within the household is governed by a utility-maximization model. In each period, adults decide how much of their income to consume and how much to save on the basis of their current wealth, 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. (In our earlier study we analyzed the impact of transfers in steady states.) While children are present in the home, they are supported by their parents, who give them 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 percent more resources than in a six-child family if household income is the same. Thus our model does entail some tradeoff between the number of children and their "quality."

Each householder calculates the present value of expected lifetime earnings, including the earnings of co-resident children. The present value of expected consumption over the household's lifetime is constrained to equal this amount. Couples distribute their household consumption over time so as to maximize their lifetime utility. Given the lifetime 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 r to be 0. For $(1/\gamma)$ we use an estimate of 0.6 for Taiwan calculated by Ogaki, Ostry, and Reinhart (1996). Because cohort wealth is never negative in the simulations presented here, we have not imposed a nonnegative wealth constraint in our model. We assume that the weight of children in consumption calculations by their parents rises as the children age, averaging 0.5. Additional elements of the simulation model are described in the Appendix 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. Householders formulate their plans on the basis of their expected years of life at each future date. Those 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 householders 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 profile of age earnings. The profile is equal to the average shape over the years from 1976 to 1990 in Taiwan, calculated from the annual 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 assumes 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 (1999).

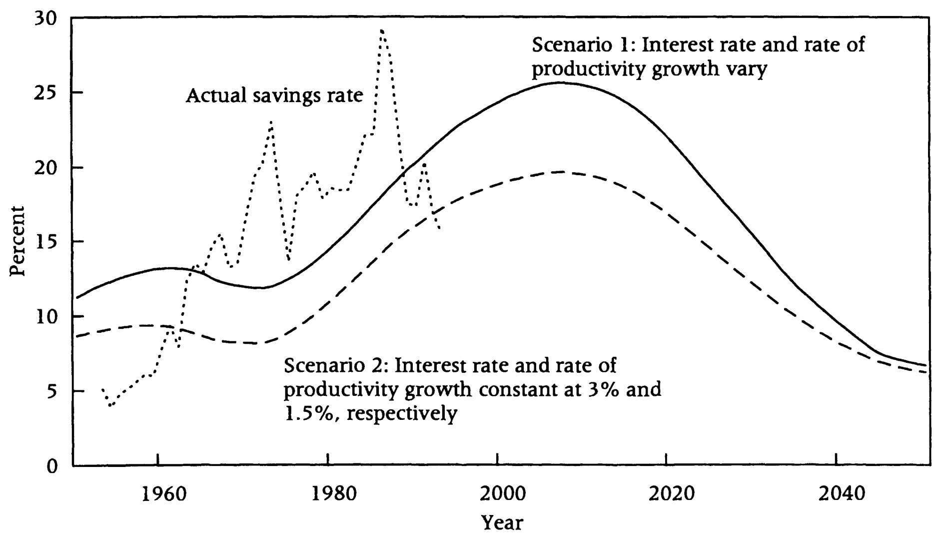
For the interest rate and productivity growth rate, we do not assume perfect foresight. Instead we make the ad hoc assumption that people base their expectations on the average experience of the past five years. Then, rather than assuming that this rate continues for the rest of their lives, we assume that they expect the rate to tend exponentially toward a long-term target rate, which is their long-term future expectation. These rates we have taken in our baseline simulation to be an interest rate of 0.03 and a productivity growth rate of 0.015. Our rationale 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, which will occur at a rate similar to the rates experienced in mature economies once the economy reaches equilibrium. Given that r has averaged 7.4 percent since 1950, and productivity growth has averaged 5.5 percent, we assume that people have been constantly surprised by continuing high rates. Our analysis is inconsistent, however, 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 chapter.

We start the simulations in 1800 to permit convergence to the steady state before the transition begins. Our results are presented either for 1900–2050 or, in some cases, for 1950–2050. We have not tried to take into account the loss of capital during World War II or, as mentioned earlier, the massive immigration to Taiwan of the 1950s. For our baseline scenario the productivity growth rate conforms to our best guess at historical and future trends. Thus it rises from a pretransition level of 1.0 percent per year, peaks at 5.5 percent over the period 1950–99, and then declines to a long-run average of 1.5 percent. The real interest rate is set at 1.5 percentage points above the productivity growth rate. People's expectations about eventual long-term values remain unchanged at 3.0 percent for the interest rate and 1.5 percent for the productivity growth rate. We assume a zero rate of time preference throughout.

Results of the simulations

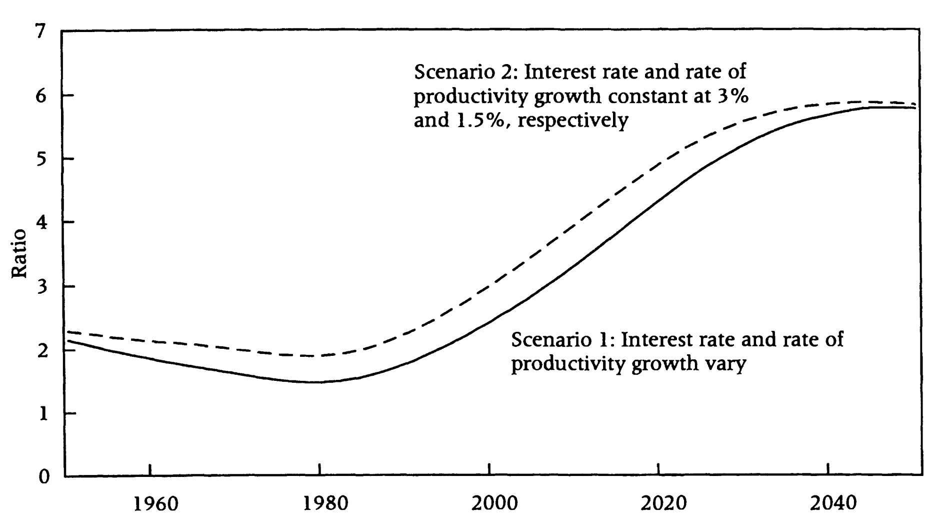
Figures 3 and 4 chart the trend in saving and wealth from 1950 to 2050 for the baseline simulation and several alternatives. The most prominent feature of the baseline simulation is the substantial swing in saving that begins about 1973 (Figure 3). The saving rate increases by almost 14 percentage points, doubling the 1973 rate by the time it peaks in 2007. This is followed by an even greater decline in the saving rate. The large swing in saving is a phenomenon that comparative-static analyses miss entirely but

FIGURE 3 Simulated saving rate: Pseudo-Taiwan, two scenarios 1950–2050



NOTES: In Scenario 1 (the baseline scenario) the interest rate equals the productivity growth rate plus 1.5 percent, whereas the productivity growth rate equals 1 percent (pre-1950), 5.5 percent (1950–99), 4.5 percent (2000–19), 2.5 percent (2020–29), and 1.5 percent (2030–50). In Scenario 2 the interest rate equals 3.0 percent and the productivity growth rate equals 1.5 percent. Long-run expectations are the same as in Scenario 2.

FIGURE 4 Simulated wealth-to-output ratio: Pseudo-Taiwan, two scenarios 1950–2050



NOTE: Interest rates and productivity rates for the two scenarios and long-run expectations are as described in the Note to Figure 3.

which we 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, the wealth-to-output ratio (Figure 4). A second important feature of the saving simulation is the dip that occurs in the 1960s and early 1970s. This dip in saving is related in complex ways to the changing numbers of surviving children in households.

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 that holds the interest rate and productivity growth rate constant at 3.0 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, which we are currently developing, interest rates and productivity growth would be determined in large part by the changes in capital induced by demographic factors. As W/Y approached 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 saving rate for the available years. There are significant dissimilarities between it and the simulated rates. The short-term fluctuations need not concern us; persistent differences are more relevant. As compared with the life cycle simulation, Taiwan was saving too little during the 1950s and early 1960s, too much between 1964 and 1988, 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 life cycle 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 life cycle 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 because we assume that people repeatedly underestimate the future productivity growth rate and interest rate. The second issue is the erosion of the family support system. Low saving rates are sufficient to satisfy life cycle needs when the elderly rely heavily on their children for economic support. Hence the rapid increase in saving is consistent with a shift from a transfer-based system to a system of self-reliance combined with purely demographic changes. As discussed earlier, during such a shift, saving 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 may 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. To assess the robustness of our results we have investigated different parameter values, different economic-input time series, and different formations of expectations. Given the many parameters of the model, it would be possible to tailor our assumptions to improve the fit to the observed results. For example, raising the long-run expected interest rate from 0.03 to 0.04 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.

For parameter values, we set the elasticity of substitution at 0.3 and at 1.0, in contrast to 0.6 in the baseline. The resulting level of the saving rate is much lower for 0.3 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. We obtain similar results when we vary the Equivalent Adult Consumer 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 being equal, a higher interest rate raises saving rates, and higher rates of productivity growth reduce savings, but the impact of demography on the saving rate remains qualitatively similar.[1] For expectations, the results are largely unchanged if, instead of having perfect foresight about future mortality, householders expect that each period's age-specific mortality will persist. We conclude that the effects of demographic change on aggregate saving 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 with household data provides another check on the realism of the simulations, once we take into account some issues of noncomparability. First, household surveys provide a narrow measure of saving and wealth, excluding, 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 consists of 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 with the simulated age-saving profile for the same period. The actual and 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 life cycle 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 life cycle model to Taiwan. (See Hurd 1997 for a recent review of these issues.)

Results presented in Figure 6 address a recent criticism of the life cycle saving model. Empirical studies show that consumption tracks income quite closely (Carroll and Summers 1991; Paxson 1996), whereas the standard

FIGURE 5 Household age-specific saving rates: Baseline simulation and actual survey results for Taiwan

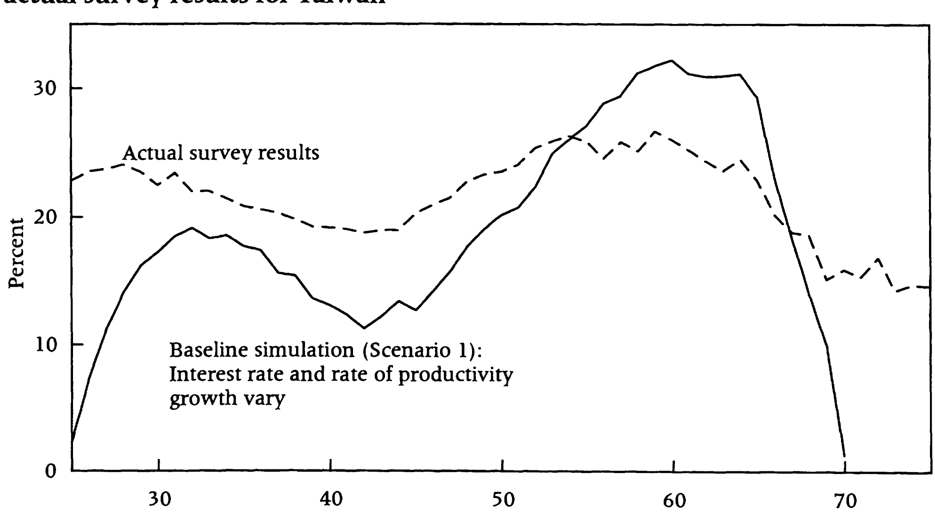
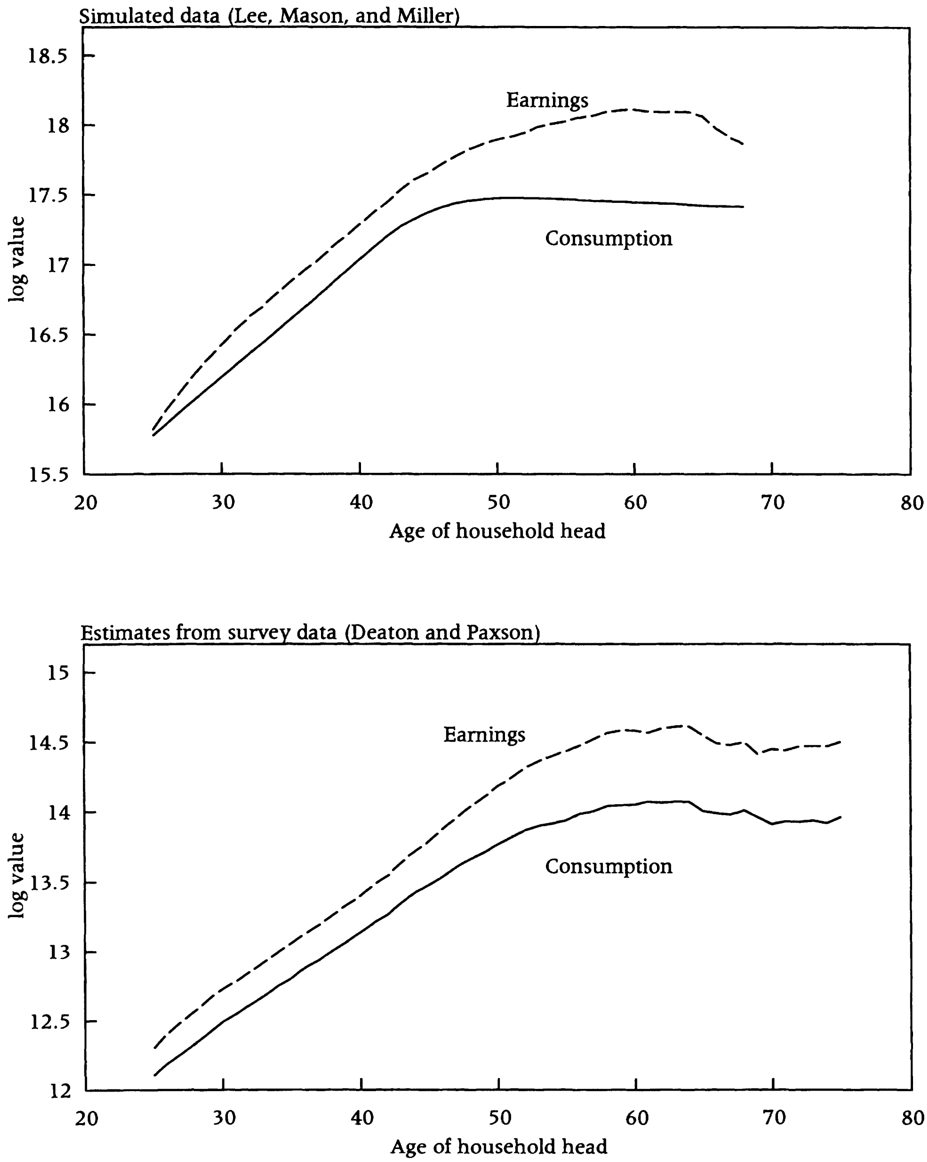


FIGURE 6 Household consumption and earnings by age of head: Our simulations for Taiwan and Deaton and Paxson's estimates from survey data



life cycle model implies that the path of consumption should depend only on total lifetime 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 the issue with respect to our simulation model by duplicating the upper right portion of Figure 1 from Deaton and Paxson's chapter in this volume, except that their figure is based on an analysis of survey data, whereas ours is based on an analysis of simulated data for the same period. The plots show the estimated "age effects" from regressions of the logarithm of consumption and of income on age and cohort. Deaton and Paxson include restricted year effects in their plot to capture short-term fluctuations. We do not include these restrictions because our simulations are not influenced by short-term fluctuations. In addition, their estimates include the effects of co-resident elderly whereas our simulations do not.

The two plots are very similar, although not identical. They show the logarithm of income rising by the same amount (no surprise there, since that is in the data), and consumption rising by less, leveling out well below income in the later years. In the simulations this leveling of consumption occurs in the mid- to late 40s, reflecting declines in household size, whereas 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 for Taiwan, together with others for other countries, as showing that "consumption 'tracks' income over the life cycle." They state that this 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. 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 $0.07 \times 0.6 = 0.042$; 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. In addition we simulate single-adult households rather than adult couples. With couples, mortality would continue to reduce household size after the children's departure.

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 lifetime earnings, consume about the same amount as the concurrent elderly, who have much lower lifetime earnings. The longitudinal and cross-sectional implications of the simulation are empirically realistic (see the preceding discussion in this section). However, it is doubtful that consumption and saving behavior are so strongly influenced by interest rates, since the empirical literature suggests that behavior is fairly insensitive to interest-rate variations. We would like to experiment with nonstandard models that contain elements of life cycle saving but build on simpler "rule of thumb" specifications, modified by demographic factors. One such model we have examined assumes that householders save a fixed proportion of income throughout their lives until "retirement," with the amount set to provide a retirement income equal to 70 percent 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 as a result of longer life and the changing age distribution of household heads.

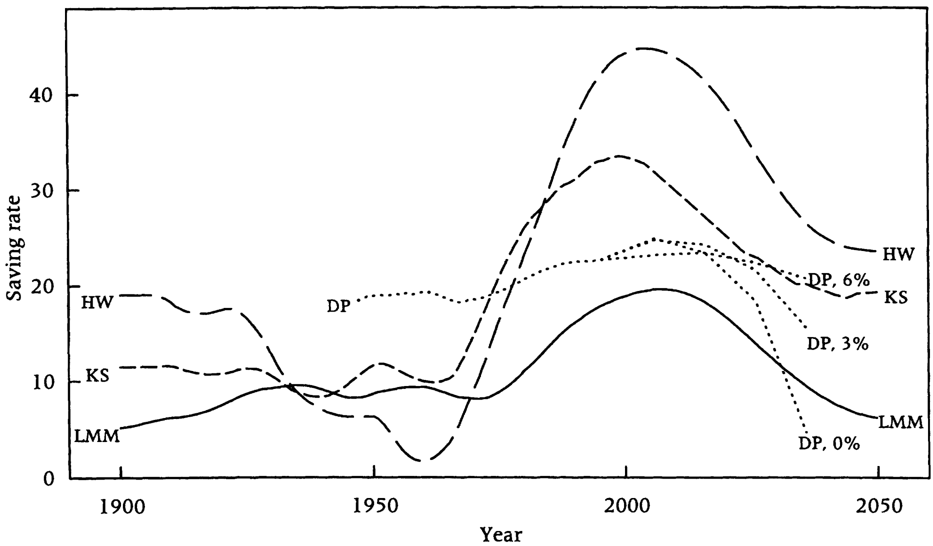
Demographic influences on savings implied by different approaches

We are now in a position to compare the implications of savings derived from three contrasting 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 such studies, those of Kelley and Schmidt (1996) and of Higgins and Williamson (1997), labeled, respectively "KS" and "HW" in the figure. The simulations show gross saving rates. The main effect to note is the large upswing in saving rates followed by a downswing 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 saving rates due to deteriorating child dependency ratios in earlier stages of the transition.

Deaton and Paxson (in this volume) employ a very different approach, the results of which are also graphed in Figure 7 (where they are labeled "DP"). Using data from 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), they found that demographic change essentially had no impact. Their current analysis accounts for the effects of co-residency of older and younger adults on household age profiles and examines the effects of transitional changes in population age distributions. They conclude that demographic change has a modest effect on saving. Although the changes they observe are substantially smaller than in the Higgins and Williamson simulation 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 Higgins and Williamson (1997) or our simulations. Saving then rises, reaching a peak in about the same year as the simulations. The swing from trough to peak is 6 to 7 percentage points (depending on the scenario), much smaller than the rise in the

FIGURE 7 Simulated demographic effects on aggregate savings based on four methods: Taiwan, 1900–2050



SOURCES: DP: Deaton and Paxson (in this volume); KS: Kelley and Schmidt (1996): HW: Higgins and Williamson (1997); LMM: Lee, Mason, and Miller (this chapter).

other two analyses, but far from inconsequential. For the future they find a very slight decrease in saving if Taiwan's current rate of productivity growth persists (at 6 percent per year). With lower productivity growth (0 percent or 3 percent), they estimate large declines in saving.

Our own macrosimulations (labeled "LMM" in Figure 7) show swings 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 percentage points for gross savings (the measure used in cross-national studies). Reconciling the macro- and microstudies 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's simulations, although not as large as estimated by Higgins and Williamson. But given a sufficiently strong transfer system, either family-based or public, demographic changes would have a considerably smaller impact than in our simulations. Thus one cannot 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 that future economic growth will decline slowly to a long-run average of 1.5 percent. We chose two of Deaton and Paxson's scenarios (0 percent and 3 percent economic growth), 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. Higgins and Williamson's simulation examines only the effect of changes in demographic structure on savings, holding economic growth constant.

The results can be partly reconciled by taking definitional differences into account. Higgins and Williamson analyze a very broad measure of saving, gross national saving rates, which 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. Nevertheless, definitional differences almost surely do not account for all of the differences apparent in Figure 7.

An additional feature of Deaton and Paxson's 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 theirs 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, we find that 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 of the transition when the total dependency rate was falling. In the presence of productivity growth, savings would be higher after the transition than before, but otherwise not. In reality, pretransitional old age was supported largely by family transfers. Over the demographic transition a concurrent move from family transfers to individual responsibility for old age (or funded pension systems) would itself generate a larger increase in savings than there would have been had life cycle saving always been the rule.

Life expectancy at birth is now two or three times as long as in the past, but the implications of mortality decline for savings have been largely ignored. Declining mortality could explain a large part of increased savings even with no change in a population's 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 the mortality decline would have less, if any, effect on saving. But at this point in the history of 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: microanalysis of survey data, macroanalysis of cross-national data, and our macrosimulation based on microdata. However, the simulation based on analysis of survey data shows swings of 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 saving rates, in Taiwan. Our simulations do not fit the timing of changes particularly well, and they predict a modest early decline in saving rates in the 1950s and 1960s that was not observed. The levels and expected changes in family transfers must surely play an important role in the explanation of saving behavior in Taiwan, and we have not yet examined this possibility systematically. Other influences on saving, such as buffering against the 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 it the massive demographic changes over the course of the demographic transition have influenced saving behavior and wealth accumulation, and will continue to do so in the future.

Appendix

For the demographic components of our model, we specify time paths of life expectancy at birth (e_0) and the total fertility rate (TFR). We then derive age-specific rates from these summary measures by assuming that rates for age x and 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 1993; Lee and Carter 1992). In the case of mortality, $m_{x,t}$ is the log of the age-specific death rate for age x at time t, and in the case of fertility it is the 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 e_0 or TFR. The vectors a and b are chosen (for each of fertility and mortality) to provide a good fit to Taiwan's 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. Here, unlike elsewhere, we assume that the population is closed to migration. This means that we ignore the demographic effects of immigration from the Chinese 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."

Details of our model of economic behavior can be found in the appendixes 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 lifetime utility, V:

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

where z is the head's age at forming a household, ω is oldest age with nonzero 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 (EAC) units, 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 as $H(x)$, 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 but subject to the constraint that the present value of expected future lifetime earnings of householders, and their children while co-resident $[PV(Y_l)]$, 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:

$$C(x) = \frac{H(x) PV[Y_1] e^{(r-\rho)x/\gamma}}{\int_z^{\omega} e^{-ra} H(a) e^{(r-\rho)a/\gamma} da} \ .$$

It follows that the life cycle trajectory of consumption per EAC rises at the rate $(r-\rho)/\gamma$, where γ is the inverse of the intertemporal elasticity of substitution. Bearing in mind that $C(x)/H(x)$ is consumption per surviving EAC, we readily show this to be consistent with the well-known analysis by Yaari (1965: Case C) for consumption paths under uncertain lifetimes, given the availability 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 actors make every decision as if they were completely certain about the future (except that survival is a probability, albeit a fully ensured one). We make this assumption 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 that the only uncertainty concerns future economic change as reflected in productivity rates and interest rates. Actors form their life cycle plans on the basis of their expectations of future productivity rates and interest rates, which turn out to be incorrect. Each year they must form new life cycle plans because their current circumstances are different from what they foresaw earlier.

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 rates [$r^*(t)$] 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 lifetime 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.

$$C(x,a,t) = \frac{H(x,a,t)\left[W(x,t) + PV\left[Y_1^*(x,a,t)\right]\right]e^{(r^*(t)-\rho)a/\gamma}}{\int_0^{\omega-x} e^{-r^*(t)g} H(x,g,t)e^{(r^*(t)-\rho)g/\gamma}\,dg} \; .$$

Notes

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1 The reason that higher productivity growth rates reduce savings is that, in our model, productivity growth occurs in all age groups in a given year, rather than only in the cohort entering the labor force in that year. Therefore profiles of life cycle earnings rise more rapidly in our simulations when productivity growth is more rapid, contrary to the usual formulation.

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