Why Nations Become Wealthy:
The Effects of Adult Longevity on Saving

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Abstract

Many countries experienced a remarkable increase in life expectancy during the 20th century, but the development implications have received only modest attention. We analyze steady state and out-of-steady-state effects of the transition in adult longevity on the national saving rate using an overlapping generations model. We show that the national saving rate depends on both the level and rate of change in adult survival. Countries with rapid transitions have particularly elevated saving rates. Empirical evidence is drawn from two sources: long-term historical trends for a small number of countries and world panel data for 1960-95. Two important conclusions are supported by the empirical analysis. First, the demographic transition had a large positive effect on aggregate saving, but over three-quarters of the gain was due to improvements in old-age survival rather than declines in youth dependency. Second, population aging will not lead to a decline in aggregate saving rates. The compositional effect – lower

saving rates among the elderly – is dominated by the behavioral effect – individuals will save more to provide for a longer old age.

1.Introduction

One of the most salient features of modern economic development is the increase in wealth and capital. In the US, for example, GDP grew at annual rate of 3.6 percent between 1820 and 1992. By comparison, the non-residential capital stock grew at an annual rate of 5.0 percent. As a result, the ratio of non-residential capital stock to GDP increased by twelve-fold. The experience of the UK, with a thirteen-fold increase between 1820 and 1992, was similar. Over a considerably shorter period, 1890 to 1992, Japan's capital-output ratio increased eleven-fold increase and, in the process, passed the US (Maddison 1995). The extraordinary growth in wealth and capital was repeated, in a more condensed form, in the Newly Industrializing Economies. High rates of saving and investment in South Korea, Taiwan, Singapore, and several other Asian countries has led to rapid capital deepening.

Why did this occur? The demand side undoubtedly played an important role. Technological innovation led to new and better equipment and machinery. Structural change led to industrialization and the growth of the manufacturing and service sectors with accompanying investment. The possibility explored in this study, however, is that the modern rise in wealth was driven in large part by an important supply side factor – the rise in adult mortality.

The proportion of adult life lived after age 60 began to increase steadily in the West in the late 19th Century. In other parts of the world increases began much later – in the middle of the 20th Century. Retirement emerged as a significant feature of the lifecycle creating a powerful saving incentive. Institutional responses, the emergence of funded employment-based pension plans, the rise of the commercial financial service sector, the creation of tax incentives, and, in some countries, the establishment of funded public retirement systems, reinforced the effects of increased longevity. Other responses, particularly the creation of transfer-based public pension programs in Latin America, Europe, and to a lesser extent in Japan and the US, undoubtedly undermined the incentive effects of a longer life span.

That rising life expectancy leads to higher saving is not a new idea. Yaari's (1965) seminal work established the micro-level theoretical foundation. Since then other scholars have explored the aggregate effects using steady-state models and simulation analysis. Previous empirical work supports the existence of an important link between saving and life expectancy (Bloom and others, 2003; Borsch-Supan, 1996; Cutler and others, 1990; Davies, 1981; Kageyama, 2003; Kuehlwein, 1993; Leung, 1994; Schieber and others, 1996; Yaari, 1965; Zilcha and others, 1985).

The theoretical analysis described briefly in Section 2 employs an overlapping generations model which extends previous work to a dynamic context. A unique implication of the model is that the aggregate saving rate is influenced by both the level and the rate of change of adult life expectancy. Given the current level of mortality, countries experiencing rapid mortality transitions will have higher saving rates. The underlying logic behind this result is straight-forward. If a rapid mortality transition country is playing catch-up, for example, the wealth required to support a longer retirement must be accumulated over a shorter period of time. Thus, saving rates must be elevated during the catch-up period.

The empirical analysis relies on two different approaches. Section 3 takes an historical perspective by looking at data for seven countries for which we can track saving and mortality trends over all or a substantial part of the entire demographic transition. In the sub-group of Western countries, adult life expectancy changed very slowly or not at all until the middle or end of the 19th Century. Thereafter, life expectancy changed at a pace that was remarkably constant and varied little from one country to the next. The sub-group of Asian countries began their mortality transitions later, went through a catch-up period when adult longevity increased rapidly, followed by a period of steady increase at a rate similar to that found in the West.

The difference in the demographic transitions between the West and East Asia offers a useful opportunity to compare the implications of our theoretical model with the experiences of these two groups of countries. Some of the idiosyncratic features of the saving trends are not explained by our model, but there is broad consistency. The increase in adult mortality was accompanied by a rise in aggregate saving rates in most countries. Rapid mortality transition was clearly accompanied by elevated saving rates.

In Section 4, we estimate the saving model using aggregate cross-national data. The evidence is consistent and robust in its support of the hypothesis that an increase in old-age survival leads to higher saving rates. In a sub-sample consisting of Western and East Asian countries, the rate of increase in old-age survival also has a positive effect on saving. In other parts of the developing world, however, we do not find evidence that the rate of change in old-age survival has an effect on saving. Why different patterns persist is an issue requiring further exploration.

Two additional features of the analysis are important. First, several recent studies conclude that changes in age structure, especially the decline in the youth dependency ratio, accounted for high saving rates especially in East Asia (Higgins and others, 1997; Kelley and others, 1996). Simulation studies (Lee and others, 2000; 2001a; 2001b) and empirical work based on household survey data (Deaton and Paxson, 2000) ascribe a substantially less important role for age structure. The empirical analysis presented here offers some reconciliation of these views. Once we control for adult life expectancy and its rate of change, the youth dependency ratio has a smaller effect than previously estimated. The decline in youth dependency accounts for about one-quarter of the increase in saving rates in East Asia, while changes in adult survival account for about three-quarters of the increase.

Second, while some studies conclude that population aging will lead to substantial declines in aggregate saving rates, we do not find this to be the case. So long as adult mortality continues to rise – as it has for many decades – will not drive saving rates lower.

2. The Theory[1]

Changes in adult survival influence aggregate saving in two ways in the lifecycle model employed here. First, there is a behavioral effect. The expected duration of retirement rises as the survival rate increases. Thus, individuals will consume less and save more during their working years in order to support more expected years of consumption and greater dis-saving during retirement. Second, there is a compositional effect as increases in the adult survival rate lead to an increase in the share of retirees in the adult population. Given that retirees are saving at a lower rate than workers, the compositional effect of an increase in adult survival is to reduce aggregate saving.

The net effect on saving is considered in steady-state and in dynamic settings. We approach the dynamics in two ways, first, by considering the effect of a one-time increase in survival and, second, by considering the effect of continuing increases in survival rates. As is shown in the empirical section, considering these alternatives brings a clearer understanding of how the mortality transition – as it is actually evolving – will influence aggregate saving rates.

Consider a population consisting of two generations of adults. Each person lives for up to two periods – the first period as a working, prime-age adult and the second period as a retiree. All individuals survive their working period, and q_t survive to the

[1] Theoretical results are summarized here. More details are available in Kinugasa, 2004.

end of their retirement period. The remaining members of the population (1-q_t) die at the end of the first period of life. Thus, q_t is the probability of reaching retirement age, the expected years lived during retirement, and the ratio of retirement years to working years for the average member of the population. Individuals cannot foresee whether they will survive, but they know the value of q_t for the population. Costless annuities are available so that individuals protect themselves against longevity risk by purchasing an annuity. Individuals know the interest rate that the annuity will pay.

The consumer's optimization problem is to maximize lifetime utility, assuming constant relative risk aversion, $V_t = \frac{c_{1,t}^{1-q}}{1-q} + dq_t \frac{c_{2,t+1}^{1-q}}{1-q}$, given the lifetime budget constraint: $w_t A_t = c_{1,t} + \frac{q_t}{1+r_{t+1}} c_{2,t+1}$; $c_{1,t}$ is consumption while a prime-age adult and $c_{2,t+1}$ is consumption while elderly; d is the discount factor, defined as *d=1/(1+?)*, where *?* is the discount rate; *1/?* is the intertemporal elasticity of substitution; r_{t+1} is the interest rate; A_t is labor-augmenting technology; and w_t is the wage per unit of effective labor.

Kinugasa (2004) shows that the per capita savings of prime-age adults and retirees are:

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\begin{aligned}
s_{1,t} &= \Psi_t A_t w_t = \frac{q_t d^{\frac{1}{q}} A_t w_t}{q_t d^{\frac{1}{q}} + (1+r_{t+1})^{\frac{q-1}{q}}} \\
s_{2,t} &= -s_{1,t-1} = -\Psi_{t-1} A_{t-1} w_{t-1} = \frac{q_{t-1} d^{\frac{1}{q}} A_{t-1} w_{t-1}}{q_{t-1} d^{\frac{1}{q}} + (1+r_t)^{\frac{q-1}{q}}}
\end{aligned}
\qquad (1)
$$

where ? $_t$ is the share in wage income of saving by prime-age adults. An increase in the adult survival rate has an unambiguous positive effect on ? $_t$ and, hence, on per capita saving by prime age adults. An increase in the adult survival rate has an unambiguous negative effect on per capita saving by retirees. The response of the combined saving of workers and retirees to changes in survival depends on additional features of the macro-economy to which we now turn.

Gross domestic product (Y_t) is produced by a Cobb-Douglas production function with labor-augmenting technological growth, i.e., $Y_t = K_t^f L_t^{1-f}$, where f is the share of capital in GDP, $0 < f < 1$. $L_t = A_t N_{1,t}$ is the aggregate labor supply measured in efficiency units. $N_{1,t}$ is the population of prime-age adults and A_t is the technology index. The population growth rate per generation is *n-1* and, hence, $N_{2,t} = N_{1,t} / n$.

The technological growth rate per generation is *g-1*. Hence, the relationship between the total lifetime labor income of prime-age adults and pensioners is given by $w_{t-1}A_{t-1}N_{2,t} = w_t A_t N_{1,t} / gn$. Using lower case letters to represent quantities per unit of effective worker, output per effective worker is $y_t = k_t^f$ and the capital-output ratio is k_t^{f-1}. The depreciation rate (x) is assumed to be constant; hence, depreciation as a share of GDP is $x k_t^{f-1}$.

Total gross national saving is the sum of the saving of adults ($S_{1,t}$), the saving of the elderly ($S_{2,t}$) and depreciation (*?K*$_t$). Dividing by Y_t yields the gross national saving rate at time t:

$$\frac{S_t}{Y_t} = (1-f)\left(\Psi(q_t, k_t) - \Psi(q_{t-1}, k_{t-1}) \frac{1}{gn} \right) + x k_t^{1-f} \qquad (2)$$

The term $(1-f)$ is the share of labor income in GNP, $\Psi_t(q_t, k_t)$ is saving by current workers as a share of current labor income, $-\Psi(q_{t-1}, k_{t-1})\frac{1}{gn}$ is saving by current retirees as a share of current labor income, and $x k_t^{1-f}$ is depreciation as a share of current GNP.

Steady-state Rate of Growth Effects

The steady-state gross national saving rate is:

$$\left(\frac{S}{Y}\right)^* = (1-f)\Psi(q^*, k^*)\left(\frac{gn-1}{gn}\right) + x k^{*1-f} \qquad (3)$$

where the * superscript denotes equilibrium values. Standard and well-known implications of the lifecycle model (Modigliani and others, 1954) follow directly from equation (3). First, the net saving rate is zero if the economy is not growing (*gn=1*). Second, the partial effect of an increase in the GDP growth rate is equal to the mean age of earning less the mean age of consumption, as in the variable rate-of-growth model (Mason (1981,1987) and Fry and Mason (1982)),. As shown in Kinugasa, ? is the difference between the mean ages consumption and earning.[2]

The Effect of Adult Survival in Steady-State and in Transition

The effect of changes in adult survival on saving depends on whether or not the capital-labor ratio and interest rates are endogenous. In a small open economy, the equilibrium capital-labor ratio and interest rates are determined by global economic conditions. A rise in domestic saving – and factors that influence the saving rate – will have no effect on domestic investment nor on domestic interest rates. In a closed economy, however, saving and investment are equal and the rate of interest is endogenously determined by the interplay of the supply of capital by households and the demand for capital by firms. The effect on saving of an increase in adult survival in each of these environments is considered in turn.

Saving in a Small Open Economy

The effect of an increase in adult survival on the steady state saving rate in a small open economy depends on the rate of growth of income. If the economy is growing, $gn>1$, the steady state saving rate rises with adult survival. In an economy with negative economic growth, the steady state saving rate declines with an increase in adult survival. The steady state saving rate given by equation (3) holds with k^* exogenously determined. An increase in adult survival leads to a rise in the share of labor income saved by prime age adults, i.e., $\partial\Psi^* / \partial q^* > 0$, but the dis-saving by retirees increases, as well. In a growing economy, the increase in saving by prime age adults dominates the decline in saving by retirees and the aggregate saving rate rises with adult survival. In a declining economy, the decline in saving by retirees dominates and the aggregate saving rate declines as adult survival rises.

The response of saving rates in a dynamic context is more complex. Consider a small open economy that is in equilibrium, but experiences and increase in the survival rate in period *t*. Prime age adults respond by increasing their saving rates, while saving by retirees is unaffected. The aggregate saving rate must rise in period *t*. The transitory increase in saving is independent of the rate of economic growth *gn*. In period *t+1*, dis-saving by retirees rise and the aggregate saving rate declines. In the absence of further changes in survival, a new equilibrium saving rate is established in period *t+1*. As shown above, the new equilibrium depends on the rate of economic growth. In a growing economy, it will be higher than the rate of saving in period *t-1*, but lower than saving in period *t*.

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[2] In this model, the mean age of consumption is $(c_{1,t} + 2q_t c_{2,t+1})/(c_{1,t} + q_t c_{2,t+1})$ and the mean age of earning is 1.

Saving in a Closed Economy

In a closed economy, an increase in the saving rate leads to greater investment, capital deepening, more rapid growth in wages, and a decline in the interest rate. The supply of capital follows directly from the saving model presented above, because the capital stock in period *t+1* is equal to total saving by prime-age adults in period *t*. Expressed as capital per effective worker, the supply of capital in year *t+1* depends on the wage per effective worker in year *t*, the share of that wage that is saved by prime-age adults, and the rate of growth:

$$k_{t+1} = \frac{y\,(r_{t+1}, q_t) w_t(k_t)}{gn} = \mathbf{S}_t(\underset{?}{r_{t+1}}, \underset{+}{w_t(k_t)}, \underset{+}{q_t}), \qquad (4)$$

where S_t is the supply function of capital. The effect of the interest rate on the supply of capital is ambiguous.[3] The wage is equal to the marginal product of an effective worker, $w_t = f(k_t) - k_t f'(k_t)$ and is increasing in capital per effective worker. An increase in the survival rate leads to an increase in the share of labor income saved by prime-age adults and, hence, capital per effective worker and the supply of capital.

The demand for capital, **D**, is governed by the marginal condition that the cost of capital equals the net return, i.e., $r_{t+1} = f'(k_{t+1}) - x$. That $f''<0$ implies that the demand curve is downward sloping. The demand for capital is independent of the survival rate.

The effect of an increase in the survival rate from q^* to q' in period 1 is traced in Figure 1. The demand curve, **DD**, is unaffected. Workers in period 1 increase their saving because in period 2 they expect to live longer and, perhaps, because they expect lower interest rates to depress the rate of return on annuities. Thus, the supply curve, **SS**, shifts to the right in period 2. This leads to a rise in capital per worker and wages for the new generation of workers. As a result, the saving function shifts further to the right, in part, because of the expected further decline in interest rates. The process continues until a new equilibrium is established.[4] Unless the decline in interest rates leads to a substantial reduction in saving by prime-age adults – a possibility not born out by empirical research – an increase in adult survival in period *t* leads to capital deepening.

The effect of survival on aggregate is readily inferred from its effect on capital per

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[3] In the simulation results presented below we assume that an increase in the interest rate leads to greater saving. Qualitative results hold unless an increase in interest rates have a large negative effect on saving – a possibility not supported by empirical evidence. For details see Kinugasa 2004.

[4] The economy converges in a non-oscillatory pattern to the steady state under plausible parameter values. See Kinugasa (2004) for details.

effective worker. In a closed economy, the saving rate is:

$$\frac{S_t}{Y_t} = \left(gn\frac{k_{t+1}}{k_t} - 1 + x \right) k_t^{1-f}. \tag{5}$$

In steady state, the relationship simplifies to:

$$\left(\frac{S}{Y} \right)^{*} = (gn - 1 + x)\, k^{*1-f} \tag{6}$$

From inspection of equation (6) an increase in the equilibrium capital-labor ratio and, hence, the capital-output ratio (k^{1-f}), leads to an increase in the equilibrium net saving rate ($(gn-1)k^{*1-f}$) in a growing economy. The gross saving rate increases if the depreciation rate plus the rate of growth is positive.

During transition, as is clear from equation (5), the saving rate is elevated above the equilibrium level depending on the rate of capital deepening (k_{t+1}/k_t). As with the open economy case, a one-shot increase in the survival rate leads to a large increase in the saving rate for one generation followed by a decline in the saving rate to a steady-state level as a new equilibrium is established. In an economy with positive labor-augmenting growth, the net saving rate will be higher than in the initial equilibrium, but lower than during the transition period.

Simulation Results

Figure 2 compares the simulated saving rates in a small open economy and a closed economy produced by an increase in adult survival from 0.4 in year *t-1* to 0.5 in year *t*.[5] The initial impact is large in both cases. The response is somewhat muted in the closed economy because the declines in interest rates lead to reduced saving rates among prime-age adults. A new equilibrium is established in period *t+1* in the open economy, but the adjustment is more gradual in the closed economy as described above. The equilibrium saving rate in the closed economy is greater than in the open economy, because of capital deepening in the closed economy. Higher net saving is required to sustain a higher capital-output ratio. Greater depreciation leads to an increase in gross saving beyond the increase in net saving.

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[5] Each period consists of 30 years. We assume that population growth and productivity growth are both 1.5 percent per year implying values of $n=g=1.563$. The discount rate is 0.811, intertemporal elasticity of substitution is 1.3, and depreciation rate is 0.785. The elasticity of output with respect to capital is 1/3. Kinugasa (2004) provides additional details.

One would not be likely to observe the simulated saving paths shown in Figure 2. Adult survival rates trend upward at a relatively constant rate in many countries – as we will show below. Figure 3 presents simulated saving rates assuming that adult survival increases by 0.1 per period starting from 0.4 in year *t-1*. Otherwise, parameters are identical to those employed in the simulations presented in Figure 2. The onset of adult mortality decline leads to a secular rise in saving rates that continues as long as adult survival rates continue to increase. Saving rates appear to be very nearly linear in adult survival after period *t-1* in the open economy case and after period *t* in the closed economy case.

3. Historical Perspectives on Old-Age Survival and Saving

The modern mortality transition began in the West. Early gains were concentrated at young ages, but by 1900 old-age survival rates were rising steadily in Sweden, the United Kingdom, Italy, and the US – the four Western countries we examine below. The mortality transition began much later outside of the West. The three Asian populations for which we have relatively complete historical data – Japan, Taiwan, and India – did not experience significant gains in old-age survival until the middle of the 20th Century. When the mortality transition began, however, it was very rapid as these Asian countries caught or, in the case of Japan, surpassed the West.

Historical mortality transitions are of great interest here because of their implications for long-run trends in national saving rates. Previous empirical research – and the analysis presented in Section 4 – relies on data that cover a relatively small portion of the mortality transition. This is unfortunate given the long-term nature of the processes under consideration. The distinctive experiences of Asia with the West, however, provide an opportunity to assess long-term effects of mortality change on saving.

We begin with an examination of the mortality transitions of seven countries. In six of the countries – all but India – we are able to construct an old-age survival index (q) that is also used in Section 4.[6] The old-age survival index is the expected years lived after age 60 per expected year lived between the ages of 30 and 60 given the age specific death rates observed during the year of observation. The value of q ranges from less than 0.2 expected years lived after age 60 per expected year lived between the ages of 30 and 60 in Taiwan *circa* 1900 to close to 0.8 in current day Japan.

[6] In India we analyze life expectancy at age 30, which is highly correlated with the old-age survival index.

Historical data for Sweden allows us to trace the transition in old-age survival from the mid-18th Century. The 250 years of data can be described remarkably well as consisting of a pre-transition period during which old-age survival was virtually stagnant and a transition period during which old-age survival increased steadily . In 1751 adults could expect to live about one-third of a year after age 60 for every year lived between the ages of 30 and 60. Between 1761 and 1876 the old-age survival index increased at an annual rate of only 0.0006. Between 1876 and 2001 the old-age survival index increased four times as rapidly - at an annual rate of 0.0026. Allowing for three short-run mortality crises – famine in 1772-73, the Finnish War in 1808-09, and the Spanish flu epidemic of 1918 – a piece-wise linear regression with one break-point at 1876 explains 93 percent of the variance in adult mortality (Table 1).[7]

Table 1. Structural Changes of the Old-Age Survival Index. About here.

The old-age survival transitions of the three other Western countries can be characterized in equally simple fashion. For the United Kingdom, old-age survival increased at an annual rate of 0.0009 between 1841 and 1900 and at a rate of 0.0024 between 1900 and 1998, with 96 percent of the variance explained by the piece-wise linear model with a single break point. The available data for Italy and the United States do not extend into the pre-transition period. Old-age survival in Italy from 1872 to 2000 and in the United States from 1900 to 2001 can be explained as consisting of a single transition period with old-age survival increasing by 0.0029 years per year in Italy and by 0.0033 years per year in the United States.

That the gains in these four countries have been remarkably constant during the 20th Century has important – and unfortunate – implications for testing the dynamic saving model. In the absence of time series variation in the rate at which old-age survival is increasing, estimates of the effect of the rate of change in old-age survival will depend entirely on cross-country differences. Even though there are small year-to-year fluctuations and instances of more significant fluctuations, e.g., the flu epidemic of 1918, short-term fluctuations may have little or no effect on long-term expectations. In our model, it is long-term expectations that matter. To add to the difficulties, the cross-national differences among the four Western countries are quite modest. The historical experience of the West is useful to the extent that we explore the

[7] The break points were assigned visually. A more precise iterative approach would improve the fit of the piece-wise linear approximations, but the analysis presented below would not be affected in any important way. .

effect on saving of the shift from pre-transition to transition. We return to this issue below.

The mortality experience in East Asia is quite distinctive judging from the relatively complete data for Japan and Taiwan. Their pre-transition periods lasted until much later, but were followed by a significant catch-up period during which old-age survival increased quite rapidly. Having closed the mortality gap with the West, the gains in adult mortality have slowed. Recent mortality gains in Taiwan are similar to those found in the West while Japan continues to experience larger gains in old-age survival (Table 1).

Indian life expectancy at age 30 also increased very gradually until 1951. For the next forty years substantial gains were achieved. The 1990s saw a marked slow-down. The pattern is similar to that found in Japan and Taiwan although direct comparison is not possible.

To what extent are the saving trends in these six countries consistent with the predictions of our saving model? Three implications of the model can be examined. First, prior to the transition in old-age survival, saving rates would have been relatively low. Second, constant increases in old-age survival during the transition would have produced relatively constant increases in saving rates. Third, East Asian countries would have experienced relatively elevated saving rates during their period of rapid transition. Of course, these patterns would consistently emerge only if the trends in old-age survival dominated other factors.

First, were pre-transition saving rates low? Estimates for five countries are available and presented in Table 2. In all cases, the pre-transition saving rates are low as compared with the saving rates that followed, but the UK saving rate during pre-transition is only slightly less than its transition saving rate and Taiwan's pre-transition saving rate is quite high as compared with the other countries.

Table 2 Mean National Saving Rates in Pre-Transition and Transition Periods. About here.

Second, are saving and old-age survival correlated? The observed saving rates are plotted against the observed survival values in Figure 4 for each of the countries. The US stands out as an exception with a negative simple correlation between saving rates and old-age survival. In the United Kingdom, the positive correlation is modest (0.37). In the other five countries, the correlation between the two variables ranges from 0.64 upward.

The third question is whether rapid changes in survival rates (observed mostly in the countries of East Asia) were associated with higher saving rates. As a simple analytic device we compare the six countries at three benchmark old-age survival rates – 0.4, 0.5, and 0.6 – observed for the six countries for which we have values (Figure 5). There is a clear positive association between the national saving rate and the change in the old-age survival rates over the subsequent decade. The simple correlation between the variables ranges from 0.58 to 0.72. The effects are essentially identical for q equal to 0.4 and 0.5 and somewhat attenuated for 0.6. These results provide modest but consistent support for the dynamic model of adult survival and saving.

4. Analysis of World Panel Data 1965-1995

Estimates of national saving rates, life expectancy at birth, and other variables that may influence saving are available for 76 countries in 1965 increasing to 94 countries in 1995. In this section we present analysis of national saving rates employing these data. Using the world panel data offers advantages over the historical analysis. First, we can move to a multivariate framework that explicitly incorporates the role of other factors in determining national saving rates. Second, we can explore whether the Western/East Asian distinctions drawn in the historical analysis can be generalized to other countries of the world. There are also disadvantages that are discussed below.

Model Specification

The empirical model incorporates the two effects of old-age survival derived from the OLG model presented in Section 2: the steady-state effect, which interacts with the rate of economic growth, and the transitory effect, which depends on the rate at which old-age survival is increasing. The OLG model implies that both the steady-state effect (b_1) and the transitory effect (b_2) are positive in equation (1):

$$S/Y = b_0 + b_1 q \cdot Y_{gr} + b_2 \Delta q + b_3 D1_t \cdot Y_{gr} + b_4 Y_{gr} + b_5 PRI_t + e \quad (1)$$

where *S/Y* is the national saving rate, *q* is the old-age survival index, Y_{gr} is the growth rate of GDP, ? *q* is the change in the old-age survival index during the previous five year period, *D1* is the youth dependency ratio, and *PRI* is the relative price of investment goods.

The basic empirical model incorporates three other saving determinants that have been explored in previous studies. The first is the effect of youth dependency. As youth dependency varies over the demographic transition, aggregate saving can be influenced in a variety of ways of which two seem particularly important. First, an increase in the number of children may have a direct effect on current household consumption because of the costs of additional children. The direction of the effect will depend, however, on whether or not a decline in the number of children is associated with a decline in total consumption by children. If the price of children relative to adults is rising and the demand for children is price inelastic, expenditures on children will increase as the number of children declines. In this instance, youth dependency would have a positive effect on saving. If the demand for children is price elastic or if the number of children is changing for reasons unrelated to changes in relative prices, youth dependency will have a negative effect on saving (Mason 1987).

Changes in youth dependency may also influence saving because children provide old-age support either through familial support systems or through public pension and health care systems. To the extent that children are seen as a substitute for pension assets, youth dependency will have a negative effect on saving. The specification of the youth dependency effect follows the variable rate-of-growth (VRG) model (Fry and Mason 1982; Mason 1981, 1987; Kelley and Schmidt 1996).

The second effect included in the basic model is the rate-of-growth effect, that is a feature of the OLG model presented in Section 2 and life-cycle saving models in general (Modigliani and Brumberg 1954). In an economy experiencing more rapid GDP growth, the lifetime earnings of young cohorts are greater relative to the lifetime earnings of older cohorts. To the extent that lifecycle saving is used to shift resources from younger to older ages, saving is concentrated among younger cohorts. Hence, the rate of growth effect is typically positive, but can in principle be negative.[8] The effect of GDP growth is variable, equal to $b_1 q + b_3 + b_4 D1$, because the old-age survival rate and the youth dependency ratio influence the life-cycle profile of consumption. The coefficient $ß_3$ has no economic interpretation in isolation and, hence, may be positive or negative depending on the effects of q and $D1$.

The third determinant included in the empirical model is the relative price of investment goods (*PRI*) following Taylor (1995) and Higgins and Williamson (1996, 1997). The *PRI* captures the effect of changing interest rates. An increase in the interest rate will lead to an increase or decrease in saving by prime-age adults and by the elderly depending on the relative strengths of the substitution and wealth effects. Thus, the effect of the *PRI* on the national saving rate is an empirical issue.

A potentially important extension of the model, considered below, allows for a transitory youth dependency effects following Higgins (1994) and Williamson and

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[8] The saving mechanism can be used to shift consumption to younger ages, by accumulating credit card debt, for example, but constraints on indebtedness limit the importance of these transactions.

Higgins (2001). A drop in youth dependency would induce prime age adults to save more during their working years in anticipation that they would rely less on familial or public transfers during their retirement years. Current retirees would be unaffected as they are simply dis-saving the (small) assets they accumulated in the expectation that they would be supported by the many children they chose to bear. Hence, aggregate saving would rise steeply. In the next period, however, the higher saving by the new generation of prime age adults would be offset by the higher dis-saving by the new generation of retirees. Hence, saving would decline from the transitory peak to a steady-state peak that would be higher than saving in period *t*, but lower than saving in period *t+1*. Just as is the case for survival, the saving rate would depend on the current level of youth dependency and its rate of change.

Variables, Definitions, the Sample, and Estimation Methods

Except as noted below, all variables are taken directly from or constructed using data from the World Development Indicators (WDI 2003). The saving rate (S/Y_t) is the average gross national saving rate for the five-year period *t* to *t+5*. The rate of growth of income is measured by the real rate of growth of GDP during the preceding five-year period. The relative price of investment goods (PRI_t) is taken directly from the Penn World Table (PWT) and is the average value for the period *t* to *t+5*. The youth dependency ratio ($D1_t$) is the ratio of the population 0-14 to the population 15-64.

The old-age survival index (q) is the ratio of expected person years lived after age 60 (T_{60}) to expected person years lived between ages 30 and 60 ($T_{30} - T_{60}$) given contemporaneous age-specific death rates. T_x, total number of years lived after age *x*, is a standard life table value. Life tables are not available for many countries in many years. Hence, life expectancy at birth from the World Development Indicators (World Bank 200x) were used in conjunction with Coale-Demeny model life tables (Coale and Demeny 1983) to construct estimates of q.[9] The change in the old-age survival index is the average increase over the preceding five-year period, i.e., $\Delta q_t = q_t - q_{t-5}$.

The full sample consists of 566 observations for 76 countries in 1965 increasing to 94 countries in 1995. Estimates for Western and East Asian countries and for Other Developing Countries are presented separately. Sample means and a list of countries are reported in the appendix.

The equations are estimated by ordinary least squares (OLS) and two stage least squares (2SLS) because the Hausman-Wu test indicates that GDP growth is endogenous. Following Higgins and Williamson (1996, 1997) the rate of growth of

[9] See Kinugasa (2004) for additional details.

the labor force and the lagged values of the national investment rate, the rate of growth of the labor force, the price of investment goods, the price index, real GDP per worker, real GDP per capita, and a measure of openness are used as instruments. All estimates include year and regional dummy variables.

Results

Estimates of the basic model, equation (1), are presented in Table 3. OLS and 2SLS estimates are both presented and they are generally similar. We will limit ourselves to discussion of the 2SLS results. Old-age survival consistently has a large, statistically significant positive effect on national saving rates for the full sample and for the two sub-samples. The change in survival has a statistically significant positive effect on national saving in the West/East Asia (W/EA) sample, but not in the other sub-sample. The youth dependency effect is not statistically significant for the full sample or for the two sub-samples. The effect of *PRI* has a large positive effect in the W/EA and a smaller negative effect elsewhere, but the effects are only marginally significant. The rate of growth effect evaluated at the mean value of *q* and *D1* is consistently positive with a value that ranges from 1.4 in W/EA to 0.75 in the non-W/EA sample. An additional result of interest is the substantial East Asian dummy variable coefficient in the W/EA analysis. Rapid increases in adult survival and a high rate of economic growth, both characteristic of East Asia, do not fully explain why saving rates are higher in East Asia than in the West.

The results presented in Table 4 differ from those in Table 3 only in the inclusion of the change in the youth dependency effect – designed to capture the transitory component of its effect on saving. We do not find a significant transitory effect of youth dependency. The inclusion of the change in youth dependency had no important effect on other aspects of the estimates. Old-age survival has a strong positive effect in all estimates; the change in old-age survival has a positive effect in W/EA but not elsewhere. The effects of other variables are similar to those reported in Table 3.

Two aspects of the results warrant emphasis. First, the results imply that the demographic transition has had an important effect on aggregate saving rates. To explore this issue, we have projected saving rates using UN projections of mortality and the youth dependency ratio. Projections for the West and East Asia, holding the youth dependency ratio and all other variables constant, are presented in Figure 6. Projections allowing both the old-age survival ratio and the youth dependency ratio to vary, while holding all other variables constant, are presented in Figure 7. Values for all projections are provided in Appendix Table 2.

The combined effect of the rise in adult mortality and the decline in youth dependency was to increase the aggregate saving rate by 10.5 percentage points in East Asia, by 4.1 percentage points in the West, and by 10.4 percentage points in the remaining countries based on the 2SLS estimates. Improvements in adult mortality accounted for a little more than three-quarters of the increase in each region while the decline in the youth dependency ratio accounted for a little less than one-quarter of the increase. These results bridge the gap, to some extent, between recent aggregate level analyses that find large demographic effects and the micro-level analysis that find small demographic effects. The combined effects of demographic change are substantial as in the aggregate analysis (Higgins and others, 1997; Kelley and others, 1996). The age structure effects are of similar magnitude to those found by Deaton and Paxson, while the effects of longevity would be part of the cohort effect in the Deaton and Paxson analysis (Deaton and others, 2000).

The second important feature of the results is the implication for population aging and aggregate saving. There is widespread concern, though limited empirical support, that population aging will lead to a decline in aggregate saving rates. The empirical results presented here do not support that conclusion. If old-age survival rates continue to increase, as is widely expected, our empirical results imply that saving rates will continue to rise. This empirical finding is consistent with the Lee, Mason and Miller (2003) simulations and suggests that economic growth may not slow as much with population aging as is anticipated in some quarters.

5. RESERVATIONS

An important unanswered question in this analysis is why no dynamic effect of old-age survival is found in the non-W/EA sample. One possibility is that drawbacks with the world panel data are responsible. The first limitation of the data is its relatively short time frame. For most economic analysis thirty years of data are more than adequate, but thirty years is only the length of a single generation. In a sense, we have a single observation of the OLG model presented in Section 2. The prime age adults/workers of 1965 are the old-age population in 1995.

A second difficulty, discussed in Section 3, is that the 1965-95 period may not be well-suited to testing our theoretical saving model. The countries of the West enjoyed similar and relatively constant increases in old-age survival; hence, analyzing variation across countries or across time is unlikely to shed much light on the role of increases in old-age survival. The Asian experience may be more fertile ground to analyze as suggested in Section 3. What about the rest of the developing world? Until the mid-1980s the gains in life expectancy were relative constant across the world. That the simple correlation between life expectancy at birth for the first half of the 1960s and the second half of the 1960s was 0.997 for the 176 countries for which the UN reports estimates illustrates the point.

Two groups of countries experienced significant departures from their historical trends beginning in the mid-1980s primarily because of two important events – the break-up of the Soviet empire and the emergence of the HIV/AIDS epidemic in sub-Saharan Africa. Regional conflicts also played a role in the Middle East and Africa. If the saving model is applicable to these mortality crises, saving rates should have declined. Evidence on this point is limited, but Gregory et al. (1999) conclude that the rise of mortality rates among middle-aged Russian men depressed their saving rates.

A third and related issue is that the measures of mortality in the international panel data are not ideal. Although estimates of life expectancy at birth are reported by the World Bank, these values are often based on very incomplete information. We rely on model life tables to transform life expectancy at birth into the old-age survival ratio described in the previous section. Whether this is appropriate in all circumstances and, in particular, is reliable under severe mortality crises is a question to which we do not have a satisfactory answer. Moreover, the measure of the speed of mortality decline is for five-year periods. It may be that expectations about increases in old-age survival evolve much more slowly. Perhaps even generation length changes in old-age survival – a measure more consistent with our theoretical model – would be more appropriate.

It is not our intention to suggest that absence of a dynamic effect in the non-W/EA sample must surely be the fault of the data rather than the model. More fundamental explanations are possible. Higher saving rates are not the only possible response to an increase in the number of years lived at old age. One possibility is that consumption at old age may decline. Another is that the elderly may choose to increase their labor force participation, although the opposite is the case as an empirical matter with the recent exception of the US. Still another response is that transfer systems, either public or familial, may expand to meet the needs of a growing elderly population. Further work on these topics is clearly needed.

6. CONCLUSIONS

This is not the first paper to conclude that the increased duration of life could lead to higher saving rates. At the individual or household level, it is obvious that higher saving rates are a likely response to an increased duration of retirement. The effect on aggregate saving is more complex, however, because there are both behavioral responses and age composition effects at play. An important contribution of this paper is to show that the aggregate saving rate depends on both the level and the rate at which adult survival is increasing.

The empirical results provide strong and consistent evidence that an increase in the portion of adult life lived at old ages leads to an increase in saving rates. This finding holds for all samples and specifications. The historical evidence suggests and the international panel data confirms that the increase in adult survival was a major impetus to the rise in the wealth of many nations.

The evidence for the dynamic effect, i.e., the effect of the rate of change in old-age survival, is more fragile. When analysis is confined to the West/East Asia sample we find a statistically significant effect. Moreover, the long-run historical patterns available for countries from East Asia and the West are consistent with the dynamic effect. In other parts of the contemporary developing world, however, we do not find any support for a dynamic effect.

There are two additional important implications of the empirical analysis. The first is that the demographic transition had a strong positive effect on aggregate saving rates, but that most of the effect was a response to improvements in old-age survival rather than to changes in youth dependency. This result may help to reconcile the divergent findings of studies based on the analysis of aggregate data and household survey data. The second important implication is that population aging will not lead to a decline in saving rates. Any compositional effects associated with population aging are outweighed by the behavioral effects of continued increases in longevity.

Appendix 1 National Saving Rate in a Closed Economy

A greater survival rate brings capital deepening ($\partial k^* / \partial q^* > 0$). If GDP growth rate is greater than the deprecation rate, the saving rate increases. If GDP is growing at a rate less than the rate of depreciation, an increase in q^* has a negative effect on the saving rate.

The effect of the national saving rate of a one-time, anticipated increase of the survival rate is $\frac{\partial (S_t / Y_t)}{\partial q_t} = \frac{gn}{k^{*f}} \frac{dk_{t+1}}{dq_t} > 0$. An anticipated increase in the survival rate at time t leads to a higher national saving rate. At time t, saving of prime-age adults increases, which causes an increase in k_{t+1}. The supply of capital increases and the saving rate increases. The effect of an increase in the survival rate at time t on the national saving rate at time t+1 is:

$$\frac{\partial (S_{t+1}/Y_{t+1})}{\partial q_t} = k_{t+1}^{-f} \left[gn\left(\frac{\partial k_{t+2}}{\partial k_{t+1}} - \frac{k_{t+2}}{k_{t+1}} f \right) - (1-f)(1-x) \right] \frac{\partial k_{t+1}}{\partial q_t},$$

where $0 < \partial k_{t+2} / \partial k_{t+1} < 1$ and $\partial k_{t+1} / \partial q_t > 0$ hold. For plausible parameter values, this expression is negative. The saving at time $t+1$ is the difference between the wealth at time t+2 and t+1. An increase in q_t induces capital deepening at time t+1, but the wealth of the previous period and depreciation are also higher than at time t. The net increase in wealth at time t+1 is less than that at time t. In a closed economy, the survival rate at time t also influences the saving rate at time $t+2$. This stands in contrast to the case of small open economy. The survival rate at time t has a negative effect on the saving rate after time t+2.[10]

10 $\frac{\partial (S_{t+2}/Y_{t+2})}{\partial q_t} = k_{t+2}^{-f} \left[gn\left(\frac{\partial k_{t+3}}{\partial k_{t+2}} - \frac{k_{t+3}}{k_{t+2}} f \right) - (1-f)(1-x) \right] \frac{\partial k_{t+2}}{\partial k_{t+1}} \frac{\partial k_{t+1}}{\partial q_t}$, $0 < \partial k_{t+3} / \partial k_{t+2} < 1$, $0 < \partial k_{t+2} / \partial k_{t+1} < 1$, and $\partial k_{t+1} / \partial q_t > 0$ hold, therefore, in the right hand side of this equation, the value inside the bracket is negative for plausible parameters, so that the saving rate at time t has a negative effect on the saving rate at time $t+2$. In the same way, the effects of the survival rate at time t on the saving rate after time $t+2$ can be derived. q_t has a negative effect on the saving rate after time $t+2$.

Appendix 2 List of Countries

Western countries contain Austria, Azerbaijan, Belgium, Bulgaria, Belarus, Canada, Switzerland, Czech Republic, Denmark, Spain, Finland, France, United Kingdom, Greece, Hungary, Ireland, Iceland, Italy, Kazakhstan, Kyrgyz Republic, Lithuania, Luxembourg, Latvia, Moldova, Macedonia, Netherlands, Norway, New Zealand, Poland, Portugal, Romania, Slovak Republic, Slovenia, Sweden, Tajikistan, Turkey, Ukraine, and United States. East Asian countries contain Japan, South Korea, Thailand and Malaysia.

Other countries contain Angola, Burundi, Benin, Burkina Faso, Botswana, Central African Republic, Cote d'Ivoire, Cameroon, Congo Republic, Comoros, Cape Verde, Ethiopia, Gabon, Ghana, Guinea, Gambia, Guinea Bissau, Equatorial Guinea, Kenya, Madagascar, Mali, Mozambique, Mauritania, Mauritius, Malawi, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Seychelles, Chad, Togo, Tanzania, Uganda, South Africa, Democratic Republic of the Congo, Zambia and Zimbabwe, Bangladesh, China, Hong Kong, Indonesia, India, Sri Lanka, Macao, Nepal, Pakistan, Philippines, Argentina, Antigua and Barbuda, Belize, Bolivia, Brazil, Barbados, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Grenada, Guatemala, Guyana, Honduras, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Trinidad and Tobago, Uruguay, St. Vincent and the Grenadine, Venezuela, Algeria, Egypt, Iran, Israel, Jordan, Lebanon, Morocco, Syrian Arab Republic, Tunisia, and Yemen.

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Figure 1 Demand and Supply of Capital in a Closed Economy

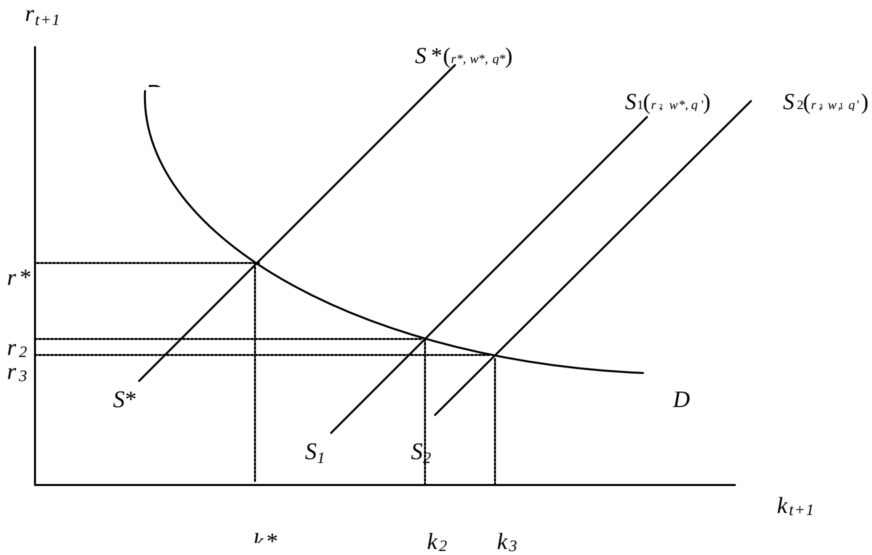


Figure 1 The Effect of an Increase in the Survival Rate at Time *t*

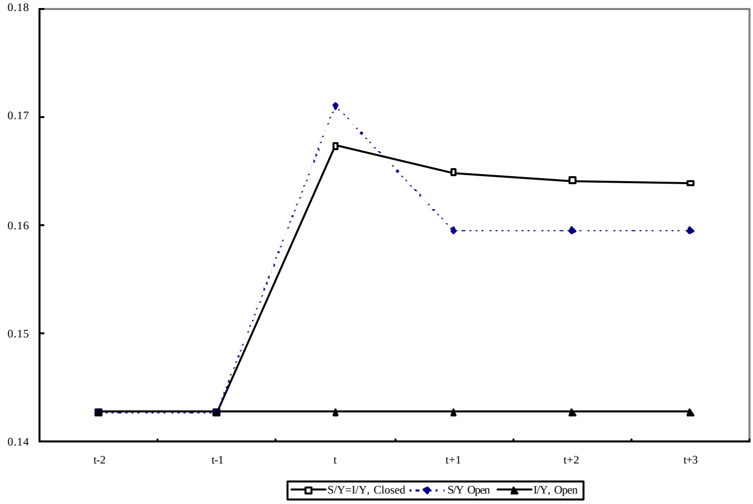


Figure 2 The Effect of a Continuing Increase in the Survival Rate

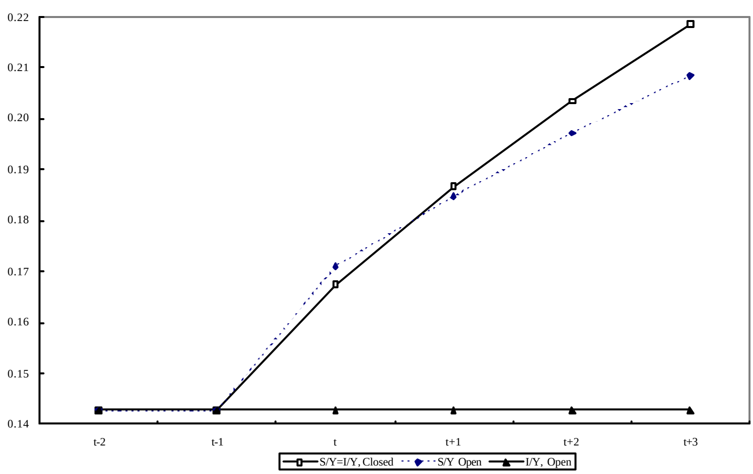


Figure 4 Adult Survival Index and the National Sa ving Rate

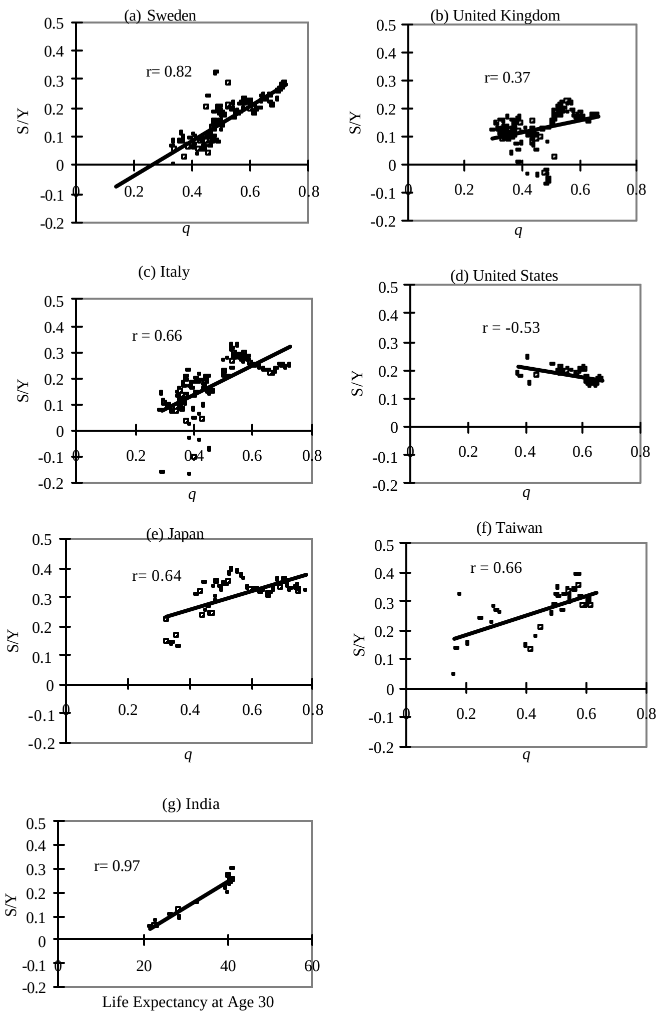


Figure 5 Changes in Old-Age Survival Index and the National Saving Rate

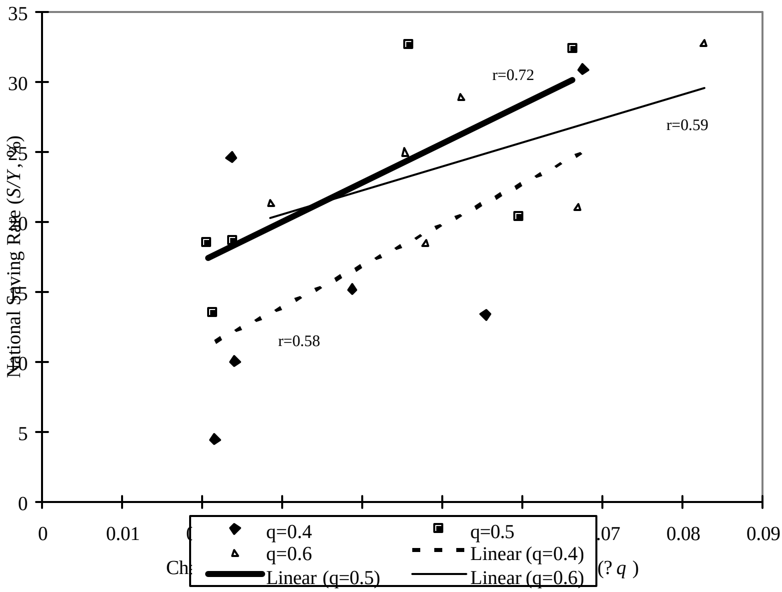
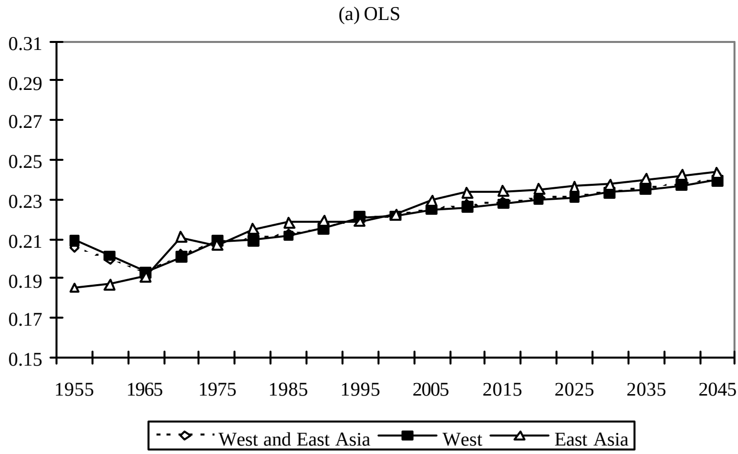


Figure 6 Projected Saving Rates of Western Countries and East Asia (Constant Youth Dependency, 1955-2050)



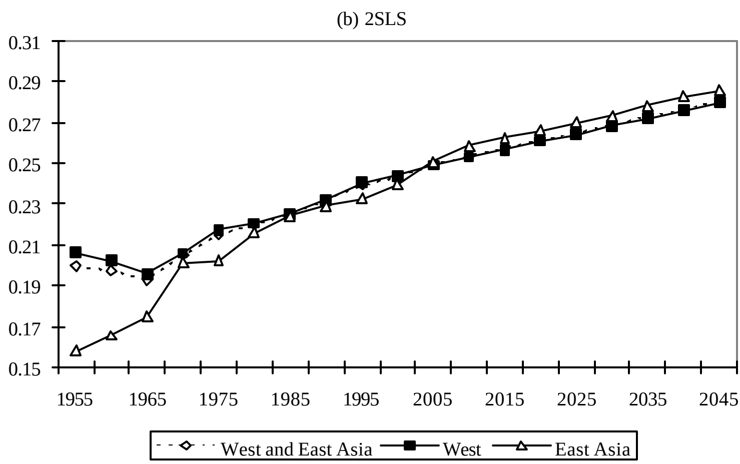
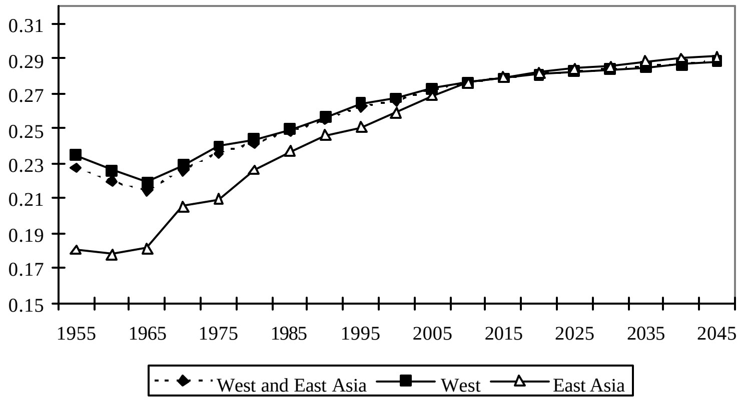


Figure 7 Projected Saving Rates of Western Countries and East Asia (Changing Youth Dependency, 1955-2050)

(a) OLS



(b) 2SLS

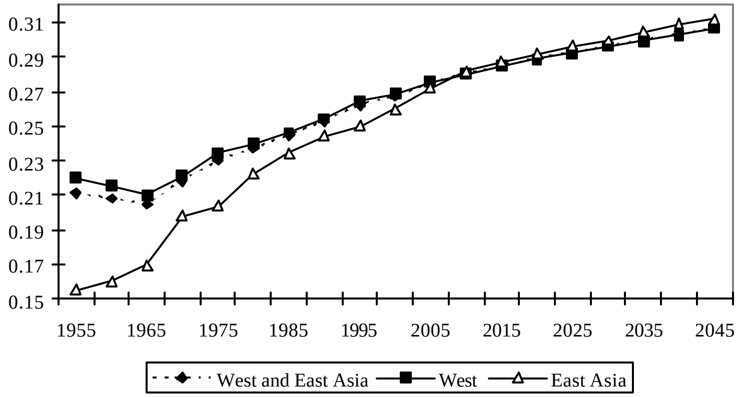


Table 1. Structural Changes of the Old-Age Survival Index

	Sweden	United Kingdom	Italy	United States	Japan	Taiwan	India
years	1751-2002	1841-1998	1872-2000	1900-2001	1891-2001	1906-2002	1881-1997
t_1	1876	1900			1947	1940	1951
t_2					1989	1983	1989
t	0.0006 ***	0.0009 ***	0.0029 ***	0.0033 ***	0.0010 ***	0.0004	0.0392
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0010)	(0.0232)
$(t\text{-}t_1)d_1$	0.002 ***	0.0024 ***			0.0065 ***	0.0056 ***	0.3457 ***
	(0.0001)	(0.0001)			(0.0004)	(0.0011)	(0.0599)
$(t\text{-}t_2)d_2$					-0.0014 ***	-0.0024 ***	-0.3075 *
					(0.0007)	(0.0003)	(0.1568)
Dm1773	-0.0231 ***	0.0004 ***	-0.1231 ***				
	(0.0027)		(0.0023)				
Dm1808	-0.1625 ***						
	(0.0063)						
Dm1918	-0.096 ***						
	(0.0040)						
Constant	0.2869 ***	0.3205 ***	0.2518 ***	0.2245 ***	0.3250 ***	0.2860 ***	22.7955 ***
	(0.0080)	(0.0049)	(0.0053)	(0.0195)	(0.0104)	(0.0322)	(0.8454)
Adjusted R^2	0.9251	0.9587	0.9471	0.9585	0.9872	0.9944	0.9628
N	252	158	129	48	59	43	20
P-value	0.0000	0.0000			0.0000	0.0000	0.0000
D.W.	0.5765	0.7026	0.397	0.0958	0.3897	0.3651	0.0338

(Note) Dependent variables are adult survival index except India. The dependent variable for India is life expectancy at age 30. The equation $q_t = b_0 + b_1 t + b_2 d_1 (t - t_1) + b_3 d_2 (t - t_2) + e_t$ is estimated, where $d_1 = 1$ if $t \geq t_1$ and 0 otherwise, and d_2=1 if $t \geq t_2$ and 0 otherwise. Dm1773 is dummy variable of year 1773=1. In the same way, Dm1808, Dm1918 are defined. *N* is number of observations. "P-value" is the p-value of F-test for the null hypothesis that $ß_1$, $ß_2$, and $ß_3$ are all zero. D.W. is Durbin-Watson statistics. The low Durbin-Watson statistics imply serial correlation. The Augmented Dickey-Fuller test indicates that some variables are not trend stationary. These issues will be explored further.

Table 2 Mean National Saving Rates in Pre-Transition and Transition Periods.

	Sweden	United Kingdom	Italy	United States	Japan	Taiwan	India[a)]
Pre-transition	1751-1875	1841-1899	<1872	<1900	1891-1947	1906-1939	1900-1950
Survival rate	0.31	0.34	na	na	0.35	0.24	24.0
Saving rate	7.3	11.6	na	na	15.7	22.1	6.9
Transition	1876-2000	1900-1998	1872-2000	1900-2001	1947-2000	1940-1999	1951-1997
Survival rate	0.53	0.49	0.47	0.57	0.60	0.54	37.7
Saving rate	16.6	13	17.7	17.7	32.6	26.1	17.7

(Note) Life expectancy at age 30 is presented instead of survival rate in India.

Table 3 Estimated Saving Equation with Old-Age Survival Index and Youth Dependency

	(1) Whole World		(2) West and East Asia		(3) Non-West, Non East Asia	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
$q{*}Y_{gr}$	8.2055 ***	14.8399 ***	8.3714 **	14.8129 ***	9.1327 ***	15.7251 ***
	(1.8606)	(2.6660)	(3.7148)	(3.5266)	(1.9979)	(2.9857)
dq	0.8615	0.5104	1.7954 **	1.8115 **	0.3284	-0.2538
	(0.5266)	(0.5752)	(0.8192)	(0.8519)	(0.5962)	(0.6823)
$D1{*}Y_{gr}$	0.7461	0.9319	-3.0912 ***	-1.7057	0.4379	1.0155
	(0.7639)	(0.9345)	(1.1164)	(1.1246)	(0.9871)	(1.2978)
Y_{gr}	-3.7274 ***	-6.5927 ***	-2.9073	-6.4693 ***	-3.6892 **	-6.8701 ***
	(1.3526)	(1.9655)	(2.4628)	(2.3958)	(1.5577)	(2.4026)
PRI	-0.0053 *	-0.0028	0.0422 **	0.0350 *	-0.0084 **	-0.0064 *
	(0.0032)	(0.0036)	(0.0207)	(0.0212)	(0.0035)	(0.0036)
y70	0.0100	0.0075	0.0093	0.0105	0.0069	0.0026
	(0.0181)	(0.0184)	(0.0161)	(0.0159)	(0.0251)	(0.0253)
y75	-0.0175	-0.0253	-0.0280 *	-0.0250	-0.0261	-0.0373
	(0.0166)	(0.0176)	(0.0159)	(0.0159)	(0.0233)	(0.0241)
y80	-0.0253	-0.0290	-0.0280	-0.0167	-0.0433 *	-0.0543 **
	(0.0165)	(0.0188)	(0.0198)	(0.0238)	(0.0222)	(0.0234)
y85	-0.0031	-0.0013	0.0001	0.0184	-0.0272	-0.0345
	(0.0163)	(0.0218)	(0.0173)	(0.0207)	(0.0226)	(0.0272)
y90	-0.0102	-0.0185	-0.0340 *	-0.0255	-0.0258	-0.0398
	(0.0161)	(0.0197)	(0.0175)	(0.0191)	(0.0225)	(0.0257)
y95	-0.0009	-0.0086	-0.0039	0.0196	-0.0339	-0.0598 **
	(0.0168)	(0.0235)	(0.0197)	(0.0231)	(0.0235)	(0.0285)
East Asia	0.0312 **	0.0189	0.1073 ***	0.0855 ***		
	(0.0137)	(0.0175)	(0.0165)	(0.0202)		
Other	-0.1190 ***	-0.0915 ***				
Countries	(0.0093)	(0.0125)				
Constant	0.1775 ***	0.1487 ***	0.1544 ***	0.1267 ***	0.0758 ***	0.0855 ***
	(0.0161)	(0.0245)	(0.0247)	(0.0306)	(0.0205)	(0.0305)
N	566	566	189	189	377	377
Adjusted R	0.4357	0.3945	0.4191	0.3848	0.1275	0.0852
P-values, Yg	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pvalues, year	0.2800	0.1160	0.0125	0.0006	0.2261	0.0954
Y_{gr} Effect	0.7203	1.1739	0.6967	1.4105	0.6177	0.7543
P-value, Hausman		0.0000		0.0037		0.0000

Note: The dependent variable is the national saving rate.

q: Adult survival index, Y_{gr}: GDP growth rate, $D1$: young dependency rate, *?q*: change in the adult survival rate, *PRI*: price of investment goods, yXX dummy variables of year XX, N: number of observation. "P-value, *Ygr*" is the p-value of F-test of the null hypothesis that the both coefficients of $q{\cdot}Y_{gr}$ and $D1{\cdot}Y_{gr}$ are zero. "Pvalue, year dummies" is the p-value of F-test of the null hypothesis that all the year dummies are zero. "Y_{gr} Effect" is the partial effect of an increase in GDP growth.

*** denotes significant at 1 % level, **denotes significant at 5 % level, and * denotes significant at 10 % level. Figures in parentheses are standard errors.

Table 4 Estimated Saving Equation with Old-Age Survival Index, Youth Dependency Ratio, and Change in Youth Dependency Ratio.

	(1) Whole World		(2) West and East Asia		(3) Non-West, Non East Asia	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
$q*Y_{gr}$	7.7208***	15.0384***	8.3557**	14.9335***	8.5464***	15.5319***
	(1.9440)	(2.6829)	(3.7186)	(3.5232)	(2.1327)	(3.0590)
dq	0.7583	0.5583	1.7700**	1.8046**	0.1871	-0.2512
	(0.5219)	(0.5917)	(0.8029)	(0.8247)	(0.5895)	(0.6847)
$D1*Y_{gr}$	0.7615	0.8210	-3.0871***	-1.6881	0.7026	0.9864
	(0.7684)	(0.9166)	(1.1214)	(1.1255)	(1.0056)	(1.3233)
$dD1$	-0.1753	0.0543	-0.0373	-0.0186	-0.2402	-0.0387
	(0.1417)	(0.1475)	(0.1696)	(0.1787)	(0.1757)	(0.1820)
Y_{gr}	-3.5424***	-6.6263***	-2.9015	-6.5589***	-3.6873**	-6.8041***
	(1.3817)	(1.9559)	(2.4665)	(2.3938)	(1.6018)	(2.4076)
PRI	-0.0049	-0.0029	0.0426**	0.0346*	-0.0078**	-0.0064*
	(0.0033)	(0.0036)	(0.0207)	(0.0210)	(0.0036)	(0.0036)
y70	0.0066	0.0084	0.0090	0.0103	0.0010	0.0016
	(0.0183)	(0.0186)	(0.0164)	(0.0161)	(0.0257)	(0.0257)
y75	-0.0234	-0.0238	-0.0289*	-0.0255	-0.0353	-0.0389
	(0.0167)	(0.0180)	(0.0173)	(0.0177)	(0.0236)	(0.0248)
y80	-0.0331**	-0.0272	-0.0292	-0.0176	-0.0546***	-0.0564**
	(0.0169)	(0.0195)	(0.0222)	(0.0267)	(0.0229)	(0.0241)
y85	-0.0105	-0.0001	-0.0012	0.0172	-0.0372*	-0.0370
	(0.0168)	(0.0226)	(0.0196)	(0.0243)	(0.0232)	(0.0281)
y90	-0.0175	-0.0174	-0.0349*	-0.0264	-0.0376*	-0.0423
	(0.0164)	(0.0202)	(0.0186)	(0.0209)	(0.0235)	(0.0268)
y95	-0.0097	-0.0072	-0.0046	0.0186	-0.0476*	-0.0627**
	(0.0171)	(0.0237)	(0.0205)	(0.0250)	(0.0244)	(0.0290)
East Asia	0.0285**	0.0207	0.1065***	0.0856***	0.0035	
	(0.0141)	(0.0176)	(0.0163)	(0.0194)	(0.0136)	
Other Countries	-0.1192***	-0.0896***				
	(0.0094)	(0.0125)				
Constant	0.1836***	0.1471***	0.1544***	0.1279***	0.0850***	0.0886***
	(0.0162)	(0.0246)	(0.0249)	(0.0311)	(0.0214)	(0.0309)
N	566	566	189	189	377	377
Adjusted R^2	0.4373	0.3897	0.4160	0.3822	0.1298	0.0856
P-values, Ygr	0.0001	0.0000	0.0000	0.0000	0.0002	0.0000
Pvalues, year dummies	0.1703	0.1466	0.0144	0.0007	0.0873	0.0815
Y_{gr} Effect	0.6821	1.1621	0.6951	1.3976	0.5767	0.7133
P-value, Hausman		0.0000		0.0033		0.0000

Appendix Table 1 Summary of the Variables

	Total			1965			1970		
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
S/Y	566	0.1279	0.1211	76	0.1355	0.1369	76	0.1462	0.1300
Y_{ar}	566	0.0387	0.0318	76	0.0548	0.0315	76	0.0510	0.0240
q	566	0.4816	0.1004	76	0.4380	0.0977	76	0.4503	0.0960
dq	566	0.0126	0.0097	76	0.0140	0.0066	76	0.0134	0.0068
$D1$	566	0.6646	0.2374	76	0.7230	0.2137	76	0.7202	0.2170
$dD1$	566	-0.0151	0.0417	76	0.0191	0.0370	76	-0.0003	0.0336
PRI	566	0.8473	0.7492	76	0.7143	0.6090	76	0.8310	0.8267
D	566	0.4938	0.5182	76	0.2667	0.3829	76	0.3185	0.4234
dD	566	0.0678	0.0778	76	0.0197	0.0511	76	0.0518	0.0774

	1975			1980			1985		
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation	N	Mean	Standard Deviation
S/Y	76	0.1261	0.1114	78	0.1140	0.1152	81	0.1241	0.1168
Y_{gr}	76	0.0481	0.0270	78	0.0418	0.0344	81	0.0252	0.0319
q	76	0.4686	0.0955	78	0.4846	0.0960	81	0.4959	0.0961
dq	76	0.0147	0.0072	78	0.0149	0.0081	81	0.0143	0.0069
$D1$	76	0.6963	0.2258	78	0.6644	0.2326	81	0.6466	0.2440
$dD1$	76	-0.0173	0.0406	78	-0.0267	0.0453	81	-0.0221	0.0427
PRI	76	1.0199	1.3963	78	0.8903	0.7807	81	0.7923	0.3353
D	76	0.4139	0.4803	78	0.5010	0.5106	81	0.5596	0.5406
dD	76	0.0823	0.0930	78	0.0783	0.0750	81	0.0772	0.0716

	1990			1995		
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation
S/Y	85	0.1256	0.1142	94	0.1257	0.1235
Y_{gr}	85	0.0335	0.0219	94	0.0219	0.0332
q	85	0.5104	0.0949	94	0.5119	0.1034
dq	85	0.0119	0.0108	94	0.0067	0.0144
$D1$	85	0.6232	0.2486	94	0.5996	0.2500
$dD1$	85	-0.0245	0.0307	94	-0.0287	0.0392
PRI	85	0.8623	0.4620	94	0.8264	0.3861
D	85	0.6337	0.5393	94	0.6946	0.5638
dD	85	0.0759	0.0776	94	0.0835	0.0750

	Western and East Asian Countries			Other Countries		
Variable	N	Mean	Standard Deviation	N	Mean	Standard Deviation
S/Y	189	0.2295	0.0711	377	0.0770	0.1082
Y_{gr}	189	0.0395	0.0280	377	0.0383	0.0335
q	189	0.5779	0.0487	377	0.4333	0.0834
dq	189	0.0122	0.0075	377	0.0128	0.0106
$D1$	189	0.3992	0.1405	377	0.7976	0.1473
$dD1$	189	-0.0253	0.0305	377	-0.0099	0.0455
PRI	189	0.7983	0.2404	377	0.8718	0.9015
D	189	1.0653	0.3641	377	0.2073	0.3013
dD	189	0.0975	0.0802	377	0.0528	0.0722

Appendix Table 2 Adult Survival Index and Projected National Sa ving Rate

(1) West and East Asia				Projected National Saving Rate			
	Means of the variables			Constant D1		Changing D1	
	q	dq	D1	OLS	2SLS	OLS	2SLS
1950	0.4972		0.4715				
1955	0.5193	0.0220	0.4852	0.2059	0.1997	0.2274	0.2115
1960	0.5349	0.0157	0.4972	0.1996	0.1972	0.2196	0.2082
1965	0.5450	0.0101	0.4854	0.1929	0.1928	0.2143	0.2047
1970	0.5579	0.0128	0.4626	0.2019	0.2051	0.2261	0.2185
1975	0.5718	0.0139	0.4348	0.2084	0.2152	0.2359	0.2303
1980	0.5844	0.0126	0.4015	0.2101	0.2199	0.2416	0.2373
1985	0.5961	0.0117	0.3654	0.2123	0.2251	0.2481	0.2448
1990	0.6077	0.0116	0.3358	0.2158	0.2315	0.2552	0.2532
1995	0.6198	0.0121	0.3147	0.2207	0.2393	0.2625	0.2624
2000	0.6306	0.0108	0.2924	0.2218	0.2431	0.2663	0.2676
2005	0.6413	0.0108	0.2714	0.2253	0.2493	0.2723	0.2752
2010	0.6513	0.0100	0.2527	0.2271	0.2535	0.2763	0.2807
2015	0.6605	0.0092	0.2447	0.2287	0.2574	0.2789	0.2851
2020	0.6691	0.0086	0.2410	0.2304	0.2613	0.2811	0.2893
2025	0.6772	0.0080	0.2419	0.2320	0.2649	0.2826	0.2928
2030	0.6849	0.0077	0.2454	0.2340	0.2688	0.2841	0.2964
2035	0.6924	0.0075	0.2497	0.2359	0.2725	0.2855	0.2999
2040	0.6997	0.0073	0.2536	0.2380	0.2765	0.2871	0.3036
2045	0.7069	0.0071	0.2572	0.2400	0.2803	0.2887	0.3072

(2) Non-West, Non East Asia				Projected National Saving Rate			
	Means of the variables			Non-West, Non East Asia			
	q	dq	D1	OLS	2SLS	OLS	2SLS
1950	0.3716		0.7424				
1955	0.3894	0.0178	0.7717	0.0807	0.0728	0.0716	0.0591
1960	0.4055	0.0161	0.8066	0.0858	0.0830	0.0775	0.0704
1965	0.4213	0.0158	0.8368	0.0913	0.0927	0.0834	0.0811
1970	0.4359	0.0146	0.8434	0.0961	0.1019	0.0890	0.0907
1975	0.4504	0.0145	0.8348	0.1012	0.1107	0.0949	0.1001
1980	0.4656	0.0152	0.8220	0.1068	0.1198	0.0997	0.1092
1985	0.4802	0.0146	0.8069	0.1117	0.1289	0.1038	0.1173
1990	0.4863	0.0061	0.7859	0.1111	0.1347	0.1029	0.1220
1995	0.4911	0.0047	0.7513	0.1123	0.1379	0.1014	0.1227
2000	0.4956	0.0045	0.7103	0.1139	0.1408	0.1013	0.1220
2005	0.5040	0.0085	0.6715	0.1181	0.1449	0.1053	0.1236
2010	0.5153	0.0112	0.6345	0.1230	0.1510	0.1100	0.1281
2015	0.5270	0.0117	0.5984	0.1273	0.1580	0.1138	0.1338
2020	0.5388	0.0118	0.5600	0.1316	0.1652	0.1178	0.1399
2025	0.5516	0.0127	0.5198	0.1363	0.1727	0.1224	0.1464
2030	0.5640	0.0124	0.4808	0.1406	0.1804	0.1266	0.1533
2035	0.5759	0.0119	0.4444	0.1446	0.1877	0.1306	0.1601
2040	0.5872	0.0113	0.4122	0.1485	0.1948	0.1343	0.1667
2045	0.5978	0.0106	0.3848	0.1520	0.2014	0.1378	0.1731

Appendix Table 2 Adult Survival Index and Projected National Saving Rate (Continued)

(3) West				Projected National Saving Rate			
	Means of the variables			Constant D1		Changing D1	
	q	dq	D1	OLS	2SLS	OLS	2SLS
1950	0.5108		0.4334				
1955	0.5322	0.0214	0.4511	0.2091	0.2060	0.2346	0.2201
1960	0.5468	0.0146	0.4612	0.2015	0.2020	0.2259	0.2154
1965	0.5552	0.0084	0.4467	0.1931	0.1956	0.2192	0.2100
1970	0.5658	0.0106	0.4260	0.2006	0.2057	0.2291	0.2215
1975	0.5787	0.0129	0.4040	0.2087	0.2171	0.2399	0.2343
1980	0.5899	0.0112	0.3767	0.2094	0.2206	0.2438	0.2396
1985	0.6003	0.0105	0.3444	0.2114	0.2252	0.2497	0.2463
1990	0.6111	0.0107	0.3208	0.2154	0.2318	0.2565	0.2545
1995	0.6228	0.0117	0.3026	0.2210	0.2404	0.2643	0.2643
2000	0.6331	0.0103	0.2823	0.2217	0.2436	0.2674	0.2688
2005	0.6431	0.0101	0.2612	0.2246	0.2490	0.2729	0.2757
2010	0.6524	0.0092	0.2441	0.2261	0.2528	0.2764	0.2805
2015	0.6610	0.0086	0.2381	0.2278	0.2567	0.2788	0.2848
2020	0.6692	0.0082	0.2363	0.2297	0.2606	0.2810	0.2889
2025	0.6769	0.0077	0.2363	0.2313	0.2641	0.2825	0.2924
2030	0.6844	0.0075	0.2429	0.2334	0.2681	0.2839	0.2959
2035	0.6917	0.0072	0.2478	0.2352	0.2717	0.2851	0.2992
2040	0.6988	0.0071	0.2521	0.2373	0.2756	0.2866	0.3028
2045	0.7058	0.0070	0.2562	0.2395	0.2795	0.2883	0.3064
(4) East Asia				Projected National Saving Rate			
				Constant D1		Changing D1	
	q	dq	D1	OLS	2SLS	OLS	2SLS
1950	0.3429		0.7190				
1955	0.3596	0.0167	0.7066	0.18540	0.15826	0.1804	0.1555
1960	0.3755	0.0158	0.7406	0.18712	0.16557	0.1780	0.1606
1965	0.3909	0.0154	0.7466	0.19127	0.17497	0.1815	0.1696
1970	0.4064	0.0155	0.7098	0.21062	0.20115	0.2052	0.1982
1975	0.4227	0.0163	0.6426	0.20667	0.20234	0.2093	0.2038
1980	0.4380	0.0153	0.5687	0.21482	0.21591	0.2263	0.2222
1985	0.4517	0.0137	0.5070	0.21825	0.22428	0.2371	0.2347
1990	0.4575	0.0057	0.4367	0.21889	0.22918	0.2462	0.2442
1995	0.4590	0.0016	0.3959	0.21863	0.23247	0.2508	0.2502
2000	0.4606	0.0016	0.3583	0.22235	0.23968	0.2590	0.2599
2005	0.4682	0.0076	0.3377	0.22959	0.25075	0.2687	0.2723
2010	0.4796	0.0114	0.3086	0.23363	0.25848	0.2762	0.2820
2015	0.4916	0.0121	0.2871	0.23426	0.26229	0.2794	0.2872
2020	0.5042	0.0126	0.2717	0.23496	0.26577	0.2820	0.2917
2025	0.5181	0.0138	0.2642	0.23666	0.27003	0.2845	0.2965
2030	0.5319	0.0138	0.2619	0.23742	0.27304	0.2856	0.2996
2035	0.5452	0.0133	0.2617	0.24008	0.27793	0.2883	0.3045
2040	0.5579	0.0127	0.2632	0.24239	0.28241	0.2904	0.3089
2045	0.5698	0.0119	0.2636	0.24341	0.28537	0.2914	0.3118