WORKING PAPER SERIES

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Working Paper 1994-031A
http://research.stlouisfed.org/wp/1994/94-031.pdf

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ABSTRACT

This paper presents a model of economic growth based on the life-cycle hypothesis to determine the path of international capital flows as the baby boom passes through the U.S. economy. The model predicts that a baby boom causes a temporary increase in capital flow into the U.S. but the increase in capital is not sufficient to maintain the capital-labor ratio in the U.S. The baby boom increases saving in the U.S. but decreases the saving abroad due to the higher world interest rates.

KEYWORDS: baby boom, simulation, capital flows, life-cycle, demographiccs, aging

JEL CLASSIFICATION: D91, E17, E21, F32, J11

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I would like to thank Jim Bullard, Mike Pakko and Joe Ritter for their helpful comments and suggestions. All remaining errors are mine.

I. Introduction

One often stated concern about the baby boom is its impact on capital accumulation. Yoo [1994] examines the impact of the baby boom on the U.S. using a closed economy model, but with the degree of international capital mobility, it is possible that international capital flows can satisfy the increased demand for capital in the U.S. Indeed, recent U.S. experience shows increased capital flow from abroad. This paper presents a model of economic growth based on the life-cycle hypothesis to determine the path of capital accumulation and economic growth. Unlike standard neoclassical growth models, a growth model based on the life-cycle hypothesis is well suited to an examination of the effects of a large retired population because retirement is an integral part of the life-cycle hypothesis. Using the life-cycle hypothesis as the basis for an individual's saving decision, I incorporate general equilibrium considerations to determine the relationship between demographic changes, capital accumulation and capital flows.

The model predicts that a baby boom causes a temporary increase in the demand for capital due to the rapid growth of labor. Increase in domestic saving and importation of capital offset the increased demand, but only partially. The model predicts that the increased saving and capital inflow is not sufficient to maintain the pre-baby boom capital-labor ratio. The temporary drop of the capital-labor ratio increases world interest rates, which reduces saving abroad. The increase in the world interest rate and lower saving abroad are not the only effects of the U.S. baby boom; the model also predicts that the impact of the U.S. baby boom will affect the capital-labor ratio and standards of living abroad.

The remainder of the paper is divided into three parts. The first section solves the individual's utility maximization problem. The second section incorporates the life-cycle hypothesis based capital accumulation model in a general equilibrium framework. The third section examines the likely impact of the baby boom generation on the U.S. and world economies by simulating the model presented in section two. The final section presents a few concluding thoughts along with some implications of the results for the U.S. and abroad as the baby boom generation ages.

II. Consumer's Maximization Problem

The life-cycle hypothesis states that an individual's lifetime path of accumulated assets reflects his saving and dissaving for retirement, gradually increasing while working and then declining once retired. This implies that an individual's age is an important determinate of how much wealth he has. If the growth rate of the population fluctuates over time, the age distribution of the population fluctuates as well. Consequently, the desired holdings of wealth of the population will vary with the age distribution of the population.

For simplicity, I assume that each consumer works and lives for T' and T years, respectively, from his time of birth, t.[1] The consumer maximizes his lifetime utility subject to the budget constraint that in each period his consumption and net saving must equal his total income. I assume lifetime utility is additively separable and isoelastic with constant relative risk aversion.

$$\max \sum_{s=1}^{T} (1+\delta)^{1-s} \frac{c_{t+s-1,s}^{1-\rho}}{1-\rho} \tag{1}$$

subject to the lifetime budget constraint

$$\sum_{s=1}^{T'} \frac{w_{t+s-1,s}}{(1+r_t)^{s-1}} + a_{t,0} \geq \sum_{s=1}^{T} \frac{c_{t+s-1,s}}{(1+r_t)^{s-1}} \tag{2}$$

$c_{t,s}$ and $w_{t,s}$ are consumption and labor income in period t of an agent s periods old, respectively, and $a_{t,0}$ is the endowment received by a new entrant to the economy. δ is the subjective discount rate. r_t is the rate of return to assets in period t.

The optimal consumption and saving paths are

$$c_{t+s-1,s} = \theta_s \left[\sum_{i=s}^{T'} \frac{w_{t+i-1,i}}{(1+r_t)^{i-s}} + (1+r_t)\, a_{t+s-2,s-1} \right] \tag{3}$$

$$a_{t+s-1,s} = \begin{cases} (1+r_t)\, a_{t+s-2,s-1} + w_{t+s-1,s} - c_{t+s-1,s} & \text{if } s \leq T' \\ (1+r_t)\, a_{t+s-2,s-1} - c_{t+s-1,s} & \text{if } s > T' \end{cases} \tag{4}$$

[1]The model can accommodate uncertainties about life expectancy and the duration of labor force participation. However such complications add little insight into the economic impact of the baby boom generation.

where

$$\theta_s = \left[1 + \sum_{i=s+1}^{T} \left(\frac{1+r_t}{1+\delta}\right)^{\frac{i-s}{\rho}}\right]^{-1} \tag{5}$$

and $a_{t,s}$ is the end of period wealth held by an individual s years old in period t. I also assume that labor productivity varies with an individual's age, so that productivity increases until the worker reaches middle age and declines thereafter. Given plausible values for the parameters in equation (4), the pattern of asset accumulation over an individual's lifetime reflects the familiar humped shaped asset profile of the life-cycle hypothesis.

III. Equilibrium Effects of a Baby Boom

Starting at steady state, I first calculate initial domestic and rest of the world capital stocks. I then calculate the size of the labor force. Given some production function, equilibrium in world capital markets forces capital flows to equalize the domestic and world interest rates.

$$r_t = \hat{r}_t \tag{6}$$

where $\hat{r}_t$ denotes interest rate abroad.[2] This equilibrium condition yields domestic capital stock, which together with the size of the labor force yield aggregate output and capital-labor ratio, as well as equilibrium interest rates and wages.[3] Once I know the interest rate and wage, I can then calculate the consumers consumption from equation (3).[4] Given each individual's consumption, I then calculate equilibrium asset holdings for each individual using (4). Aggregating the savings of individuals determines the size of aggregate world saving for the following period.

The labor force in each period t, equals the sum of the population age distribution from 0 to T'.

$$L_t = \sum_{s=1}^{T'} \varphi_t(s) \tag{7}$$

[2]All variables with a hat denote variables for the rest of the world.

[3]I assume labor is not mobile across countries.

[4]To simplify the simulation, I assume static expectations by the consumers, i.e., each consumer assumes that current interest rates and wages will persist into the future.

where $\varphi_t(s)$ is the age distribution of the population in period t.

Given the asset profile of individuals, aggregate saving is merely the sum of all assets of every individual present in the economy. As before let $a_{t,s}$ be quantity of assets held by an individual aged s in period t. Aggregate saving equals

$$S_t = \sum_{s=1}^{T} a_{t,s}\varphi_t(s) \tag{8}$$

If the aggregate production function has constant returns to scale and markets are competitive, the equilibrium rate of return of capital is

$$r_t = f'(k_t) \tag{9}$$

where k_t is the capital-labor ratio and $f(k_t)$ is the net production function of the economy. Under the same conditions equilibrium wages equal

$$w_t = f(k_t) - f'(k_t)\,k_t \tag{10}$$

In addition the economy grows at some exogenous rate γ which augments aggregate labor productivity. To close the model, I assume a simple Cobb-Douglas production function with labor augmenting productivity growth for the economy.

$$f(k_t) = A(1+\gamma)^t k_t^{\alpha} \tag{11}$$

where α is capital's share of output A is a scaling factor and γ is labor productivity growth.

IV. Simulating the U.S. Baby Boom

To simulate the impact of the baby boom on the U.S. economy, I make the following simplifying assumption about the baby boom: initially the population grows at rate n until period $t = 0$ when the growth rate changes to $n + \epsilon$, where $\epsilon > 0$ and indicates the magnitude of the baby boom. The

new growth rate persists for τ periods and then the population growth rate returns to n.[5] Table 1 presents the parameters used in the simulation.[6]

Figure 1 shows the path of output per worker and the path of the capital-labor ratio as the baby boom passes through the economy. Initially the baby boom enters the economy without sufficient capital so that the capital-labor ratio decreases. k_t continues to decline at an increasing rate until the entire baby boom generation has entered the economy. Once the entire baby boom is within the economy, the rate of decrease of the capital-labor ratio diminishes, and after thirty years the saving of the baby boom reaches its lowest point, some 0.1 percent lower than the economy without a baby boom. Thereafter the capital-labor ratio begins to increase at an ever increasing rate, especially so as the baby boom generation begins to retire. At this point the retirement rate from the labor force is higher than the entry rate, therefore every person still in the labor force sees an increase in the capital per labor unit. The net effect increases the capital-labor ratio at even a faster rate. Eventually the dissaving of the retiring baby boomers decreases the available capital stock and the rate of increase in the capital-labor ratio slows, and as the baby boom generation dies, the growth of the capital-labor ratio slows even further, eventually returning to the capital-labor ratio to the old steady state level. The figures also indicate that a U.S. baby boom affects the rest of the world as well, and in most instances, affects them in exactly the same way as it affects the U.S. economy. As equation (6) requires interest rate equalization, equation (9) requires k_t and $\hat{k}_t$ to move together, which in turn comovement in y_t and $\hat{y}_t$, and w_t and $\hat{w}_t$.

Figure 2, panel A shows the paths of interest rates implied by equations (9), (6) and (11) and figure 1. The decrease in the capital-labor ratio generated by the temporary increase in the population growth rate causes interest rates to increase, until it reaches its maximum some five basis points higher than the baseline economy. Thereafter interest rates decrease returning to its original level after the baby boom has completely passed through the economy.

In contrast to interest rates, real wages follow the paths outlined by

[5]The actual baby boom had a period of increasing birth rate followed by a gradual decline to a rate below the pre-baby boom era. The simplified baby boom is calibrated to the average annual population growth rate during the baby boom.

[6]The subjective discount rate, coefficient of relative risk aversion and the Cobb-Douglas parameters are equal to the values used by Auerbach and Kotlikoff [1987]. An individual's labor productivity profile equals $exp(4.47 + 0.033age - 0.00067age^2)$, the same equation used by Auerbach and Kotlikoff.

the capital-labor ratio, decreasing as the capital-labor ratio decreases and increasing as the capital-labor increases. Panel B of figure 2 graphs the paths of wages suggested by figure 1 and equations (10) and (11). The faster rate of entry of individuals into the labor force diminishes their marginal product as capital is slow to respond to the sudden increase in the growth rate. With decreasing marginal product of labor, wages decrease. The drop in real wages continues until thirty years has passed and real wages reaches its minimum, some 0.03 percent lower than the economy without the baby boom. The decrease in wages reverses itself once the quantity of capital held by the baby boom generation becomes sufficient to reverse the decline in the capital-labor ratio.

Figure 3 shows the implications of the baby boom for saving and capital flows. National saving rate, shown in panel A, reflects in part the relative size of the young, working population to the older, retired population. As the baby boom enters the economy the number of young saving for retirement increases, thereby increasing the national saving rate. The saving rate continues to increase as the baby boom generation is within the labor force increasing to a rate some thirty-five percent greater than the steady state rate of saving. As the baby boom generation begins to retire, the saving rate decreases until it returns to the pre-baby boom level, soon after the entire baby boom generation has died. Abroad, consumers react to the higher interest rate and lower their saving, although the size of reduction is quite small. As expected panel B of figure 3 shows that a U.S. baby boom creates a large capital inflow from the rest of the world. The capital inflow coincides with the path of the baby boom.[7]

Figure 4 shows the impact of the U.S. baby boom on domestic and rest of the world consumption per capita. The decline in labor productivity diminishes per capita consumption.[8] The decline in per capita consumption lasts for thirty years, dropping nearly four percent relative to the baseline economy. As real wages returns to the old steady state level, per capita consumption returns to its steady state value. The rest of the world also share in the fortunes of the U.S. baby boom, although with a smaller effect.

[7]Since the baby boom is a temporary phenomenon, the U.S.'s intertemporal budget constraint vis-a-vis the rest of the world is not violated.

[8]Not all consumers suffer a drop in consumption. Individuals who are retired or are near retirement enjoy greater consumption as the returns to their saving increases. This suggests that perhaps income and wealth distributions favor individuals who hold their wealth as physical capital rather than human capital.

V. Conclusion

The model presented in this paper suggests that a domestic baby boom has consequences for the rest of the world, and the domestic and foreign economies share most of the effects of the baby boom. The primary difference between an open and closed economy simulations is that the resources of the rest of the world damps the magnitudes of the effects. The model also suggests that the baby boom may create large capital flows between countries, specifically capital moves to the country experiencing the baby boom. While the effects of the baby boom on output and factor prices are small, its impact on saving and capital flows are quite large.

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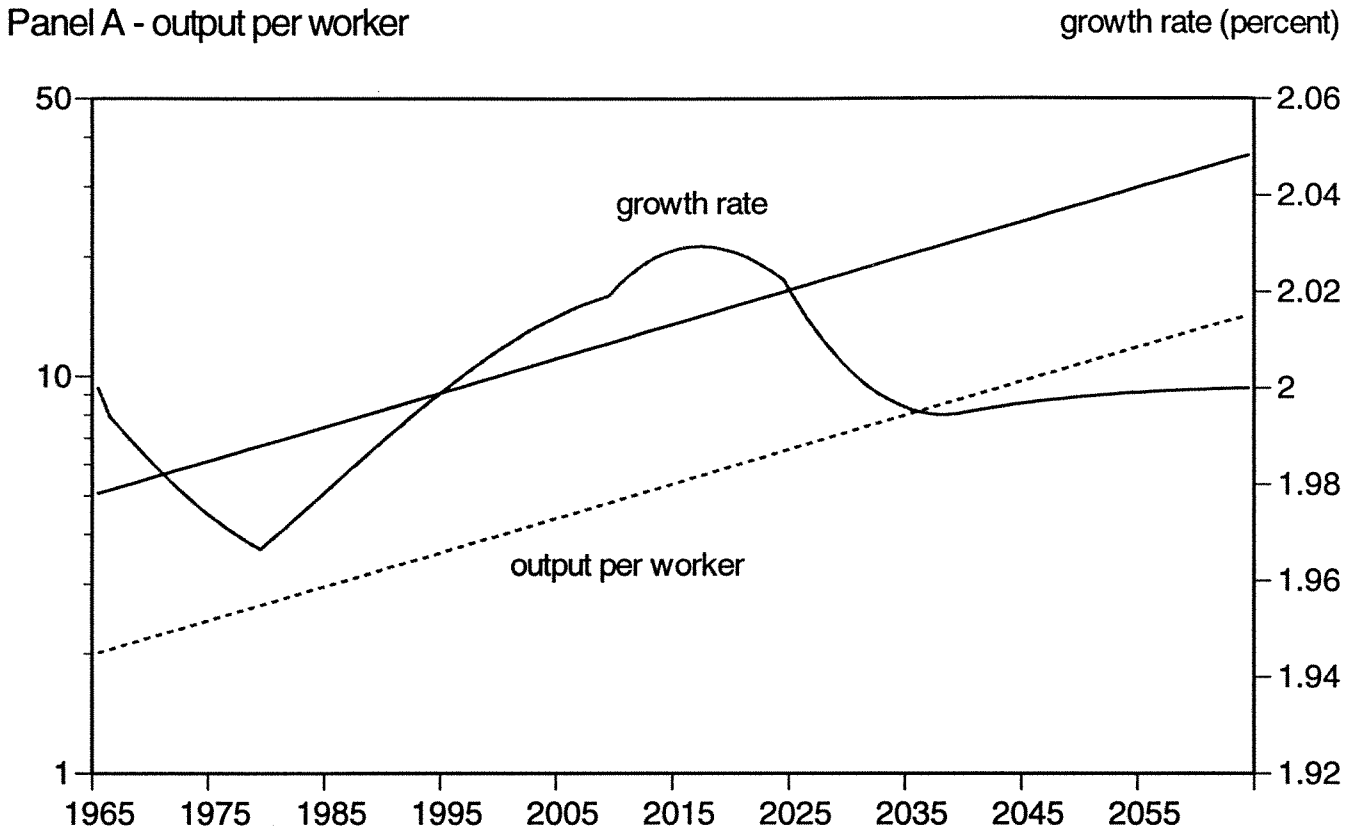
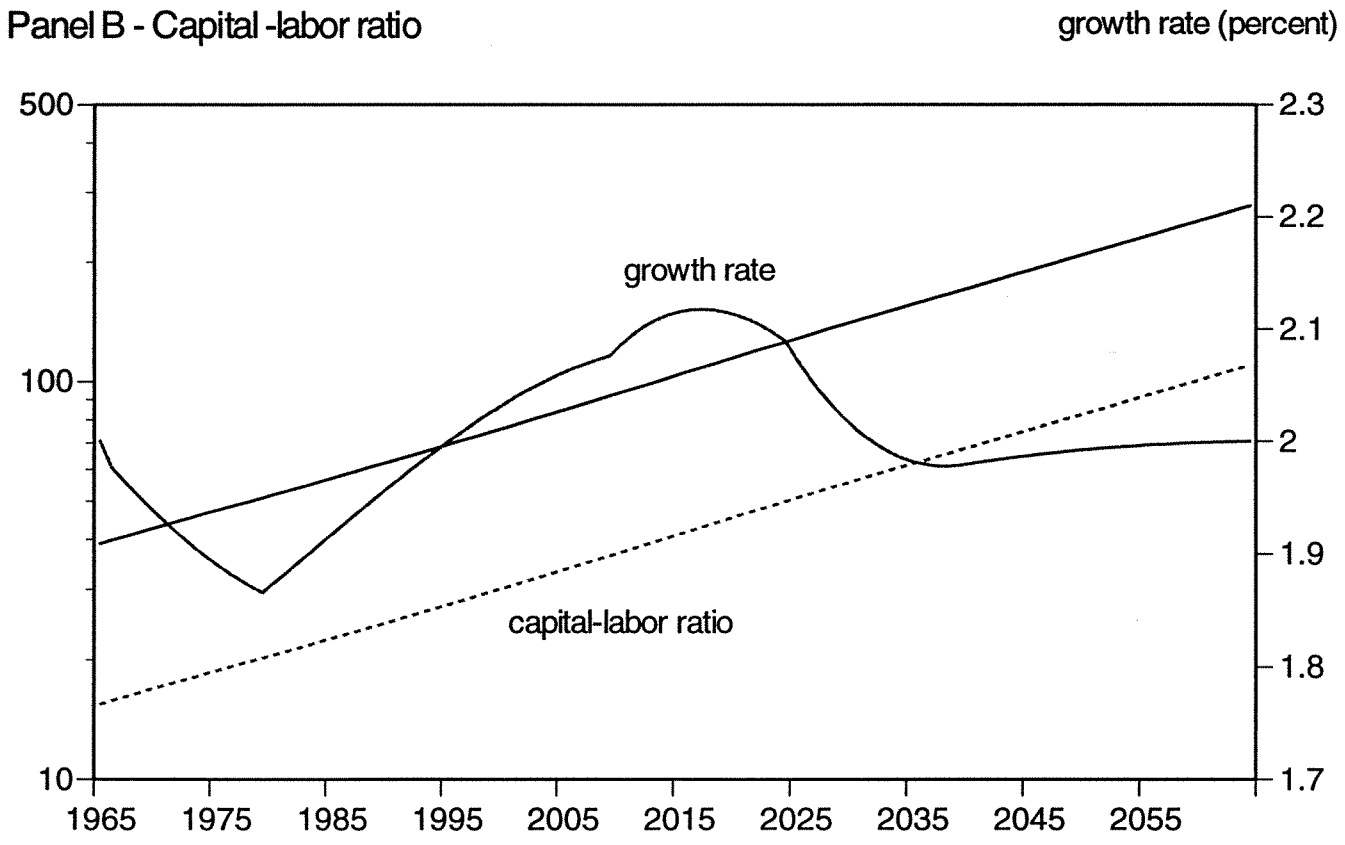
Table 1: Model Parameters

parameters		U.S.	r.o.w.
T	lifespan	60	60
T'	working life	45	45
n	initial pop. growth rate	0.01	0.01
ϵ	size of baby boom	0.01	
τ	duration of baby boom	15	
δ	subjective discount rate	0.015	0.015
ρ	coefficient of relative risk aversion	4	4
α	capital's share of output	0.25	0.25
γ	labor productivity growth	0.02	0.02
A	scaling factor	2	1

Figure 1: Output per Worker, Capital-labor Ratio

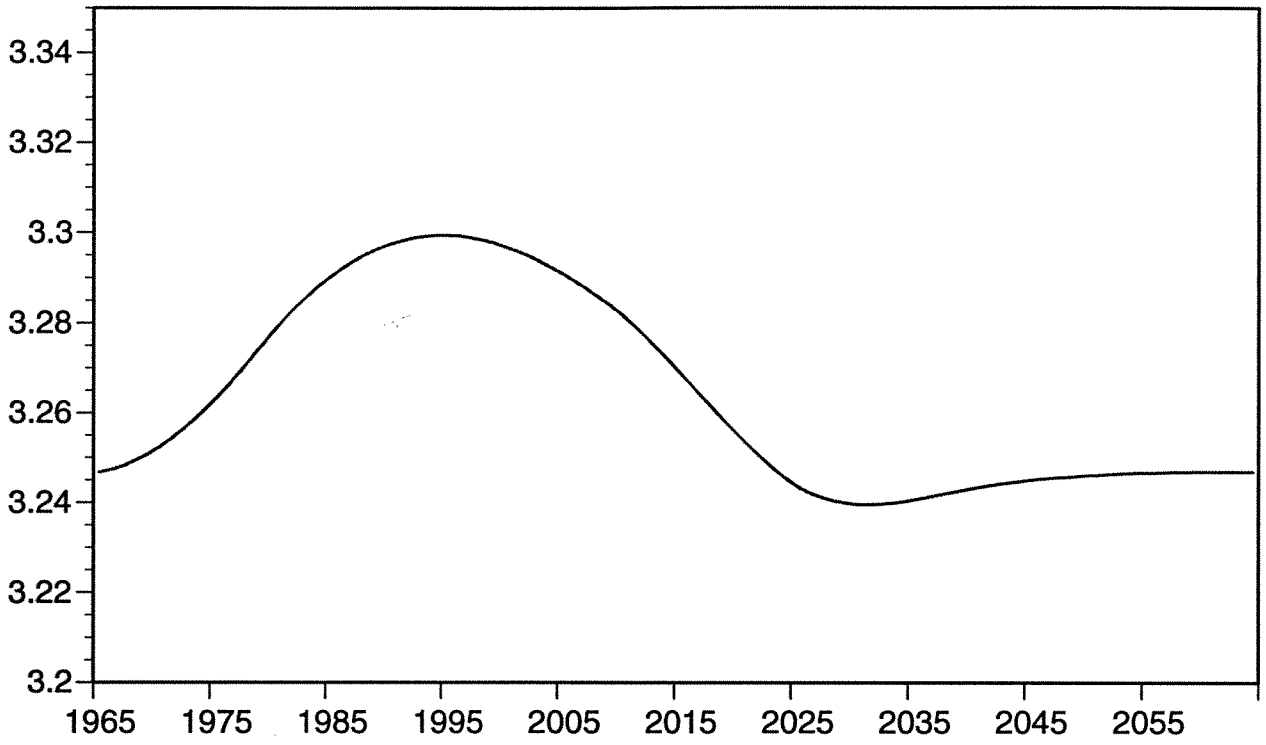




solid - baby boom economy, dotted - rest of the world

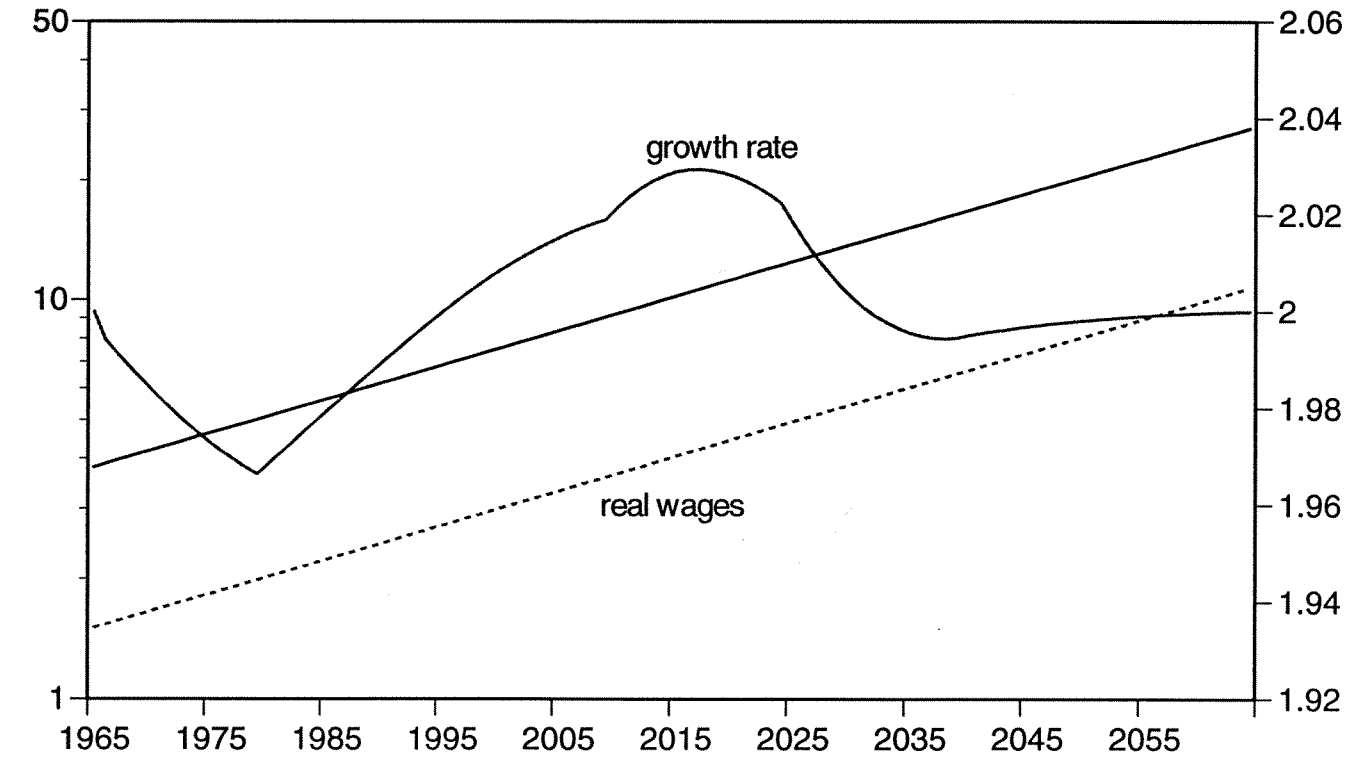
Figure 2: Returns to Capital, Real Wages

panel A - real rates of return to capital



panel B - real wages

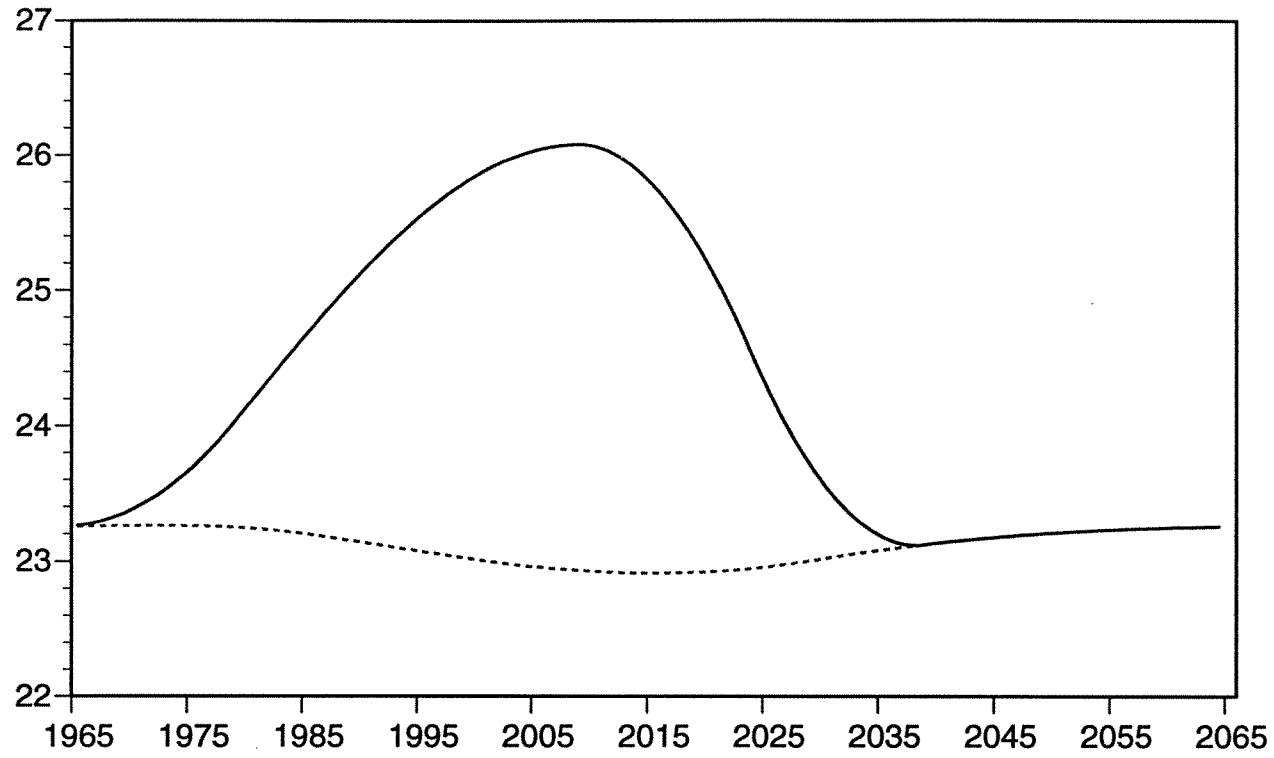
growth rate (percent)



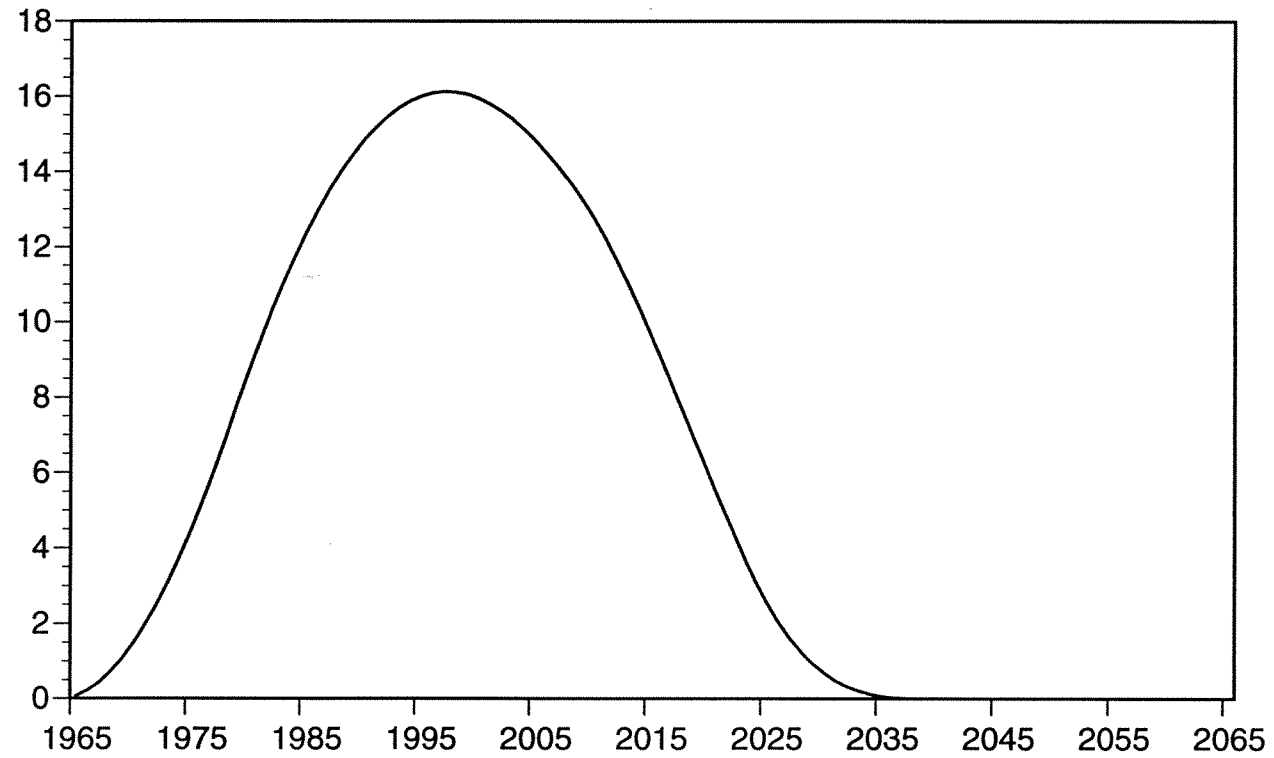
solid - baby boom economy, dotted - rest of the world

Figure 3: Saving Rate, Capital Flows

panel A - saving rate



panel B - capital account as percent of output, baby boom economy



solid - baby boom economy, dotted - rest of the world

Figure 4: per capita Consumption