A Demographic Explanation of U.S. and Japanese Current Account Behavior*

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Abstract

During the last two decades, academics and policy makers have been puzzled by the large and sustained U.S. and Japanese deviations from current account balance. Over this period, the bilateral current account balances have averaged -0.8% and 1.6% of GDP for the U.S. and Japan respectively. Over the same period the demographic dynamics in the two countries have differed significantly. This paper asks to what extent the current account deviations can be explained by differences in the demographic dynamics. This question is addressed within a general equilibrium framework with time-varying demographics where two economies are connected through a common capital market. The model is calibrated to U.S. and Japanese historical and projected demographic patterns and national accounts. Both the magnitude and persistence of the current account deviations predicted by the model economy are close to observed current account behavior.

Key words: Current account, demographics, life-cycle behavior.

JEL Classification Codes: E21, E27, F21, F32.

1 Introduction

Large and sustained U.S. and Japanese deviations from current account balance have received widespread attention over the last 20 years. The U.S. current account deficit has averaged -1.4% of GDP over the period 1979-98, a stark contrast to an average of 0.3% from 1960-79. The Japanese current account surplus has averaged 2.3% over the years 1979-98. While these balances are relative to the rest of the world, their behavior seems strongly related, with a correlation coefficient of -0.72. In bilateral terms, the U.S. and Japanese deviations from current account balance have averaged -0.8% and 1.6% of GDP.

Several explanations have been offered for this behavior, ranging from increasing U.S. time preference to financial crises in emerging markets leading to "safe haven" inflows of capital, to a technology shift in the U.S. economy increasing productivity and returns on investments.[1] This paper asks whether demographic behavior may be an important factor. Demographics can influence trade balance behavior because of standard life-cycle savings reasons; countries with differing age distributions may exhibit different aggregate savings behaviors. In addition, the associated equilibrium effects on the return on savings in an integrated global capital market may have important consequences. This paper uses an equilibrium life-cycle model to examine these effects.

A demographic explanation would not be plausible if U.S. and Japanese demographic behavior were sufficiently similar. This, however, has not been the case over the last 30 years and will not be the case for the forseeable future. Over the past three decades, the share of the population of working age has been stable in both countries. In Japan this age group's share of the total population has increased slightly from 60% to 62%, whereas in the U.S. it has increased from 52% to 58%. However, due to lower fertility rates, lower mortality rates, and lower immigration rates, these numbers hide the fact that the Japanese population is aging much more quickly than the U.S. population. During the last 30 years, the share of the population over 65 in Japan has increased from 7.1% to 17.2% compared with an increase from 9.8% to 12.5% in the U.S. Further, over this period the average age of the working population (20-65 years old) in Japan has increased from 38.4 to 42.3, whereas in the U.S. it has stayed the same; 40.6 and 40.8. According to available projections, these trends are likely to continue.

The question then is to what extent U.S.-Japanese current account be-

[1] See Hervey and Merkel (2000) for a survey.

havior can be accounted for by differences in demographic dynamics. I construct a general equilibrium heterogeneous-agent model with two open economies interacting through a common capital market. Market clearing implies that the marginal product of capital is equalized between the two economies. Since there is no migration this condition endogenizes the current account. The model economy is calibrated to national accounts and realized and projected demographic patterns.

The model predicts current account movements that are close to observed data, both in magnitude and persistence. What drives the results is the interaction between demographic dynamics and consumption and savings decisions over the life cycle, given expected factor prices. A country with relatively more young people entering into the labor market tends to be a capital importer in order to provide each efficiency unit of labor with a market clearing level of capital such that the marginal product of capital is equalized between countries. Capital exporters will be countries with a large share of their population in their peak earning years combined with high life expectancy and few young people entering the labor market. Everything else equal, countries with higher life expectancy, but the same pension age, will tend to be capital exporters since each individual will be accumulating more wealth during working years.

2 Related literature

Starting with the seminal work of Auerbach and Kotlikoff (1987), much work has been done to study the fiscal implications of changing demographic patterns. These contributions, however, have almost solely focused on closed economies, drawing few implications for current account behavior. Ríos-Rull (2001) for instance develops a general equilibrium overlapping generations (OLG) model with stochastic population where the agents are living for a large number of periods. He asks the question how an aging baby-boom affects capital accumulation in a closed economy, and finds that it has substantial effects.

Attanasio and Violante (2001) construct a two-region model with an OLG structure similar to Ríos-Rull (2001) to analyze welfare effects of capital liberalization between North and South America. Their results indicate that there are substantial welfare gains from free capital flows between the regions and that the distribution of these welfare gains might differ substantially between generations.

With a traditional OLG model where a representative agent lives deterministically for three periods, Higgins and Williamson (1997) analyze how consumption smoothing, variable-sized cohorts, and varying growth rates affect international capital flows.[2] Brooks (2000) divides the world into eight regions and analyzes capital flows between these regions using an OLG model with a representative agent who lives deterministically for four periods.[3]

Because of the deterministic life-cycles and limited number of periods, these models are only able to account for the dynamics of macroeconomic variables in the very long run. In order to account for more frequent phenomena like the U.S. and Japanese current account behavior the last decades, this paper constructs a model with a detailed specification of the demographic dynamics and how demographic variables enter into the individuals' decision problem. This specification allows us to carefully calibrate the model in order to provide quantitative answers to the questions we are asking.

3 Evidence

Figure 1 shows that U.S. and Japanese current accounts balances fluctuated around zero in the period up to the beginning of the 1980s. Subsequently, the U.S. has run large deficits on the current account relative to GDP, whereas Japan has run large surpluses. It is important to note how the Japanese current account surpluses have been roughly the same during both the boom in the 1980s and the contraction in the 1990s. Similarly, with exception for the recession in 1991, the U.S. has run current account deficits for the entire period since 1980 despite variable growth rates.

More specifically, Figure 1.1 shows Japanese and U.S. current account balances relative to the rest of the world for the period 1968-2001. The two series are negatively correlated with a correlation coefficient of -0.72. The

[2] Higgins and Williamson (1997) is following in the tradition from Coale and Hoover (1958) and the so called "dependency rate" literature. One of the motivations for this line of research was to analyze the effects on developing countries of a rising population as the mortality rates fall and where a high ratio of young relative to working-age population would imply that aggregate saving is low and demand for investment is high.

[3] Statistical studies give support to these qualitative results. Higgins (1998) study the links between age distribution and savings and investment rates for a sample of 100 countries and finds a substantial demographic effect. With a sample of 66 countries, Lane and Milesi-Ferretti (2001) estimate how the *stock* of net foreign asset positions is influenced by relative output levels, the stock of public debt and demographic factors. Their results with respect to demographics are quite strong. Other related empirical studies include Higgins and Williamson (1997), Herbertsson and Zoega (1999), and Chinn and Prasad (2000).

magnitude is, as expected, much larger than in Figure 1.2 which shows the bilateral balance. Even though the magnitude is different, the implications are similar. Since the numerator is the same for the two series, the differences are a result of differences in denominator (GDP) for each country.

Are there any striking patterns between current account behavior and other macroeconomic time series? Several attempts have been made to find support such for relationships.[4] Figure 2 shows the movements in the period 1960 to 2000 of the real GDP growth rates and the real exchange rates which are the two variables that most frequently used to account for current account behavior. As shown in Figure 2.1, in the period 1960-1973 the real GDP growth rates were significantly higher in Japan than in the U.S., more similar in the period 1973-91, and higher in the U.S. in the period after 1991. These regime changes do, however, not seem to be reflected in the current account movements. The real exchange rate movements are shown in Figure 2.2. In real terms, the yen has appreciated significantly relative to the dollar since the break-up of the Bretton Woods system. There are two exceptions: the first half of the 1980s and, to a lesser extent, the second half of the 1990s. It is, however, hard to spot anything that indicate systematic co-movement with the current account.

3.1 Demographics

During the period 1960-96 population growth in the U.S. was stronger than in Japan. Average annual population growth in the U.S. was 1.06%, compared with 0.76% in Japan. Accumulated over the entire period, the U.S. population increased by 52% compared with 34% in Japan.

The size and growth of the population by itself is insufficient to offer an explanation of the evolution of the current account balance. More interesting is the age composition of the population. Figures 3.1 and 3.2 show that the population composition in the two economies changed substantially over the period 1950-96. The share of young people in Japan decreased rapidly while the share of the population of 65 years old increased. Less obvious is how the average age of the working population in Japan increased over the period, whereas in the U.S. it has been much more stable. In the period 1970-2000, the average age of the working population (20-65 years old) in Japan increased from 38.4 to 42.3, whereas it in the U.S. hardly increased; from 40.6 to 40.8.

Some of the underlying dynamics are shown in Figure 4. Natural in-

[4] Lane and Milesi-Ferretti (2001) and Chinn and Prasad (2000) are recent examples.

crease, defined as births minus deaths, has shown a steady downward trend in both economies (Figure 4.1). As we see from Figure 4.2, this can mainly be attributed to lower fertility rates. The rapid aging of the Japanese population compared with the U.S. population is to a large extent due to the combination of lower fertility rates and lower death rates.

Another important factor determining demographic dynamics is the difference in immigration regimes. As we see from Figures 4.3 and 4.4, net immigration, measured both in absolute numbers and relative to the total population was significantly higher in the U.S. than in Japan during the entire post war era. As shown by Figure 5.6, the age distribution of immigrants is also important for the impact of immigration on demographic dynamics and the age distribution.

3.2 Demographic projections

Intermediate population projections are shown in Figure 5.[5] We see that the population of Japan is projected to decrease by 39% between year 2000 and 2080. Over the same interval the U.S. population is projected to increase by 34%. A striking feature is the decrease over time in the working-age (15-64 years old) population in Japan. This age group is projected to decrease by more than 50%, from more than 80 million in 2000 to less than 40 million in 2100.

Figures 5.3 and 5.4 show projected fertility rates and life expectancy at birth. The total fertility rate in the U.S. is projected to decrease until it stabilizes at 1.90, whereas the total fertility rate in Japan is projected to increase until it stabilizes at 1.61. In both countries, mortality rates are assumed to decrease and the life expectancy to increase. Even though the mortality rates are projected to decrease slightly more in the U.S. than in Japan, the life expectancy in Japan is projected to be higher than in the U.S. over the entire period both for women and men.

Migration rates are assumed to be roughly the same level as they have been historically (Figures 4.3 and 4.4). Equally interesting are the age distribution and the impact immigrants will have on demographic dynamics, in particular how immigration tend to lower the average age of the population and increase the share in the working years. The Social Security Administration's assumptions of age distribution for immigrants entering the U.S.

[5]Discussions of methodology and assumption for the projections may be found in Takahashi, Kaneko, Ishikawa, Ikenoue and Mita (1999) for Japan and in Bell (1997) and Hollmann, Mulder and Kallan (2000) for the U.S..

is shown in Figure 5.6 together with the actual age distribution of the U.S. population in year 2000.

The overall message is shown in Figure 5.5: In Japan the youth (0-14 years old) and working age (15-64 years old) population will constitute a smaller portion of the total population than in the U.S., whereas pensioners (65 years and over) will constitute a larger share.

4 The Model Economy

The model follows previous work by Auerbach and Kotlikoff (1987), Ríos-Rull (1999), Storesletten (2000) and Ríos-Rull (2001).

There are two countries. Each country is populated by individuals who live up to I periods, with ages denoted by $i \in \mathcal{I} \equiv \{1, \ldots, I\}$. Individuals remain children for I_0 periods. As children they neither accumulate capital nor supply labor. After I_0 periods the agents enter the economy as autonomous decision makers.

The survival probability between age i and $i+1$ is denoted s_i and varies with ages i. Mortality rates are assumed constant over time. The unconditional probability of reaching age i is denoted s^i and is the product of conditional survival probability rates; $s^i = \prod_{j=1}^{i-1} s_j$.

Let $x_t \in \mathbb{R}^I$ be the vector of number of members in each cohort in period t. The demographic structure of the population changes through changes in fertility. According to time and age-specific fertility rates $\varphi_{i,t}$, in each period these individuals give birth to a certain number of new individuals, and the number of newborns in period $t+1$, $x_{1,t+1}$, is the product of x_t and the vector of fertility rates φ_t. The law of motion of a population with survival rates as given above, but deterministic fertility, can be described by a simple $(I \times I)$ matrix

$$\hat{\Gamma} = \begin{pmatrix} \varphi_1 & \varphi_2 & \varphi_3 & \cdots & \varphi_I \\ s_1 & 0 & 0 & \cdots & 0 \\ 0 & s_2 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & s_{I-1} & 0 \end{pmatrix},$$

where the diagonal elements $(s_1, \ldots, s_{I-1})$ are the conditional survival probabilities.[6]

[6]The largest eigenvalue of the matrix Γ is the rate of growth of the population in steady state regardless of the initial condition. The eigenvector corresponding to this eigenvalue describes the share of each age group in the steady state population.

Individuals migrate to and from a third country each period. This country is not part of the model. Let $m_t \in \mathbb{R}^I$ be a vector with each element representing the cohort-specific number of net immigrants at time t. Denoting $\hat{\Gamma}_t$ the matrix of deterministic fertility and mortality rates at time t, the actual law of motion for the population may be written

$$x_{t+1} = \hat{\Gamma}_t x_t + m_t.$$

4.1 Preferences and technology

Preferences of an agent born in period t may be summarized by a standard time-separable utility function with age specific weight β^i

$$\mathrm{E}_{t+I_0} \left\{ \sum_{i=I_0+1}^{I} \beta^i s^i u_i \left(c_{i,t} \right) \right\}, \tag{4.1}$$

where u_i is the instantaneous utility function, and $(c_{i,t}, l_{i,t})$ is consumption and leisure of an agent of age i born in period t.

The instantaneous utility function has the standard isoelastic specification

$$u\left(c_{i,t}\right) = \frac{\left(\frac{c_{i,t}}{\eta_i}\right)^{1-\sigma} - 1}{1-\sigma},$$

where $\{\eta_i\}_{i=1}^I$ is a vector of cohort specific factors to adjust for consumption of dependents (children).

Each individual supplies labor inelastically to the market. The productivity and the rate of return on labor supplied changes with age according to a deterministic pattern. The vector of age specific efficiency units of labor is denoted $\{\epsilon_i\}_{i=1}^I$. An easy way to exogenously capture childhood inactivity and old age retirement is to set labor efficiency for those cohorts equal to zero.

There are at least two ways of closing the model by introducing bequests. On the one hand, like Storesletten, Telmer and Yaron (2002, p. 13) and Ríos-Rull (2001, pp. 8-9), where each agent has written a contract with the members of it's own cohort that make the survivors share the wealth or debts of those who die prematurely. This way of closing the model does, however, eliminate the risk element by disturbing the intertemporal price of capital and the result is that the Euler equation and policy function makes the model very close to a model with no surivial/death probability.[7]

An alternative way to close the model where the individuals still face mortality risk is by dividing total aggregate bequest equally among all inhabitants. Agents may accumulate assets in positive and negative amounts. The agent maximizes utility subject to the budget constraint

$$c_{i,t} + a_{t,i+1} = a_{i,t}\left(1 + r_{t+i-1}\right) + \epsilon_i w_{t+i-1} + h_{i,t}, \tag{4.2a}$$

and the constraints following from the absence of a bequest motive

$$a_{1,t} = a_{I+1,t} = 0. \tag{4.2b}$$

$a_{i,t}$ is wealth, r_{t+i-1} is the spot market net rate of return of one unit of capital, w_{t+i+1} is the spot market price of one efficiency unit of labor, and accidental bequests, h_t, is the fraction of total inheritance or bequests that devolve on each individual alive at time t

$$h_t = \frac{H_t}{\sum_{i=I_0}^{I} x_{i,t}},$$

where

$$H_t = \sum_{i=I_0}^{I} \left(1 - s_i\right) a_{i,t}.$$

In order to close the model and limit the heterogeneity, immigrants who enter the economy are assumed to have the same stocks of human and physical capital stock as the existing members of their cohort. The physical capital is assumed transferred from the members of their own cohort. In summary, the individual's optimization problem is to maximize (4.1) subject to (4.2b) and (4.2a).

4.1.1 Production

The consumption good is produced by a neoclassical constant returns to scale production function with two input factors, capital and labor. The natural choice of functional form is Cobb-Douglas

$$y_t = f\left(K_t, N_t\right) = \theta_t K_t^{\alpha} N_t^{1-\alpha}.$$

[7] If $h = \left(1 - s_{-1}\right)\left(1 + r\right) a_{-1}$, then envelope condition wrt. the state variable a_{-1}, updated one period, is

$$\partial v'\left(a\right)/\partial a = \left(1 + r'\right)\left(2 - s\right)\left[\left(1 + r'\right) a + w\epsilon' - a'\right]^{-\sigma},$$

and the intertemporal marginal rate of substitution between consumption in two consecutive periods is equal to $\beta\left(1 + r\right)\left(2 - s\right)s$, with $\left(2 - s\right)s > s$ for all $0 < s < 1$. So "cohort specific insurance" is to close to canceling out the effect of the mortality risk.

The factor prices will in equilibrium equal the value of the marginal product with respect to the factor.

4.2 Equilibrium

The open economy equilibrium is defined as a sequence of the variables $\{c_{i,t}, a_{i,t}, K_t, N_t, h_t, w_t, x_{i,t}\}$ in each country, an international capital flow and a world interest rate r_t such that: the population shares are determined by the country specific transition matrix $\hat{\Gamma}_{n,t}$; households solve optimally their problems taking prices as given; wages in each country are set to marginal productivity of labor; the aggregate resource constraint is binding; and the national labor markets clear. The no-arbitrage condition that integrates the two countries and generates the current account is set to be that the net rate of return on capital in the two countries is equalized.

Formally, the recursive competitive equilibrium for the open economy satisfies the following criteria:

1) The allocation is feasible, i.e. for all (x, k)

$$\sum_i \left(a_i'(x, k, a_i) + c_i(x, k, a_i)\right) x_i = f(K(x, k), N(x, k)),$$

where k is the vector of assets owned by individuals in each age group.

2) Prices are competitively determined

$$\begin{aligned} r(x, k) &= f_1(K(x, k), N(x, k)) - \delta \\ w(x, k) &= f_2(K(x, k), N(x, k)) \end{aligned}$$

3) Capital is allocated across countries such that the net rate of return on capital is equalized. For all p, q

$$r = [f_1(K_p(x, k), N_p(x, k)) - \delta_p] = [f_1(K_q(x, k), N_q(x, k)) - \delta_q]. \tag{4.3}$$

4) Given the laws of motion for the aggregate state variables population, Γ, and capital holdings, G, the decision rules of the agents a_i and c_i, solve their maximization problem: $\{a_i'(x, k, a_i), c_i(x, k, a_i)\}$

$$v = \underset{a', c}{\operatorname{argmax}}\, u_i(c) + \beta_i s_i v_{i+1}\left(x', k', a'\right)$$

subject to

$$
\begin{aligned}
k' &= G(x,k), \\
x' &= \hat{\Gamma} x, \\
c_i + a_i' &= a_i \left[1 + r(x,k)\right] + \epsilon_i w(x,k) + h, \\
h &= \frac{\sum (1 - s_i) a_i}{\sum x_i},
\end{aligned}
$$

5) The value functions are generated by the agents' decision rules and by the fact that they do not have any explicit bequest motive. The law of motion of the capital stocks is generated by the decision rules of the agents

6) Aggregate function K and N are generated by summing over the cohorts at each period of time t

$$
\begin{aligned}
K(x,k) &= \sum_i x_i k_i, \\
N(x,k) &= \sum_i x_i \epsilon_i.
\end{aligned}
$$

Worth noting is that the no-arbitrage condition (eq. 4.3) implicitly implies that we do not distinguish between investment flows and capital stocks; investments are fully reversible and the price of capital in terms of consumption good is 1. Due to the five-year periods and no shocks to technology, gross investment are positive in both countries in almost all periods, and this assumption has therefore no quantitative effect on the findings.

4.3 Closed economy equilibrium

The difference between the closed economy and the open economy is that the open economy may use international capital markets to smooth consumption across periods of time. In the closed economy savings will have to be equal to investment in every period. Formally, the closed economy equilibrium is a sequence for the variables $\{c_{i,t},\ a_{i,t},\ l_{i,t},\ K_t,\ N_t,\ h_t,\ w_t,\ r_t,\ x_{i,t}\}$ such that the population shares are determined by the transition matrix $\hat{\Gamma}$, households and firms solve optimally their problems taking prices as given; the factor markets clear; factor prices are competitively determined and equal to the marginal product with respect to the factors of production; and the aggregate resource constraint is satisfied.

Table 1: Benchmark parameter values

U.S.A.		
Technology		
Capital share	α	0.4
Capital depreciation rate (annual)	δ	0.04
Preferences		
Time discount factor (annual)	β	1.001
Coefficient of risk aversion	σ	4
Japan		
Technology		
Capital share	α	0.4
Capital depreciation rate (annual)	δ	0.04
Preferences		
Time discount factor (period-by-period)	β	1.001
Coefficient of risk aversion	σ	4

5 Calibration

In order to keep the framework as simple as possible, to the extent possible the same key ratios and parameter values are chosen for the two economies.

Preference and technology parameter values for both economies were set to match an annual capital to output ratio of 3. The capital share of income is set to .4 which is in line with most of the business cycle literature.

The annual discount rate is set to 1.001 in accordance with the study of mortality risk and bequests by Hurd (1989). The coefficient of risk aversion is set equal to 4. The depreciation rate is calibrated to approx. 4% annually which is slightly less than what I have seen used in the business cycle literature. The parameters are summarized in table 1.

Efficiency units of labor $\{\epsilon\}_{i=1}^{I}$ is chosen to match the lifetime wage profile as in Hansen (1993). The wage profile peaks between ages 45 and 55 when it is approximately 80% higher than for ages 20-25 years. Family size $\{\eta\}_{i=1}^{I}$ is taken from Ríos-Rull (2001) and defined such that consumption enjoyed is an age specific fraction of consumption spent.

To calibrate the technology growth and relative size of the economies, I used real GDP data series from Penn World Tables[8]. Calibrating the model to fit the four ratios of the relative size of the two economies in 1970 and

[8] http://pwt.econ.upenn.edu/

1990 and for each economy the ratio of the size in 1970 and 1990, the annual TFP growth rate for the U.S. was roughly .9%. For the period after 1990, this is the growth rate for both economies. Note that since we are simulating the model over five-year periods, all annual values have to recalculated to five-year values.

5.1 Demographics

For the period up until 1997, data for demographic dynamics are taken from the extensive data sets from the United Nations Demographic Yearbook Historical Supplement 1948-97.[9] For each five-year period the vector of fertility rates and mortality rates are set equal to the five-year moving average with equal weights.

Demographic dynamics from 2000 and onwards are based on projections from the Social Security Administration (SSA) and from the National Institute of Population and Social Security Research (IPSS) for the United States and Japan, respectively.[10] The baseline model is based on what the respective organizations in each country characterize as the middle alternative. Both institutions have published projections up to 2100.

According to the projections, the populations have not reached their stationary distribution by 2100. In order to calculate the second steady state, the paths to the stationary distribution of the populations are calculated by iterating over the transition matrix, using the fertility and mortality assumptions for the periods up to 2100.

The data sets from the United Nations provide detailed demographic dynamics from 1950 till today. A fundamental assumption for our model economies is free capital flows. In the years preceding the breakdown of the Bretton Woods system and managed capital flows, this was not the case and it would have been too strong an assumption to make. I have therefore chosen to start the simulations from 1970, which is about the time when the Bretton Woods broke down.[11]

[9] `http://www.un.org/Depts/unsd/demog/dybcd-pub/`

[10] For documentation and methodology, see Takahashi et al. (1999) and Bell (1997).

[11] When extending the dataset to also cover the period 1950-70, the simulations predict substantial capital movements in the period 1950-65. Most probably due to extensive capital regulations, this is not observed in the data series which show only small net capital movements.

6 Findings

Figure 6 shows the simulated initial steady state distribution of savings over the life cycle for the Japanese and U.S. model economies. Worth noticing is the shape of the steady state consumption and savings curves. The consumption curve is first increasing and then decreasing due to the cohort specific survival probabilities over the life cycle. The intuition is simply that since the probability of getting very old is low when a person is young, he or she will accordingly put less weight on consumption in these periods. Despite the large differences in the marginal product of labor across the cohorts or age-groups, as a result of the retirement savings motive, the young population borrows little to increase consumption.

Figure 7 presents the resulting current account in absolute and relative terms as we simulate the model economy from 1970 till 2015. As we see from Figure 7.1, our model model economies predict that the economy with the main characteristics of the Japanese economy will run substantial current account surpluses, whereas the economy with the characteristics of the U.S. economy will correspondingly run substantial deficits. In particular, when we look at simulated capital flows as shares of GDP, the results are very close to what has been observed. The averages for the period 1980-2000 are +2.0% and -0.8% of GDP for Japan and the U.S., respectively. For comparison, as cited in Section 3, the observations of bilateral current account for the 20-year period 1979-98 are +1.6% and -0.8% of GDP.

Figure 8 shows the simulated marginal products of the two factors of production. The no-arbitrage condition gives one international interest rate which is given in Figure 8.1. The difference the marginal product of labor, the wage rates, are simply the difference in technological levels between the two economies which is kept constant at the 1990-level.

Figure 9 shows the simulations for additional 17 periods ($\sim$ 85 years). According to these simulations, the U.S. will, except for a few years around 2030, continue to run current account deficits against Japan for the next 50 years. In the following 50 years the signs will change and Japan will be a net capital importer for the first 25 years, before the current account is close to "balanced" from 2075.

6.1 Robustness

The next step is to see how robust these results are. We will consider what effect changes in the coefficient of risk aversion and changes in the relative productivity growth will have.

6.1.1 High coefficient of risk aversion

To assess the effect of a higher coefficient of risk aversion (σ), the model is simulated with $\sigma = 6$. Since this also changes the steady state capital over output ratio, the depreciation rate is adjusted accordingly. The deviations from the benchmark model were negligible.

6.1.2 Productivity growth

The effect of changes in the relative growth rates do, however, have significant impact on the simulated results. In the benchmark economy, the annual rate of TFP growth in Japan in the period 1970-90 was 33% higher than in the U.S. The simulation results when setting the annual rate of TFP growth in Japan equal to two times the rate in the U.S. are presented in Figures 10. As we see from the Figures, for the periods with higher technology growth, the simulation results indicate that more capital would have been allocated to Japan. However, the effect diminishes quickly with time.

The model economy is also simulated when setting the growth rates equal for all periods. As we see from Figure 11, the effect is the same, just with opposite sign. So, for the period, Japanese surpluses and U.S. deficits get larger.

6.2 Alternative projections

In addition to the median projections of future demographic dynamics in Japan and the U.S., the respective government agencies have also projected the demographic dynamics with a high and a low fertility regime.

Figures 12 and 13 show the simulated current account dynamics for low fertility regimes in both countries and high fertility regimes in both countries, respectively. As we see from Figures 12.1 and 13.1, the impact on pre-2000 CA dynamics is small. In the long run, however, as we see from Figures 12.2 and 13.2 that given the high fertility projections the both economies, the Japanese CA/GDP surplus and the U.S. CA/GDP will be significantly larger than given the low fertility projections.

7 Conclusion

This paper asks to what extent the large and sustained U.S. and Japanese deviations from current account balance can be accounted for by differences in demographic dynamics. This question is answered using a two-country general equilibrium OLG model with time-varying demographics. Simulations are based on U.S. and Japanese realized and projected demographic patterns.

Both magnitude and persistence of the current account dynamics predicted by the model economy are close to those observed between the U.S. and Japan over the two last decades. These findings indicate that the Japanese current account surpluses and the U.S. deficits can be understood as the result of free capital movements, optimizing agents and differences in demographic dynamics. According to the simulations, based on the middle projections for future population, the U.S. will continue to run deficits and Japan continue to run surpluses on the bilateral current account for the next 20 years.

What drives the results is a combination of lower fertility rates, lower mortality rates and lower immigration rates in Japan than in the U.S. Lower fertility and lower migration rates, implying that fewer young people enter the labor market in Japan than in the U.S., reducing the relative demand for investment in Japan. Both the share of the working-age population and the average age of the workers are higher in Japan. This means that relatively more people are in their highest earning years, where savings for retirement are highest, increasing aggregate savings and the supply of capital in Japan relative to the U.S. Finally, the mortality rate is lower, hence life expectancy is higher in Japan than in the U.S. Individual savings for retirement in Japan will therefore be higher than in the U.S. and increase the relative supply of capital.

A possible limitation of the analysis is that the number of simulated data points which can be compared with historical data is small. Further the simulated dynamics are sensitive to changes in the drift of the technological progress. Nonetheless, the results show that demographic dynamics can play a critical role in understanding long-term international capital flows.

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A Computational procedure

The model is calibrated to the steady state for the realized demographic structure for 1970 and then again as the two economies, according to the population projections, converge to a new steady state after 2100. Our interest is then in the transition between the steady states and the capital flows that are generated.

A.1 Computing steady state distribution

In order to generate an initial wealth distribution $\{a_i\}_{i=1}^{I}$ we compute the initial steady state allocation using the mortality, fertility and immigration rates, and the steady state age distribution given by these rates, for the first year covered by our analysis. The computation of the steady state requires effectively to solve a difference equation

$$a_{i+1} = g\left(a_i, a_{i-1}\right)$$

with given initial and terminal conditions

The steps are

1) Compute aggregate labor supply

$$N_t = \sum_{i=1}^{I} \epsilon_{i,t} x_{i,t}.$$

2) Make a guess for initial factor prices $\left\{r^0, w^0\right\}$.

3) Derive the second order difference equation from the first order conditions from maximizing (4.1) subject to (4.2a)

$$\begin{aligned} a &= (1+r)\, a_{-1} + w\epsilon + h \\ &\quad - \frac{\eta}{\eta_{-1}} \left[\beta\left(1+r\right)\right]^{\frac{1}{\sigma}} \left[\left(1+r_{-1}\right) a_{-2} + w\epsilon_{-1} + h_{-1} - a_{-1}\right] \end{aligned} \tag{A.1}$$

4) Given the factor prices $\left\{r^0, w^0\right\}$, solve for the agents' optimal asset holdings $\{a_i\}_{i=1}^{I}$ using the second order difference equation (A.1) and the initial and terminal conditions $a_0 = a_I = 0$.

5) Obtain a (new) value for aggregate capital holdings as the sum of individual asset holdings;

$$K_t = \sum_{i=1}^{I} s^i a_i$$

x_i and s^i are here identical.

6) Update the factor prices;

$$\begin{aligned} r^1 &= f_1\left(K^1, N\right) - \delta, \\ w^1 &= f_2\left(K^1, N\right) \end{aligned}$$

7) Iterate from 4) until $r^1 = r^0$ and $w^0 = w^1$. If $r^1 \neq r^0$ and $w^1 \neq w^0$, $r^0 \equiv r^1$ and $w^0 \equiv w^1$.

A.2 Demographic dynamics

Given the initial age and asset distribution, we can solve for the non-steady-state allocations given the demographic dynamics. For each jurisdiction we solve for the following asset matrix

$$\begin{pmatrix} a_{1,2} & \cdots & a_{1,I_0+1} & a_{1,I_0+2} & \cdots & a_{1,I} \\ a_{2,2} & \cdots & a_{2,I_0+1} & a_{2,I_0+2} & \cdots & a_{2,I} \\ a_{3,2} & \cdots & a_{3,I_0+1} & a_{3,I_0+2} & \cdots & a_{3,I} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ a_{T,2} & \cdots & a_{T,I_0+1} & a_{T,I_0+2} & \cdots & a_{T,I} \end{pmatrix},$$

where T is endogenously defined as the point of time after both the population size and distribution have converged to their projected long-term steady state, where the factor prices have converged to their new state states.

Fundamentally, nothing is different from the calculation of the steady state distribution. Here, what is pinning down the problem is that we know (1) that all elements of the last column have to be equal to zero and (2) that the last row should equal the new steady state distribution.

The actual algorithm

1) Calculate the vectors of aggregate labor supply $\left\{N_i^j\right\}_{i=1}^{T}$ for each jurisdiction j.

2) Let the first guess for the rate of return vector $r^0 = \{r_i\}_{i=1}^T$ and the wage vector $w_j^0 = \left\{w_i^j\right\}_{i=1}^T$ for each jurisdiction j be that each element is equal to the state state values.

3) Given the factor price vectors, use the individuals' law of motions

$$\begin{aligned} a = {} & (1+r)\,a_{-1} + w\epsilon + h \\ & - \frac{\eta}{\eta_{-1}}\left[\beta s\,(1+r)\right]^{\frac{1}{\sigma}}\left[(1+r_{-1})\,a_{-2} + w\epsilon_{-1} + h_{-1} - a_{-1}\right] \end{aligned} \tag{A.2}$$

to find optimal asset holdings for each cohort at each point of time in each country.

4) Given the factor prices $\left\{r^0, w_j^0\right\}$ for each j, solve for the agents' optimal asset holdings for each cohort at each point $\left\{\left\{a_{i,t}^j\right\}_{i=1}^I\right\}_{t=1}^T$ for each economy j using the second order difference equation (A.1).

5) Calculate the value of the aggregate asset holdings at each point of time for each economy j

$$\{K_t\}_{t=1}^T = \left\{\sum_{i=1}^I x_{i,t}a_{i,t}\right\}_{t=1}^T$$

6) For each period, distribute aggregate asset holding over the economies such that rate of return on capital is equalized

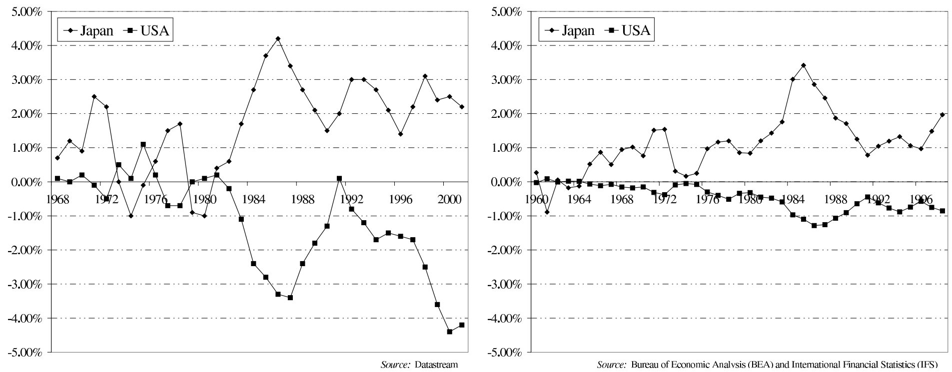
$$r^1 = f_1\left(K^j, N^j, \theta^j\right) - \delta \quad \forall j \tag{A.3}$$

7) Given the distribution of the capital stock determined by equation (A.3), calculate the marginal product of labor in each economy j

$$w^1 = f_2\left(K^1, N\right)$$

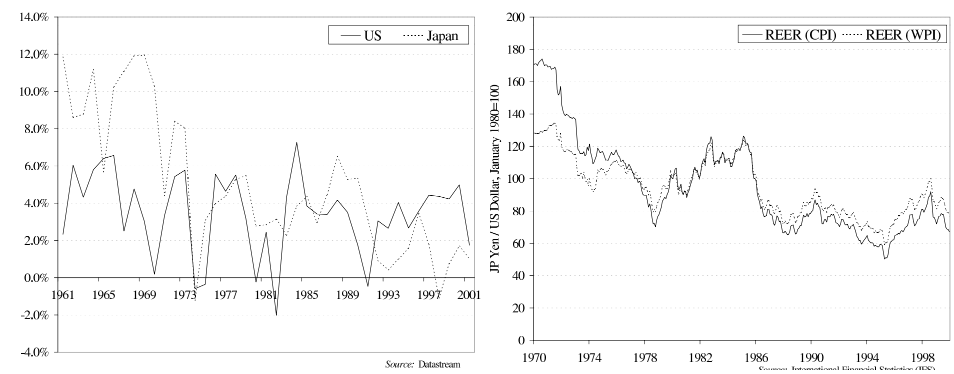
8) Iterate from 3) until $r^1 = r^0$ and $w^1 = w^0$. If $r^1 \neq r^0$ and $w^1 \neq w^0$, $r^0 \equiv r^1$ and $w^0 \equiv w^1$.

B Figures



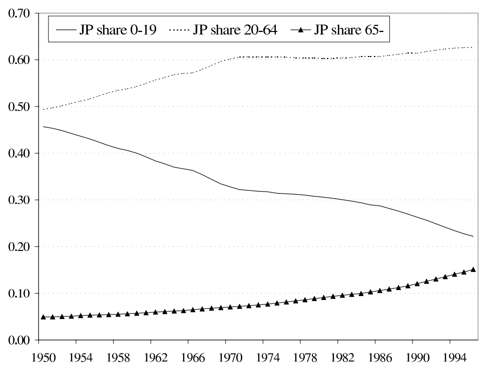
1.1: Current account 1968-2001　　　1.2: Bilateral current acc. 1960-1998

Figure 1: Current account balances as % of GDP for Japan and USA

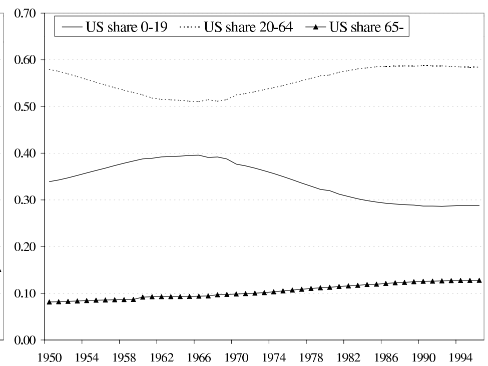


2.1: Real GDP growth　　　2.2: Real Exchange Rate

Figure 2: Aggregate time series, Japan and USA, 1960-2000

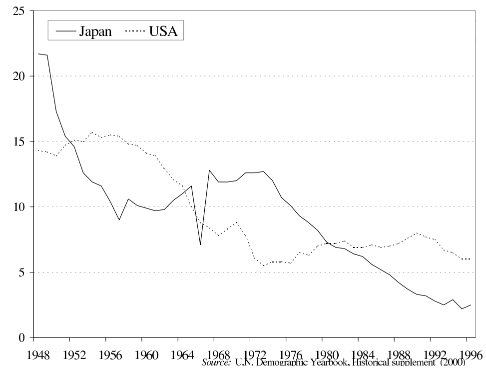


3.1: Age composition Japan

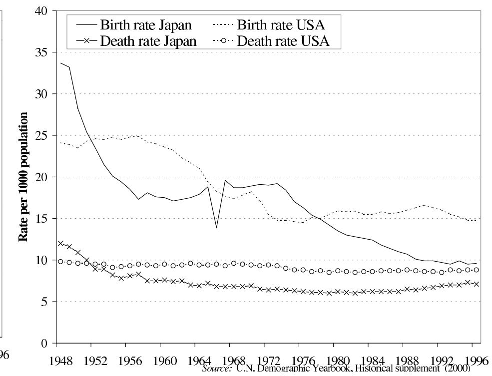


3.2: Age composition U.S.

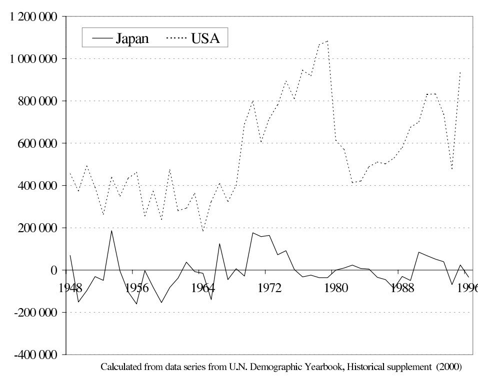
Figure 3: Historical demographic trends



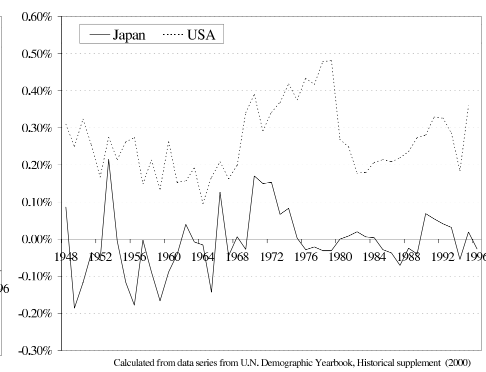
4.1: Natural increase per 1000 pop.



4.2: Fertility and mortality rates

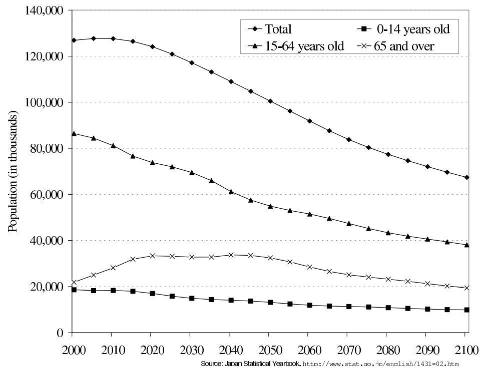


4.3: Net absolute immigration

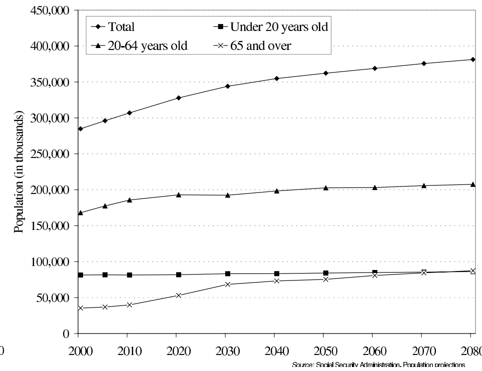


4.4: Net relative immigration

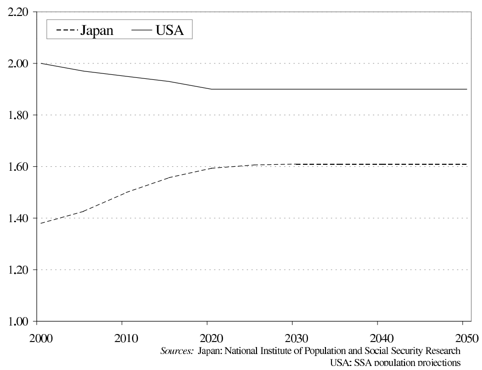
Figure 4: Historical demographic details



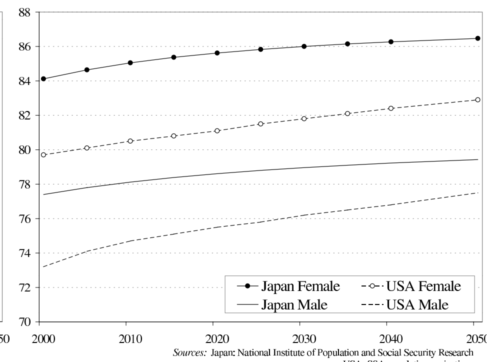
5.1: Japan



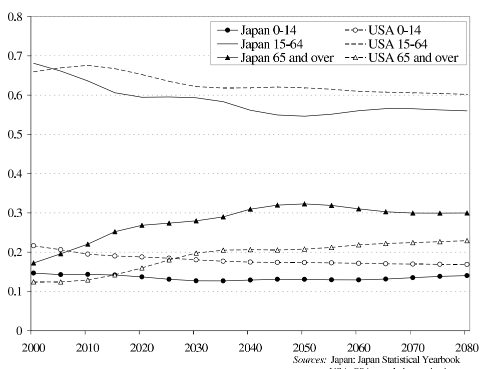
5.2: USA



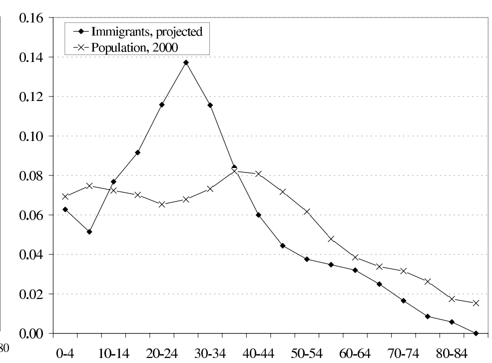
5.3: Tot. fertility rate, projected



5.4: Life expectancy at birth

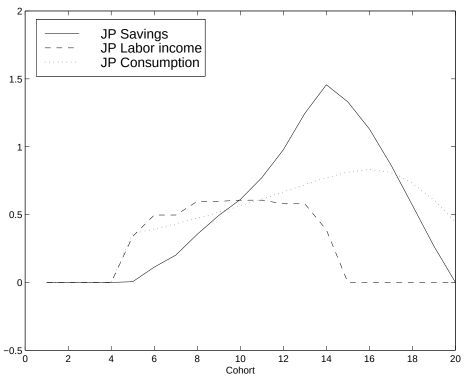


5.5: Age groups, projected

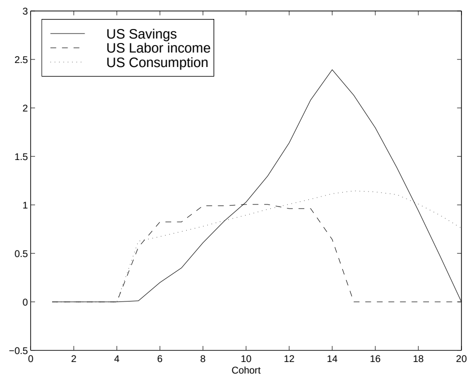


5.6: Age distributions of immigrants and existing population in the U.S.

Figure 5: Central details in demographic projections



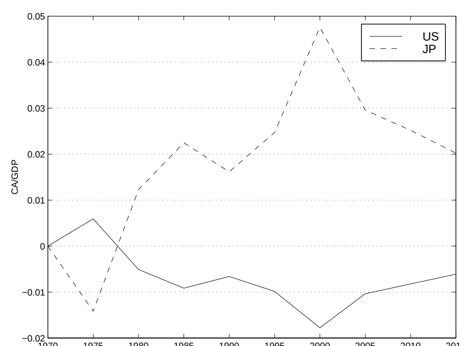
6.1: Japan



6.2: U.S.A.

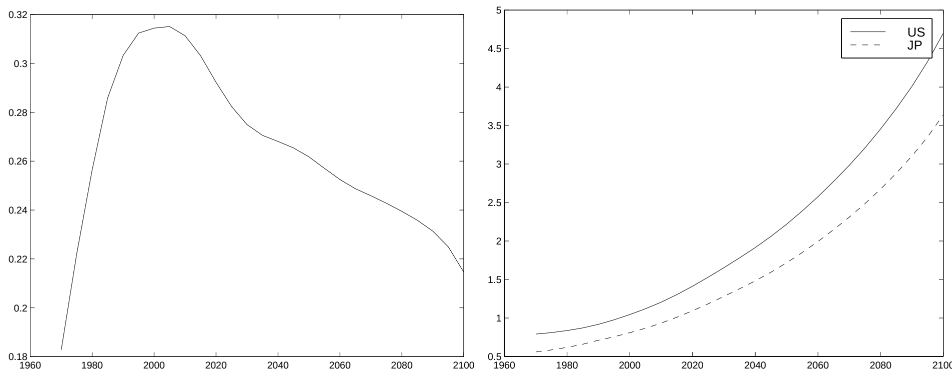
Figure 6: Simulated initial steady state wealth distributions

7.1: Current account



7.2: Current account/GDP

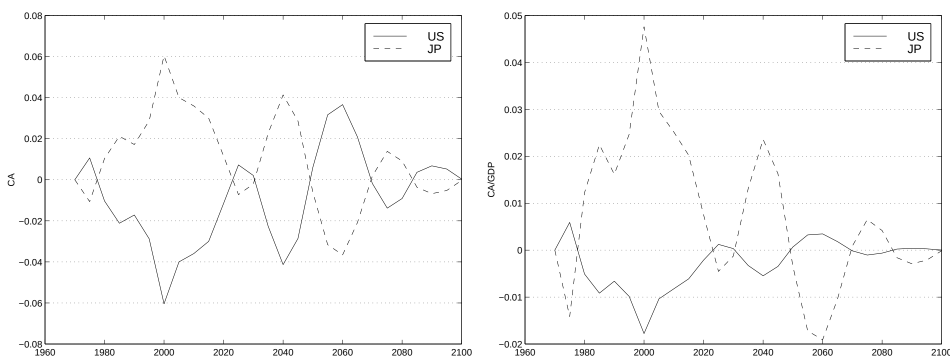
Figure 7: Simulations 1970 - 2015



8.1: Marg. prod. of capital (net)

8.2: Marg. prod. of labor

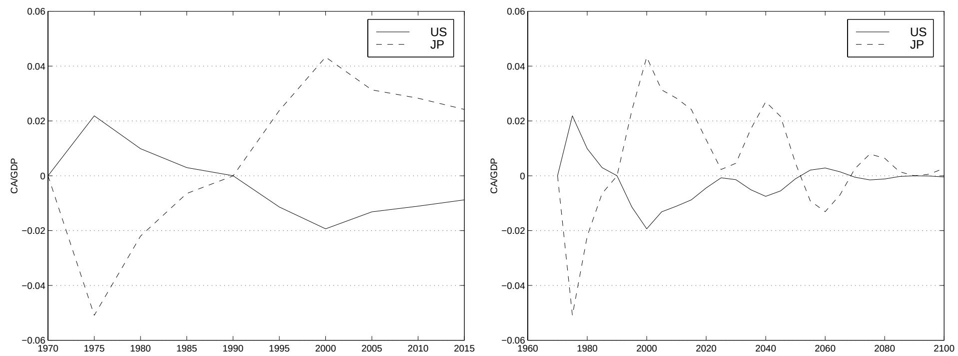
Figure 8: Marginal products of factors of production



9.1: Current account

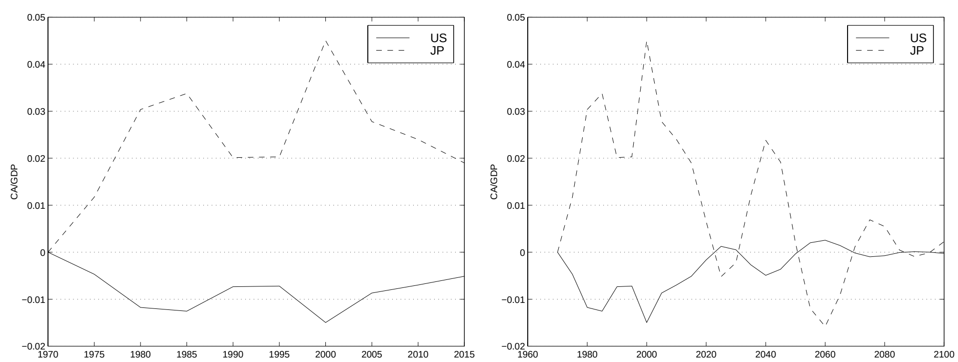
9.2: Current account/GDP

Figure 9: Simulations 1970-2100



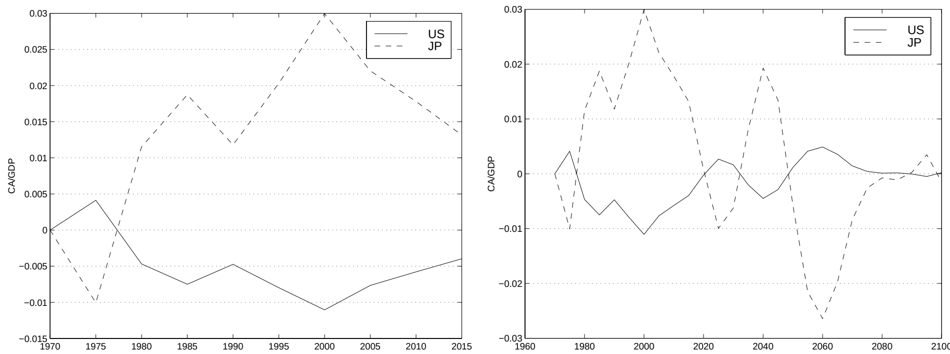
10.1: Current account/GDP 10.2: Current account/GDP

Figure 10: Robustness test: higher JP productivity growth 1970-90



11.1: Current account/GDP 11.2: Current account/GDP

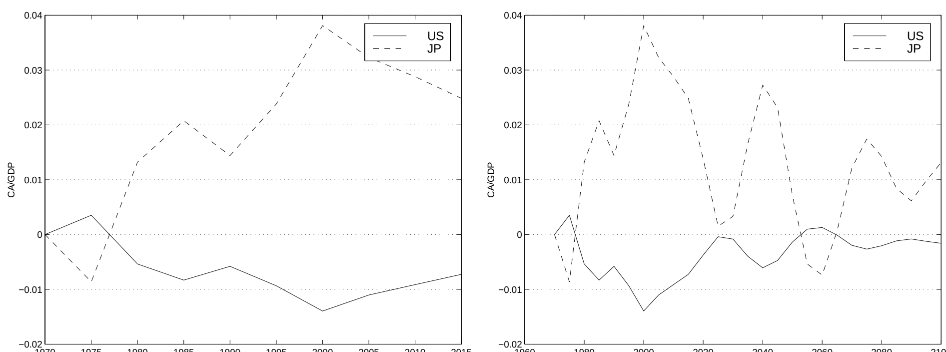
Figure 11: Robustness test: lower JP productivity growth 1970-90



12.1: Current account/GDP

12.2: Current account/GDP

Figure 12: Low fertility regimes



13.1: Current account/GDP

13.2: Current account/GDP

Figure 13: High fertility regimes