Demography and Low-Frequency Capital Flows*

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Abstract

We verify that fluctuations in international capital flows and stocks are persistent and consider a role for demography. In an overlapping generations model with uncertain lifetimes, we explore the impact of increases in life expectancy caused by decreases in adult mortality. Reductions in mortality affect the aggregate accumulation of assets in two ways: by changing household saving behavior and by changing the age distribution of the population. In an open economy, demographic differences across countries can produce large persistent capital flows, even if the countries are otherwise similar. We use a quantitative version of the model to illustrate the impact of demography on capital flows and net foreign assets in China, Germany, Japan, and the United States.

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Keywords: current account balance, net foreign asset position, life expectancy, mortality rates, population aging.

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1 Introduction

International capital flows continue to attract attention, both as a mechanism to allocate resources across countries and, more commonly, as "imbalances" that need "adjustment" or "correction." Whether one or the other, in need of correction or not, we wonder where they come from. What are the root causes of the extensive capital flows we see in the world around us?

We focus on what we call low-frequency net capital flows: the persistent flows of capital between countries that we have observed since (at least) the late nineteenth century. Michael Bordo (2002) describes this earlier period: "The fifty years before World War I saw massive flows of capital from Western Europe to (mainly) the Americas and Australasia. At its peak, the outflow from Britain reached nine percent of GNP and was almost as high in France, Germany, and the Netherlands." Over this period, Great Britain accumulated claims on the rest of the world equal to about one year's GDP. Among the recipients were Australia, Canada, Sweden, and the United States. In recent times, we have seen significant capital flows into the US and out of Germany, Japan, and China. In both periods, countries experiencing capital flows, in or out, were likely to be doing the same one or two decades later.

If capital flows are persistent, the question is why. One possibility is institutions, which evolve slowly and might be expected to lead to similarly slow-moving flows of capital. Another is tax rates, which change infrequently. We emphasize demography, specifically increases in life expectancy and the associated aging of populations. These demographic trends are evident worldwide, but countries exhibit enough heterogeneity to make capital flows a plausible consequence. Thus in Japan we might expect to see capital outflows as a middle-aged population saves for retirement and capital inflows once enough of the population passes retirement age — as it will in the coming decades.

The mechanism connecting demography to capital flows is complex enough to require a model. We build an overlapping generations (OG) model in which we can feed in realistic demographics and explore their consequences. In our model, changes in the age distribution affect international capital flows in two ways. First, working people save, on the whole, and those who have retired dissave. A change in their proportions changes the aggregate saving rate. Second, the observed decrease in mortality rates raises saving rates if retirement ages don't increase in response — and they don't. Together, they can generate substantial effects on saving and capital flows.

The idea of using an OG model to study the impact of demography on international capital flows isn't new. Attanasio, Kitao, and Violante (2007), Boersch-Supan, Ludwig, and Winter (2006), Brooks (2003), Domeij and Floden (2006), Feroli (2003), Ferrero (2010), Henriksen (2003), and Krueger and Ludwig (2007) all took this approach. Others before them expressed similar ideas without the formal structure of a model. A larger literature explores the impact of demography on aggregate saving rates. New or not, we think the idea is a good one and worth pursuing further.

We build a one-good model in which we can explore the role of demography. In each country, households have power utility and firms have identical constant elasticity aggregate production functions. Countries differ only in their demography: the mortality rates and life expectancies faced by households and the age distribution of their populations. The question is how much variation in capital flows we can generate across countries and over time from these differences alone. We show, using steady state calculations, that changes in life expectancy can, in principle, have large effects on international capital flows and net foreign asset positions. We go on to simulate paths for capital flows for China, Germany, Japan, and the United States, countries with large capital flows, both in or out. [coming soon!]

The challenge with this kind of model are the dozens of decisions we must make about details, far more than we would have in a representative agent model. Did households foresee the large drop in mortality we've seen around the world? How do they deal with uncertain lifetimes? Bequests? Are pensions substitutes for private saving or something more? You probably have a few questions of your own. We've done our best to emphasize details that we think are important and exclude completely those we think are not. One thing we think is important is the time interval. Most of the data, and most of the work based on it, uses five-year intervals. We use an interval of one year to get more precise control over the effects of mortality on life expectancy. This also brings the model closer to other work in macroeconomics, where annual or even quarterly frequencies are typical.

[Compare to other work on capital flows, including Caballero, Farhi, and Gourinchas (2008), Engel and Rogers (2006), Ohanian and Wright (2010), ...]

2 Facts

We start with some facts: facts about international capital flows and stocks, facts about demography, and facts about capital-output ratios. In describing these facts, we look at four countries: China (ISO country code CHN), Germany (DEU), Japan (JPN), and the United States (USA). These countries account for a substantial fraction of net capital flows in the world, and they have striking, and different, demographics. We show — for these countries anyway — that capital flows are persistent. If the ratio of the current account balance to GDP has a tendency to revert to zero, as it does in most multi-country business cycle models, it's well hidden in the data. The same holds for net foreign assets. Demography, of course, is inherently persistent. We describe changes in the age distribution of the population, in life expectancy, in old-age dependency, and in retirement ages. All but the retirement age have changed dramatically over the last few decades. Finally, we look at capital-output ratios, a central component of the modeling exercise that follows.

2.1 Capital flows and stocks

We plot current account balances in Figure 1 and net foreign assets in Figure 2, both as ratios to GDP. Current accounts are from the IMF's *World Economic Outlook* database for April 2013. Net foreign asset positions were computed by Lane and Milesi-Ferretti (2007).

We see, for a start, that Japan has had persistent current account surpluses since the 1980s. These correspond to capital outflows and amounted to 50 percent of GDP in 2007, the last date in the available data. The US has had the opposite experience and now has a negative net foreign asset position. In both cases, the direction of net capital flows has been the same for almost three decades. Germany and China have had more variation, but there is a great deal of persistence in their capital flows as well. China, for example, has had capital inflows for almost twenty years. Germany has had the same for ten. Although there is a clear cyclical component in the current account, the bulk of current account fluctuations operate at a lower frequency. Henriksen and Lambert (2009) make the same argument more formally for a broader range of countries.

2.2 Demography

Could demography play a role in these capital flows? Certainly demography evolves slowly enough to produce persistent effects on the economy. It also differs across countries, a requirement for it to affect international capital flows.

Consider the evidence reported in the UN's *World Population Prospects*, the 2010 revision. We see in Figure 3 that UN data and projections for the future show significant aging of the populations of China, Germany, Japan, and the US. Japan's aging is the most pronounced, with more than a third of the population expected to be over 70 by 2040. The US, in this group, is aging the most slowly. This aging refects, in part, a continuing increase in life expectancy; see Figure 4. The levels of life expectancy differ, but we see the same pattern of increase in all four countries. In each of them, life expectancy has increased almost a decade since 1970 and is projected to increase another decade by the end of the century.

The increase in life expectancy reflects a significant drop in mortality at all ages. We document this with data from the WHO's *Global Health Observatory*. Figure 5 shows how mortality has changed in the US: we plot the log of age-specific mortality rates for the years 1990, 2000, and 2011. We see a consistent drop at all ages. The drop at higher ages is larger in absolute terms, because the underlying rates are larger. In Figure 6 we see mortality rates for all four countries for the year 2011. The differences reflect those in life expectancy: Japan has the lowest mortality rates and China the highest.

The aging of the population and rise in life expectancy are projected to produce sharp increases in the old-age dependency ratio, measured here as the ratio of the population aged 65 and above to the population with ages between 20 and 64. See Figure 7. In Japan, the ratio was about 20% in 1990, is now about 40%, and is projected to be over 70% in 2050. Germany is only slightly less extreme. China exhibits a similar pattern somewhat latter, with a current dependency ratio of about 10% projected to increase to 60% by 2060. Aging in the US looks modest by comparison, with a projected dependency ratio of about 40% in 2050.

The other side of population dynamics is fertility, which we summarize in Figure 8. The numbers come from the UN's *World Population Prospects* and refer to the period 2005-2010.

We see that fertility rates in Germany and Japan have been low, lower even than in China with its one-child policy. The lower input of young people into the population reinforces the impact of reduced mortality on the aging of their populations. The US has the highest fertility of the four countries, with 414 births per thousand women. The same number for China is 328, for Germany 271, and for Japan 264. [NB: Numbers are labeled as in the source, but the units seem to be off by ten.]

We see, in short, gradual but significant aging of the populations of all four countries, but also significant differences among them. We conclude with one last fact about demographic trends. We show in Figure 9 how the retirement age has changed with time. The retirement age comes from the OECD's *Statistics on average effective age of retirement* and is computed from labor market participation rates of older workers. We see in the figure that retirement ages differ across countries but show little variation over time over the period 1980-2011. Evidently, increases in life expectancy are leading to longer periods of retirement.

None of these facts are new. Bongaarts (2004) provides a more comprehensive analysis and a good summary of related work.

2.3 Capital stocks

We look at one last variable, the capital-output ratio, which plays a central role in our model. We compute capital stocks by standard methods from the Penn World Table, version 7.1. We take data on investment, estimate an initial capital stock value from a steady state approximation, and update by the perpetual inventory method using an annual depreciation rate of 6 percent. Caselli (2005) is one of many to describe the approach.

We show in Figure 10 how the ratio has evolved in our four countries. Over the period 1980 to 2010, the capital-output ratio has been between two and three in the US and China, about three in Germany, and has risen above four in Japan. China is the most surprising. Between 1990 and 2010, its real investment share of GDP averaged 37 percent, significantly higher than the 22 percent experienced by the US, yet its capital-output ratio is similar. The reason it's not higher, of course, is that output has been growing so quickly. Could our calculation be grossly wrong for China? Our guess is no: Holz (2006) constructs similar estimates directly from company balance sheets.

3 An overlapping generations model

These demographic changes are striking, but we need a model to quantify their impact on saving, investment, and international capital flows. We follow others in building a model with one good, overlapping generations of agents who spread their consumption over their lifetimes and supply labor inelastically, and a common technology for producing the good from capital and labor. Countries differ primarily in their demographics, including their age distribution and mortality rates.

The central market here is the capital market, with households supplying capital and firms demanding it. Given an interest rate path, the production decisions of firms determine the capital-output ratio. The consumption decisions of households generate paths for cohort and aggregate net worth, which we also express as a ratio to GDP. Net foreign assets is the difference between the aggregate net worth of agents and capital used by firms. Flows such as saving, investment, and the current account are then computed from the laws of motion of the stocks.

We consider two equilibrium concepts for this environment. One is a closed economy in which the interest rate adjusts so that net worth and the capital stock are equal. We illustrate the impact of demography in steady state versions of this economy. The other equilibrium concept is an open economy facing a given world interest rate path. Fixing the interest rate path simplifies the computations enormously and allows us to focus our attention on other issues.

3.1 Demography

Our treatment follows a long line of work in demography and in overlapping generations models that use demographic inputs. Each country is populated by overlapping generations, or cohorts, of agents who live up to I periods. At any date t, x_{it} is the number of people in the cohort of age i, $x_t = (x_{1t}, x_{2t}, \ldots, x_{It})^\top$ is the age distribution, and $X_t = \sum_i x_{it}$ is the total population.

Changes in the age distribution x_t are affected by births, deaths, and migration. Births are connected to the population by age- and date-specific fertility rates. Each period, an agent of age i produces φ_{it} children of age $i = 0$ at date t. Deaths are handled the same way. The probability of an agent of age i at date t surviving until date $t+1$ is s_{it}. The chance of surviving beyond age I is zero: $s_{It} = 0$. The mortality rate at each age is the complementary probability $1 - s_{it}$. The dynamics of the population follow the difference equation

$$x_{t+1} \;=\; D_t x_t + m_{t+1},$$

where

$$D_t \;=\; \begin{bmatrix} \varphi_{1t} & \varphi_{2t} & \varphi_{3t} & \cdots & \varphi_{It} \\ s_{1t} & 0 & 0 & \cdots & 0 \\ 0 & s_{2t} & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0 & 0 & \cdots & s_{I-1,t} & 0 \end{bmatrix}$$

captures the impact of fertility and mortality and m_{t+1} is net migration by age. Evidently most of the φ_{it}'s are zero.

The dynamics of survival/mortality rates are a critical ingredient in what follows. We deal with them when they arise.

3.2 Households

We refer to households as agents or cohorts. They do two things: they work and they consume. Work is inelastic once the agent hits working age. Formally, the agent begins to work at age I_w (w for work) , supplying one unit of labor every year until retirement. At age I_r (r for retirement), the household stops working.

Consumption starts at age I_w and continues until death. Utility has a time-additive power form, which we express recursively by

$$U_{it} \;=\; c_{it}^{1-\sigma}/(1-\sigma) + \beta s_{it} U_{i+1,t+1} \tag{1}$$

for $i = I_w, \ldots, I$. Here U_{it} is utility from date t forward for an agent of age i, c_{it} is date-t consumption for the same agent, and β is the discount factor. The intertemporal elasticity of substitution is $1/\sigma$. The limiting case $\sigma = 1$ corresponds to log utility. The use of the survival probability s_{it} follows the now-familiar application of expected utility to uncertain lifetimes proposed by Yaari (1965).

We build productivity into labor. Each individual of working age supplies one unit of labor. For an agent of age i at date t, that unit has efficiency e_{it}. Efficiency is zero for children and retirees: $e_{it} = 0$ for $i < I_w$ and $i > I_r$. If the wage per efficiency unit is w_t, the agent earns labor income $e_{it} w_t$.

[Describe dependence of e_{it} on i and t, build in difference between aggregate growth and growth within a cohort.]

Consumption and income are connected to changes in net worth through the budget constraint. Let a_{it} be financial assets or net worth owned by agents of age i at the start of the period t. The sequence budget constraint for an agent of age i is

$$a_{i+1,t+1} \quad = \quad (1 + r_t) a_{it} + e_{it} w_t - c_{it} + b_{i+1,t+1},$$

where r_t is the real return between t and $t+1$. We have one of these constraints for each age $i = I_w, \ldots, I$, plus boundary conditions

$$a_{I_w,t} \quad = \quad a_{I+1,t} \quad = \quad 0. \tag{2}$$

Bequests b_{it} are a necessary ingredient here, because we need to distribute the accidental bequests of agents who die before age I. The simplest method is to give agents annuities. Effectively, we spread the assets of those who die among the living of the same generation: $b_{i+1,t+1} = (1 - s_{it}) a_{i+1,t+1}$. That gives us the budget constraint

$$s_{it} a_{i+1,t+1} \quad = \quad (1 + r_t) a_{it} + e_{it} w_t - c_{it}. \tag{3}$$

See, among many others, Hansen and Imrohoroglu (2008), Rios-Rull (2001), and Yaari (1965).

Preferences (1) and the budget constraint (3) lead to the familiar necessary condition

$$c_{i,t}^{-\sigma} \quad = \quad \beta c_{i+1,t+1}^{-\sigma} (1 + r_t).$$

This tells us that the slope of the lifetime consumption profile is governed by the discount factor β, the interest rate r_t, and the preference parameter σ. The absence of s_{it} stems from the annuity. The asset profile depends on consumption and the profile for labor income.

Each of these individual or cohort variables has an aggregate analog. Aggregate consumption is the sum across generations: $C_t = \sum_i c_{it} x_{it}$. Aggregate net worth is the same: $A_t = \sum_i a_{it} x_{it}$. The total supply of labor at date t is the sum over all agents of working age: $N_t = \sum_i e_{it} x_{it}$.

3.3 Firms

Firms in aggregate combine capital K_t and efficiency units of labor N_t to produce output Y_t. We give their technology a constant elasticity form:

$$Y_t = F(K_t, N_t) = \left[\omega K_t^{1-\nu} + (1-\omega) N_t^{1-\nu}\right]^{1/(1-\nu)}. \qquad (4)$$

The elasticity of substitution between capital and labor is $1/\nu$. The limiting case $\nu = 1$ corresponds to Cobb-Douglas. The law of motion for capital is the usual

$$K_{t+1} = (1-\delta) K_t + I_t, \qquad (5)$$

where I_t is gross investment in new capital and δ is the rate of depreciation.

A representative firm with this technology facing prices (r_t, w_t) chooses capital and labor equate marginal products to prices:

$$\partial F(K_t, N_t)/\partial K_t = r_t + \delta \qquad (6)$$

$$\partial F_n(K_t, N_t)/\partial N_t = w_t. \qquad (7)$$

With the constant elasticity function (4), the marginal product of capital takes the form

$$\partial F(K_t, N_t)/\partial K_t = \omega (K_t/Y_t)^{-\nu},$$

a decreasing function of the capital-output ratio.

3.4 Equilibrium

A competitive equilibrium in this environment starts with two conditions. Given paths $\{r_t, w_t\}$ for prices:

- Households choose consumption to maximize utility (1) subject to their budget constraint (3) and the boundary conditions (2); and
- Firms choose capital, labor, and investment at each date to maximize profit subject to the technology (4) and the law of motion for capital (5).

At this point, we consider two alternatives:

- In a closed economy, the interest rate path clears the capital market: $A_t = K_t$ for all t.
- In an open economy, the path of the interest rate is given. Household and firm decisions therefore determine the path of net foreign assets: $NFA_t = A_t - K_t$.

The latter, of course, is how we address capital flows: if the domestic supply and demand for capital aren't equal, net foreign assets makes up the difference.

4 Demography and steady states

We consider the impact of increased life expectancy in the steady state. The advantage of the steady state is that we can easily see how everything works.

Here's an outline. First, the demographic inputs give us a stationary age distribution. When we decrease mortality rates, this increases life expectancy and changes the age distribution, making it older. Second, this change in the age distribution has consequences for all of the variables in the model: consumption, labor supply, aggregate net worth, the capital stock, the wage, and the interest rate. In our closed economy, an increase in life expectancy raises aggregate net worth and the stock of capital. This reduces the marginal product of capital and hence the interest rate. In our open economy, we fix the interest rate, so the increase in aggregate net worth shows up as an increase in net foreign assets. We describe these effects in a supply and demand diagram, where the demand for capital comes from firms' first-order condition and the supply comes from households accumulation of assets.

4.1 Parameter values

We review the inputs to the model, starting with demography. We use stylized demographics to illustrate the impact of increases in life expectancy. We start with benchmark mortality rates, adapted from WHO data, associated with a life expectancy at birth of 60 years:

$$\log(1 - s_i) \quad = \quad \mu_i.$$

The shape is evident from Figure 6, with mortality high for the young and old and low in between. Only the latter matters here, because agents do nothing until they reach working age. We then scale them up and down by some constant z,

$$\log(1 - s_{it}) \quad = \quad \mu_i - z_t \tag{8}$$

to reproduce other life expectancies. Demographers will recognize this as a simplified version of Lee and Carter (1992). The larger is z_t, the lower are mortality rates and the longer is life expectancy. We see the results in Figure 11, where we plot the resulting survival probabilities. The logarithmic form of (8) means that the greatest impact is on the largest mortality rates: those of the young and old.

With these mortality rates, and one birth each period, we can compute the stationary age distribution. The result is pictured in Figure 12. We see that this mechanism gives us an older population, on average, when we reduce mortality rates to reproduce longer life expectancies.

The next input is the technology. We set $\delta = 0.06$, which we used to generate the data. We also set $\nu = 1$, which corresponds to an elasticity of substitution of one, and choose ω to set capital's share equal to one-third at a capital-output ratio of three. The capital share in general is

$$\partial F(K,N)/\partial K \cdot (K/Y) \quad = \quad \omega (K/Y)^{1-\nu}.$$

With $\nu = 1$, the capital share is one-third when $\omega = 1/3$. With other values of ν, we adjust ω appropriately. The interest rate is the marginal product of capital minus depreciation:

$$r_t \quad = \quad \omega (K_t/Y_t)^{-\nu} - \delta. \tag{9}$$

Evaluated at a steady state with $K_t/Y_t =$ and $\nu = 1$, we have $r = 0.0511$.

A typical household's problem includes the interest rate and labor income as inputs and generates paths for consumption and net worth. We choose labor efficiencies $e_{it} = 1$ for agents of working age and zero otherwise. Working age starts at age $I_w = 21$ and ends at retirement age $I_r = 65$. Finally, we set $\sigma = 1$ (log utility) and choose β to match the steady state ratio of aggregate net worth to output of three. Since net worth and the capital stock are the same, net foreign assets is zero in the benchmark case.

4.2 Steady states

The interaction between the supply of capital by households and the demand for it by firms takes its cleanest form in a steady state, where we can capture its properties in a supply-and-demand diagram.

Demand is relatively simple. The demand for capital comes from the first-order condition (6). If we express capital as a ratio to output, the inverse demand function is equation (9). This equation holds at every date, as well as in a steady state.

Supply requires calculations that go beyond what we can show in an equation or two. But suppose we have a steady state age distribution for the population. Then we can compute the ratio of aggregate net worth to output for any constant interest rate. The overlapping generations structure is essential here. In a representative agent model, supply in a steady state is horizontal at the discount rate $(1 - \beta)/\beta$. Here there is some slope, which depends on intertemporal elasticity.

The results of these two sets of calculations are pictured in Figure 13. The downward-sloping line is demand, the upward-sloping one is supply. They cross by design at our steady state point: $K/Y = A/Y = 3$ and $r = 0.0511$. We show two examples of each. The solid downward-sloping line is the demand curve for $\nu = 2/3$ and the dashed line the demand curve for $\nu = 3/2$. As we might guess from (9), the line is flatter when ν is smaller. The supply curves depend in a less obvious way on household decisions, but they have a similar form. The solid line corresponds to $\sigma = 1/2$ and the dashed line to $\sigma = 2$. Evidently the line gets flatter as we increase σ. In what follows, we compute steady states for the intermediate values $\nu = \sigma = 1$ (log utility and Cobb-Douglas production).

Now consider an increase in life expectancy on the steady state from 65 to 80. That doesn't change the demand for capital, because life expectancy has no impact on the marginal product of capital. It does change the supply of capital. As we see in Figure 14, an increase in life expectancy increases the supply of capital. In a closed economy, we get an increase in the capital-output ratio and a decline in the interest rate. These effects of aging are well-known features of OG models. Here the impact combines two effects. One is a composition effect: we have more households at ages associated with high net worth. The other is that households have more wealth at all ages. The mechanism is one noted by

Bloom, Canning, and Graham (2003): with longer life expectancy, households save more. We see this in Figure 15, where net worth rises at most ages. The dashed line in the figure shows the effect of the composition effect alone: we fix net worth at all ages but change the age distribution. We see that this is a small part — less than ten percent — of the shift in supply.

In an open economy facing a fixed interest rate, the impact of increased life expectancy falls entirely on aggregate net worth. The demand for capital, and therefore the capital-output ratio, doesn't change, but with aggregate net worth rising, the result is a positive steady state net foreign asset position. If we take a general equilibrium perspective, we might imagine a world with two countries, one with longer life expectancy than the other. The equilibrium interest rate will split the difference, leading the country with longer life expectancy to lend to the other — forever, if this situation continues.

[Things to try: change retirement age, connect stocks to flows.]

5 Country dynamics

We now compute time paths for net foreign assets and other variables for our four countries. In each case, we feed in an interest rate path based loosely on the findings of other work: the interest rate declines steadily from about 2000 to 2020. That is, as we've seen, the likely impact of increases in life expectancy worldwide.

The other parameters are similar to those in our steady state calculations. We use log utility ($\sigma = 1$) and a Cobb-Douglas production function ($\nu = 1$). The discount factor is chosen to match steady state net worth for a benchmark economy and is the same in all countries.

The differences are in the demographics. We take mortality rates from the WHO's *Global Health Observatory* and update them using equation (8), with the shift z_t chosen to match reported life expectancy. This gives us the survival probabilities that enter household consumption and saving decisions. Since mortality rates change with time, every generation has different ones. The age distributions are adapted from the UN's *World Population Prospects*. They report distributions every five years from 1950 to 2100 for five-year cohorts. We interpolate them to get annual numbers.

The last input is the initial values of household asset positions. We compute initial asset positions from their steady state values. From that point on, asset positions are computed recursively, starting in 1950. We report capital stocks and flows starting in 1980, with the hope that the effect of the initial conditions has worn off.

5.1 The United States and Japan

We see the results of this effort in Figure 17, where we plot capital flows for the US and Japan for the period 1980 to 2040. The paths are broadly similar to what we saw in Figure 1 for the last three decades, with the US experiencing capital inflows and Japan capital outflows. The difference between the two, in the model, is due entirely to demography. Obviously other factors have an influence, too, but this suggests that demography isn't a bad starting point.

We also see that Japan's three decades of capital outflows is projected to turn around over the next twenty years.

[We need to figure out why these lines are changing — what are the key demographic inputs?]

One issue for Japan is that its capital-output ratio has risen significantly over the last twenty years; see Figure 10. That's inconsistent with our model unless either Japan has a different technology or faces, for some reason, a different interest rate than the other countries. This increase in capital tends to offset what would otherwise be an even larger increase in net foreign assets.

5.2 Germany

[coming]

5.3 China

[coming]

The challenge for China is accounting for its sky-high saving rate. We've seen that the capital-output ratio isn't out of line, but it strikes us an unlikely that a model of this sort will explain what others have failed to explain. But see, among others, Chamon and Prasad (2010), Coeurdacier, Guibaud, and Jin (2013), Wei and Zhang (2011), and Yang, Zhang, and Zhou (2010).

6 Final thoughts

Things to consider:

- Surprises in life expectancy. The evidence suggests that experts have consistently underestimated life expectancy. Should we build something like that into the model?
- Intergenerational transfers. Examples include social security and the Norwegian petroleum fund (NBIM). They should affect saving decisions of all the generations affected, hence capital flows.
- China. Why is saving so high? Why does a large fraction of GDP not show up as private income? Could this work like intergenerational redistribution toward the future?

References

Attanasio, Orazio, Sagiri Kitao, and Giovanni Violante, 2007, "Global demographic trends and social security reform," *Journal of Monetary Economics* 54, 144-198.

Bloom, David, David Canning, and Bryan Graham, 2007, "Longesvity Demographic change, social security systems, and savings," *Journal of Monetary Economics* 54, 92-114.

Boersch-Supan, Axel, Alexander Ludwig, and Joachim Winter, 2006, "Ageing, pension reform and capital flows: A multi-country study," *Economica* 73, 625-658.

Bongaarts, John, 2004, "Population aging and the rising cost of public pensions," *Population and Development Review* 30, 1-23.

Bordo, Michael, 2002, "Globalization in historical perspective," manuscript, Rutgers University.

Brooks, Robin, 2003, "Population aging and global capital flows in a parallel universe," *IMF Staff Papers* 50, 200-221.

Caballero, Ricardo, Emmanuel Farhi and Pierre-Olivier Gourinchas, 2008, "An equilibrium model of 'global imbalances' and low interest rates," *American Economic Review* 98, 358-393.

Caselli, Francesco, 2005, "Accounting for cross-country income differences," *Handbook of Economic Growth, voluma 1A*, edited by P. Aghio and S.N. Durlauf, Elsevier.

Chamon, Marcos, and Eswar Prasad, 2010, "Why are saving rates of urban households in China rising?" *American Economic Journal: Macroeconomics* 2, 93-130.

Coeurdacier, Nicolas, Stephane Guibaud, and Keyu Jin, 2013, "Credit constraints and growth in a global economy," manuscript, London School of Economics.

Domeij, David, and Martin Floden, 2006, "Population aging and international capital flows," *International Economic Review* 47, 1013-1032.

Engel, Charles, and John Rogers, 2006, "The US current account deficit and the expected share of world output," *Journal of Monetary Economics* 53, 1063-1093.

Feroli, Michael, 2003, "Capital flows among the G7 nations: A demographic perspective," FEDS Working Paper No. 2003-54.

Ferrero, Andrea, 2010, "A structural decomposition of the US trade balance: Productivity, demographics, and fiscal policy," *Journal of Monetary Economics* 57, 478-490.

Henriksen, Espen, 2002, "A demographic explanation of US and Japanese current account behavior, manuscript.

Henriksen, Espen, and Frederic Lambert, 2009, "Technology shocks and current account dynamics," manuscript.

Holz, Carsten, 2006, "New capital estimates for China," *China Economic Review* 17, 142-

185.

Krueger, Dirk, and Alexander Ludwig, 2007, "On the consequences of demographic change for rates of return to capital, and the distribution of wealth and welfare," *Journal of Monetary Economics* 54, 49-87.

Lane, Philip, and Gian Maria Milesi-Ferretti, 2007, "The external wealth of nations mark II," *Journal of International Economics* 73, 223-250.

Hansen, Gary, and Selahattin Imrohoroglu, 2008, "Consumption over the life cycle: The role of annuities," *Review of Economic Dynamics* 11, 566-583.

Lee, Ronald, and Lawrence Carter, 1992, "Modeling and forecasting US mortality," *Journal of the American Statistical Association* 87, 659-671.

Lee, Ronald, and Timothy Miller, 2001, "Evaluating the performance of the Lee-Carter method for forecasting mortality," *Demography* 38, 537-549.

Ohanian, Lee and Mark Wright, 2010, "Capital flows and macroeconomic performance: lessons from the golden era of international finance," *American Economic Review: Papers & Proceedings* 100, 6872.

Rios-Rull, Jose-Victor, 2001, "Population changes and capital accumulation: The aging of the baby boom," *Advances in Macroeconomics* 1, article 7.

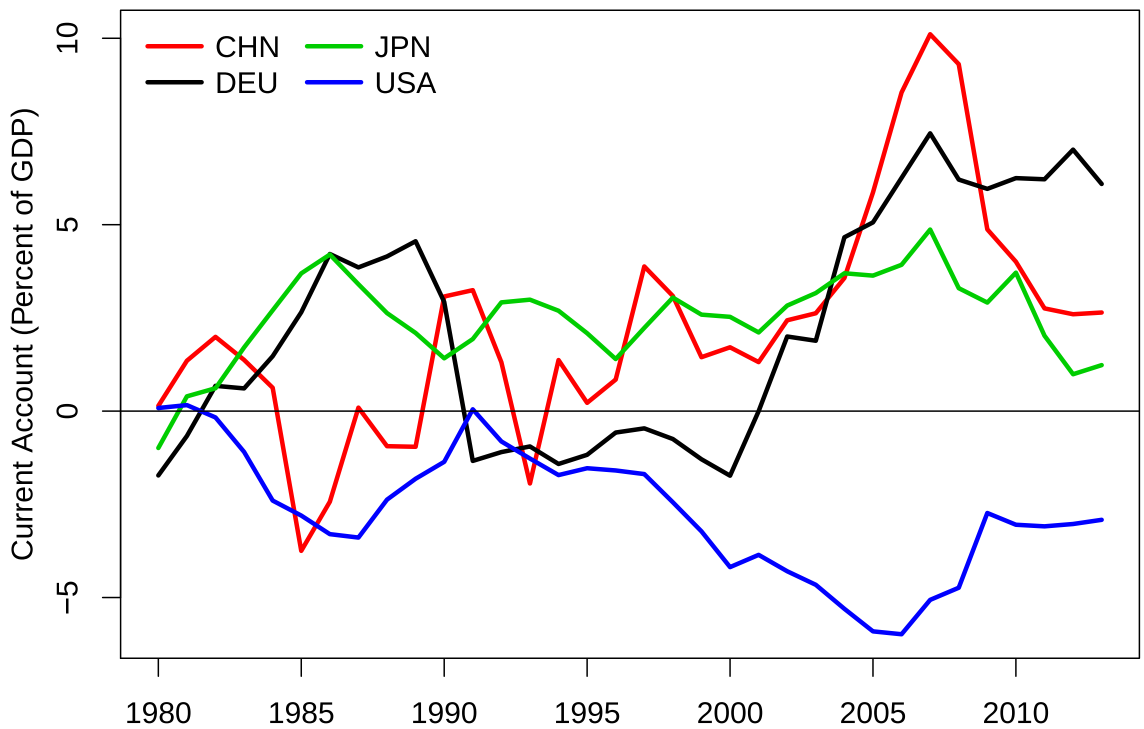
Song, Zheng Michael and Dennis Tao Yang, 2010, "Life-cycle earnings and the rise in household saving in China," manuscript, Chinese University of Hong Kong.

Wei, Shang-Jin, and X. Zhang, 2011, "The competitive saving motive: evidence from rising sex ratios and savings rates in China," *Journal of Political Economy* 119, 511-564.

Yaari, Menahem, 1965, "Uncertain lifetime, life insurance, and the theory of the consumer," *Review of Economic Studies* 32, 137-150.

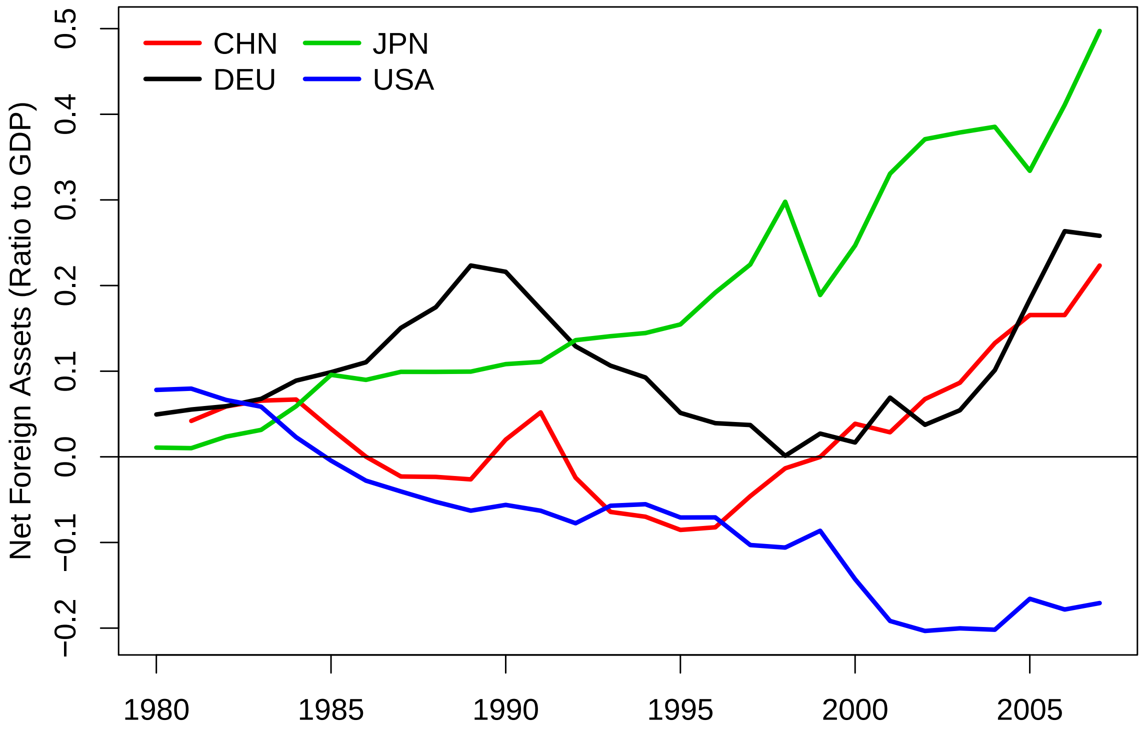
Yang, Dennis Tao, Junsen Zhang, and Shaojie Zhou, 2010, "Why are saving rates so high in China?" manuscript, Hong Kong Institute for Monetary Research.

Figure 1
Current account balances



Source: IMF, World Economic Outlook, April 2013

Figure 2
Net foreign asset positions



Source: Lane and Milesi−Ferretti

Figure 3
Age distributions of populations

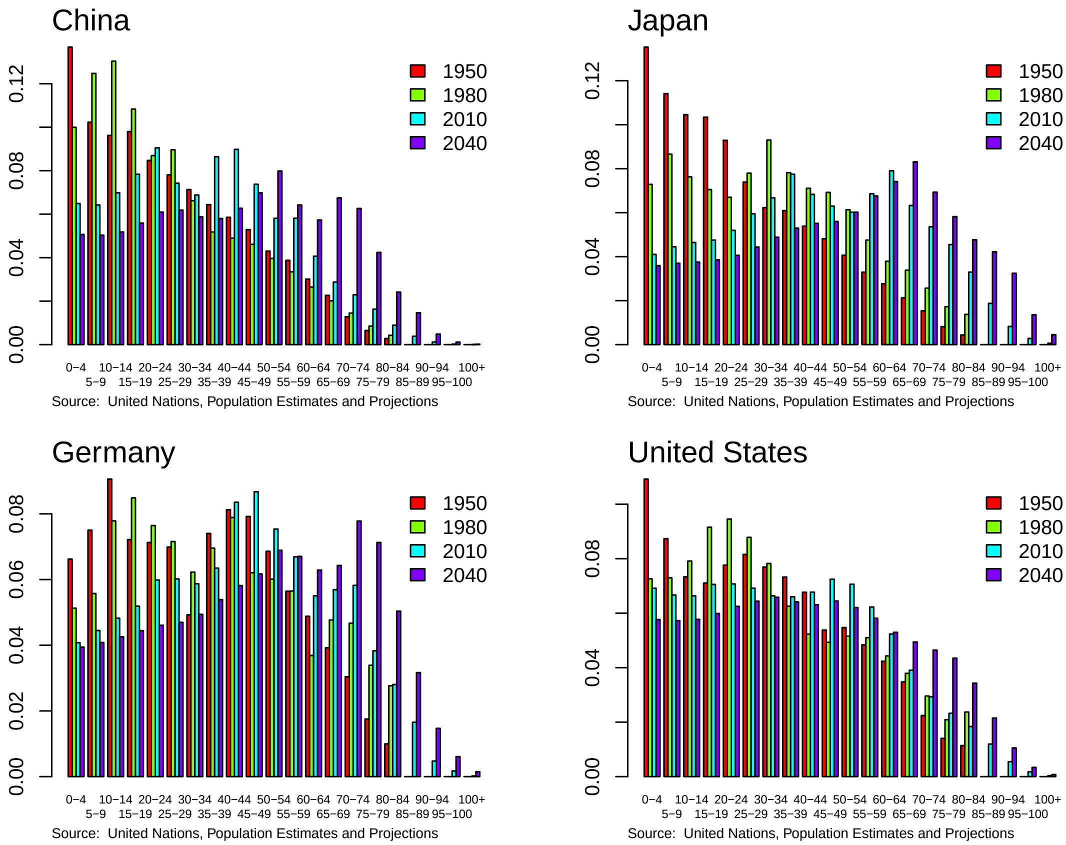
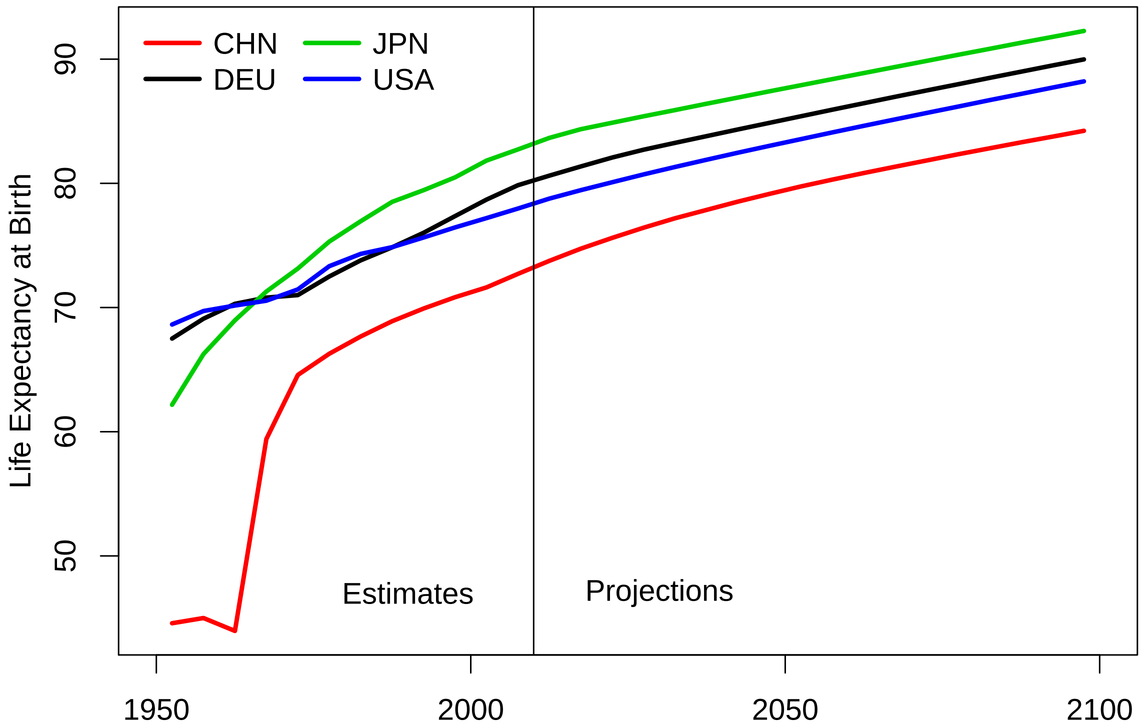
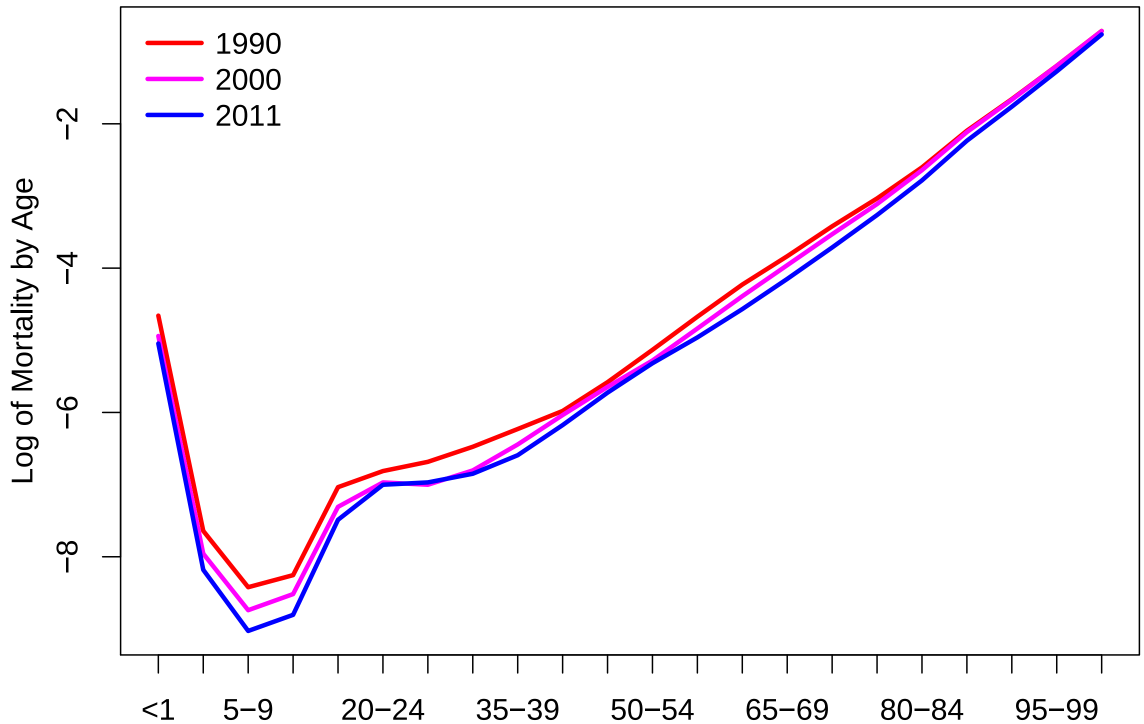


Figure 4
Life expectancy at birth



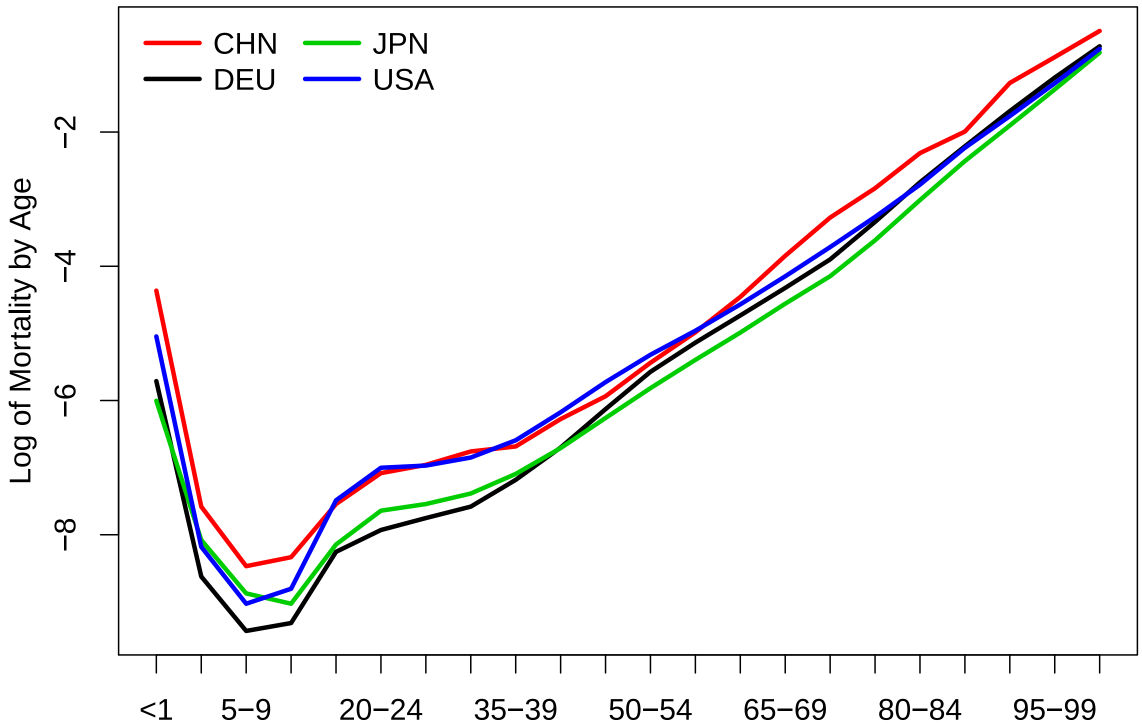
Source: UN, World Population Prospects, 2010 revision

Figure 5
Changes in mortality rates



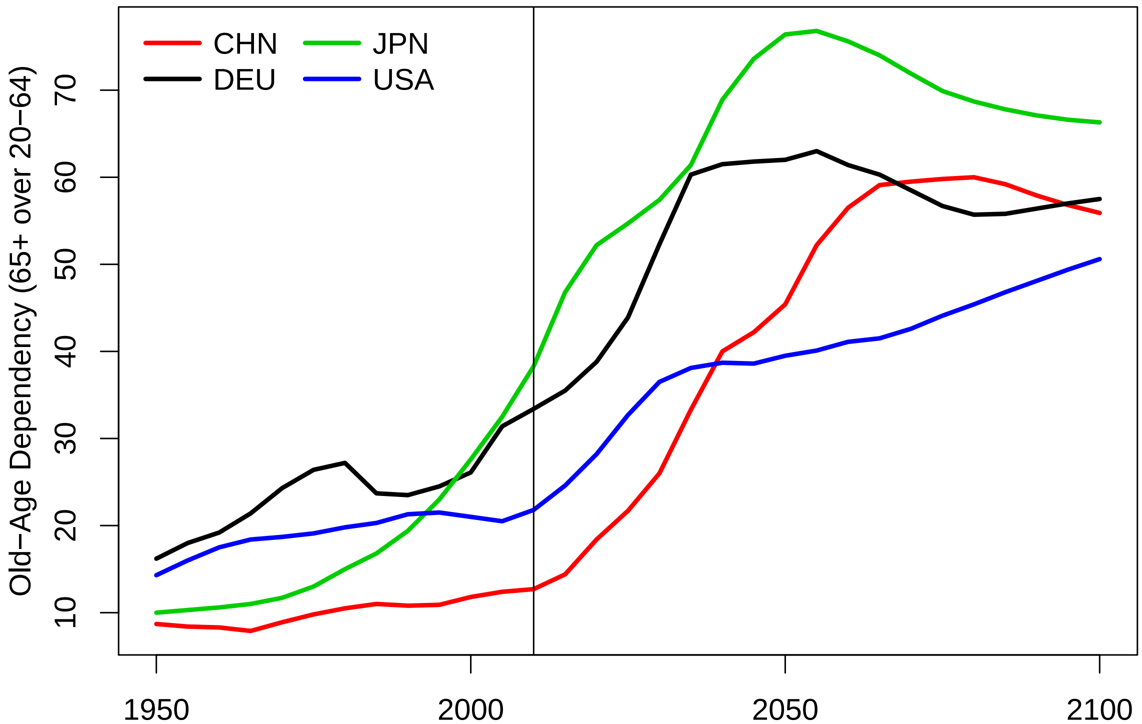
Source: WHO, Global Health Observatory

Figure 6
Mortality by age: estimates for 2011



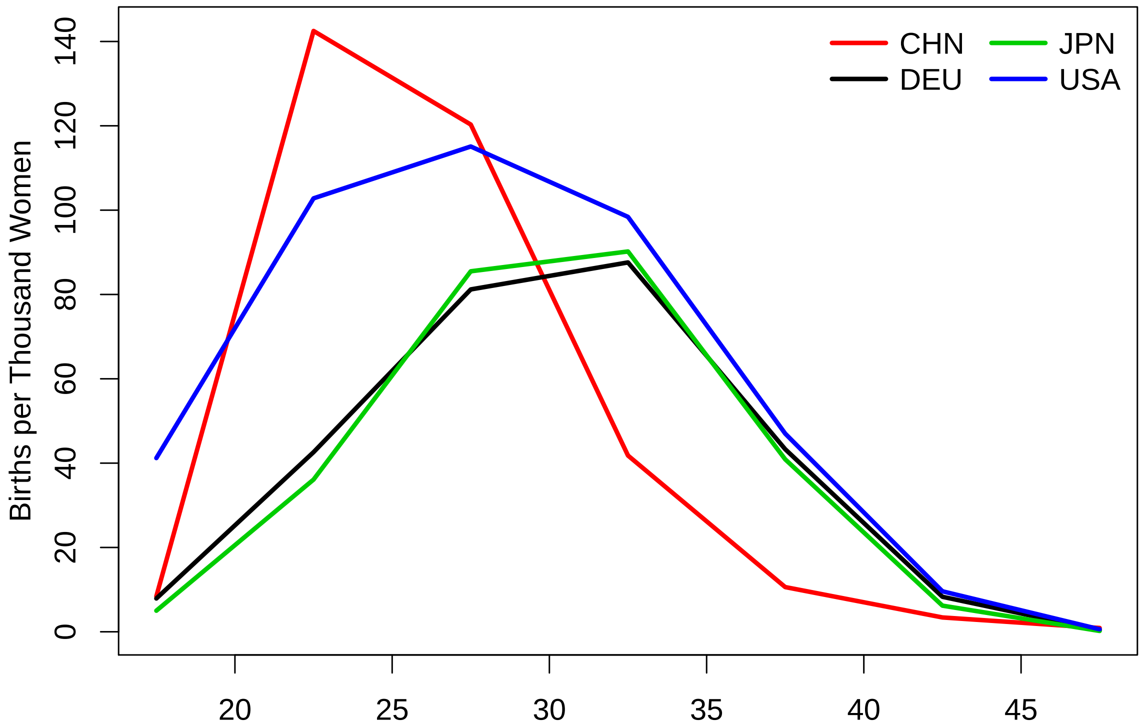
Source: WHO, Global Health Observatory

Figure 7
Old-age dependency: population 65 and over to 20-64



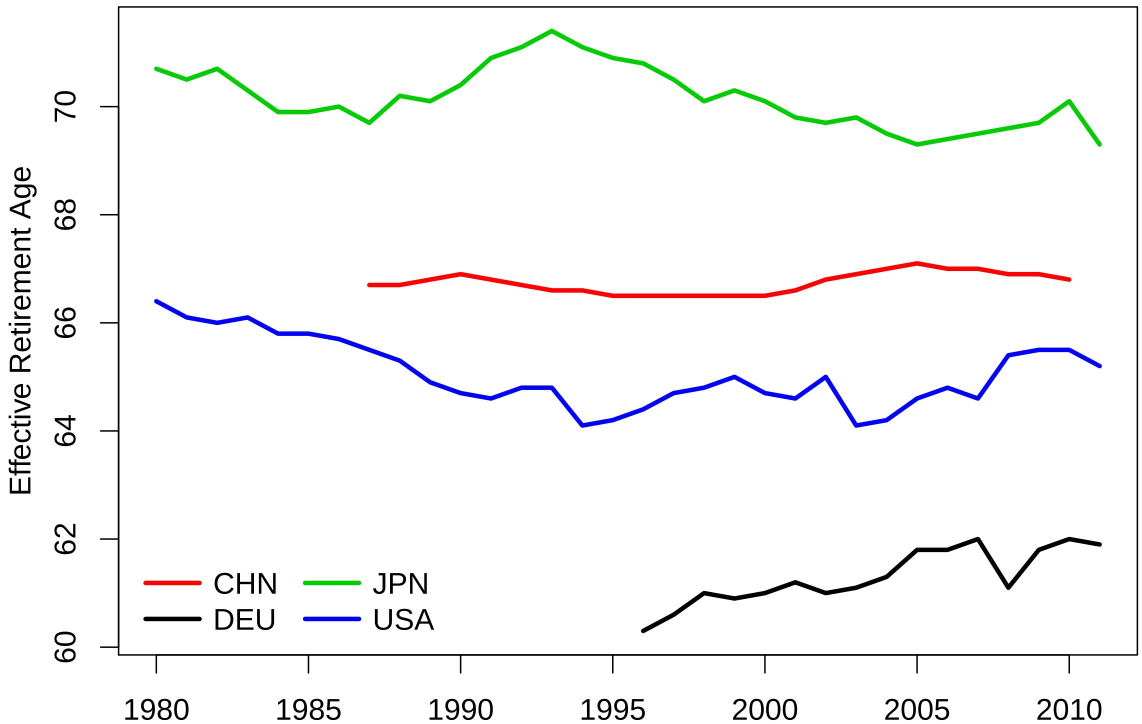
Source: UN, World Population Prospects, 2010 revision

Figure 8
Fertility by age: estimates for 2005-2010



Source: UN, World Population Prospects, 2010 revision

Figure 9
Effective retirement ages



Source: OECD, Average Effective Age of Retirement

Figure 10
Capital-output ratios

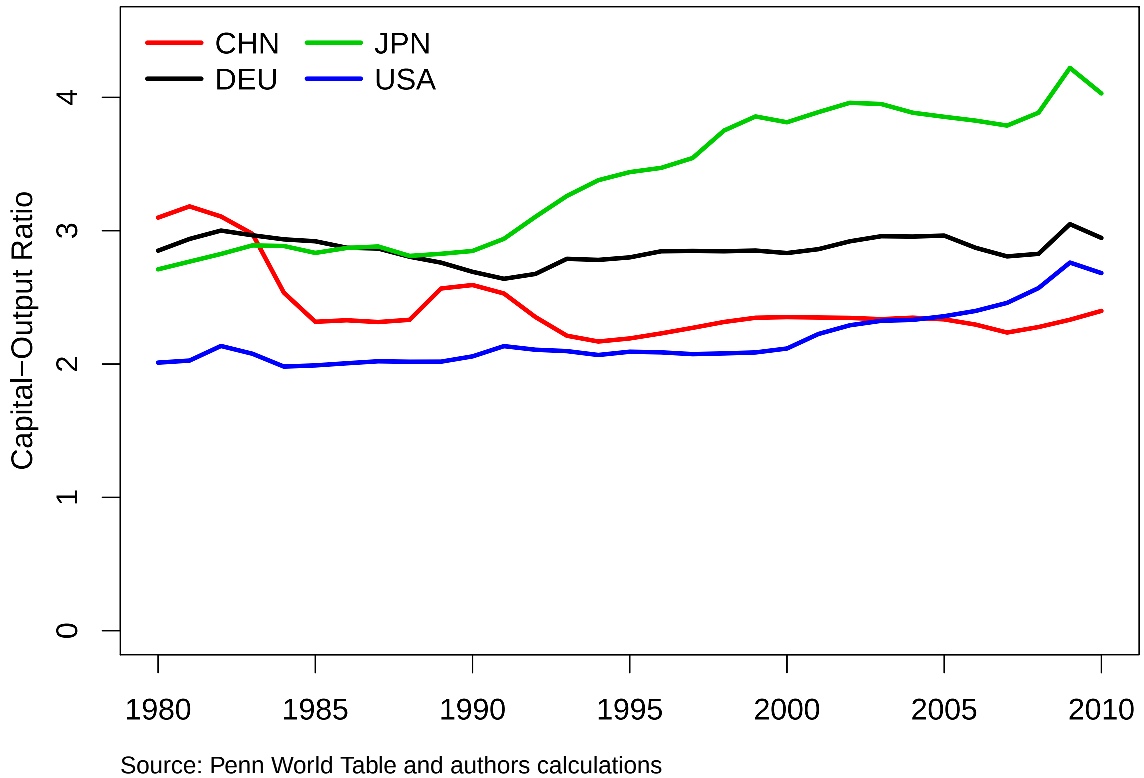


Figure 11
Representative survival probabilities

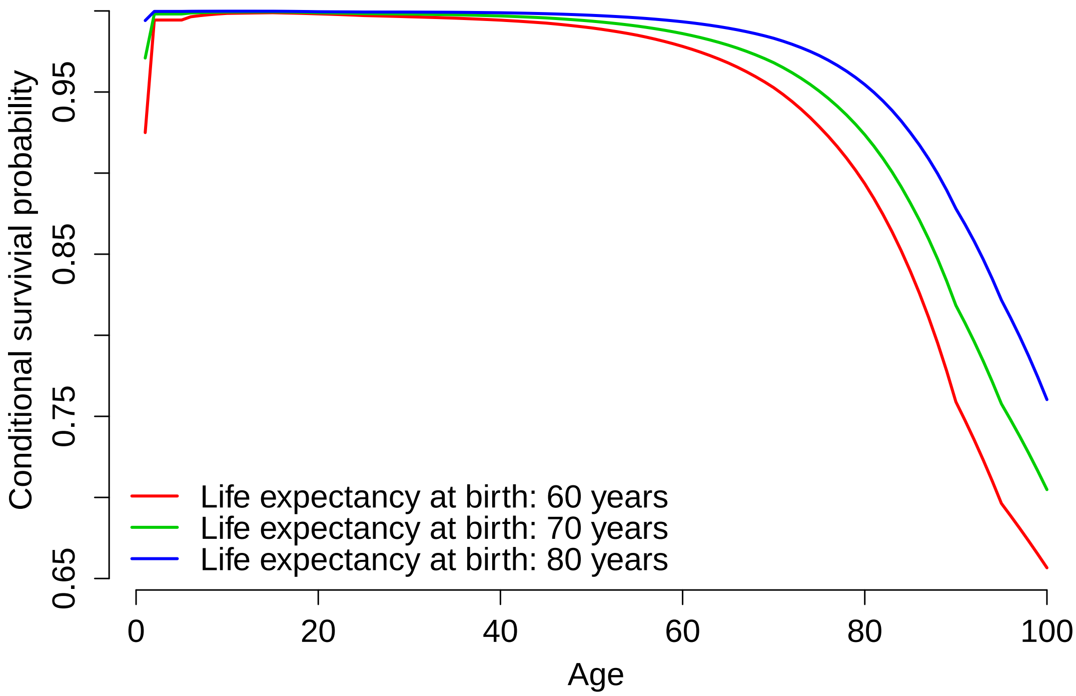


Figure 12
Representative stationary age distributions

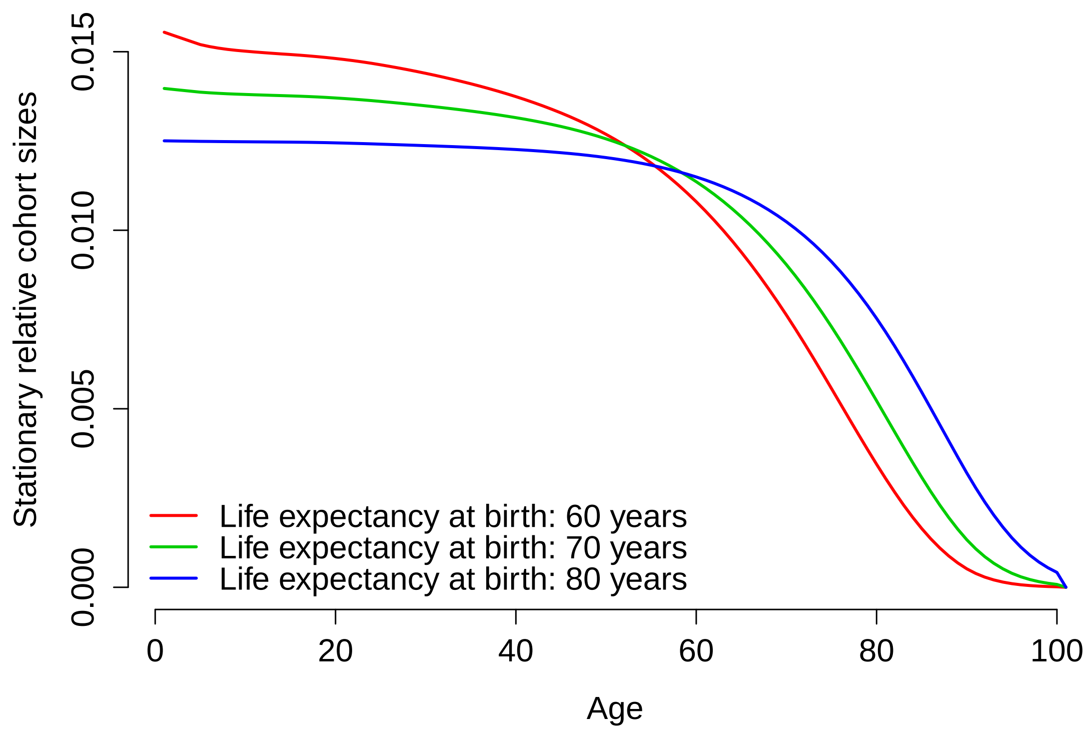


Figure 13
Steady state supply and demand for capital

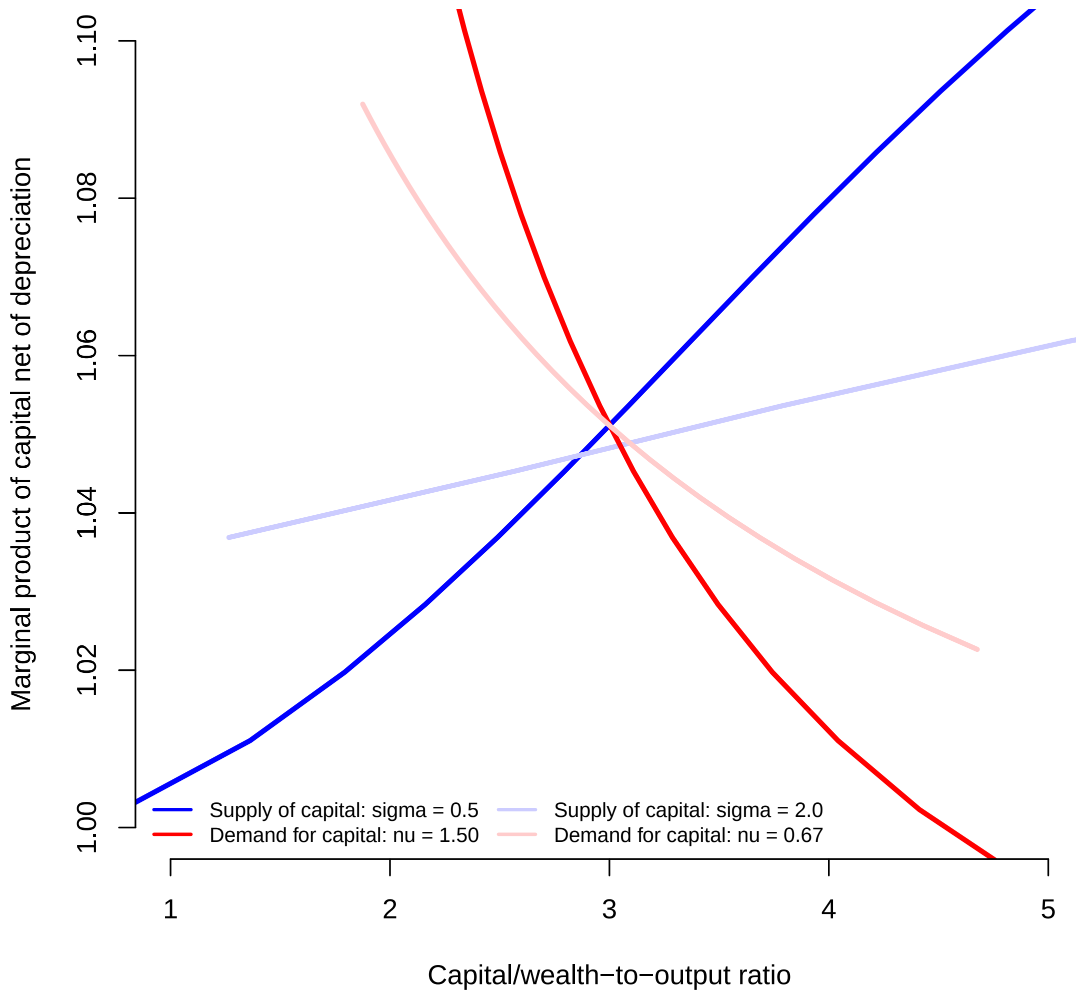


Figure 14
Life expectancy and the steady state supply and demand for capital

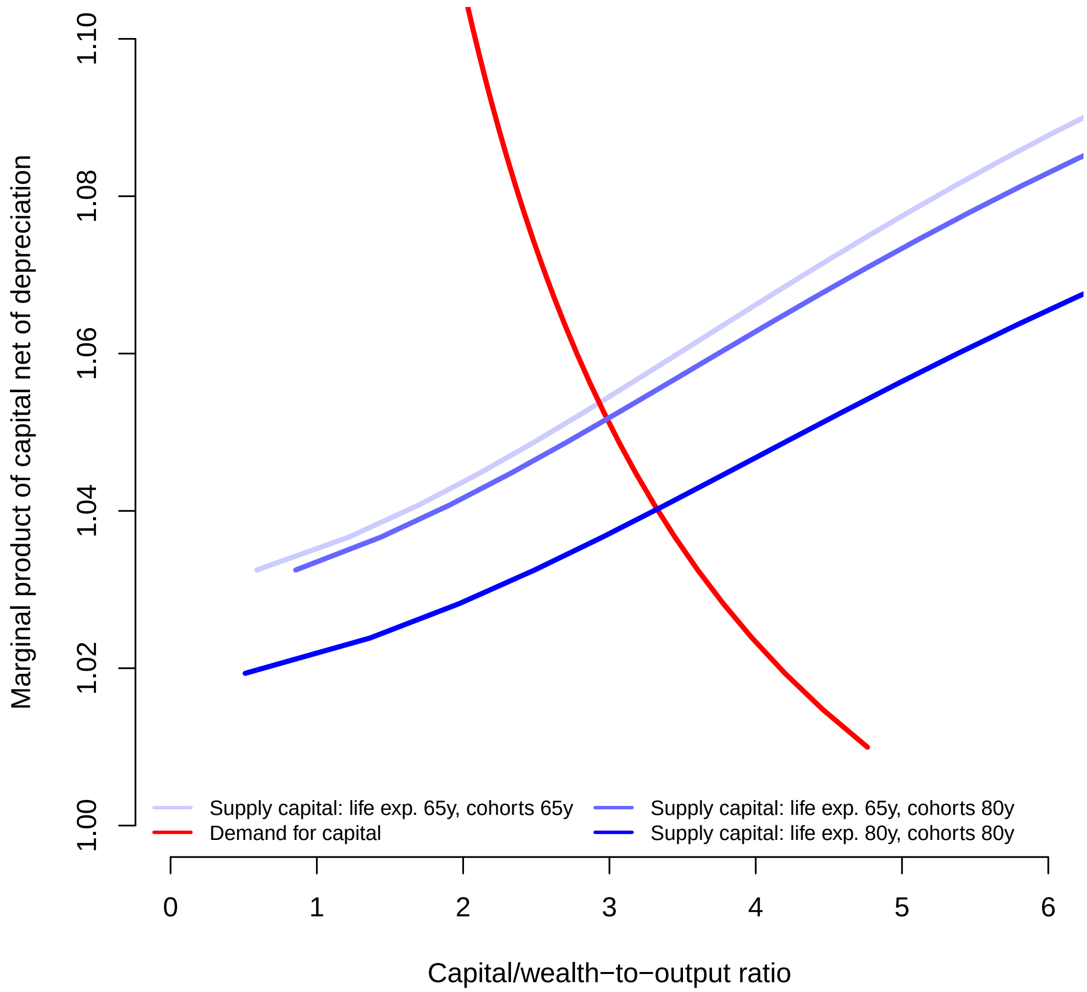


Figure 15
Steady state net worth by age

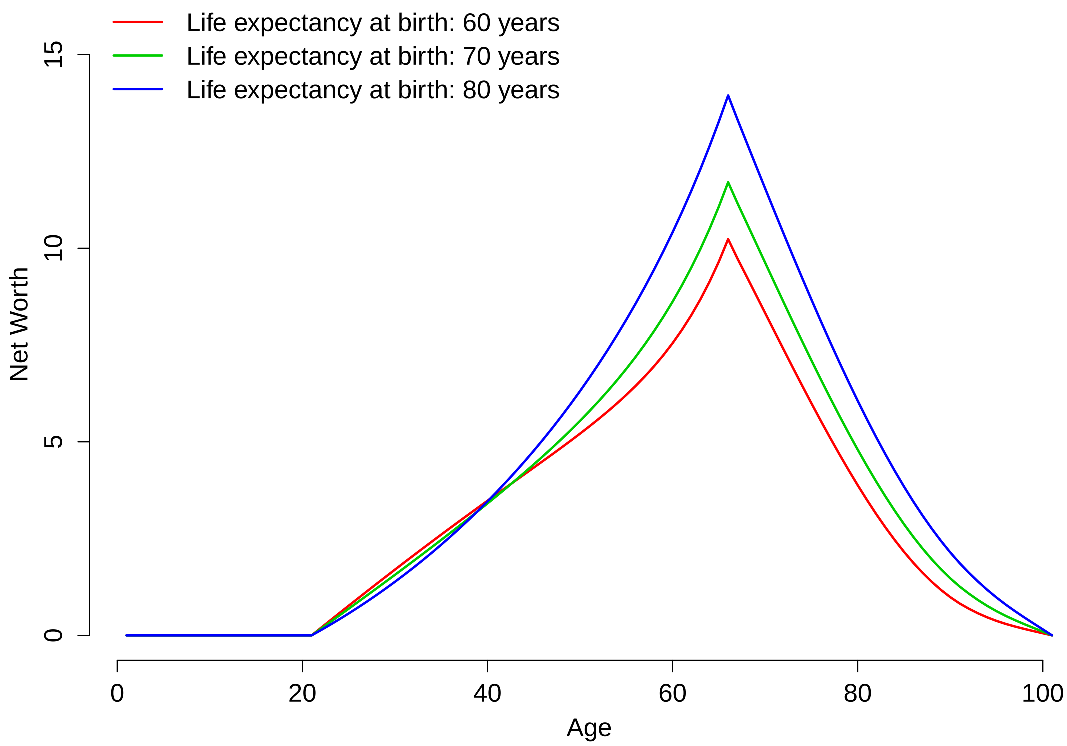


Figure 16
Dynamics of capital flows in the model with constant interest rate

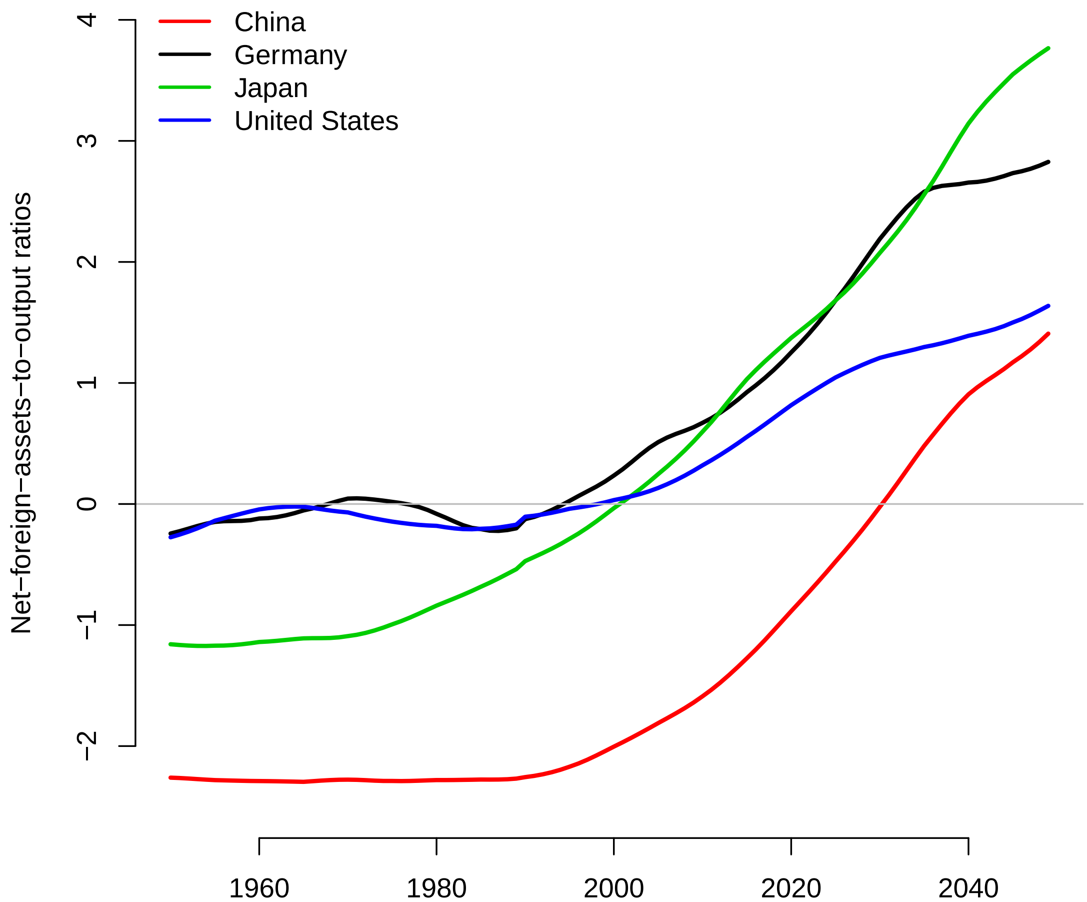


Figure 17
Dynamics of capital flows in the model