Generational Accounting in Open Economies

Eric O'N. Fisher
and Kenneth Kasa

The authors are, respectively, Professor of Economics, Ohio State University, and Economist, Federal Reserve Bank of San Francisco. The authors would like to thank Ramon Moreno and Charles Horioka for helpful comments.

Using data on U.S. and Japanese government debt, we calibrate a version of Weil's (1989) model and study the international and intergenerational consequences of recent fiscal policy.

Assuming debt/GDP ratios stabilize at current levels, the model implies: (1) the world real interest rate rises by fewer than two basis points; (2) the United States runs small but persistent external deficits; and (3) current generations in the United States experience a slight increase in wealth, while future generations both at home and abroad suffer analogous decreases. Most of the wealth effects are intergenerational rather than international.

Measurement is fundamental to all science. Newton's laws would be useless without an independent measure of mass. Psychology has not lived up to its early promise for the very reason that it has encountered difficulties in even defining, let alone measuring, such concepts as neurosis and psychosis. In fact, one might say that the hallmark of scientific progress is the replacement of the nonmeasurable with the measurable.

Despite great advances, it is probably fair to say that economics still resembles psychology more than physics.[1] Difficult to measure concepts like "excess profits" and the "natural rate of unemployment" still permeate economic theory. For the past several years, Alan Auerbach, Jagadeesh Gokhale, and Laurence Kotlikoff have been working to improve the measurement of an important economic concept: the government budget deficit. They argue that the conventional measure of the deficit is meaningless, since it is based on an arbitrary labeling of receipts and payments. It's not that government accountants are doing a poor job of measuring what they set out to measure, but simply that they are measuring the wrong thing. That is, there is a mismatch between economic theory and accounting practice.[2]

The explanation of this mismatch provides a good example of Prescott's (1986) well-known argument that in science theory often precedes measurement. To see why, recall the state of public finance theory in the 1930s and 1940s, when Kuznets and Stone first began laying the groundwork for national income accounting. Before the 1970s, economists lacked the analytical tools to construct consistent dynamic models of market equilibrium. These tools were supplied by the so-called "rational expectations revolution." Before this revolution, quantitative analyses of fiscal policy necessarily adopted a static framework. Predictions about how households and firms would react to fiscal policies were based on the presumption that they would respond mechanically, without giving any thought to how these policies might change in the future.

---

1. We do not mean to deprecate empirical psychology. Rosenberg (1992), for example, argues that economics can benefit greatly from incorporating some of the techniques of experimental psychology.

2. Auerbach and Kotlikoff (1987) contains a detailed exposition of this argument.

Now, Prescott's provocative thesis is that static economic theorizing produced a static government accounting system. That is, public finance theorists didn't use static models because they were given static, cash-flow accounting numbers, but rather, government accountants produced the kind of data that were useful to the static theories of the 1930s and 1940s. Auerbach, Gokhale, and Kotlikoff's basic point is that it is time to begin constructing data that are more consistent with the way modern public finance theorists analyze fiscal policy. Doing this requires careful attention to life-cycle planning and intertemporal budget constraints.

As an example of the difference a dynamic perspective can make, consider a fully funded social security program. In such a program, fluctuations in birth or death rates naturally lead to fluctuations in contributions or withdrawals from the system. In a purely cash-flow accounting system these fluctuations register as budget deficits or surpluses. However, as long as the program remains fully funded there are no deficits or surpluses in the economically relevant sense that any *individual's* lifetime payments to, or receipts from, the government change. Accordingly, modern dynamic theory would predict no economic effects from these deficits or surpluses because it assumes people look to the future when deciding how much to save and invest today. What matters to individuals is their expected lifetime *wealth,* not their current *income.*

Because individuals respond to changes in their wealth, not income, Auerbach, Gokhale, and Kotlikoff recommend that government accountants keep track of how fiscal policy changes each individual's lifetime wealth. They argue implicitly that doing this will improve economists' ability to predict the effects of fiscal policy. Unfortunately, keeping track of how fiscal policy affects every *individual's* lifetime wealth is not feasible. Instead, Auerbach, Gokhale, and Kotlikoff recommend that the government keep track of how fiscal policy affects each *generation's* lifetime wealth, since most individual heterogeneity derives from life-cycle differences.[3] Auerbach, Gokhale, and Kotlikoff call this system of measurement "Generational Accounting." Their main finding is that post-war fiscal policy in the United States has involved a massive shift of resources from the young and those not yet born to the generations in or near retirement. Most of this redistribution has taken place through the Medicare and Social Security systems.[4] For example, Auerbach, Gokhale, and Kotlikoff (1994, Table 4) conclude that a representative male born in 1920 paid an average lifetime net tax rate of about 24 percent, while a representative male born in 1980 can expect to pay a lifetime net tax of about 34 percent. Paying 10 percent more in taxes over the course of a 40-year working-life adds up to a lot of money!

Auerbach, Gokhale, and Kotlikoff develop their accounts in the context of a closed economy. In particular, they ignore the fact that individuals trade assets with residents of other countries. Recently, Fisher (1995) has argued that their work has important implications for how economists should interpret conventional measures of these asset flows. He shows that the same imprecision that plagues the conventional measure of the budget deficit also plagues the conventional measure of a country's current account, and for essentially the same reason.

Consider an arbitrary combination of foreign fiscal policies. Then a country can always select its own fiscal policy so that it will achieve *any* conventionally measured current account sequence, without having welfare implications for *anyone.* Thus, to the extent that current accounts are supposed to measure the intertemporal transfer of real resources between countries, conventionally measured current accounts are irrelevant. Fisher goes on to offer the same advice as Auerbach, Gokhale, and Kotlikoff: countries should adopt forward-looking, accrual-based balance of payments accounts.[5]

An important corollary of Fisher's argument is that policy debates about the sustainability of trade imbalances are essentially meaningless. As Gale (1971) first emphasized, countries do *not* face budget constraints, individuals do. Countries are comprised of heterogeneous generations, and there is simply no necessary relationship between the individuals' budget constraints and a "national budget constraint." Indeed, countries can have *permanent* trade deficits.[6]

This paper continues this recent work on generational accounting in the open economy. Our main contribution is to adopt a general equilibrium approach. Existing studies of generational accounting are partial equilibrium, in the sense that interest rate and output paths are specified exogenously.[7] This approach tends to understate the extent to

3. However, due to different life expectancies and labor force participation rates, in most instances they construct separate accounts for men and women.

4. The Social Security system is *not* fully funded. It is primarily a simple "pay-as-you-go" transfer from workers to the retired.

5. In an effort to follow his own advice, Fisher (forthcoming) constructs international generational accounts for Japan. These accounts indicate that changes in the (real) value of the yen can have vastly different effects on different cohorts.

6. Gale made this point in the context of a barter economy. His argument was extended to a monetary economy by Fisher (1990).

7. Note, existing generational accounts also neglect the welfare effects of government purchases of public goods. Thus they are essentially an analysis of how the government finances a *given* pattern of expenditure. Our paper also has this shortcoming.

which recent fiscal policy has redistributed wealth from the young and middle-aged to the old and retired. Since young and middle-aged people tend to save more out of each dollar than do old people, this redistribution produces a decline in national saving and thus raises interest rates and lowers investment. Lower investment leads to a lower future capital stock and lower future output. Thus, not only are future generations getting thinner slices of the national pie, but the pie itself is likely to get smaller! The current work in generational accounts looks only at the size of the slices, not the size of the pie.

The second contribution of this paper is to construct simultaneously generational accounts for two countries: the United States and Japan. The United States fiscal expansion in the last decade raised world real interest rates. Higher rates made servicing *every* country's national debt more onerous. We show below that unborn generations in Japan actually have lower welfare because of domestic policy in the United States. Likewise, the Japanese fiscal contraction during the 1980s will benefit slightly future generations in the United States.

I. GROWTH, DEMOGRAPHICS, AND GOVERNMENT DEBT

To quantify the effects of fiscal policy, we calibrate a two-country version of Weil's (1989) overlapping generations model. In this model new individuals continuously enter the economy. A key assumption is that these individuals are unrelated (in utility terms) to existing households. As a result, their entry expands the future tax base, and the interest burden on the national debt is less than the interest obligations of individual households. Hence, deficit-financed tax cuts increase the wealth of current generations because part of the higher future taxes needed to finance the debt will be paid by new arrivals.

The arrival of these new individuals can be interpreted in several ways. Immigration is perhaps the most obvious. Alternatively, Weil's model can be thought of as representing a system of primogeniture. Whatever the interpretation, the essence of this model is that it introduces a wedge between the social discount rate and the interest rate facing individual households. This wedge provides a useful metric of the economic "disconnectedness" of successive generations.

Another important feature of this model is the assumption that individuals live forever. This feature eliminates life-cycle effects. Since everyone has the same life expectancy, people respond in a symmetric way to changes in fiscal policy. This means that the only redistributions that matter are between the living and the yet unborn.

In this sense our analysis is cruder than the work of Auerbach, Gokhale, and Kotlikoff (1994) and Fisher (forthcoming). These authors allow individuals to have arbitrary finite lifetimes, although they are deterministic and identical. Unfortunately, finite lifetimes create difficult aggregation problems since the effects of redistributive policies will depend on the entire joint distribution of age and wealth for the population. Consequently, the response of national saving to changes in tax policy, for example, depends on the relative number of people at each stage of the life cycle. Because of these difficulties, previous studies of generational accounts have resorted to partial equilibrium analysis. However, we want to incorporate general equilibrium effects, and thus we sacrifice some realism along the life-cycle dimension.[8] The remainder of this section consists of six parts. First, we describe and solve the individual's lifetime planning problem. These solutions are then aggregated to produce an equation for national savings. Second, we discuss the production side of the world economy; here we assume that goods and capital markets are fully integrated. Third, we incorporate a government sector into each of the two economies, with particular attention to each government's budget constraint. Fourth, the aggregate behavior of consumers, firms, and governments are combined into a set of differential equations that jointly determine the equilibrium evolution of the world economy. Fifth, we analyze the eventual outcome of a permanent change in fiscal policy. Finally, in the sixth step, we solve and describe the system with general time paths of government debt. In particular, we simulate paths that approximate those actually experienced by the U.S. and Japan during the period 1981–1995.

Individual Optimization and Aggregation

For simplicity, the countries are assumed to be symmetric in all respects except fiscal policy and relative size. In particular, individuals have the same preferences, and population growth rates are identical.

At time *t*, an individual who was born at time *v* solves:

$$\max_{c(v,s)} \int_0^{\infty} e^{-\rho(s-t)} \ln[c(v,s)]ds,$$

8. The assumption of infinite lifetimes is not essential. Buiter (1988) points out that we could easily follow Blanchard (1985) and assume a random lifetime with an exponential distribution. This assumption still eliminates life-cycle effects since it implies that mortality is independent of age.

where $c(v,s)$ denotes the time s consumption of a vintage v individual, and ρ denotes the subjective rate of time preference. Individuals face the following flow budget constraint:

$$\dot{a}(v,t) = r(t)a(v,t) + w(t) - \tau(t) - c(v,t)\ ,$$

where $a(v,t)$ denotes the stock of financial assets held by a vintage v individual at time t, and a dot over a variable represents a time derivative. Note that wages, $w(t)$, and lump-sum taxes, $\tau(t)$, do not depend upon an individual's vintage. At a given point in time, everyone pays the same taxes and receives the same wages. Individuals can hold three kinds of assets: claims on capital; domestic government bonds; and foreign bonds. In our world of perfect foresight, however, these assets are perfect substitutes, with identical rates of return, $r(t)$.

The solution to this problem implies that an individual's consumption evolves as:

$$\dot{c}(v,t) = (r(t) - \rho)c(v,t)\ .$$

Thus, consumption is rising when the interest rate is relatively high since a higher rate of return promotes saving.

Imposing the restriction that individuals cannot borrow beyond their means yields the following consumption equation:

$$c(v,t) = \rho(a(v,t) + h(v,t))\ ,$$

where $h(v,t)$ denotes the time t value of the individual's human capital, which is just the present discounted value of his future labor income net of tax liabilities:

$$h(v,t) = \int_t^\infty (w(s) - \tau(s))e^{-R(t,s)}ds,$$

where
$$R(t,s) = \int_t^s r(u)du\ .$$

The key feature of the consumption function is that the marginal propensity to save is independent of age. This property vastly simplifies aggregation, to which we now turn.

We assume that each economy's population grows at the constant rate n, so that $N^h(t) = N^h(0)e^{nt}$ is the home country's population and $N^f(t) = N^f(0)e^{nt}$ is the foreign country's. Thus $\theta^h = N^h(t)/(N^h(t) + N^f(t))$ is the home country's constant share of world population, and θ^f is analogous.

For any individual variable pertaining to the home country, $x^h(s,t)$, the corresponding aggregate (per capita) variable $x^h(t)$ is:

$$x^h(t) = \frac{N^h(0)x^h(0,t) + \int_0^t x^h(s,t)dN^h(s)}{N^h(t)}\ .$$

Analogous definitions hold for variables pertaining to the foreign country. Applying these definitions yields the domestic aggregate (per capita) consumption equation:

$$c^h(t) = \rho(a^h(t) + h^h(t))\ ,$$

with associated laws of motion:

$$\dot{a}^h(t) = (r(t) - n)a^h(t) + w(t) - \tau^h(t) - c^h(t)$$
$$\dot{h}^h(t) = r(t)h^h(t) - (w(t) - \tau^h(t))\ .$$

Notice that financial and human wealth accumulate at different rates because of the continuous entry into the economy of individuals with no financial wealth.

Finally, the law of motion for aggregate consumption in the domestic economy is:

(1) $$\dot{c}^h(t) = (r(t) - \rho)c^h(t) - n\rho a^h(t)\ ,$$

with an analogous expression for the foreign economy. This is one of the fundamental equations of the model. Note that if $n = 0$, it reduces to the consumption equation of a standard representative agent model.

Technology and Market Structure

We will now make explicit the production side of the economy. There is a single good, produced in both countries according to identical technologies, under constant returns to scale. Thus, the only gains from trade derive from borrowing and lending. We assume that output can be transformed costlessly into capital, so that the relative price of consumption and capital is fixed at unity.[9] Finally, we assume that capital is perfectly mobile between countries. These assumptions imply that factor prices are equalized across countries.

Letting $f(k)$ denote the net-of-depreciation per capita production function, equilibrium in the global capital market implies $r(t) = f'(k(t))$, where $k(t) = k^h(t) = k^f(t)$. That is, firms simply set the net marginal product of capital equal to the world interest rate.

The Government

As noted in the introduction, we follow previous generational accounting studies by focusing on the financing choices of the government, as opposed to its expenditure policies. Thus, without any loss in generality, we assume government expenditure is zero in all periods. Moreover,

9. Fried and Howitt (1988) develop a two-country overlapping generations model in which fiscal policy causes capital gains and losses, due to an assumption that one of the assets is in fixed supply.

we do not impute any optimizing behavior to the government. Governments just levy lump-sum taxes in order to finance an exogenous path of public debt. As a result, the behavior of the government is summarized by its budget constraint:

$$\dot{d}^h(t) = (r(t) - n)d^h(t) - \tau^h(t)\ , \tag{2}$$

with an analogous expression for the foreign government. Equation (2) is the second fundamental relation in the model. Note that governments effectively borrow at the rate $r(t) - n$ since the tax base is expanding. Hence, one can interpret n, the arrival rate of new individuals, as the difference between the private and public costs of borrowing.

Market Equilibrium

The third fundamental equation of the model states that a country's current account is the sum of its trade balance and the interest on its net foreign assets. For the home country this identity can be written:

$$\dot{b}^h(t) = (r(t) - n)b^h(t) + f(k(t)) - \dot{k}(t) - nk(t) - c^h(t)\ , \tag{3}$$

where $b^h(t)$ denotes net foreign assets per capita at time t.

The model is now complete. The equilibrium of the economy is summarized by equations (1), (2), and (3), and by the capital market equilibrium condition, $f'(k(t)) = r(t)$.

For a small economy, these four conditions determine the time paths of consumption, capital, net foreign assets, and domestic debt, all as functions of the exogenous world interest rate. However, for large countries like the U.S. and Japan, we also need to consider how the interest rate is determined. Our symmetry assumptions imply that the equations for consumption and savings also apply to the foreign economy, with c^f, d^f, and b^f in place of c^h, d^h, and b^h.[10] The only difference, of course, is that foreigners are taxed by their own government to service the stock of their own national debt. One can pin down r by noting that $\theta^h b^h + \theta^f b^f = 0$. That is, in a world with just two countries, one country's borrowing is necessarily the other's lending.

Defining the aggregates $c = \theta^h c^h + \theta^f c^f$, $d = \theta^h d^h + \theta^f d^f$, and $\tau = \theta^h \tau^h + \theta^f \tau^f$, and using the definition of the interest rate, yields the aggregate system:

$$\dot{c} = (f'(k) - \rho)c - n\rho(k + d)$$

$$\dot{d} = (f'(k) - n)d - \tau$$

$$\dot{k} = f(k) - nk - c\ .$$

The equilibrium interest rate then follows from the profit maximization condition $r = f'(k)$.

10. Henceforth, when there is no ambiguity, we will drop the notation that the endogenous variables depend upon time.

Once the path of the interest rate for the world economy is known, each country's consumption is found by a simple iterative procedure. Since a country's debt must be serviced by taxes levied on its own residents, the profiles of national debt determine taxes, and thus net human capital, for agents in each country. Since the stock of financial assets is predetermined, the simple rule for household savings yields consumption in each country in the initial steady state. The current account identity in equation (3) then describes how financial wealth evolves in each country. Then, from equation (1), the sum of financial and human wealth determines each country's consumption in the next period. This procedure is repeated until the world economy reaches its new steady state.

Steady-State Analysis

Although this system of differential equations is straightforward to analyze *qualitatively,* we are ultimately interested in *quantitative* results. It's pretty obvious that, in a world where future generations receive no weight in today's decisions about fiscal policy, government debt imposes a burden on the unborn. The real issue, however, is how big this burden is and how it depends on the underlying parameters of the economy. To address these sorts of questions we need actually to solve these differential equations.

In general, solving these nonlinear equations requires numerical approximation methods. However, since we are really only interested in how *changes* in fiscal policy *change* the equilibrium, we can linearize them around an initial steady state, which we take to be 1981, when national debt/GDP ratios first started to increase. If we let c_0, k_0, and d_0 be the values of the endogenous variables in the initial steady state, then a linearization of the dynamical system yields:

$$\begin{bmatrix} \dot{c} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} f'(k_0) - \rho & f''(k_0)c_0 - n\rho \\ -1 & f'(k_0) - n \end{bmatrix} \begin{bmatrix} c - c_0 \\ k - k_0 \end{bmatrix} - \begin{bmatrix} n\rho(d - d_0) \\ 0 \end{bmatrix}.$$

It is convenient to write this system more compactly as:

$$\dot{z} = Jz - h\ .$$

Now, to compute the change in the steady state following a change in world fiscal policy captured by $d - d_0$ we simply set $\dot{z} = 0$, which yields $z = J^{-1}h$. Thus:

$$\begin{bmatrix} c - c_0 \\ k - k_0 \end{bmatrix} = \frac{(d - d_0)}{\Delta} \begin{bmatrix} n\rho(r_0 - n) \\ n\rho \end{bmatrix}, \tag{4}$$

where r_0 is the interest rate in the initial steady state, and $\Delta = (r_0 - \rho)(r_0 - n) + f''(k_0)c_0 - n\rho$ is the determinant of J. The stability of the dynamical system requires that $\Delta < 0$.

Equation (4) nicely summarizes the long-run crowding out effects of fiscal policy. In particular, as long as $n \neq 0$ a permanent net increase in the global debt stock reduces the long-run capital stock and output in *both* countries. Since taxes are not lower, long-run consumption must also fall. This does not necessarily make the current generation worse off. The current generation enjoys temporarily lower taxes and higher take-home pay while the debt stock is increasing. In contrast, future generations will not only have to pay higher taxes to finance the increased debt, but crowding out rubs salt in their wounds by also lowering gross wages.

Finally, note that the aggregate debt stock, not its distribution among countries, matters for crowding out. This implies that crowding out can occur, and future generations can be harmed, even in countries that do not engage in their own redistributive fiscal policy. Thus, the global capital market can *transmit* redistributive fiscal policies.

Transitional Dynamics

Unfortunately, steady state comparisons can provide misleading gauges of welfare changes, since long-run and short-run effects can be different. The misleading nature of these comparisons is especially true in this model, since the composition of the population is changing over time. Hence, a complete welfare analysis requires attention to transitional dynamics. In fact, transitional dynamics are the essence of generational accounting.

Consider the transitional effects of an unanticipated permanent increase in government debt. The increased government debt—induced, for example, by temporarily lower taxes—causes aggregate consumption to increase initially. The jump in consumption reflects the wealth effect experienced by current generations. Increased consumption, however, reduces investment, which gradually lowers the capital stock. In the long run, as taxes rise to stabilize the debt, the world economy ends up with a lower capital stock and lower consumption.

Although this kind of "comparative statics" analysis is useful, it has two serious limitations. First, it is purely qualitative. It does not tell us how much consumption initially increases in reaction to the tax cut. Nor does it tell us how long the transition to the steady state takes. Does crowding out take place in one year, ten years, or a hundred years? From the perspective of generational accounting, the answers to these questions make all the difference in the world. The second limitation of a comparative static analysis is that it is only suited to one-time permanent changes. This is a problem, since actual fiscal policy evolves gradually and is partly anticipated.

To allow for general time paths of government debt and taxes, we follow the pioneering analysis of Judd (1985), and work with Laplace transforms.[11] Laplace transforms facilitate calibration of the model to actual fiscal policy. Taking the Laplace transform of the dynamical system yields:

$$sZ(s) - z(0) = JZ(s) - H(s) \ ,$$

where $Z(s)$ denotes the Laplace transform of $z(t)$, and $H(s)$ denotes the Laplace transform of $h(t)$. Solving for $Z(s)$ then gives:

$$Z(s) = (sI - J)^{-1} [z(0) - H(s)] \ .$$

As long as $\Delta < 0$, J will have one positive eigenvalue and one negative eigenvalue. Denote the positive eigenvalue by μ and the negative eigenvalue by $\lambda < 0$. For the solutions to remain bounded, $Z(s)$ must be well-defined for positive s. However, note that since μ is an eigenvalue of J, $(\mu I - J)$ is singular. Therefore, to have a bounded solution this singularity must be cancelled, or "removed," by setting $z(0) - H(\mu) = 0$. This fact ties down the initial condition of the system. Note that since the capital stock cannot change discontinuously, the second element of $z(0)$ is zero. In contrast, initial consumption can jump. Thus the first element of $z(0)$ is given by:

$$c(0) - c_0 = n\rho D(\mu) \ ,$$

where $D(\mu)$ is the Laplace transform of the aggregate debt path, evaluated at μ. Thus initial consumption rises in proportion to the present discounted value of the increase in government debt, with a discount factor given by μ. Moreover, the proportionality constant increases with the economic disconnectedness of successive generations.

These two equations completely characterize the time paths of the capital stock and aggregate consumption in response to debt policies. The solutions are in terms of the Laplace transform of aggregate debt. To express the solutions in their original form, we must invert these transforms. We specify aggregate debt policy with an eye toward making this inversion manageable, yet reasonably consistent with observed debt policies. In particular, we assume the aggregate government debt stock follows:

$$d(t) - d_0 = \varepsilon d_0 \left(1 - e^{-\gamma t}\right) \ ,$$

11. The Laplace transform, $F(s)$, of a function $f(t)$ is defined by

$$F(s) = \int_0^\infty e^{-st} f(t)\, dt \ .$$

These transforms are useful because they convert differential equations into algebraic equations. Once the algebraic equations are solved, one can invert the transforms to get the solution in terms of the original functions. The key property of Laplace transforms, which yields this simplification, is that the Laplace transform of the derivative $f'(t)$ is $sF(s) - f(0)$, where $f(0)$ is the initial condition of the function $f(t)$.

where ε measures the eventual percentage increase in per capita world debt from its initial steady state level, and γ governs how quickly it converges to this long-run level. This equation leads to the following solution for the dynamical system:

$$\begin{bmatrix} c(t)-c_0 \\ k(t)-k_0 \end{bmatrix} =$$

$$(5) \quad \frac{n\rho\varepsilon d_0\gamma}{\mu(\gamma+\mu)} \begin{bmatrix} \frac{(r_0-n)(\gamma+\mu)}{\gamma\lambda} - \frac{\mu(r_0-n+\gamma)}{\gamma(\gamma+\lambda)} e^{-\gamma t} + \frac{(\lambda-(r_0-n))(\gamma+\lambda+\mu)}{\lambda(\gamma+\lambda)} e^{\lambda t} \\ \frac{\gamma+\mu}{\gamma\lambda} - \frac{\mu}{\gamma(\gamma+\lambda)} e^{-\gamma t} - \frac{\gamma+\lambda+\mu}{\lambda(\gamma+\lambda)} e^{\lambda t} \end{bmatrix}.$$

The time paths of all the other variables follow, since output, the interest rate, and wages are all determined by the capital stock. Also, since the path of interest rates is determined, so are the asset holdings for each household. Then the household savings rules determine consumption in each country and thus pin down the path of the current account. In the next section, we use these equations to construct generational accounts for the United States and Japan and also to illustrate the international transmission of fiscal policy.

II. International and Intergenerational Accounts

During the past 20 years, nearly all industrialized countries have experienced a rapid increase in government debt. For example, in 1980 the average ratio of debt to gross domestic product among the OECD countries was about 20 percent. By 1995 it had climbed to almost 46 percent. From an historical perspective this increase is unusual, since it occurred during peacetime. Previous episodes of rapid debt growth have almost always been accompanied by political instability. Thus, it is no surprise that the Maastricht Treaty's limits on government debt have been among the thorniest issues in moving to a common currency in Europe.

This recent growth in government debt is all the more surprising in light of the criticisms of Auerbach, Gokhale, and Kotlikoff, since conventional measures of the debt tend to understate it, primarily because of underfunded social security and public pension systems.[12]

At the same time governments have been running massive budget deficits, real interest rates have risen, and current account imbalances have reached levels not seen since the late 19th century.

The previous section developed a model that is designed to explain this recent experience. It links the rise in real interest rates to the common component of government debt, and current account imbalances to country-specific government debt policies. The flexible structure of the model allows us to quantify both the international and the intergenerational redistributions that accompany these policies. To keep the analysis tractable we confine our attention to the United States and Japan, the two largest participants in the global capital market.

Before the model can be used to construct international and intergenerational accounts, it must be calibrated. Figure 1 plots the ratio of debt to GDP for the U.S. and Japan using conventional measures of government debt stocks. Notice the disparate paths of U.S. and Japanese government debt stocks. Japan is one of the few countries in the world where the ratio of government debt to GDP has not risen. As a result, the increase in world debt is less than the increase in U.S. debt.[13]

Given the widely varying fiscal stances of the two governments, it is not surprising that large current account imbalances have emerged. These are depicted in Figure 2.[14] Expansionary fiscal policy in the United States produced a relative decline in national saving that spilled over to the current account.

Figure 3 shows our attempt to mimic the recent behavior of observed government debt in this two-country world. It should be compared with Figure 1. We regard 1981 as the initial steady state, and our assumption that the aggregate debt/GDP ratio stabilizes near its level in 2000 is certainly open to question. When computing national generational accounts, we need to parameterize these country-specific debt paths. For the U.S. we postulate an eventual increase of 30 percentage points in the ratio of debt to GDP, and for Japan an eventual decrease of 10 percentage points. These national debt paths then determine the country-specific tax rates shown in Figure 4. We calculate that the taxes needed to service the debt were about $96 per person in the original steady state. The run-up in U.S. debt is produced by an

12. However, it is important to keep in mind that there are also overstating biases. For example, inflation reduces the real value of government debt, and currency depreciations reduce the burden of foreign liabilities. More importantly, the end of the Cold War dramatically reduced the implicit liabilities to our allies. Conventional measures of the "peace dividend" are likely to understate the true magnitude of the "capital gain" the U.S. experienced upon the collapse of the Soviet empire. Still, most experts believe the debt is understated, due to underfunded entitlements.

13. These data are from the OECD and are net of government-held financial assets. Gross debt figures are of course higher for both countries, but particularly so for Japan. In fact, the gross debt/GDP ratio in Japan is almost 100 percent. The lion's share of the difference arises from the surpluses of the Postal Savings Sytem in the last decade.

14. Figure 2 plots *aggregate* imbalances, not bilateral imbalances. However, bilateral trade is quite significant for both countries. In fact, the U.S. deficit is almost a mirror image of the Japanese surplus.

FIGURE 1

Government Debt as a Percentage of GDP

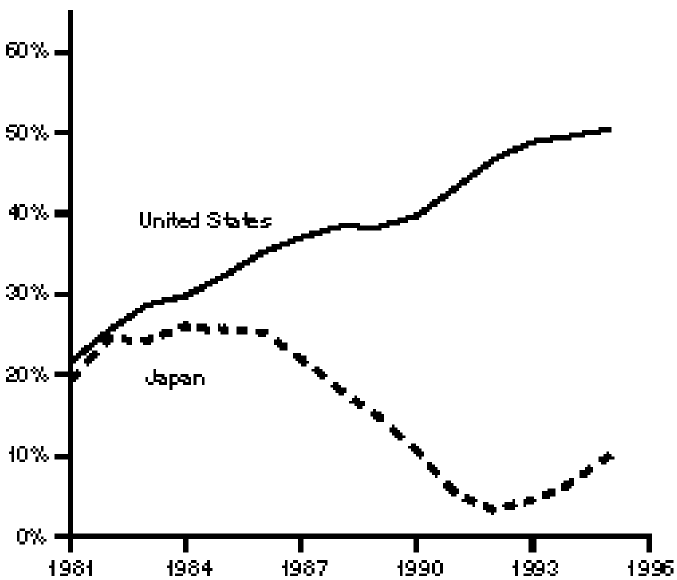


FIGURE 3

Calibrated Debt as a Percentage of GDP

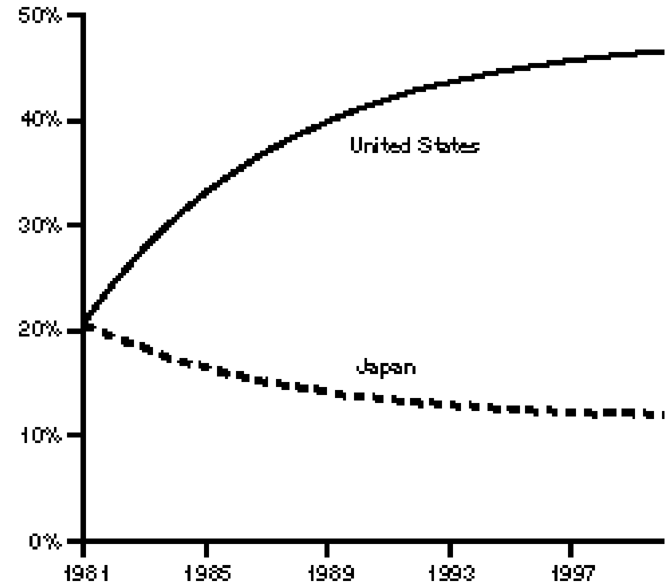


FIGURE 2

Current Account as a Percent of GDP

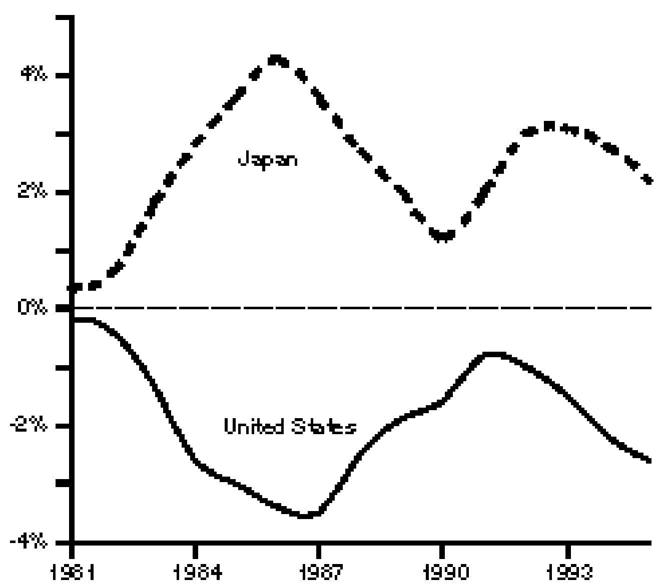
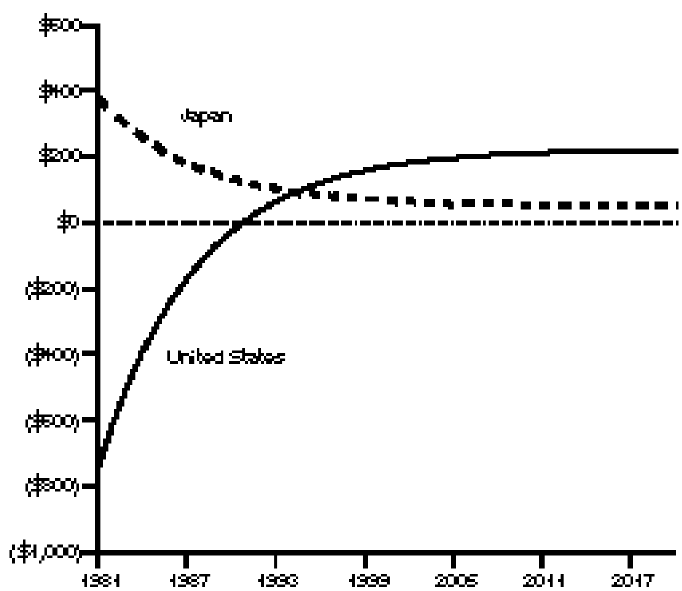


FIGURE 4

Taxes for Debt Service



initial tax cut of nearly $840 per person in 1981; after about 15 years taxes are permanently higher. In contrast, Japanese tax policy is characterized by an initial tax *increase* of about $280 per person, and taxes needed to service the debt then fall gradually to near zero. Finally, since the United States has roughly twice the population of Japan, we set $\theta^h = 2/3$ and $\theta^f = 1/3$ in constructing the world debt stock.

One of the main contributions of this paper is incorporating general equilibrium effects into generational accounts. Of course, the general equilibrium effects of fiscal policy depend upon the entire structure of the model economy. First, we assume that aggregate output per capita is given by:

$$f(k) = ak^{\alpha} - \delta k .$$

Then we use real GDP per capita in the United States in 1981 to calibrate our original steady state using the parameters in Table 1. The calibrated aggregate production function is $f(k) = 836k^{0.3} - 0.1k$, and the predicted steady state real interest rate is about 4.2 percent.

The model's parameters are contained in Table 1.

Most of these values are fairly standard. The share of capital in net national product is 30 percent, the depreciation rate is 10 percent, the discount parameter is 4 percent, and the demographic parameter is 2 percent. Although we have couched some of the discussion in terms of population growth, it would probably be misleading to calibrate this parameter to actual population growth, which is only about 1 percent in the United States and even less in Japan. The real issue is the strength of intergenerational linkages, and we simply view n as a free parameter whose magnitude must be inferred from its effects on the data we do observe. Our choice of $n = 0.02$ is therefore somewhat ad hoc, and it implies that in equilibrium, for every extra $1 billion of government debt, a debt service of $20 million is paid

TABLE 1

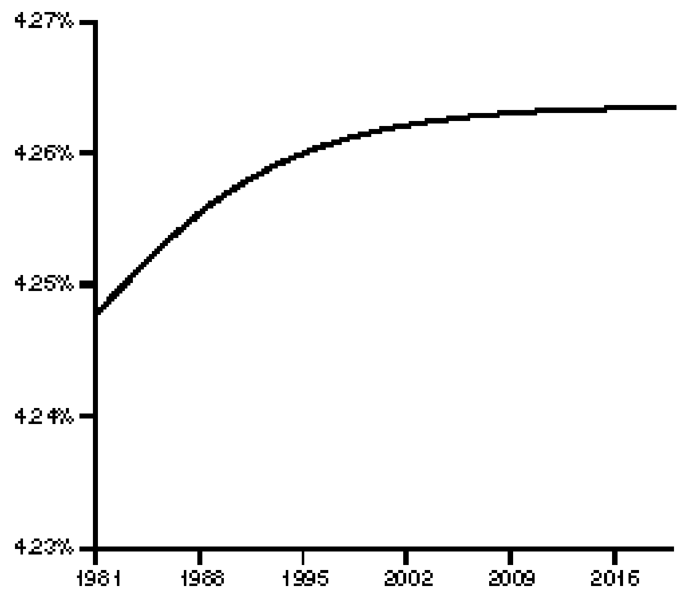
BASELINE PARAMETER VALUES

n	ρ	a	α
0.02	0.04	836	0.30

δ	d_0	γ	ε
0.10	0.21	0.15	0.73

FIGURE 5

THE WORLD REAL INTEREST RATE



by the current beneficiaries of this deficit, while $20 million is paid by the increased future tax base. Thus we assume that the current body politic internalizes only about half the costs of the deficits it generates.

Figure 5 summarizes the crowding out implied by our model; it reports one of the first examples in the literature on generational accounts of a general equilibrium effect. Notice that real interest rates rise by only 2 basis points over 20 years. This slight increase affects both the United States and Japan, and it increases the burden of debt service in every country. Eventually, annual real wages decline by only $7, and per capita GDP declines by $10.[15] This drop corresponds to a $2.3 billion permanent reduction in annual output. These small effects are robust to alternative parameter values. Basically, crowding out effects are small because calibrated government debt is less than 9 percent of wealth in the initial steady state, so the *aggregate* wealth effects of fiscal policy just aren't that significant.

Another way to think about these effects is to ask: How much would the relevant variables have changed in a closed economy? Consider the effects of U.S. policy in isolation. Then our model predicts that interest rates would have risen by another 1.5 basis points, and national output would have

15. These and all analogous units are 1992 chain-weighted dollars per person. Real GDP per capita was about $20,550 in 1981.

declined eventually by about $4.1 billion. Still, these small general equilibrium effects suggest that Auerbach, Gokhale, and Kotlikoff have not been greatly mistaken in taking the path of real interest rates as given in their simulations.[16]

The heart of the paper is contained in Figure 6, showing the generational accounts for the United States and Japan. These shift attention from aggregate wealth effects to distributional effects. Here the results are more significant. First, our symmetry assumptions imply that the generational accounts in the base case are identical for each country. Also, since taxes are assumed equal for all current and future generations, the generational accounts are equal within countries as well. As it turns out, the present value of a cohort's steady state human capital is about $336,700.

We constructed these figures by using the capital stock equation to derive interest rates and wages in the world economy. Each country's tax policy determines wages net of taxes. Then we compute the present value of each cohort's take-home pay in the year it is born, i.e., the value of its human capital at birth. This figure is a cohort's generational account, and it is a great advantage of using Weil's model.

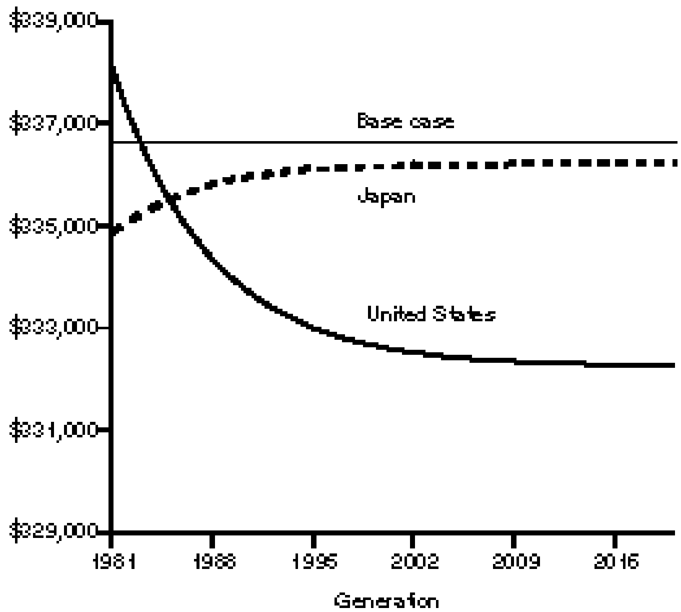
The dollar amounts in Figure 6 are larger than those reported by Auerbach, Gokhale, and Kotlikoff because they include the present value of the entire stream of a cohort's wages. This is the proper way to define generational accounts in general equilibrium since it is entirely appropriate to consider the effect that fiscal policy has on an economy's output. Fiscal deficits crowd out capital and reduce future real wages; this effect is a cost imposed on the unborn, just like the increased debt service that is "bequeathed" to them.

There is an important subtlety used in constructing the data reported in Figure 6. Weil's model allows one to solve explicitly for the taxes implied by any path of government debt; thus it is not necessary for us to make the assumption, as Auerbach, Gokhale, and Kotlikoff must do, about equal treatment for the unborn. There is a more appealing "equal treatment" postulate inherent in Weil's model; taxes in any period do not depend upon who is paying them, but they rise or fall for everyone according to the need to service the government debt.

Figure 6 illustrates vividly the intergenerational wealth transfers that take place in the United States and Japan. Notice first that the horizontal axis refers to generations, not chronological dates. Generational accounts are indexed by representative people, not by time. In the United States, those who are alive at the time of the tax cut experience

FIGURE 6

GENERATIONAL ACCOUNTS



about a 0.4 percent increase in lifetime wealth, reflecting a combination of temporarily lower taxes and a higher return on savings. Since taxes and interest rates rise rapidly at first, these are dissipated after three years. Unfortunately, the gains of the current generations are purely at the expense of future generations. Those born after taxes have been permanently increased to finance the debt suffer about a 1.3 percent decline in their lifetime wealth. Note that the break-even generation roughly corresponds to the date at which taxes first turn positive.

The generational accounts of Japan are the mirror image of those in the United States, as current generations are transferring wealth to future generations. However, since the change in Japanese fiscal policy is less dramatic than in the United States, the intergenerational redistribution is much smaller. But the crucial point about the Japanese accounts is that future generations are worse off than in the base case. They suffer this deleterious effect in spite of the fact that the Japanese fiscal authority runs current surpluses! The Japanese suffer a loss of wealth precisely because of the international transmission of effects of the U.S. deficit. Real wages in the world economy drop by about $7 per year; the capitalized value of this loss is near $175. The rest of the loss has to do with the change in long-run interest rates; although they rise less than 2 basis points, they have a nontrivial effect on the valuation of human capital. Since the original interest rate was near 4 percent, a

16. Small general equilibrium effects are also reported by Fehr and Kotlikoff (1995).

rise of 2 basis points entails a 0.5 percent capital loss for an asset with an infinite duration, such as human capital in Weil's model. In the long run, this would reduce each cohort's generational account by about $1,700. The fact that Japanese fiscal authorities are reducing their national debt is of course an offsetting boon to future generations in that country, and Figure 6 shows the sum of these three effects.

Figure 7 illustrates how international asset trade *transmits* the effects of fiscal policy. It plots conventional measures of the two countries' current accounts. Since there are no unilateral transfers between countries, and there is no uncertainty, this figure also illustrates what Fisher (forthcoming) calls the *aggregate generational current account.* As one would expect, the relative increase in U.S. government debt causes a current account deficit, since the current generation increases its consumption. In Weil's model, the budget and current account deficits really are twins. The Japanese surplus is exactly twice as large as the United States' deficit because all variables are measured in per capita terms.

There are three things to notice about these external imbalances. First, they are quite small. During the period of fiscal expansion it is only about 0.25 percent of GDP in the United States, while actual current account imbalances have averaged about 2 percent of GDP. The model's failure to produce current accounts of the same order of magnitude as those actually observed is disappointing, but not too surprising. Glick and Rogoff (1995) show that the investment effects of country-specific productivity shocks explain much of the recent imbalance. In our model there are no productivity shocks. Trade imbalances derive entirely from the wealth effects of fiscal policy. Second, Figure 7 shows that the current account imbalances are very persistent. According to the model, the United States can expect to run current account deficits for many years to come. Again, these enduring imbalances are a general feature of overlapping generations models. Third, Figure 7 shows a monotone deficit for the U.S. In contrast, the actual current account imbalances initially increased, peaking sometime in 1987.

Our final figure shows the *generational pattern of net foreign assets,* the second measure described by Fisher (forthcoming). Figure 8 shows who owns the net foreign assets that the two countries' fiscal policies have induced. Japanese residents who were alive during the time of the fiscal expansion in the United States eventually come to own about $5,400 in dollar-denominated assets, representing about 9 percent of their wealth. This ownership of net foreign assets decreases monotonically since international lending decreases as the agents in the world economy adjust to the initial fiscal imbalances. Still, an important part of the wealth of Japanese generations well into the next

FIGURE 7

Predicted Current Account Surplus as a Percent of GDP

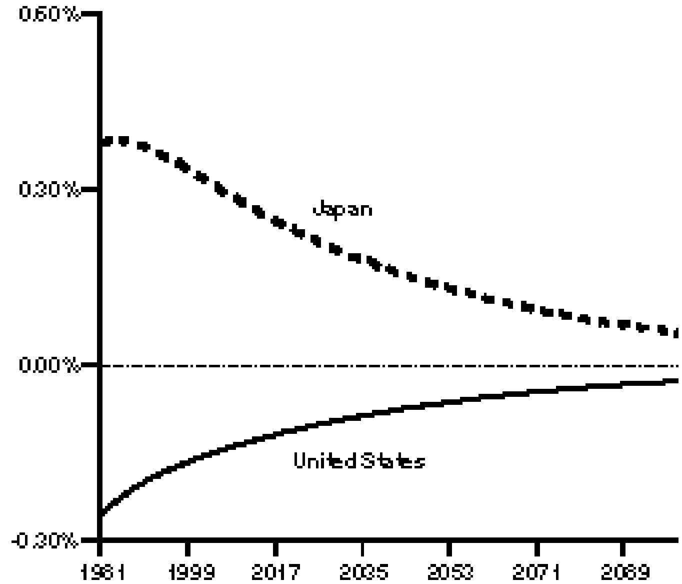
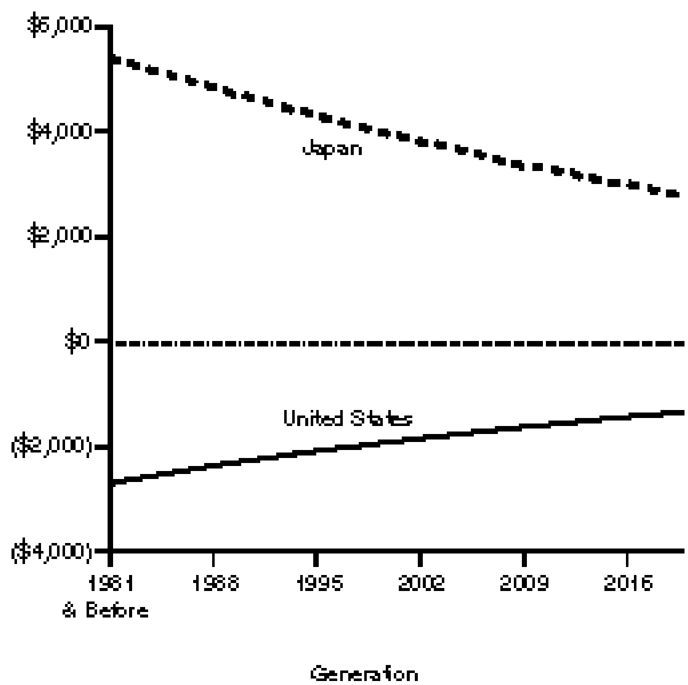


FIGURE 8

Generational Pattern of Net Foreign Assets



century will consist of foreign assets. Thus, any unexpected inflation in the United States or real depreciation of the dollar will be a capital loss for the Japanese.

III. CONCLUSION

This paper began by pointing out flaws in the way government accountants measure the budget deficit and the current account. Unfortunately, it is easier to find flaws than it is to fix them. While Auerbach, Gokhale, and Kotlikoff have made great strides in constructing more useful measures of the budget deficit, their work abstracts from international and general equilibrium considerations. This paper is an attempt to incorporate both of these considerations into generational accounting. In doing so, we build on the theoretical research of Weil (1989) and Fisher (1995).

Like Auerbach, Gokhale, and Kotlikoff, we find that recent U.S. fiscal policy has induced a transfer of resources to current generations. Given our hypothesis that future debt/GDP ratios remain near their current levels, we find that those who were alive during the fiscal expansion of the 1980s experienced a slight increase in wealth, while all those who are born after taxes have been increased find their wealth lower by about 1.3 percent. At the same time, the opposite wealth transfer has been taking place in Japan. However, their debt policy has been less dramatic, and we find that intergenerational wealth transfers are only about one-fourth as large as those in the United States.

Although different policy and demographic assumptions make a direct comparison impossible, these costs and benefits are similar to those of Auerbach, Gokhale, and Kotlikoff. The main difference is that in their simulations, future generations are hurt much more. They postulate a more gradual, but much more expansionary fiscal policy.

The main contribution of our work is the ability to incorporate crowding-out effects and international spillovers. We find that recent fiscal policy will produce only slight upward pressure on the future world interest rate. The real interest rate will eventually rise by less than two basis points. This crowding out makes future generations worse off. Also, it transfers wealth from Japanese generations to generations currently alive in the United States. Without Japanese fiscal surpluses, interest rates would be higher and the future capital stock lower. At an individual level, these spillover effects are quite small: about $1,700 in present value terms. However, since the effect is nearly the same for everyone, the aggregate spillover is not trivial. Interestingly, the increase in American debt is enough to offset the long-run benefits of the domestic surpluses for future generations of Japanese.

Of the many simplifying assumptions we make to obtain these results, perhaps the most important pertain to demographics. Throughout our analysis we assume an identical and constant n across countries. Both assumptions are counterfactual, and it would be of interest to see how robust our results are with respect to the degree of generational disconnectedness. For example, Iwata (1991) uses a model of overlapping generations with differing, time-varying birth rates and concludes that the relative aging of Japan will produce a dramatic narrowing of the bilateral current account imbalance during the first decade of the next century. Also, our projections about the long-run size of the Japanese national debt may be too optimistic. In the last several years, policymakers in Japan have been worried about the fiscal effects of Japan's aging population. Our predictions about the Japanese surplus are based upon calibrating this model to data from the last decade, when the Japanese Postal Savings System ran large surpluses. Thus our forecast of long-run U.S. external deficits might be tempered if Japan's internal balance worsens sharply in the next few years. Further work on the causes and size of trade imbalances will be a fecund area of future research.

REFERENCES

Auerbach, Alan J., Jagadeesh Gokhale, and Laurence J. Kotlikoff. 1994. "Generational Accounting: A Meaningful Way to Evaluate Fiscal Policy." *Journal of Economic Perspectives* 8, pp. 73–94.

__________, and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy*. Cambridge: Cambridge University Press.

Blanchard, Olivier J. 1985. "Debt, Deficits, and Finite Horizons." *Journal of Political Economy* 93, pp. 223–247.

Buiter, Willem H. 1988. "Death, Birth, Productivity Growth and Debt Neutrality." *Economic Journal* 98, pp. 279–293.

Fehr, Hans, and Laurence J. Kotlikoff. 1995. "Generational Accounting in General Equilibrium." NBER Working Paper No. 5090.

Fisher, Eric O'N. 1990. "Sustainable Balance of Trade Deficits." *Journal of Monetary Economics* 25, pp. 411–430.

__________. 1995. "A New Way of Thinking about the Current Account." *International Economic Review* 36, pp. 555–568.

__________. Forthcoming. "A Measure of the Current Account Related to the Well-being of Japan: Generational Accounts in the Open Economy." In *Geography and Ownership as a Basis for Accounting*, ed. J. David Richardson. NBER Project Report. Chicago: University of Chicago Press.

Fried, Joel, and Peter Howitt. 1988. "Fiscal Deficits, International Trade and Welfare." *Journal of International Economics* 24, pp. 1–22.

Gale, David. 1971. "General Equilibrium with Imbalance of Trade." *Journal of International Economics* 1, pp. 141–158.

Glick, Reuven, and Kenneth Rogoff. 1995. "Global vs. Country-Specific Productivity Shocks and the Current Account. *Journal of Monetary Economics* 35, pp. 159–192.

Iwata, Kazumasa. 1991. "Budgetary Balance, Aging, and External Balance: The Future of the United States–Japan External Imbalance." *Journal of the Japanese and International Economies* 5, pp. 473–497.

Judd, Kenneth L. 1985. "Short-Run Analysis of Fiscal Policy in a Simple Perfect Foresight Model." *Journal of Political Economy* 93, pp. 298–319.

Prescott, Edward. 1986. "Theory Ahead of Business Cycle Measurement." *Carnegie-Rochester Conference Series on Public Policy* 24, pp. 11–44.

Rosenberg, Alexander. 1992. *Economics—Mathematical Politics or Science of Diminishing Returns?* Chicago: University of Chicago Press.

Weil, Philippe. 1989. "Overlapping Families of Infinitely-Lived Agents" *Journal of Public Economics* 38, pp. 183–198.