Simulating Fundamental Tax Reform in the United States

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Abstract

This paper uses a new, large-scale, dynamic life-cycle simulation model to compare the welfare and macroeconomic effects of transitions to five fundamental alternatives to the U.S. federal income tax, including a proportional consumption tax and a flat tax. The model incorporates intragenerational heterogeneity and a detailed specification of alternative tax systems. Simulation results project significant long-run increases in output for some reforms. For other reforms, namely those that seek to insulate the poor and initial older generations from adverse welfare changes, long-run output gains are modest.

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Fundamental tax reform has been a hot issue, and for good reason. The U.S. tax system — a hybrid of income- and consumption-tax provisions — is complex, distortionary, and replete with tax preferences. Recent "reforms" of the tax code, including the Taxpayer Relief Act of 1997, have made the system even more complex and buttressed the argument for fundamental reform.

"Fundamental tax reform" means different things to different people. The definition adopted below is the simplification and integration of the tax code by eliminating tax preferences and taxing all sources of capital income at the same rate. Several current tax proposals certainly deserve to be called "fundamental." They include Robert Hall and Alvin Rabushka's (1983, 1995) flat tax, the retail sales tax, and David Bradford's (1986) X tax. The flat tax and the retail sales tax are two alternative ways of taxing consumption. The X tax also taxes consumption, but

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places high-wage earners in higher tax brackets than low-wage earners. Another fundamental reform is to adopt a broad-based, low-rate income tax.

This paper uses a computable general equilibrium simulation model to compare the welfare and macroeconomic effects of fundamental tax reform. The model is a substantially enhanced version of the Auerbach-Kotlikoff (1987) dynamic life-cycle simulation model.[1] The new model follows the significant lead of Don Fullerton and Diane Lim Rogers (1993) in incorporating intra- as well as intergenerational inequality. Specifically, it includes 12 different groups within each cohort, each with its own earnings ability (its own endowment of human capital).

Our new model approximates U.S. fiscal institutions much more closely than does its predecessor. It includes an array of tax preferences, a progressive social security system, and a Medicare system. Including tax preferences is not only crucial for studying fundament tax reform. It also permits our use of actual tax schedules in calibrating the model.[2] Stated differently, omitting tax preferences would mean unrealistically low tax rates since the current federal income tax covers only 57 percent of national income.[3] The improved modeling of social security and Medicare is also vital since both programs materially alter the intergenerational and intragenerational distributions of welfare and the initial set of fiscal distortions from which tax reform proceeds.

Like Auerbach and Kotlikoff (1987), we compute the economy's perfect foresight transition path. Given the magnitude of factor-price and tax-rate changes along our simulated transition paths, permitting agents to think rationally about the future is of great importance.

[1] A similar model, used to consider only steady states, is presented in Altig and Charles Carlstrom (1999).

[2] The Fullerton-Rogers model, in contrast, assumes that all agents face the same marginal tax rate independent of income.

This and other advantages vis a vis the Fullerton-Rogers (1993) model, which assumes myopic expectations, must be set against some disadvantages. Our model has a simpler production and preference structure than does the Fullerton-Rogers model, which features multiple consumption and capital goods, intermediate inputs, and industry-specific capital income taxation. As such, it cannot measure the efficiency gains from the removal of inter-sectoral and inter-asset distortions. Nor does it incorporate the externalities present in endogenous growth models, which might provide another source of efficiency gains from tax reform (e.g. Nancy Stokey and Sergio Rebelo 1995).

Our model also omits the impact on labor supply of low-income programs such as the Earned Income Tax Credit, and several influences on saving, including earnings and lifespan uncertainty, transfer program asset tests, and liquidity constraints. The impact of these factors has been evaluated in simulation studies by Glenn Hubbard and Kenneth Judd (1987), Hubbard et al. (1995), and Eric Engen and William Gale (1996). The low intertemporal elasticity of substitution used in our simulations is, in part, a reflection of the fact that not all saving is driven by standard life-cycle concerns. However, the lack of a richer model should be borne in mind in assessing our findings.

We use our model to examine five fundamental tax reforms that span the major proposals currently under discussion. Each reform we consider replaces the federal personal and corporate income taxes in a revenue-neutral manner.[4] The reforms are a proportional income tax, a proportional consumption tax, a flat tax, a flat tax with transition relief, and the X tax.

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[3] See Congressional Budget Office (CBO 1997).

[4] To be precise, in each tax reform simulation the levels of government purchases and outstanding debt are held constant through time when measured in effective units of labor.

The proportional income tax applies a single tax rate to all labor and capital income, with no exemptions or deductions. The proportional consumption tax differs from the proportional income tax by permitting 100 percent expensing of new investment. One may think of it as being implemented via a wage tax at the household level plus a business cash-flow tax. The flat tax differs from the proportional consumption tax by including a standard deduction against wage income and by exempting implicit rental income accruing from the ownership of housing and consumer durables. The remaining two proposals modify the flat tax to address distributional concerns. The flat tax with transition relief aids existing asset holders by permitting continued depreciation of old capital (capital in existence at the commencement of the reform). The X tax aids lower-income taxpayers by substituting the flat tax's single-rate wage tax with a progressive wage tax. To recoup the lost revenue, its sets the business cash-flow tax rate equal to the highest tax rate applied to wage income. Alternatively, one can think of the X tax as a high rate flat tax with a progressive subsidy to wages.

Each of the reforms broadens the tax base, permitting reductions in statutory marginal tax rates on labor supply and saving. And each reform imposes an implicit tax on existing wealth by introducing full expensing and, thus, shifting the tax structure toward consumption taxation. The expensing of new capital effectively eliminates the taxation of capital income at the margin. However, unlike the simple elimination of capital income taxes, this tax reduction is available to new capital only, and, consequently, reduces the value of existing capital relative to that of new capital in a manner equivalent to that of a one-time tax on their wealth. As discussed in Auerbach and Kotlikoff (1987), this capital levy is crucial to both the efficiency and long-run welfare gains from switching to consumption taxation. It permits a permanent reduction in distortionary marginal tax rates and shifts the burden of paying for government spending from young and future generations to middle-age and older initial wealth owners.

As indicated, the five reforms differ in the treatment of marginal and inframarginal capital income, the extent of base-broadening, and progressivity. These differences translate into different income and substitution effects on consumption and labor supply, which, in turn, generate the different responses to the five policies. These responses depend on our choices of parameter values. In our base case results we find the following:

The proportional income tax raises the long-run level of output by almost 5 percent. It also generates sizable increases in the capital stock and the supply of labor. However, the reform hurts the poor, who face low effective rates of income taxation under the current federal income tax system due to its deductions and exemptions. The proportional consumption tax raises long-run output by over 9 percent. The implicit wealth tax generated by this reform reduces the welfare of the initial middle aged and elderly. They respond to this and the increase in after-tax interest rates by consuming less and working more, which raises national saving and investment. The expanded capital stock and reduced fiscal burden make most of those alive in the long run significantly better off. However, eliminating tax progressivity lowers the welfare of the poorest members of society.

The flat tax's standard deduction alleviates some of the distributional concerns raised by the proportional income and proportional consumption taxes. But this deduction increases the tax rate needed to satisfy the government's intertemporal budget constraint. Consequently, long-run output rises by less than 5 percent. Although the flat tax's standard deduction insulates the poor from welfare losses, it hurts middle-income groups, especially in the short run but even in the long run. Its capital levy also hurts initial high-income elderly cohorts. Those welfare losses must be set against the welfare gains enjoyed by all groups in the long run.

Adding transition relief to the flat tax limits the welfare losses of initial capital owners. But this modification of the flat tax reduces aggregate income gains again, with long-run output now rising by less than 2 percent. Furthermore, because replacement tax rates must increase to compensate for the lost revenue associated with transition relief, all but the richest and poorest lifetime-income groups suffer welfare losses in the long run. The X tax, which raises long-term output by 6.4 percent, provides no transition relief. It also confronts the rich with higher effective tax rates on their labor supply. It is not surprising, then, that the X tax helps those who are poor in the long run by more than it helps those who are rich. Still, all long-run cohorts gain.

Thus, fundamental reform of the U.S. tax system offers significant long-run gains in output and general welfare, but these gains come at the expense of certain groups. Modifications that mitigate adverse transition and distributional effects also substantially reduce the long-run gains. In considering the plausibility of the results, one should bear in mind that these changes are generally much more radical than any U.S. fiscal policy change enacted in recent memory. Moreover, the structure of economic incentives and the distribution of resources are being altered in two ways — by the policies themselves and by their general equilibrium impacts on the time paths of factor prices. Hence, simple intuition about the expected magnitude of individual responses is difficult to apply to the reforms being considered.

I. The Model

A. Demographic Structure

The model's agents differ by their dates of birth and their lifetime labor-productivity endowments. Every cohort includes 12 lifetime-earnings groups, each with its own endowment of human capital and pattern of growth in this endowment over its lifetime. The lifetime-earnings groups also differ with respect to their bequest preferences. All agents live for 55 periods with certainty (corresponding to adult ages 21 through 75), and each *j*-type generation is 1+*n* times larger than its predecessor. At age 21, each *j*-type cohort gives birth to a cohort of the same type. Population growth is exogenous, and each cohort is $(1+n)^{20}$ larger than its parent cohort.

B. Preferences and Household Budget Constraints

Each *j*-type agent who begins her economic life at date *t* chooses perfect-foresight consumption paths (*c*), leisure paths (*l*), and intergenerational transfers (*b*) to maximize a time-separable utility function of the form

(1) $$U_t^j = \frac{1}{1-\frac{1}{g}} \left[\sum_{s=21}^{75} ß^{s-21} \left(c_{s,t+s-21}^{j\;1-\frac{1}{r}} + a\, l_{s,t+s-21}^{j\;1-\frac{1}{r}} \right)^{\frac{1-\frac{1}{g}}{1-\frac{1}{r}}} + ß^{54} \mu^j b_{75,t+54}^{j\;1-\frac{1}{g}} \right].$$

In (1), *a* is the utility weight on leisure, *g* is the intertemporal elasticity of substitution in the leisure/consumption composite, and *r* is the intratemporal elasticity of substitution between consumption and leisure. The parameter μ^j is a *j*-type specific utility weight placed on bequests left to each child when the agent dies, representing a "joy of giving" bequest motive, a formulation of bequest preferences studied by Alan Blinder (1973) and others. The term $ß = 1/(1+d)$, where d is the rate of time preference, is assumed to be the same for all agents.[5]

Letting $a^j_{s,t}$ be capital holdings for type j agents, of age s, at time t, maximization of (1) is subject to a lifetime budget constraint defined by the sequence:

$$a^j_{s+1,t+1} = (1+r_t)\,(a^j_{s,t} + g^j_{s,t}) + w^j_{s,t}\,(E^j_{s,t} - l^j_{s,t}) - c^j_{s,t} - \sum_{k=1}^{K} T^k\,(B^{j,k}_{s,t}) - Nb^j_{s,t}\,,$$

(2)
$$l^j_{s,t} \;\le\; E^j_{s,t}\,,$$
and
$$a^j_{75,t} \;\ge\; 0,$$

where r_t is the pretax return to savings, $g^j_{s,t}$ are gifts received from parents, $E^j_{s,t}$ is the time endowment, $b^j_{s,t}$ are bequests made to each of the $N = (1+n)^{20}$ children, and the functions $T^k(\cdot)$ (with tax bases $B^{j,k}_{s,t}$ as arguments) determine net tax payments from income sources $k=1,...,K$. All taxes are collected at the household level, and the tax system includes both a personal income tax and a business profits tax. There are no liquidity constraints, so the assets in (2) can be negative, although terminal wealth — the wealth left over after final period bequests are made — must be non-negative.

An individual's earnings ability is an exogenous function of age, type, and the level of labor-augmenting technical progress, which grows at a constant rate l. We summarize all skill differences by age and type via an efficiency parameter e^j_s. Thus, the wage rate for an agent of type j and age s is $w^j_{s,t} = e^j_s w_t$, where w_t is the real wage at time t. The term e^j_s increases with age to reflect not only the accumulation of human capital, but also the technical progress that

[5] The relationship between g, r, and the elasticity of labor supply with respect to the current wage is discussed in the appendix.

occurs over the course of each individual's life; i.e., the values of e_s^j are set to establish a realistic longitudinal age-wage profile. To permit balanced growth without a further restriction of preferences (i.e., to keep the ratio of labor supply to labor endowment constant in the steady state), we model the growth in lifetime wages from one generation to the next as growth in time endowment rather than in the wage rate per unit of time; that is, we assume that technical progress causes the time endowment of each successive generation to grow at rate l.[6] Thus, if $E_{s,t}^j$ is the endowment of type j at age s and time t, then $E_{s,t}^j = (1 + l)E_{s,t-1}^j$, for all s, t, and j. Because E grows at rate l from one cohort to the next, technical progress imparts no underlying trend to w_t.

Children receive transfers, with interest, at the beginning of the period after their parents make them. We restrict parental transfers to bequests, so that $b_{s,t}^j$ = 0, for s ¹ 75, and $g_{s,t}^j$ = 0, for s ¹ 56. In the steady state, therefore, g^j = b^j, for all j (with age subscripts dropped for convenience).

C. The Government

At each time t, the government collects tax revenues and issues debt (D_{t+1}) that it uses to finance government purchases of goods and services (G_t) and interest payments on the inherited stock of debt (D_t). Letting j^j stand for the fraction of j-type agents in each generation, the government's official debt evolves according to:

(3) $$D_{t+1} + (1+n)^t \sum_{j=1}^{12} j^{\,j} \sum_{s=21}^{75} (1+n)^{-(s-21)} \sum_{k=1}^{K} T^k(B_{s,t}^{j,k}) = G_t + (1+r_t)D_t.$$

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[6] Both of these adjustments, to the slope of the wage profile and to the time endowment, are needed to incorporate the impact of technical progress on wage growth, the former because we assume that each cohort's time endowment is fixed at birth. See Auerbach et al. (1989) for a detailed discussion of this approach.

Government purchases are assumed to be either a) unproductive and generate no utility to households or b) be fixed and enter household utility functions in a separable fashion. The values of G_t and D_t are held fixed per effective worker throughout the transition path. Any reduction in government outlays resulting from a change in the government's real interest payments is passed on to households in the form of a lower tax rate.

The model also has a social security system that incorporates Old-Age and Survivors Insurance (OASI), Disability Insurance (DI), and Medicare's Hospital Insurance (HI). Old-age benefits are calculated according to the progressive statutory bend-point formula. Disability and Medicare benefits are provided as lump-sum transfers. The OASI payroll tax is set at 9.9 percent and applied to wage income up to a limit of $62,700. HI and DI tax rates are set at 2.9 percent and 1.9 percent, respectively. Like the OASI tax, DI contributions apply only to wages below $62,700. The HI tax, by contrast, is not subject to an earnings ceiling.

Benefits are scaled to reflect spousal and survivor benefits using distributional information provided in the 1997 OASDI Trustees Report. We set the perceived marginal link between the OASI contributions and the OASI benefits at 25 percent. The perceived effective OASI tax rate is, thus, 7.4 percent – 75 percent of 9.9 percent.[7] Lump-sum HI and DI benefits are provided on an equal basis to agents above and below age 65, respectively.

D. Firms and Technology

Aggregate capital (K) and labor (L) equal the respective sums of individual asset and labor supplies as indicated in equations (4) and (5).

(4) $$K_t = (1+n)^t \sum_{j=1}^{12} j^{\,j} \sum_{s=21}^{75} (1+n)^{-(s-21)} a_{s,t}^{j} - D_t\,,$$

[7] See chapter 10 of Auerbach and Kotlikoff (1987) for a more detailed discussion.

(5) $$L_t = (1+n)^t \sum_{j=1}^{12} j^{\,j} \sum_{s=21}^{75} (1+n)^{-(s-21)} e_s^j (E_{s,t}^j - l_{s,t}^j).$$

Output (net of depreciation) is produced by identical competitive firms using a neoclassical, constant-returns-to-scale production technology. In the base case, the aggregate production technology is the standard Cobb-Douglas form:

(6) $$Y_t = AK_t^q L_t^{1-q} ,$$

where Y_t is aggregate output (national income) and q is capital's share in production. However, in later simulations, we do consider the impact of a lower elasticity of substitution in production, s, using a constant-elasticity of substitution (CES) function.

Another important aspect of the production technology in our base case is the assumption that it is costly to adjust the capital stock. Tax reforms, particularly those that eliminate the marginal tax on capital income, can induce large increases in demand for capital. The extent to which increased demand translates into more investment, rather than higher asset values, affects both the efficiency of the tax reform and its distributional consequences. We model adjustment costs as convex, indeed as a simple quadratic function of investment:

(7) $$C(I_t) = \left[1 + 0.5y\ (I_t / K_t)\right] I_t$$

with the quadratic term y equal to 10, a value consistent with the recent results of Jason Cummins et al. (1994). With convex adjustment costs, investors will be induced to smooth out increases in investment, and the shadow price of new capital goods relative to their replacement cost — Tobin's q — will move in the same direction as investment.[8]

The competitive pre-tax, pre-expensing rate of return to capital at time t is given by the marginal product of capital (defined in terms of the capital-labor ratio, k)

$$(8) \qquad R_t = qAk_t^{q-1}.$$

In general, tax systems treat new and existing capital differently. Under the consumption tax, new capital is permitted immediate expensing, while existing capital receives no such deduction. Even under the existing income tax, the combined effect of accelerated depreciation and the lack of inflation-indexing makes the depreciation allowances per unit of existing capital lower than those given new capital. We model provisions that treat new and existing capital differently using the mechanism of fractional expensing of new capital, at rate z. That is, we set z to account for the extent to which new capital faces a lower effective tax rate than does existing capital (with z=1 under the consumption tax). If t_t^K is the time-t marginal tax rate on net capital income (i.e., the tax rate applied to capital income net of expensing) then, given (7), arbitrage between new and existing capital implies that the latter has a unit value of

$$(9) \qquad q_t = \left(1 - z_t t_t^K\right) + \left(1 - t_t^K\right)\, y\left(I_t / K_t\right),$$

[8] The restriction of our model to a single composite capital good means that we are unable to study the differential revaluation of housing, equipment, plant, inventories, and other forms of capital arising from tax reforms. The fact that the market values of particular capital goods may change to a greater degree than those of others means that we may be under- or overstating saving and labor supply responses to tax reforms, particularly if different capital goods are disproportionately held by particular age groups and particular income classes within those age groups.

assuming that adjustment costs are expensed. Equation (9) equals Tobin's *q*. Note that *q* depends not only on the strength of demand for new capital (via the second term), but also on the relative treatment of old and new capital. Tax reforms typically affect both of these terms.

The arbitrage condition arising from profit-maximization implies that the post-tax return is:

$$(10) \qquad \tilde{r}_t = \frac{\left(R_t + 0.5\ y\ \left(I_t / K_t\right)^2\right)\left(1 - t_t^K\right) + q_{t+1} - q_t}{q_t}.$$

In (10), the total return to capital includes its after-tax marginal product[9] plus capital gains.

II. Calibration

Much of our model's parameterization is relatively standard. Exceptions include earnings-ability profiles and the fiscal structure. We turn first to these elements and then discuss more familiar preference and technology parameters. Table 1 summarizes our selected parameters.

A. Earnings-Ability Profiles

The growth-adjusted earnings ability profiles in equation (5) are of the form:

$$(11) \qquad e_s^j = e^{x_0^j + (l + x_1^j)s + x_2^j s^2 + x_3^j s^3}$$

where, as discussed above, l is the constant rate of technical progress. Values of the x coefficients for j-type groups 1 through 12 – in ascending order of lifetime income – are based on regressions fitted to the University of Michigan's Panel Study of Income Dynamics, using a

[9] This equals R_t, as defined in (8), plus the reduction in proportional adjustment costs due the increase in the capital stock. See Auerbach (1989) for a derivation of equations (9) and (10).

strategy similar to that in Fullerton and Rogers (1993). The procedure involves (i) regressing the log of hourly wages on fixed-effect dummies, cubics in age, and interactions between age, age-squared, and a set of demographic variables; (ii) using the estimated coefficients from step (i) to generate predicted lifetime wage profiles; (iii) sorting the data according to the present-value of implied lifetime income, and dividing the sorted data into the 12 classes according to lifetime-wage income; and (iv) estimating the coefficients of (11) from the simulated data profiles of each of the 12 groups.

In sorting the data for steps (iii) and (iv), we divided the population into deciles. Groups 1 and 12 comprise the bottom and top 2 percent of lifetime wage income earners, and groups 2 and 11 the remaining 8 percent of the top and bottom deciles. Each other group constitutes 10 percent of the population. For example, group 3 is the second decile of lifetime-wage income, group four the third decile, and so on up to group 10.[10]

Figure 1 presents the estimated earnings-ability profiles, scaled to include the effects of technical progress. Given our benchmark parameterization, peak hourly wages valued in 1996 dollars are $4.00, $14.70, and $79.50 for individuals in classes 1, 6, and 12, respectively. More generally, steady-state annual labor incomes derived from the model's assumptions and from the endogenous labor supply choices range from $9,000 to $130,000. As discussed below, these calculations include labor compensation in the form of fringe benefits.

B. Fiscal Structure

The model includes government purchases of goods and services, government debt, and distortionary taxes. The level of government purchases, G_t, was chosen so that the benchmark steady-state ratio of government purchases to national income equals 0.211. The level of

[10] This procedure is described more fully in the appendix.

government debt, D_t, was chosen such that the associated real interest payments equal about 3.1 percent of national income in the initial steady state. These values match the corresponding 1996 values for combined local, state, and federal government in the United States.

The benchmark tax system in our initial steady state is designed to approximate the salient aspects of the 1996 U.S. (federal, state, and local) tax and transfer system. It features a hybrid tax system (incorporating wage-income, capital-income, and consumption tax elements) and payroll taxation for the social security and Medicare programs.[11] To adjust for tax evasion, we reduce income taxes by 2.6 percent. This adjustment is consistent with the degree of tax evasion reported in Joel Slemrod and Jon Bakija (1996). In the alternative tax structure experiments we assume that evasion reduces the post-reform tax base (income net of deductions and exemptions) by the same percentage as before the reform. This is a simplifying assumption that merits exploration in future research.

We approximate the current U.S. tax system by specifying a progressive wage-income tax, a flat capital-income tax, a flat state income tax, and a flat consumption tax.

1. *Wage Income Taxation*. — The wage-income tax structure has four elements: 1) a progressive marginal rate structure derived from a quadratic approximation to the 1996 federal statutory tax rates for individuals[12]; 2) a standard deduction of $4000 and exemptions of $5660 (which assumes 1.2 children per agent, consistent with the model's population growth assumption); 3)

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[11] As the payroll tax in our model is used entirely to pay for current benefits, we set the rate slightly below its 15.3 percent statutory rate to account for the portion of payroll taxes devoted to trust-fund accumulation. See Table 2.

[12] We use a quadratic approximation rather than the exact, discrete brackets to simplify the simulation problem. Using a differentiable tax function allows us to derive first-order conditions that do not involve kink points and shadow wages at these kink points. This simplification is particularly relevant because our household decision problem already has a kink point at the minimum taxable income level, and a potential corner solution at zero hours worked, both of which involve the calculation of shadow wage rates, as well as a nonconvexity at the point where the social security earnings ceiling is reached. These additional complications are discussed below in the section that discusses the solution of the model.

itemized deductions, applied only when they exceed the amount of the standard deduction, that are a positive linear function of income estimated from data reported in the *Statistics of Income*[13]; and 4) earnings-ability profiles that are scaled up to incorporate pension and fringe components of labor compensation.[14]

2. *Capital Income Taxation*. — Since our model has a single capital good, we need to calibrate marginal and inframarginal capital income tax rates based on the average values of these rates taken across different types of U.S. capital. Here, we follow closely the calculations in Auerbach (1996), who reports that income from residential capital and non-residential capital are taxed at flat rates of 6 percent and 26 percent, respectively. Given that the U.S. capital stock is split evenly between these two forms of capital, the weighted average federal marginal tax rate on total capital income is about 16 percent. Because of the difference in treatment of new and existing capital, primarily in the nonresidential sector, U.S. capital faces a higher tax rate — roughly 20 percent for the capital stock as a whole, according to Auerbach's estimates. To incorporate these tax rates in our model, we assume that all capital income faces a 20 percent tax, but that 20 percent of new capital is expensed, thereby generating a 16 percent effective rate on new capital.[15] In addition to the federal taxation, both capital and wage income are subject to a proportional state income tax of 3.7 percent.

[13] The data used in this estimation were taken from all taxable returns in tax year 1993. The function was obtained by regressing deductions exclusive of mortgage interest expense on the midpoints of reported income ranges. (The deduction of interest expense on home mortgages was included in our calculation of the capital-income tax rate, as we will subsequently describe.) The regression yielded a coefficient of 0.0755 with an R^2 equal to 0.99.

[14] Benefits as a function of adjusted gross income were kindly provided by Jane Gravelle of the Congressional Research Service and Judy Xanthopoulos of the Joint Committee on Taxation. Based on this information we regressed total benefits on AGI. The regression yielded a coefficient of 0.11295 with an R^2 equal to 0.99. In defining the wage-tax base, we therefore exempt roughly 11 percent of labor compensation from the base calculations.

[15] The absence in our model of heterogenous capital goods means that we not only fail to capture the differential revaluation of different capital goods, but we also fail to capture the additional efficiency gains that may arise from equalizing effective tax rates on different capital inputs, an issue studied by Fullerton and Rogers (1993) and others.

3. *Consumption Taxation.* — Consumption taxes in the initial steady state reflect two elements of the existing tax structure. First we impose an 8.8 percent tax on consumption expenditures, consistent with National Income and Product Account values for indirect business and excise revenues, a substantial component of which are state sales taxes. However, because contributions to both defined benefit and defined contribution pension plans receive consumption tax treatment, we add an additional 2.5 percent tax on household consumption expenditures to account for the indirect taxation of labor compensation in the form of pension benefits (Auerbach 1996). This 2.5 percent tax replaces the wage tax that otherwise would apply if pension contributions were taxed as income.

C. Preferences and Technology

Our initial choices for the remaining technology, preference, and demographic parameters are summarized in Table 1. The value for d, the pure rate of time preference -- about which there is little evidence -- is set equal to .004 to generate a realistic value for the capital-output ratio in the initial steady state. The values of g, r, and n are those in Auerbach and Kotlikoff (1987). The intertemporal elasticity, g, is set equal to .25, representing a relatively low degree of substitution between consumption at different dates. While some studies in the literature have found higher elasticities, most have not. One possible reason is the presence of liquidity constraints and other factors that may mitigate the responsiveness of saving to interest rate changes. Our use of a low intertemporal elasticity of substitution serves as an imperfect proxy for such factors.

We choose a, the utility function's leisure intensity parameter, such that, on average, agents devote about 40 percent of their available time endowment (of 16 hours per day) to labor during their prime working years (roughly ages 21-55). As discussed in the unpublished appendix, the combined values of g, r (the intratemporal elasticity of substitution), and a generate labor supply elasticities that are well within the range of empirical estimates. Still, as this range is fairly large, we also report results for values of g and r that induce smaller behavioral responses. The bequest weights in the utility function, μ^j, are chosen to match bequests as a fraction of income in the initial steady state based on estimates by Paul Menchik and Martin David (1982) reported in Fullerton and Rogers (1993).

D. Solving the Model

Following Auerbach and Kotlikoff (1987), we solve the model with a Gauss-Seidel algorithm. The calculation starts with guesses for certain key variables and then iterates on those variables until a convergence criterion is met. The model's identifying restrictions are used to compute the remaining economic variables as well as the updates for the iterations. The solution involves several steps and inner loops that solve for household-level variables before moving to an outer loop that solves for the aggregate variables including the time-paths of capital stock and aggregate labor supply.

The household optimization problem is subject to the constraint that leisure not exceed the endowment of time (equation 2). For those households who would violate the constraint, the model calculates shadow wage rates at which they exactly consume their full-time endowment. The household's budget constraint is kinked due to the tax deductions applied against wage income under the personal income tax. A household with wage income below the deduction level faces marginal and average tax rates equal to zero. A household with wage income above the deduction level faces positive marginal and average tax rates. Due to the discontinuity of the marginal tax rates, it may be optimal for some households to locate exactly at the kink. Our algorithm deals with this problem as follows. We identify a household that chooses to locate at the kink in particular periods by evaluating each period's leisure choice and corresponding wage income above and below the kink. We then calculate a set of period-specific shadow marginal tax rates from the period-specific first-order conditions that put such households exactly at kinks in each period in which being at a kink is optimal. This calculation of shadow tax rates for particular periods is simultaneous; i.e., a shadow tax rate in any particular period will influence labor supply decisions in all other periods. The payroll tax ceiling introduces additional complexity by creating a non-convexity in the budget constraint. For those above the payroll tax ceiling, the marginal payroll tax rate on labor earnings is zero. For each period, we evaluate the utility on both sides of the non-convex section and put households on the side that generates highest utility.

Aggregate variables of the model are solved with a forward-looking algorithm that iterates on the capital stock and labor supply over the entire transition path. Initial guesses are made for a) the time-path of aggregate demands for capital and labor, b) each household's shadow wage and tax rates at each age, and c) the endogenous tax rate (for which the program is solving), the payroll tax rate, and social security and Medicare benefit levels. Given the initial guesses of the time-paths of all these variables, the model calculates a) the factor prices in each period that are consistent with the use by firms of the aggregate inputs assumed to be demanded and b) the remaining lifetime consumption and leisure choices for all income classes in each current and future cohort. Shadow wages and shadow taxes are calculated to ensure that the time endowment and the tax constraints discussed above are satisfied. Households' labor supply and assets are then aggregated across cohorts and, within cohort, across lifetime income classes for each period. This aggregation generates a new guess for the time-paths of the aggregate supplies of capital stock and labor supply.

In equilibrium, the factor supply time paths for capital and labor must equal their corresponding factor demand time paths. Hence, to form a new guess of the time paths of aggregate factor demands we form weighted averages of the initial guess and the supply time paths derived using the previous guess of the time path of factor demands. The time paths of the tax rate for which we are solving and the payroll tax rate are also updated to meet the revenue-neutrality requirement and to preserve the pay-as-you-go financing of social security and Medicare benefits.[16] The algorithm then iterates in this manner until the capital stock and labor supply time-paths converge; i.e., until the time paths of factors demanded are consistent with the time paths of factors supplied.

E. The Benchmark Equilibrium

Table 2 provides summary statistics for the initial steady state. Given our parameter choices, the model generates a pre-tax, pre-expensing interest rate of 8.3 percent[17], a net national saving rate of 5.1 percent, and a capital/national-income ratio of 2.6. Consumption accounts for 73.1 percent of national income, net investment for 5.1 percent, and government purchases of goods and services for 21.1 percent. These figures are close to their respective 1996 NIPA values.

The calibrated model's initial economy-wide average marginal tax rate on wage income is 21.6 percent, close to the figure obtained from the NBER's TAXSIM model reported in Auerbach (1996). The average wage-income tax rate equals 12.2 percent. For all individuals in

[16] Note that the social security replacement rate and absolute level of Medicare benefits are exogenous.

[17] This number is somewhat lower than the estimated 1996 percent return to capital relative to replacement cost of 9.3 percent listed in Table 2. In our model with nonzero adjustment costs, the before-tax interest rate determined by expressions (9) and (10) differs from the return to capital, because market value differs slightly from replacement cost (see (9)) and because the total return to capital accounted for by the interest rate also includes the reduction in adjustment costs brought about by additions to capital (see the numerator in (10)). Ignoring these two terms, the return to capital itself, equal to the term R in (8), is 9.7 percent.

the highest lifetime income class (group 12), the average effective marginal tax rate on labor income is 29.2 percent. The highest realized effective marginal tax rate is 34.9 percent. For lifetime income class 6 – whose members have peak labor earnings of about $35,000 – the average tax rate and average marginal tax rate are 10.7 and 20.0 percent, respectively. For the poorest class (group 1), the corresponding rates are zero and 11.1 percent.[18]

In this initial steady state, bequest wealth (the accumulated value of inheritances received summed over all households) depends on the age structure of bequest receipt. Our assumption that individuals receive bequests at age 56 is made primarily for simplicity.[19] With this assumption, and our calibration of bequests themselves to the data cited earlier, bequest wealth represents 30 percent of the capital stock. This percentage is smaller than that reported for 1974 for overall transfer wealth by Kotlikoff and Lawrence Summers (1981). The percentage would, presumably, be larger had we assumed an earlier age of bequest receipt, but still is in rough agreement with the Kotlikoff-Summers findings concerning the amount of wealth generated solely by bequests as opposed to *inter vivos* transfers, which we do not model explicitly. That said, the importance of bequests and *inter vivos* transfers for U.S. capital formation appears to have diminished through time because of the remarkable increase in recent decades in the degree of annuitization of the elderly (see Auerbach et al. 1995).

[18] The average marginal rate for people with the lowest income exceeds zero due to positive shadow tax rates in peak earnings years.

[19] See William Gale and Karl Scholz (1994) for a discussion of the relative magnitudes of bequests and *inter vivos* transfers. While our choice of age 56 to receive inheritance seems reasonable, different ages could certainly be considered. However, each age of inheritance would alter the stock of inherited wealth and thus the economy-wide capital-output ratio. As this, in turn, would necessitate a recalibration of bequest preference parameters, the ultimate impact on our results would likely be small.

III. Initial Tax Reform Simulations

Table 3 summarizes the five tax reforms. Table 4 presents simulations for all five reforms for the base case assumptions. In each of these simulations, our initial steady state is the same, calibrated to the 1996 U.S. economy as described above. Table 4 also presents variables of interest for this initial steady state and for three transition years, 1997, 2010, and 2145, meant to illustrate short-run, medium-run and long-run effects. Subsequent tables, described in the next section, present the results of sensitivity analysis involving preference and technology parameters.

A. A Proportional Income Tax

Our first experiment replaces the progressive tax on wage income and the proportional tax on capital income with a proportional tax applied to all income. In addition, the proportional income tax eliminates the major preferences in the federal income tax, including the standard deduction, personal and dependent exemptions, itemized deductions, and the preferential tax treatment of fringe benefits. The last of these is implemented by decreasing the consumption tax rate by 0.025 and subjecting all compensation to the new proportional income tax. The investment expensing rate remains at its initial 20 percent level.

The first panel in Table 4 summarizes the aggregate results from this reform. The marginal tax rates required to satisfy the government's budget constraint stay close to 13 percent over the entire transition path. This value lies far below both the 21.6 percent average marginal rate applied to labor income and the 16 percent rate applied to capital income in the benchmark steady state. National income rises by 3.8 percent immediately and by 4.9 percent ultimately. In the early years of the transition, these output changes are dominated by increased work effort associated with the lower marginal tax rates. In the long run, higher wealth levels mitigate some of the increase in labor supply. However, the accumulated effects on the stock of capital from the reform more than compensate for the reduced labor supply: in the long run the capital stock increases by 5.6 percent. The short-run decrease in the capital-labor ratio produces a short-run increase in the before-tax interest rate and a short-run decrease in before-tax wage rate. The long-run increase in the capital-labor ratio produces the opposite effects on factor prices. This reform's initial impact on the market value of our composite capital good (measured via Tobin's *q*) is positive, reflecting the increase in saving and demand for capital that results from two factors: the rise in short-run disposable income (due to higher labor supply) and, to a lesser extent (because it doesn't change much), the lower marginal tax rate on capital income. The second potential effect on *q*, associated with changes in the relative treatment of old and new capital, is small because the level of expensing has not changed and the effective tax rate on capital income has decreased only slightly (housing capital is no longer exempt).

Figure 2 shows the effects of the tax reform on remaining lifetime utility for different generations by lifetime-income group.[20] For ease of exposition, the figure reports the utility gains only for classes 1, 3, 6, 9 and 12. The horizontal axis of the figure lists the period the generation enters the model — reaches adulthood — relative to the period of the regime shift (period 0). For example, -1 refers to the generation that reaches adulthood just prior to the regime shift, 0 to the generation that reaches adulthood in the period of the shift, 1 in the following period, and so on.[21] The change in remaining lifetime utility is measured as the equivalent variation of remaining *full* lifetime income. In interpreting these numbers, one should

[20] We focus on the welfare effects of tax reforms on members of different income groups and generations, rather than on the overall efficiency change that might be calculated by aggregating such individual welfare effects. As our model's disaggregation by income class is largely secondary in the context of an efficiency analysis, it seems unnecessary to repeat the extensive analysis of efficiency already provided in Auerbach (1996), based on the original AK model.

[21] For members of the fifty-five transition generations, an individual's age at the time of reform equals the

keep in mind that full lifetime income includes the value of leisure. In our model, full lifetime income is more than twice the size of remaining *actual* lifetime earnings. Hence, gains or losses will tend to be larger if measured relative to either realized earnings or consumption.

In the long run, only members of lifetime-income groups 8 through 12 experience increased utility from the proportional income-tax reform, the rise in aggregate output notwithstanding. The main reason is that average tax rates increase for income classes 1 through 7 due to the loss of deductions and exemptions. In the short run, however, the oldest agents at the time of the reform are slightly better off since the reform increases the after-tax return to capital.

B. A Proportional Consumption Tax

Our proportional consumption tax differs from the proportional income tax by including full expensing of investment expenditures. The government is now taxing income less domestic investment, which, in our closed economy, equals income less saving, i.e., consumption. Formally, we specify the consumption tax as a combination of a labor-income tax and a business cash-flow tax. The second panel of Table 4 summarizes aggregate effects. The first thing to note is the 4 percent drop in q — the value of the existing capital stock relative to new capital. This drop occurs even though the rate of investment surges, because the impact of investment demand on q is more than offset by the sharp increase in the tax advantage of new versus old capital. This second effect constitutes the one-time effective tax on existing capital assets mentioned above.

In the period just after the tax reform, labor supply increases by 6.3 percent, a higher effect than was observed under the proportional income tax. This is because there are now

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21 minus the number on the horizontal axis.

additional factors at work beyond the reduction in marginal labor income tax rates. The rise in after-tax interest rates (because capital income is now essentially untaxed) produces substitution effects that encourage delays not only in consumption, but also in leisure, impacts reinforced by the negative wealth effect among those holding old capital.[22] These two factors also generate a substantial short-run jump in the saving rate from 5.1 percent to 7.3 percent. However, as the initial negative wealth effects diminish over time and interest rates fall with the growth in capital, the saving rate eventually recedes to 5.9 percent. Fourteen years into the reform (in 2010), the capital stock (per effective unit of labor) is 10.8 percent larger than its initial steady state value, and output is 6.3 percent larger. In the long run, the capital stock exceeds its initial value by 25.4 percent, and output exceeds its initial value by 9.4 percent, strong reactions that permit the consumption tax rate to fall over time, from 14.2 percent initially to a long-run 12.7 percent.

Figure 3 shows that, despite the large aggregate income gains, lower lifetime-income groups are hurt by the reform. Although these losses are not as large as those in the proportional income-tax case — indeed, several groups switch from being long-run utility losers to long-run utility winners — the regressive nature of the outcomes persists. The figure also reveals welfare losses for initial rich elderly, who own the lion's share of the existing capital stock.[23] In contrast, the initial poorest elderly gain from the tax reform. There are two reasons. First, this group consumes almost entirely out of social security benefits, the real value of which are unaffected by the change in asset values. Second, this group also borrows against some of their social

[22] There is also an income effect associated with the rise in interest rates, equal to the reduction in the present value of future consumption less the present value of future labor income. These income effects will generally be positive and discourage saving, though the effect will be much smaller than in the simple two-period life-cycle model with first-period labor supply, in which only the future-consumption term is present.

[23] Their welfare loss is less than the 4 percent capital loss they experience on their holdings of capital, because much of their welfare comes in the form of leisure.

security benefits prior to retirement, and their slightly negative net worth in old age shrinks in magnitude due to the policy-induced fall in the value of existing capital.

C. The Flat Tax

Our flat tax experiment modifies the proportional consumption tax by including a standard deduction of $9500. In addition, it fully exempts housing wealth — about half of the capital stock — from taxation. Because policy makers are unlikely to extend the capital levy to housing, this exemption is an important step toward realism.[24]

As the third panel in Table 4 makes clear, the need to finance the standard deduction and tax exemption of existing housing increases the replacement tax rates well above those of the proportional consumption tax. As a result, the output effects under the flat tax are substantially reduced relative to its proportional counterpart. The long-run rise in the capital stock and level of output are, respectively, only 59 and 48 percent as large as those under the proportional consumption tax. The labor supply response is lower as well, reflecting the higher short- and long-run levels of marginal tax rates. The revenue-neutral flat-tax rate equals 21.4 percent initially and reaches 19.9 percent in the long run. The short-run impact on Tobin's *q* is quite similar to that of the proportional consumption tax, but this masks two offsetting effects. Investment demand rises less under the flat tax, moderating the positive impact of this factor on *q*. On the other hand, as the flat tax exempts much of existing wealth from the implicit tax old capital, it also moderates this factor's negative impact on *q*. In the longer run, as the first difference declines in importance (with net investment converging to zero in both instances), the second effect predominates, resulting in a higher value of *q* under the flat tax.

[24] To impose the capital levy on existing housing would require taxing current owners' imputed rent and eventual sale proceeds.

Figure 4 shows that the flat tax generates short-run utility effects that are similar to those of the consumption tax. The long-run utility changes 2 are bunched much more closely than those of either of the proportional tax reforms. This reflects the flat tax's attention to preserving progressivity. Interestingly, the highest relative gains are for the richest and poorest lifetime-income groups, with the poorest gaining from the higher standard deduction and the richest from the flattened marginal rate schedule.

The utility changes for the richest and poorest lifetime-income groups also differ from those of the middle groups throughout the entire transition path. Group 12 benefits the most from reduced marginal and average tax rates. Group 1, which pays very little taxes under either regime, benefits from the overall increase in wages. For those in income groups 3 through 9, the marginal and average tax rates initially change little or even rise. This stems from the revenue neutrality of the experiment, which requires a flat-tax marginal rate that initially exceeds the pre-reform tax rates for some agents in the middle-income classes in order to finance the lower tax rates at the top end. Those who belong to the lifetime middle-income range and enter the workforce close to the time of reform suffer utility losses along the transition path. They face relatively high tax rates of 20 to 22 percent on labor income for 20 to 25 years of their working life before the growth of the capital stock becomes fully effective. Once the economy grows, though, tax rates fall and wages rise, which leaves group 3 better off and raises the lifetime utility levels of groups 6 through 9 nearly to the point of indifference.

Neither the macroeconomic variables nor the welfare effects of the flat tax experiment are substantially influenced by the existence of a bequest motive. We repeated the simulation by "turning off" bequests (setting the utility bequest weight $\mu^j = 0$ for all j), simultaneously reducing the rate of time preference slightly (from .004 to .002) to maintain the same initial steady-state capital-output ratio. The resulting transition path was nearly identical to that just discussed, with the long-run increases in national income, the capital stock, and labor supply equal to 4.6 (versus 4.5) percent, 15.3 (versus 15.0) percent, and 1.4 (versus 1.3) percent, respectively, and no significant differences in the remaining initial steady-state computations nor in the post-reform changes in output or welfare.[25] While it might seem surprising that eliminating bequests has so little impact, it should be remembered that bequests are modeled here as basically another type of future consumption. Thus, the motivations for bequest saving and life-cycle saving are essentially the same.

D. The Flat Tax with Transition Relief

One important characteristic of consumption tax reform is its treatment of existing assets and their owners. In contrast to the positive welfare gains they receive under the switch to proportional income taxation, older, higher-wealth asset holders lose with the adoption of the proportional consumption tax or the flat tax. Though these losses are moderated by the surge in asset demand that limits the decline in existing asset values, the presence of such losses may make transition relief for existing assets a political necessity. Our fourth experiment adds transition relief to the flat tax by extending pre-reform depreciation rules for capital in place at the time of the tax reform. Since the present value of depreciation allowances equals roughly 50 percent of the nonresidential capital stock, transition relief is modeled by cutting the effective cash-flow tax rate in half.

As the fourth panel of Table 4 confirms, all of the salutary long-run aggregate effects of the standard flat tax are mitigated by the introduction of transition relief, which must be financed

[25] Because of the extreme similarity to the simulation just presented, the results for this experiment are not shown separately in the table.

by permanently higher tax rates. The transition relief is, in some sense, excessive, in that the value of existing assets actually rises slightly in the short run. Still, the capital stock increases by over 8 percent in the long run, affording a 1.9 percent rise in the long-run level of output. Labor supply changes little following this tax reform, actually declining slightly below its initial steady-state level, reflecting both higher marginal tax rates (on average) and positive wealth effects.

Figure 5, which shows the welfare effects of the flat tax with transition relief, differs markedly from Figure 4, which shows the effects with no transition relief. Transition relief replaces the small short-run welfare losses of the wealthier initial elderly with sizable welfare gains, and raises the welfare gains of all income classes who are in their middle ages when the reform is begun. But these welfare gains come at the cost of smaller welfare gains for certain future generations and welfare losses for others. For example, with no transition relief, the long-run rich (members of groups 12 alive in the long run) experience more than a 1.6 percent gain in welfare. But with transition relief, these gains are cut nearly to zero. For middle-class households alive in the long run, the concession to initial wealth holders transforms the flat tax from having essentially no impact to a roughly 1.5 percent loser when measured in terms of its welfare impact. Indeed, with the exception of the very poorest and very richest members of society, transition relief transforms the flat tax into a bad deal for those alive in the medium and long runs. This is critically important to keep in mind in assessing calls for a flat tax. Many advocates of the flat tax favor transition relief, apparently without sufficient understanding that offsetting wealth effects are already present, and that short-run relief undermines the results they claim the flat tax will achieve in the long run.

E. The X Tax

The X tax, using the present-law standard deduction, maintains the progressivity of the present-law wage tax schedule. It also sets the cash-flow tax rate equal to the highest marginal tax rate on labor income, in this case 30 percent.[26] An important reason for choosing equal rates of tax on labor and cash flow under the flat tax was that doing so eliminates the incentive for businesses to shift income. Under the X tax, the cash flow tax rate cannot equal all marginal tax rates on labor income simultaneously, but setting it equal to the highest labor-income tax rate is nearly as effective, as most potential shifting would involve high-income executives and business owners in the top labor-income bracket. However, an interesting byproduct of this design feature is that it raises the levy on old capital above that imposed by the basic flat tax. This higher capital levy offsets the rise in marginal tax rates on labor income due to progressivity, for it reduces the present value of revenue that labor income taxes must raise.

As shown in the bottom panel of Table 4, this reform produces large long-run output gains despite maintaining progressive wage taxation. Only the proportional consumption tax generates larger long-run output gains. The long-run welfare effects of the X tax are progressive. As shown in Figure 6, the long-run gains vary inversely with lifetime income. However, the percentage gains across groups are closer for this proposal than for any other, suggesting that, in the long run, it is — as intended — the least disruptive in its distributional impact. All groups experience welfare gains of between 1 and 2 percent of full lifetime resources. In the short run, though, those in the highest income class who are old at the time of the reform suffer the largest welfare loss — reaching 2 percent of remaining lifetime resources — since they hold the largest

[26] Recall that marginal wage-tax rates are a linear function of taxable labor income. The adjustments required to maintain budget balance are implemented by changing the intercept of this function, while holding the slope constant.

share of physical assets. The poorest elderly, on the other hand, actually benefit from the capital levy since they live essentially on their social security benefits which are, in fact, a source of a slight amount of borrowing.

IV. Sensitivity Analysis

This section considers the impact of changes in assumptions regarding three key elasticity parameters for two of the tax reforms just considered, the standard flat tax and the flat tax with transition relief. In each instance, we make offsetting parameter adjustments to maintain the correspondence between our initial steady state and the benchmark economy. Table 5 presents the results of reductions in the production elasticity of substitution between labor and capital, s, and the utility function's intratemporal elasticity, r, and intertemporal elasticity, g.

The first panel of the table presents simulations for the CES production function,

$$Y_t = A[q\, K_t^{1\text{-}1/s} + (1\text{-}q)\, L_t^{1-1/s}\,]^{\frac{1}{1\text{-}1/s}} \tag{12}$$

in which the production elasticity of substitution, s, is reduced from 1 (i.e., Cobb-Douglas) to 0.8, a reasonable alternative value to our base case assumption.[27] As one would expect, the lower elasticity of substitution means that the before-tax interest rate falls by more as capital accumulates, somewhat dampening the capital accumulation incentive. Thus, while the long-run interest rate is 8.0 percent in the base case for the standard flat tax displayed in Table 4, it is 7.8 percent in the corresponding run in Table 5 for s = .8; the long-run gain in the capital stock is

[27] As we reduce the production elasticity, we also change the capital intensity parameter, q, from 0.25 to 0.312, and multiply the production efficiency parameter, A, by 0.962. It is a matter of simple algebra to show that these two changes ensure that the levels of capital and labor and the wage and interest rates in the initial steady state are the same as for the base case with Cobb-Douglas production.

reduced from 15.0 percent to 13.6 percent. However, these differences, as well as those in other variables, are small. The same conclusion holds for the case of transition relief.

As discussed above, there is considerable uncertainty about the "correct" values of the parameters g and r. It is therefore important to determine how sensitive the results presented thus far are to reasonable variations in these parameters. In each case, because we pose the question in terms of whether tax reform might *fail* to produce welfare and income gains, we consider *smaller* values of these elasticity parameters, which reduce the degree to which agents react to improved incentives. However, one can use these simulations to infer the effects of raising g or r. The second panel of Table 5 presents results for each of the two flat tax variants, with the value of the intratemporal elasticity of substitution, r, reduced from .8 to .4. The bottom panel covers the same two reforms, this time with the intertemporal elasticity of substitution, g, reduced from .25 to .1.[28]

The experiment with a smaller intratemporal elasticity of substitution looks quite similar to the flat-tax case under our benchmark parameterization (in Table 4) in the early stages of the transition path. However, in the long run, the decreased willingness to substitute higher consumption for leisure results in a decline in aggregate labor supply relative to the higher elasticity case. The smaller increase in labor supply contributes to a smaller increase in the level of saving (even though the saving *rate* is similar) and capital accumulation. As a result, capital growth is smaller as well and, although real wage growth is similar to before, the slower growth in both labor and capital makes income growth smaller as well, only 2.8 percent in the long run, instead of 4.5 percent. The relative impact is similar when transition relief is added.

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[28] We adjust d, to -.08 to preserve the initial capital-output ratio when changing g. However, when changing r, we adjust the labor intensity parameter a, to 0.2, in order also to maintain the appropriate share of labor supply in total labor endowment.

The effects of the smaller intertemporal elasticity of substitution are greater, because this change reduces the responsiveness not only of labor supply, but of consumption as well. Thus, in addition to the smaller labor supply response just observed, we also see a smaller increase in the saving rate. As a result, short-run and long-run output gains are even smaller than in the upper panel of the table. Under the pure flat tax, output rises by just 1.3 percent in the long run; with transition relief added, long-run output actually falls by 3.1 percent. Thus, there is no guarantee that a realistic consumption tax reform — the flat tax with transition relief — will raise output in the long run.

V. Summary and Conclusion

Proponents and opponents of fundamental tax reform wrestle with the same question: Are the gains to the winners worth the costs to the losers? The answer involves value judgements that go beyond economic science. But forming one's judgements requires knowing what fundamental tax reform will do to the economy and to its current and future participants. This paper tries to provide a better sense of those outcomes by simulating fundamental tax reform in a much-improved version of the Auerbach-Kotlikoff model – one that considers intra- as well as intergenerational equity and one that is closely calibrated to U.S. fiscal institutions and tax policy.

The model predicts significant long-run increases in output from replacing the current U.S. federal tax system with a proportional consumption tax. For our base case, output would rise eventually by more than 9 percent. For middle- and upper-income classes alive in the long run, this policy is a big winner. But older transition generations suffer from the imposition of an implicit capital levy, and low-income individuals, even in the long run, suffer a significant loss as growth fails to compensate for the decline in tax progressivity.

The flat tax, which modifies the basic consumption tax by exempting housing wealth from taxation and by providing a large wage-tax deduction, improves the welfare of lower-income individuals in the long run, but at a cost of more than halving the economy's long-run output rise, to 4.5 percent for the same economic assumptions. Even then, this reform leaves initial older generations worse off. Insulating them through transition relief, in the form of maintaining present-law depreciation allowances on existing capital, further reduces the long-run output increase — to just 1.9 percent.

Other reforms produce similar tradeoffs. Switching to a proportional income tax hurts current and future low lifetime earners but helps everyone else. The X tax, which combines consumption-tax and progressive wage-tax elements, makes everyone better off in the long run and raises output by even more than the flat tax. But this reform harms initial older generations who face an implicit tax on their wealth. Further, with smaller but still plausible labor supply and saving responses to tax changes, the potential gains and hence the scope for trading off efficiency for equity are reduced. Indeed, the last reform considered, a flat tax that offers transition relief, actually reduces output in the long run for a low intertemporal elasticity of substitution. Presumably, this is not what proponents of tax reform have in mind.

Thus, the view formed on the basis of our model is that fundamental reform of the current U.S. tax structure offers the possibility of significant macroeconomic expansion and welfare gains for many, but not without true sacrifice by certain groups. Adjustments that attempt to prevent adverse distributional effects yield much more modest aggregate effects. While we have not sought to identify more complicated policies that shield all losers from sacrifice, our findings do suggest that such policies, if they exist, are likely to yield much smaller output increases than those of policies that provide no such relief.

While we have adapted our model to accommodate many of the key issues that arise when considering tax reform, there are some that we have not addressed. In treating the economy as closed, we may have overstated the depressing impact of additional capital accumulation on the rate of return and, hence, understated the potential welfare and output gains from tax reform, a conclusion consistent with the open-economy simulations presented by Auerbach (1996).

Additional gains may also accrue under any of the tax reforms considered here as a result of the more uniform treatment of different types of capital and different sectors of production. There may also be welfare gains from tax simplification arising through reduced costs of compliance and enforcement. Gains from both of these sources, though, would depend on the reformed tax system maintaining not only its reduced rates and broader base, but also it lack of special interest provisions that exist under the current tax system and could arise under at least some of the alternatives we have considered. Finally, as discussed recently by William Gentry and Hubbard (1997) the distributional and efficiency effects of tax reform might change somewhat in a richer economic model incorporating variation in risk and rates of return, for one would then need to consider the risk-sharing aspects of different tax systems and the extent to which the capital levy of the consumption tax hit not only the quasi-rents of existing capital, but also true economic rents. A challenging task for future research is to determine the relative importance of these factors.

Appendix

Labor Supply Elasticities

This section of the appendix discuss the relationship between parameters of the utility function given in expression (1) in the text and those typically estimated in the labor supply literature. Papers in this literature contain a variety of different labor supply elasticity concepts. Perhaps most useful from our perspective is that of the "l-constant" or Frisch elasticity of labor supply (e.g., Thomas MaCurdy 1981), which measures the variation in labor supply along an optimal path with the marginal utility of income constant.[29] In some studies, elasticities estimated in this way are also referred to as intertemporal elasticities of substitution, but this equivalence does not hold for our specification of preferences, which are not separable between goods and leisure.

For our time-separable utility function, a l-constant change in the after-tax wage, w_t, affects only consumption and leisure at date t. Thus, given the optimal path for these variables (Auerbach and Kotlikoff 1987, p. 31, expressions 3.11 and 3.12), date-t leisure may be shown to satisfy:

$$l_t = \left(\frac{w_t}{a}\right)^{-r} \left(1 + a^{r} w_t^{1-r}\right)^{\frac{r-g}{1-r}} x(l)$$

where $x(l)$ does not depend on w_t. Using (A1), we derive the following expression for the l-constant elasticity of *labor* supply, L_t, with respect to w_t:

[29]Our use of the variable l here follows the notation found in the relevant literature, and should not be confused with its use in the body of the paper, to represent the rate of technological progress.

$$h = (\frac{l}{L})(gz + r(1-z))$$

where

$$z = \frac{a^{r} w_t^{1-r}}{1 + a^{r} w_t^{1-r}}$$

Note that z corresponds to leisure's "share" in the within-period utility function. Since we calibrate the model for different values of r and g so that this share is roughly .6 (and the consumption/labor share is .4), the value of h from (A2) is roughly 1.5(.6g + .4r). For our base case values of r=.8 and g=.25, this gives a value of h=.7. This elasticity is reasonable, given the range of values estimated in the literature, some of which are surveyed in Martin Browning, Lars Hansen and James Heckman (1998).[30] Estimates for men are in some cases higher, but typically somewhat lower, while estimates for women are generally at least as high, and in some cases much higher. Our alternative simulations that use values of r=.4 and g=.10, yield corresponding values for h of .46 and .57, respectively.

Calculation of Earnings-Ability Profiles

Our earnings-ability profiles are based on the individual files of the University of Michigan's Panel Study of Income Dynamics (PSID) from 1976-1988. These calculations generally follow those of Fullerton and Rogers (1993, Chapter 4), except where indicated.

The sample utilized contains 9335 observations on 891 individuals. We excluded individuals with imputed real hourly earnings less than one dollar and those with clear inconsistencies in levels of educational attainment over the time period. This sample differs from that used by Fullerton and Rogers, who aggregate individual observations into household

[30] Other recent papers in the literature include Richard Blundell, Costas Meghir and Pedro Neves (1993), Casey Mulligan (1998), and James Ziliak and Thomas Kniesner (1999).

observations and consider only households with stable marital histories. We used the following procedure to obtain wage profiles.

(i) First stage regressions were run on the entire data set using a common set of explanatory variables. The specification is identical to that used by Fullerton and Rogers except a birth-year variable, which is added to control for age-cohort effects. It is given by

$$\hat{w}_{it} = p_{0i} + p_1 BY_i + p_2 AGE_{it} + p_3 AGE_{it}^2 + p_4 AGE_{it}^3 + p_5 AGE_{it} EDU_{it} + \sum_{h=1}^{3} p_{h+5} AGE_{it} DUM_{it}^h + p_9 AGE_{it}^2 EDU_{it} + \sum_{h=1}^{3} p_{h+9} AGE_{it}^2 DUM_{it}^h + u_{it}$$

where

$\hat{w}_{it}$	=	the log of the real hourly wage for person i in time t,
p_{0i}	=	fixed effect for person i,
BY_i	=	the birth year of person i,
AGE_{it}	=	the age of person i at time t,
EDU_{it}	=	the education level (in years) of person i in time t,
DUM_{it}^h	=	dummy variables for the marital status (h=1), race (h=2), and sex (h=3)of person i in time t; potentially variable over time only for h=3.

Table A1 reports the resulting coefficient estimates.

(ii) The coefficient estimates obtained from step (i) were used to construct simulated life-cycle wage profiles for each individual from age 21 through 80. Unlike Fullerton and Rogers, we do not splice wage observations from the PSID with predicted values in generating the profiles. Instead we simply use predicted values for all wage observations.[31] In constructing

[31]This difference is minor, as actual wages are observed for only a small portion of any given individual's working life. As the explanatory variables include individual fixed effects, p_{0i}, and age interacted with other individual characteristics, the use of fitted rather than actual values during the period of observed wages amounts to smoothing out high-frequency wage fluctuations.

these profiles we set education to the highest reported level and assume that marital status is constant and equal to married if the individual is married at any time over the PSID sample period.

(iii) Lifetime wage income (LI) levels are imputed from the profiles generated in step (ii) according to the formula

$$LI_i = \sum_{s=21}^{80} (1+r)^{-(s-21)} \; (\hat{w}_{is} \cdot 4000)$$

where the discount rate r is set to 8 percent, $\hat{w}_{is}$ is the predicted wage of the individual at age s, and 4000 is the potential full-time endowment of work hours. This calculation follows Fullerton and Rogers, except for the choice of r.

All observations were next sorted in ascending order of lifetime wage income, and divided into the twelve groups described in the text. Following the text and letting j^j be the fraction of the population in group j, our division yields j^j = 0.02 for j = 1 and 12, j^j =0.08 for j = 2 and 11, and j^j = 0.1 for j = 3 through 10.

(iv) Finally, regressions of the predicted wage observations on a common group intercept and a cubic in age were run for each group:

$$\hat{w}_{is}^j = x_0^j + x_1^j AGE_{is}^j + x_2 (AGE_{is}^j)^2 + x_3^j (AGE_{is}^j)^3 + u_{is}^j .$$

The estimated coefficients appear in Table A2. The profiles in Figure 1 in the paper are based on these estimates adjusted for annual efficiency growth of one percent. Taking account of the various differences in methodology, they exhibit a pattern similar to those in Fullerton and Rogers.

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Table 1. Benchmark Parameter Definitions and Values

Symbol	Definition	Value
Preferences		
a	Utility weight on leisure	1.00
d	Rate of time preference	0.004
q	Intertemporal substitution elasticity	0.25
μ^{j}	Utility weight placed on bequests by income class j[1]	
r	Intratemporal substitution elasticity	0.80
Human Capital		
e_{s}^{j}	Productivity of agent in income class j at age s.	
Demographics		
n	Population growth	0.01
N	Number of children per adult, $(1+n)^{20}$	1.22
j^{j}	Fraction of agents of income class j[2]	
Technology		
l	Rate of technological change	0.01
y	Adjustment cost parameter	0.10
q	Net capital share	0.25
s	Constant elasticity of substitution	1.00
Values of Fiscal Variables in Initial Steady State		
—	Debt service as fraction of National Income	0.0310
—	Disability Insurance tax rate	0.0190
—	Medicare (HI) tax rate	0.0290
—	Social Security (OASI) tax rate	0.0990
—	Social Security replacement rate[3]	
—	Social Security marginal tax-benefit linkage	0.25
—	Payroll tax ceiling	$62,700
t^{C}	Proportional consumption tax	0.113
t^{K}	Proportional capital income tax	0.20
$t^{W}(x)$	Progressive wage tax with deductions & exemptions[4]	
t^{Y}	State proportional income tax less evasion adjustment	0.011
—	Reduction of wage base from itemized deductions[5]	0.0755
—	Reduction of wage base from fringe benefits[5]	0.1129
z	Expensing fraction[6]	0.20

[1] Calibrated in the initial state to match the level of bequests – as a fraction of mean national income – in Fullerton and Rogers (1993, Table 3-8), in 1996 dollars.

[2] $j^{1}=0.02$, $j^{2}=0.08$, $j^{i}=0.10$ $(3 \leq i \leq 10)$, $j^{11}=0.08$, $j^{12}=0.02$

[3] The statutory progressive bendpoint formula for 1996, scaled up by a factor of 2 to account for the fact that other non-DI benefits (mainly spousal and survivors benefits) account for 50 percent of all benefits paid (see 1996 OASDI Trustees Report, Table II.C7).

[4] The 1996 statutory tax function for a single individual with a deduction equal to $9661 ($4,000 standard deduction, $2,550 personal exemption and $2,550·$N$ exemption for dependents).

[5] Total proportional base reduction above the standard deduction therefore equals 0.18845.

[6] Deductions for new investment above economic depreciation and adjustment costs.

Table 2. Key Variables in the Initial Steady-State and U.S. Data

Model		Empirical Estimate and Calculation	
Concept	Value	Estimate	Calculation (using NIPA unless indicated)
Composition of National Income (fraction)			
Personal Consumption	0.731	0.720	Personal consumption expenditures - housing services
Net Saving Rate	0.051	0.056	(National saving - capital consumption allowance)/NI
Government Purchases	0.211	0.212	Consumption expenditures + gross investment for federal (defense and nondefense) and state and local - consumption of fixed capital
Tax Rates and Revenue			
Avg. Marginal Wage Tax[1]	0.216	0.217	Auerbach (1996) based on the NBER TAXSIM model.
Government Revenue	0.239	0.239	Total receipts - contributions for social insurance - property taxes (state and local)
OASDHI Tax	0.146	0.147	1996 tax rate is 15.3 which includes trust fund contributions equal to about 0.6.
The Capital-Output Ratio and the Pre-Tax Rate of Return			
Capital-Output Ratio	2.562	2.660	(1993 current-cost net stock of fixed reproducible wealth – gov't owned fixed capital) / 1993 National Income
Pre-Tax Rate of Return[2]	0.083	0.093	The 1960-1994 average of the sum of interest, dividends, retained earnings and all corporate taxes divided by the replacement value of capital stock (Rippe, 1995).

[1] Does not include the payroll tax.
[2] The social marginal rate of return (i.e., before corporate taxes).

Table 3. Key Elements of Tax Reform Experiments	
Experiment	**Description**
Proportional Income Tax	Eliminate all Tax Base Reductions Eliminate the standard deduction, personal exemption, exemptions for dependents, itemized deductions, preferential tax treatment of all fringe benefits (the consumption tax treatment of pension and the deductibility of non-pension benefits), and the deductibility of state income taxes at the federal level.[1] Flattening of Tax Rates Replace progressive wage tax and proportional capital income tax with a proportional equal tax rate on wage and capital income. Eliminate double taxation of capital income.
Proportional Consumption Tax	Eliminate all Tax Base Reductions Flattening of Tax Rates Full Expensing Allow the deductibility of all new investment.
Standard Flat Tax	Eliminate all Tax Base Reductions Flattening of Tax Rates Full Expensing Protection of Housing Wealth Housing (including consumer durables) remain untaxed.[2] Standard Deduction Allow for a deduction for a single individual equal to $9,500.
Flat Tax with Transition Relief	Eliminate all Tax Base Reductions Flattening of Tax Rates Full Expensing Protection of Housing Wealth Standard Deduction Transition Relief All existing assets continue to receive depreciation allowances.[3]
X Tax	Eliminate all Tax Base Reductions Preserve Current-Law Progressive Wage Tax[4] Capital Income Tax Set at Highest Marginal Wage Tax Rate Full Expensing Protection of Housing Wealth[5]

[1] Consumption tax treatment of pensions is eliminated by decreasing the consumption tax by 0.025 and subjecting all compensation to the new proportional income tax.
[2] About 50 percent of the capital stock is composed of housing and consumer durables whose imputed rent is not taxed. Hence, the proportional tax rate on capital income is set to half of the tax rate on wage income.
[3] As noted in Auerbach (1996, footnote 46), under current-law and with current inflation, the present value of remaining depreciation allowances per dollar of net nonresidential capital is approximately half the value of the assets. Allowing for these depreciation allowances has the same impact as forgiving half of the cash-flow tax on existing assets. Hence, the cash flow tax on capital income is set to one quarter of the replacement proportional wage tax rate.
[4] General equilibrium effects and the constant government revenue constraint requires proportional shifts in the wage tax schedule (with an increase in the short run and a decrease in the long run). The average marginal tax rate is reported in Table 4.
[5] Since the highest marginal wage tax rate in the final steady state equals about 0.30, the capital income tax is set equal to 0.15.

Table 4. Base Case Results, Five Tax Reforms

	Year	National Income[1]	Capital Stock[1]	Labor Supply[1]	Net Saving Rate	Before-Tax Wage[1]	Interest Rate	Normalized Tobin's q	Tax Rate[2]
	1996	1.000	1.000	1.000	0.051	1.000	0.083	1.000	0.216
Proportional Income Tax	1997	1.038	1.002	1.051	0.056	0.988	0.088	1.037	0.135
	2010	1.044	1.030	1.050	0.054	0.995	0.083	1.028	0.131
	2145	1.049	1.056	1.047	0.052	1.001	0.083	1.019	0.130
Proportional Consumption Tax	1997	1.044	1.010	1.063	0.073	0.987	0.079	0.960	0.142
	2010	1.063	1.108	1.054	0.067	1.013	0.076	0.934	0.138
	2145	1.094	1.254	1.046	0.059	1.046	0.073	0.906	0.127
Flat Tax (Standard)	1997	1.010	1.006	1.016	0.065	0.997	0.076	0.964	0.214
	2010	1.022	1.059	1.013	0.061	1.011	0.078	0.958	0.211
	2145	1.045	1.150	1.013	0.056	1.032	0.080	0.941	0.199
Flat Tax (Transition Relief)	1997	0.995	1.003	0.994	0.059	1.002	0.081	1.001	0.241
	2010	1.005	1.031	0.998	0.057	1.008	0.080	0.994	0.234
	2145	1.019	1.083	0.998	0.055	1.021	0.078	0.983	0.226
X Tax	1997	1.018	1.009	1.027	0.069	0.996	0.063	0.949	0.178
	2010	1.031	1.076	1.019	0.064	1.014	0.077	0.910	0.177
	2145	1.064	1.210	1.020	0.059	1.044	0.074	0.882	0.157

[1] Measured per-effective labor unit and indexed with a value of 1.00 in 1996.
[2] Statutory federal rate; for 1996, this is the rate that applies to wage income.

Table 5. Sensitivity Analysis

	Year	National Income[1]	Capital Stock[1]	Labor Supply[1]	Net Saving Rate	Before-Tax Wage[1]	Interest Rate	Normalized Tobin's q	Tax Rate[2]
					s = **0.8**				
	1996	1.000	1.000	1.000	0.051	1.000	0.083	1.000	0.216
Flat Tax (Standard)	1997	1.009	1.006	1.014	0.064	0.994	0.077	0.967	0.215
	2010	1.022	1.055	1.013	0.060	1.010	0.078	0.952	0.210
	2145	1.043	1.136	1.015	0.056	1.032	0.078	0.936	0.198
Flat Tax (Transition Relief)	1997	0.994	1.003	0.993	0.059	1.000	0.081	1.000	0.241
	2010	1.004	1.029	0.998	0.057	1.007	0.080	0.993	0.234
	2145	1.018	1.075	1.000	0.054	1.020	0.081	0.982	0.226
					r = **0.4**				
	1996	1.000	1.000	1.000	0.049	1.000	0.086	1.000	0.213
Flat Tax (Standard)	1997	1.008	1.006	1.013	0.063	0.998	0.081	0.971	0.213
	2010	1.016	1.057	1.005	0.059	1.013	0.081	0.953	0.211
	2145	1.028	1.136	0.996	0.055	1.033	0.078	0.935	0.203
Flat Tax (Transition Relief)	1997	1.001	1.003	1.002	0.057	1.000	0.084	1.005	0.235
	2010	1.007	1.033	1.000	0.055	1.008	0.083	0.995	0.227
	2145	1.015	1.080	0.995	0.054	1.021	0.082	0.987	0.225

Table 5. Sensitivity Analysis (continued)

	Year	National Income[1]	Capital Stock[1]	Labor Supply[1]	Net Saving Rate	Before-Tax Wage[1]	Interest Rate	Normalized Tobin's q	Tax Rate[2]
					g = **0.1**				
	1996	1.000	1.000	1.000	0.051	1.000	0.083	1.000	0.216
Flat Tax (Standard)	1997	1.007	1.003	1.010	0.057	0.998	0.075	0.947	0.211
	2010	1.007	1.019	1.004	0.054	1.004	0.082	0.932	0.217
	2145	1.013	1.038	1.005	0.053	1.008	0.081	0.928	0.213
Flat Tax (Transition Relief)	1997	0.990	1.000	0.986	0.050	1.003	0.077	0.974	0.239
	2010	0.985	0.985	0.984	0.047	1.000	0.083	0.965	0.244
	2145	0.969	0.920	0.983	0.049	0.983	0.088	0.975	0.256

[1] Measured per-effective labor unit and indexed with a value of 1.00 in 1996.
[2] Statutory federal rate; for 1996, this is the rate that applies to wage income.

Table A1. PSID Regression Results

Variable	Coefficient	t statistic
Birth Year (*BY*)	-0.0005	1.47
Age (*AGE*)	0.0883	3.46
Age-Squared	-0.0016	3.20
Age-Cubed	6.66E-6	2.07
Age x Education (*EDU*)	-0.0009	2.02
Age x Marital Status (DUM^1)	0.0081	3.37
Age x Race (DUM^2)	0.0119	2.81
Age x Sex (DUM^3)	0.0339	1.69
Age-Squared x Education	2.16E-5	3.30
Age-Squared x Marital Status	-0.0001	2.84
Age-Squared x Race	-0.0002	2.70
Age-Squared x Sex	-0.0004	2.00
Adjusted R^2	0.9779	—

Table A2. Estimated Wage Profile Coefficients by Lifetime Income Group

LI Group	Intercept	Age	Age-Squared	Age-Cubed
1	-0.6421	0.0949	-0.00158	7E-06
2	-0.2294	0.0941	-0.00157	7E-06
3	0.1831	0.0929	-0.00156	7E-06
4	0.4693	0.0907	-0.00155	7E-06
5	0.6772	0.0882	-0.00150	7E-06
6	0.8865	0.0853	-0.00147	7E-06
7	0.9794	0.0884	-0.00151	7E-06
8	1.1606	0.0864	-0.00148	7E-06
9	1.3180	0.0855	-0.00147	7E-06
10	1.4814	0.0862	-0.00147	7E-06
11	1.8151	0.0856	-0.00146	7E-06
12	2.5745	0.0853	-0.00146	7E-06

Figure 1. Earnings-Ability Profiles

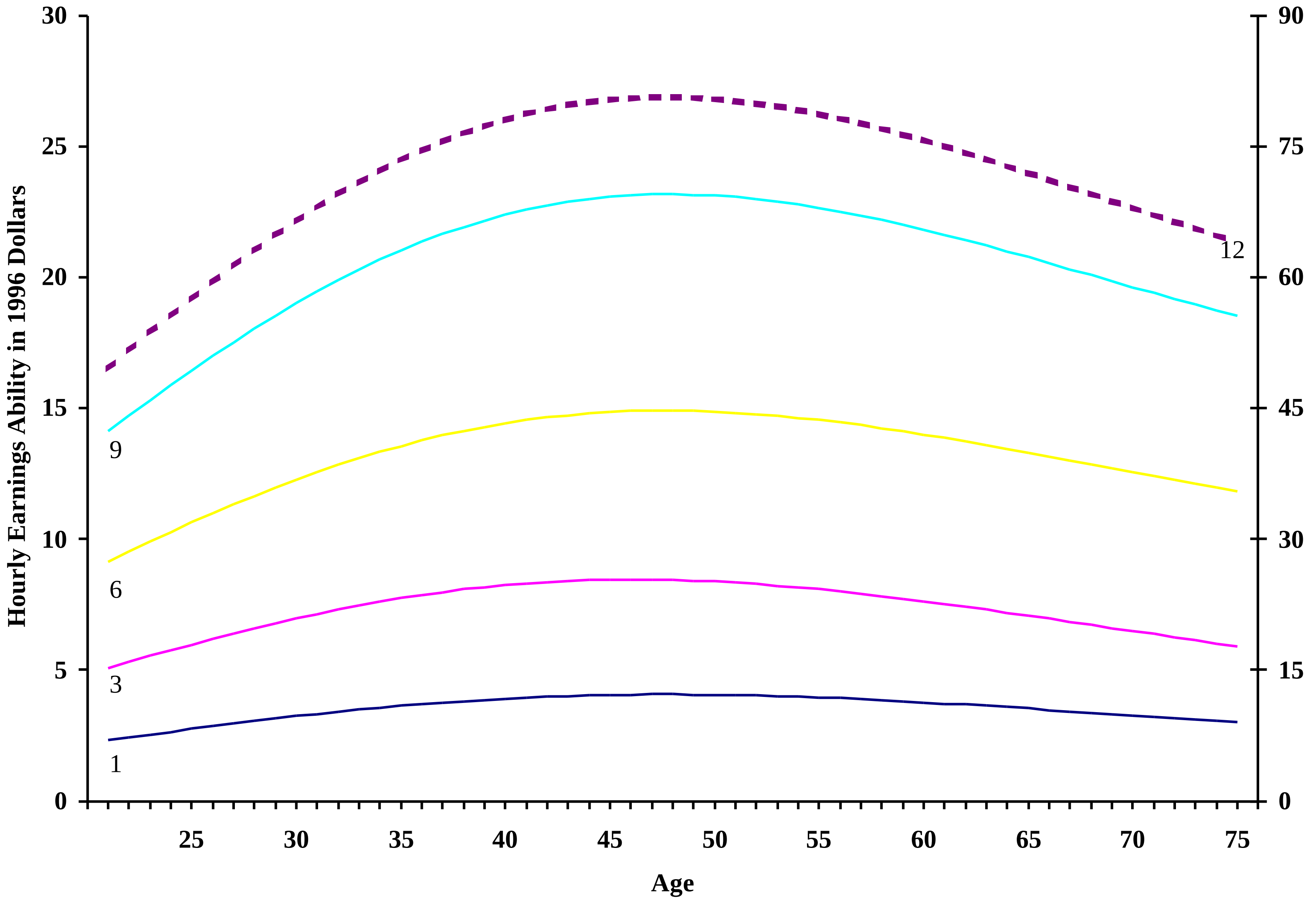

Figure 2. Remaining Lifetime Utility: Proportional Income Tax

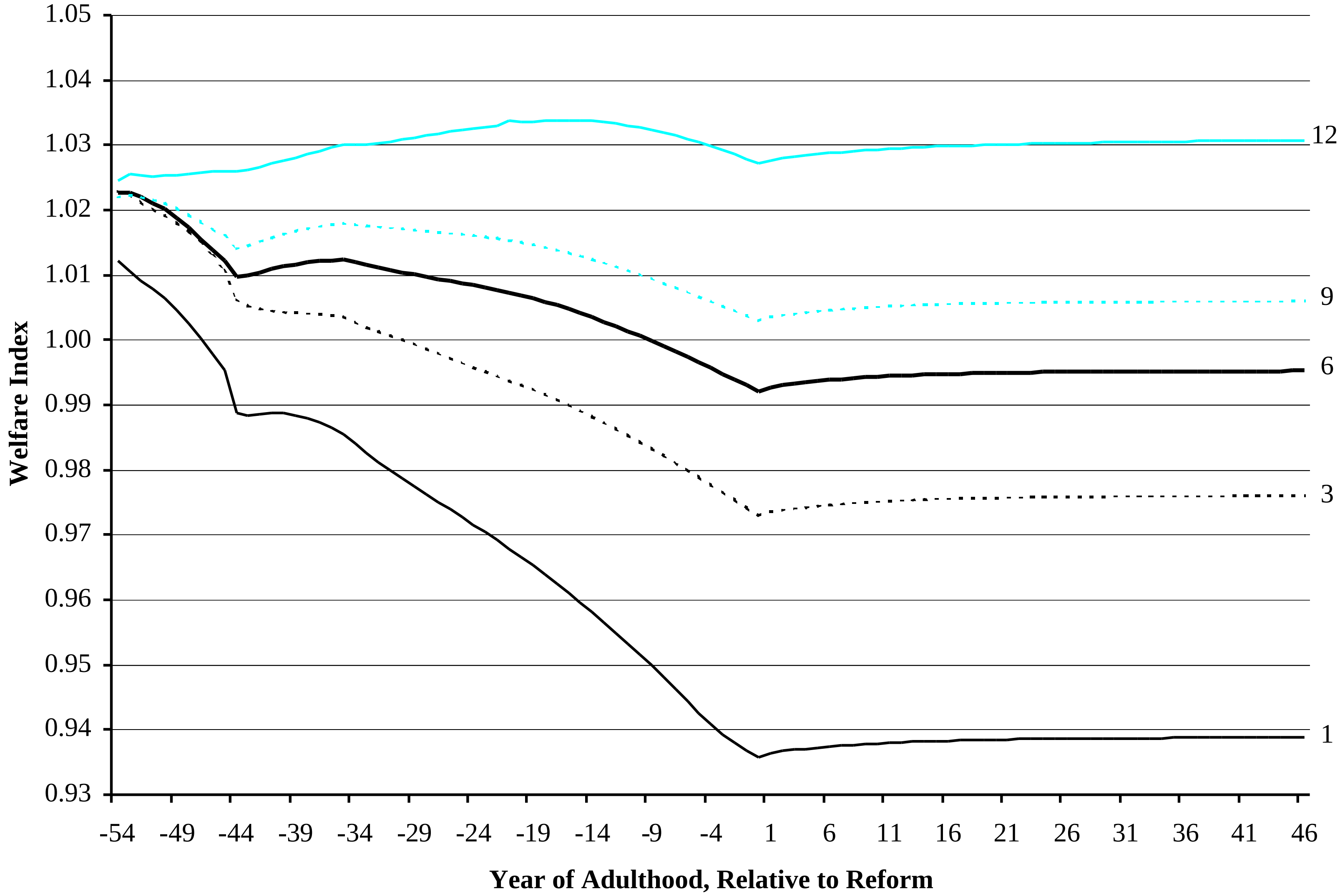

Figure 3. Remaining Lifetime Utility: Proportional Consumption Tax

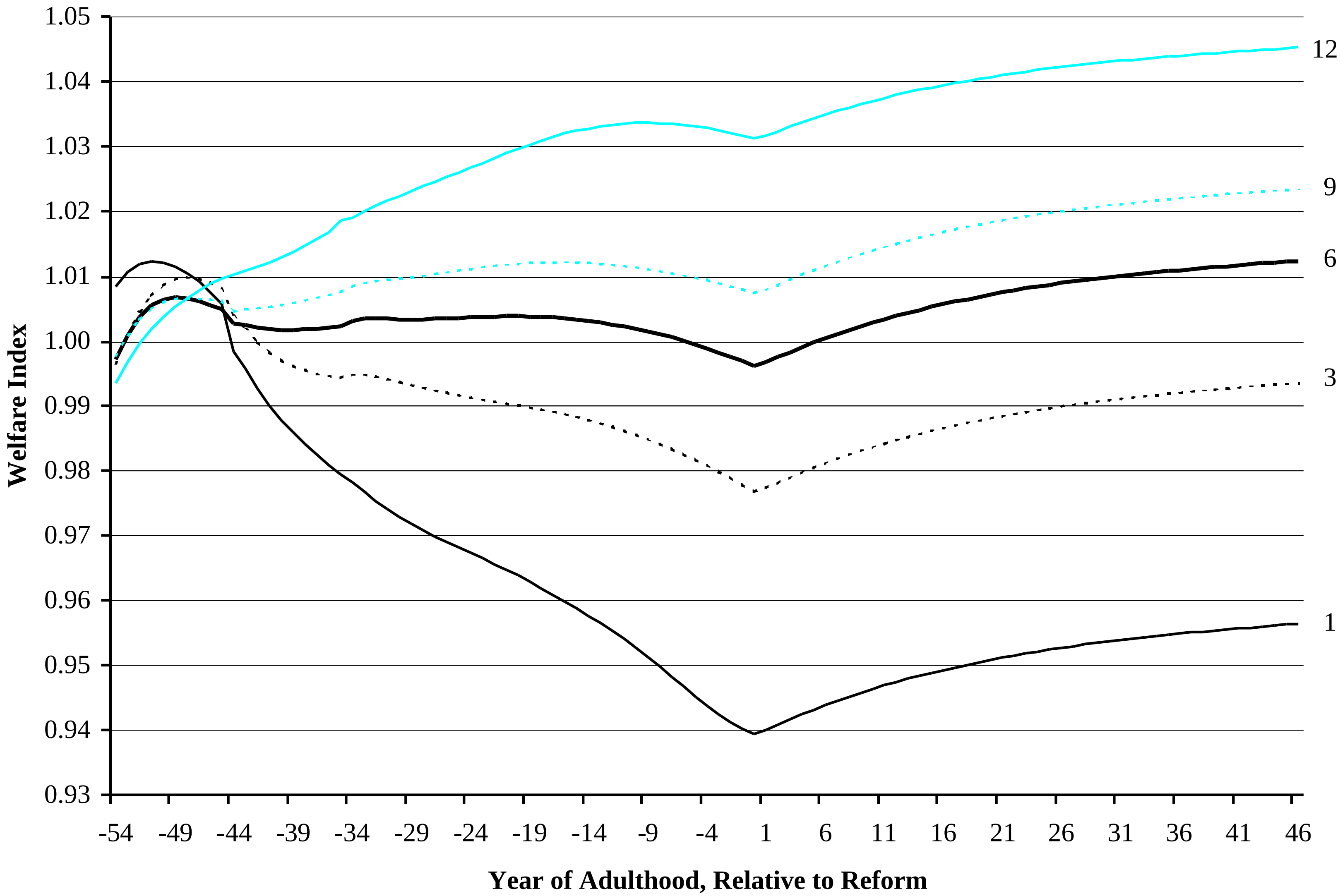

Figure 4. Remaining Lifetime Utility: Flat Tax (Standard)

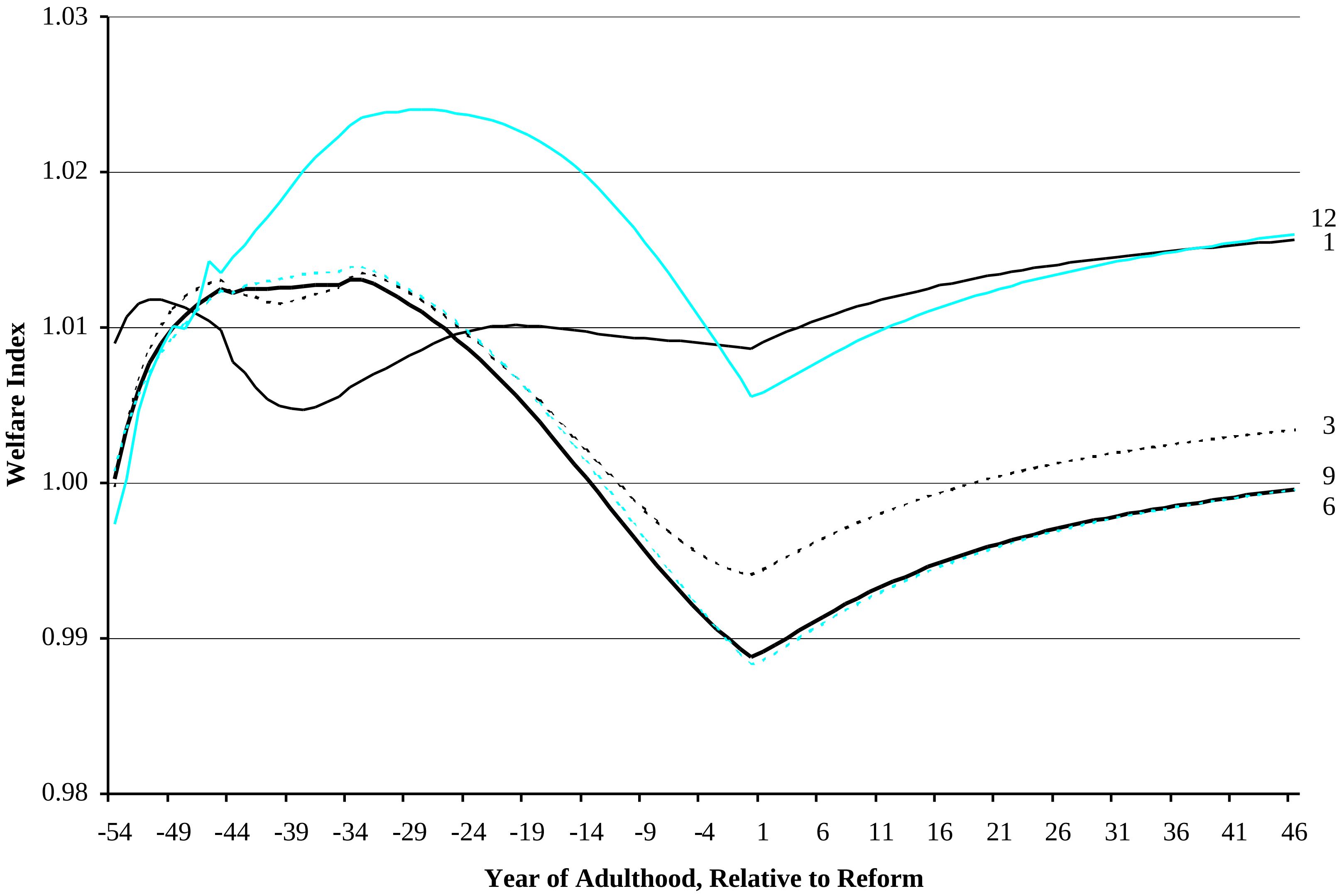

Figure 5. Remaining Lifetime Utility: Flat Tax (Transition Relief)

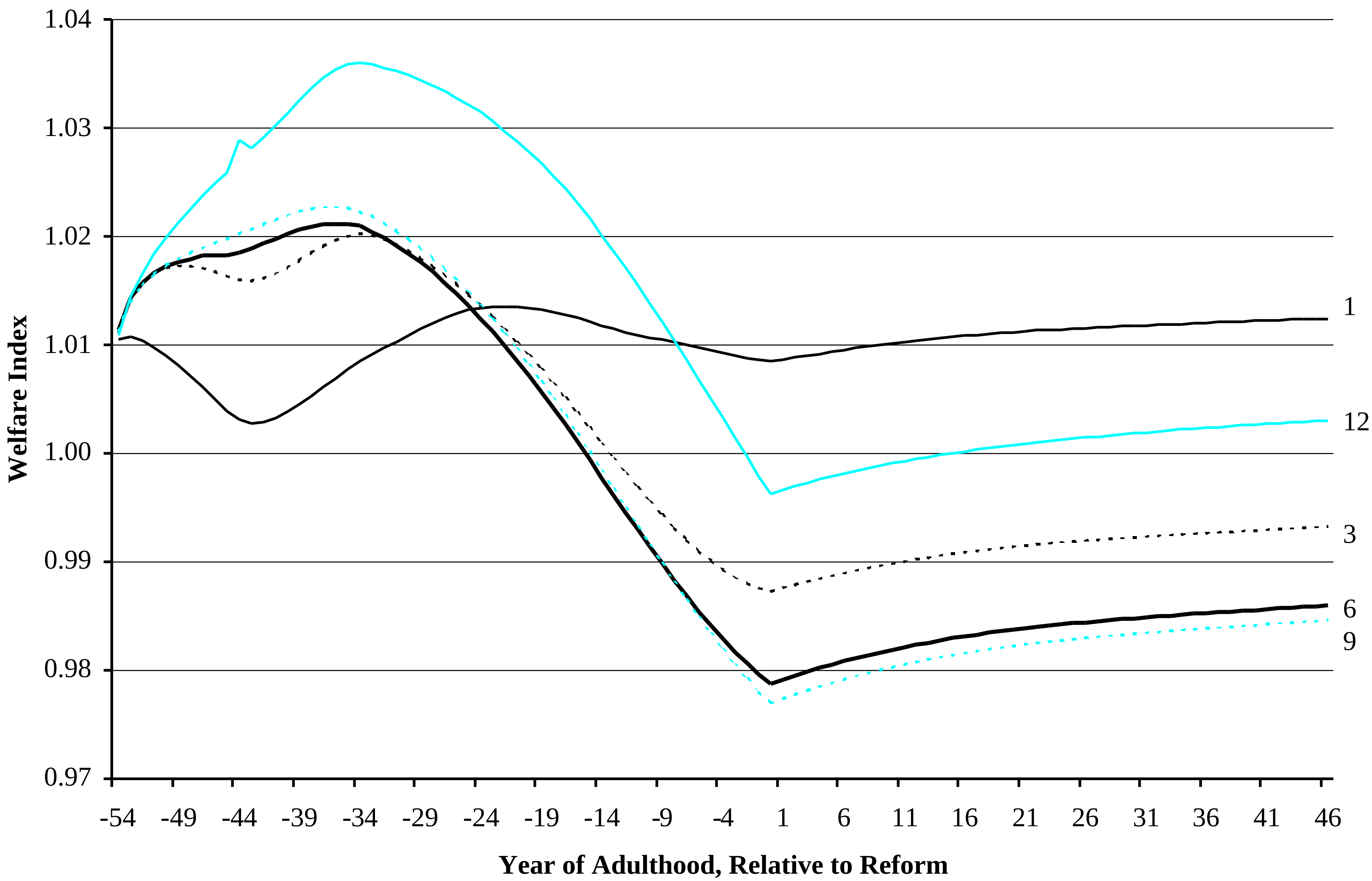

Figure 6. Remaining Lifetime Utility: X Tax