The Efficiency and Welfare Effects of Tax Reform: Are Fewer Tax Brackets Better than More?

by David Altig and Charles T. Carlstrom

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Introduction

The 1980s was the decade of tax reform. The American economy experienced two major changes in federal personal income-tax legislation, the Economic Recovery Tax Act of 1981 (ERTA) and the Tax Reform Act of 1986 (TRA86). But significant change was not limited to the United States. By 1989, tax legislation had been passed in Australia, Canada, Denmark, New Zealand, Japan, Sweden, and the United Kingdom, with proposals for reform pending in many other nations (see Tanzi [1987], Boskin and McLure [1990], and Whalley [1990b]).

Although actual and proposed tax legislation within each of these countries was multifaceted, sometimes with substantial variance in details, the reform proposals shared certain broad characteristics across countries. Most striking among these was the uniform tendency toward lower top marginal tax rates, fewer rate brackets, and "base broadening." For example, in the latest rounds of reform, top statutory marginal rates in the federal personal tax codes fell from 34 to 29 percent in Canada, 83 to 40 percent in the United Kingdom, and 50 to 31 percent in the United States.[1] Corresponding to these changes were reductions in the number of rate brackets from 10 to 3 (Canada), 11 to 2 (United Kingdom), and 15 to 3 (United States). These examples and others are summarized in table 1.

A major motivation for these changes was the growing perception that the distortionary effects of high marginal tax rates had resulted in substantial inefficiencies.[2] Consequently, an essential impulse for tax reform was — and is — the desire to create more efficient income tax systems by substituting base-broadening measures for high marginal tax rates. Reductions in the

■ 1 Effective marginal tax rates can differ from statutory rates due to special treatment of credits, deductions, and exemptions at certain threshold income levels. An obvious example is the TRA86 provision for phasing out personal exemptions for high-income taxpayers.

■ 2 In its 1984 report on early tax proposals, the Joint Committee on Taxation identified three major objectives of comprehensive reform: equity, efficiency, and simplicity. With respect to efficiency, the Committee wrote that "... a widely accepted goal of tax policy is that taxes should interfere as little as possible with the incentives to engage in specific types of economic activity, except to the extent that Congress intends such effects ... [A] major goal of tax policy is to reduce [inefficiencies] to as low a level as possible." Furthermore, they indicated that "... in all [pending] proposals, marginal tax rates are substantially reduced. This reduction appears to be motivated by efficiency and equity considerations." See Joint Committee on Taxation (1984).

TABLE 1

Specific Elements of World Tax Reform

Country	Top Marginal Tax Rate, Pre-Reform	Pre-Reform Year(s)	Number of Pre-Reform Brackets	Top Marginal Tax Rate, Post-Reform	Post-Reform Year(s)	Number of Post-Reform Brackets
Australia	60%	1980–86	5	49%	1987–88	4
				47	1992	5
Austria	62	1982–88[a]	10[b]	50	1989	5
Belgium	72	1983–88	13[b]	50	1989–92	7
Canada	34	1987[a]	10	29	1988–92	3
Italy	65	1983–87	9	56	1988	8
				51	1992	7
Japan	70	1984–86	15	60	1987	12
				50	1988–92	5
Netherlands	72	1982–86[a]	9	66	1987–88	5
				60	1990–92	4
New Zealand	66	1979–85	5	48	1986	3
				33	1988–92	2
Sweden	80	1985[a]	11	72	1986	4
				50	1991–92[c]	4
United Kingdom	83	1978[a]	11	60	1979	6
				40	1988–92	2
United States	50	1983–85	15	33	1986	3
				31	1992	3

a. Rate may have been in effect prior to earliest date indicated.

b. Figures refer to number of rate brackets in 1988.

c. From 0 to 186,600 kronor (SEK), the national tax is a flat SEK 100. For incomes in excess of SEK 186,600, the tax is SEK 100 plus 20 percent of the excess.

SOURCES: Platt (1985); Tanzi (1987); Boskin and McLure (1990); Whalley (1990a, 1990b); various issues of the Organisation for Economic Co-operation and Development's *Economic Survey*; and the 1982 and 1992 editions of Price Waterhouse's *Individual Taxes, A Worldwide Summary*.

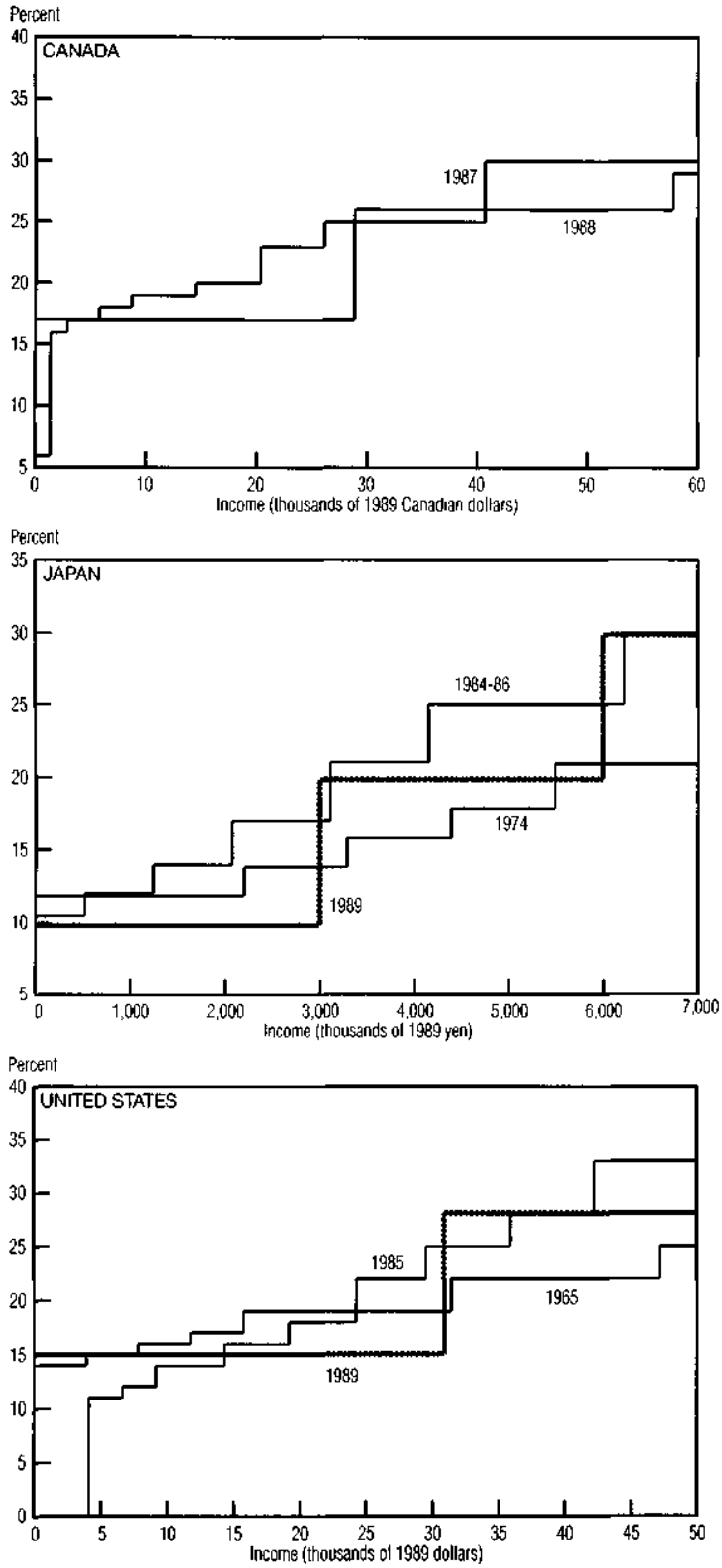
number of rate brackets are presumably meant to reinforce this goal by simplifying the tax code and minimizing distortions through the creation of broad classes of income over which marginal tax rates are essentially flat. Although often implicit, this motivation for reducing the number of rate brackets is sometimes explicit in discussions of specific tax reform proposals. For example, in discussing the Takeshita reforms in Japan, Noguchi (1990, p. 118) describes the U.K. and U.S. changes in rate structures as "developments ... toward flat-rate income taxes," while Ishi (1989) refers to the rate structure implemented in Japan as a "modified flat-tax" system.

However, a brief glance at figure 1, which depicts various vintages of Canadian, Japanese, and U.S. personal income-tax rate structures, reveals the problematic nature of concluding that a smaller number of rate brackets is less distortionary than a larger number. Although recent rate structures have wider bands of income over which the marginal tax rate is flat, jumps in the marginal rate are much more significant for some taxpayers. It is unclear, a priori, which structure will most significantly distort household consumption and work-effort decisions on net. Given the almost universal tendency toward reforms that simultaneously reduce the number of brackets and increase the distance between them, it is surprising that these issues have not been given more attention.

That, then, is the goal of this paper. Using the well-known dynamic fiscal policy framework pioneered by Auerbach and Kotlikoff (1987), we examine the welfare and efficiency implications of shifting from linear to discrete

FIGURE 1

Marginal Tax Rates



NOTE: Figures are scaled to a maximum of $50,000 equivalent U.S. dollars.
SOURCES: Whalley (1990b); Ishi (1989); Boskin and McClure (1990); Internal Revenue Service, *Statistics of Income, Individual Tax Returns*, 1965–89; and International Monetary Fund, *International Financial Statistics*, July 1992.

marginal tax-rate structures. In other words, we consider the pure distortionary effects of replacing a tax structure with many (infinitely small) steps between marginal tax rates with one defined by two large bands of flat tax rates connected by a single, large discrete jump.

We find that when our model is calibrated to match the main features of the U.S. economy, a hypothetical two-bracket code (roughly patterned after the rate structure in the 1989 U.S. personal income tax code) is *less* efficient than alternative linear-rate codes with similar average-tax progressivity and present-value revenue implications. By less efficient, we mean that there is no sequence of lump-sum transfers the government could feasibly implement that would make the shift from the linear to the discrete rate structure Pareto-improving.[3] This finding is generally robust to parameter assumptions and to the chosen method for equalizing revenues. This central message should serve as a cautionary note in the midst of growing political sentiment for further changes in the U.S. income tax code: Without disputing the merits of completely flat marginal tax rates, our results do not support the position that a modified flat-tax system is necessarily superior to all alternatives with steeply sloped marginal rate structures.

I. The Simulation Model

The model specification includes mathematical representations of the preferences and constraints of utility-maximizing households, the production technology available to profit-maximizing firms, a government budget constraint, and a specification for the income tax code, all of which are described in this section. In combination with labor-, capital-, and goods-market-clearing conditions, a competitive equilibrium is constructed by finding aggregate quantities and prices that are, given the government's behavior, consistent with the decentralized decisions of individual households and firms.

3 We argue only that a rate structure with revenue and progressivity properties similar to TRA86 is less efficient than the specific alternative we consider — not that *all* discrete marginal-rate schemes are less efficient. Although we believe that requiring the same revenue collections and average-rate progressivity is a sensible constraint on the alternative tax codes, our results should be interpreted in light of these particular restrictions.

Households and Preferences

Our model economy is populated by a sequence of distinct cohorts (individuals born on the same date) that are, with the exception of size, identical in every respect. Each generation lives, with perfect certainty, for 55 periods (interpreted as adult years) and is $1 + n$ times larger than its predecessor. One can think of life as beginning at age 21 and ending at age 75.

Individuals "born" at calendar date b choose perfect-foresight consumption (c) and leisure (l) paths to maximize a time-separable utility function of the form

$$(1) \qquad U_b = \sum_{t=1}^{55} \beta^{t-1} u(c_{t,b+t-1}, l_{t,b+t-1}),$$

where $u_i > 0$, $u_{ii} < 0$, $\lim_{i \to \infty} u_i = \infty$, and u_i is the partial derivative of the function $u(\cdot)$ with respect to argument i. The preference parameter β is the individual's subjective time-discount factor. We assume that $\beta > 0$, but do not strictly require that $\beta < 1$.

Letting $a_{t,s}$ equal the sum of capital and government debt holdings for age t individuals at time $s = b + t - 1$, maximization of equation (1) is subject to a sequence of budget constraints given, at each time s, by

$$(2) \qquad a_{t,s} = (1 + r_s) a_{t-1,s-1} + \varepsilon_t w_s (1 - l_{t,s}) + v_{t,s} - T(y^*_{t,s}) - c_{t,s},$$

where w_s is the real pre-tax market wage at time s, r_s is the real return to assets held from time $s - 1$ to s, ε_t is an exogenous labor-efficiency endowment in the t^{th} period of life, and $v_{t,s}$ refers to lump-sum transfers received by age t individuals at time s.[4]

The function $T(y^*_{t,s})$ defines the amount of income tax paid, which depends on the tax base given by $y^*_{t,s} = r_s a_{t-1,s-1} + \varepsilon_t w_s (1 - l_{t,s}) - d$. The constant d represents a fixed level of deductions and exemptions used to convert gross income to taxable income. In the linear marginal-rate case, the function $T(\cdot)$ is defined as

$$(3a) \qquad T^{Linear}_{t,s} = \int_{y=d}^{y^*_{t,s}} \tau(y)\, dy,$$

where

$$(3b) \qquad \tau(y) = a + b y_{t,s}, \quad a, b > 0$$

defines the marginal tax rate as a linear function of taxable income. In the discrete tax case, the function is defined as

$$(4) \qquad T^{Discrete}_{t,s} = \begin{cases} \tau^L y^*_{t,s} & \text{if } y^*_t \le \tilde{y}, \\ \tau^L \tilde{y} + \tau^H (y^*_{t,s} - \tilde{y}) & \text{if } y^*_t > \tilde{y}. \end{cases}$$

Note that at any time s, there are three distinct possibilities with respect to the budget constraint in the discrete tax case, corresponding to the cases where $y^*_{t,s} < \tilde{y}$, $y^*_{t,s} > \tilde{y}$, and $y^*_{t,s} = \tilde{y}$. The latter applies when individuals are at the kink in the budget constraint.

In addition to equation (2), we impose the initial condition that all individuals are born with zero wealth and the terminal condition that the present value of lifetime consumption plus tax payments cannot exceed the present value of lifetime resources. In the absence of a bequest motive and lifetime uncertainty, this wealth constraint implies that $a_{55,s} = 0$.

The Government

The government in our model raises revenue through a combination of distortionary income taxes, debt issues, and lump-sum taxes. Government purchases of output equal zero at all times, and all government revenue is eventually redistributed to households in the form of lump-sum transfers. We specifically require that revenue raised from the income tax be rebated in the form of lump-sum payments to the individuals from whom it is collected. This allows us to isolate the efficiency losses due to the distortionary nature of marginal tax-rate changes.

Initially, we assume that D_0, the amount of government debt at the beginning of time, is zero, and that the individual transfer payments, $v_{t,s}$, equal the amount of income tax revenue collected for all individuals age t at all times s. These assumptions, which we relax to calculate efficiency measures in section V, imply that debt issues are zero for all s.

Firms and Technology

Output in the model is produced by competitive firms that combine capital (K) and labor (L) using a neoclassical, constant-returns-to-scale

4 Capital and government debt are assumed to be perfect substitutes in households' portfolios.

production technology. Aggregate capital and labor supplies (in per capita terms) are obtained from individual supplies as

$$(5)\qquad K_s=\sum_{t=1}^{55}\frac{a_{t,s-1}}{(1+n)^{t-55}}-\frac{D_{s-1}}{1+n}$$

and

$$(6)\qquad L_s=\sum_{t=1}^{55}\frac{\varepsilon_t(1-l_{t,s})}{(1+n)^{t-55}}.$$

Note that the capital stock at time s is given by private and public saving decisions at time $s-1$. Also, recall that we initially assume $D_s = 0$ for all s.

The production function is written in terms of the capital–labor ratio k as

$$(7)\qquad q_s = f(k_s),$$

where q_s is per capita output and $f(\cdot)$ is defined such that $f' > 0$, $f'' < 0$, $\lim_{k\to\infty} f' = 0$, and $\lim_{k\to 0} f' = \infty$. The competitive wage rate and (gross) interest rate are given by

$$(8)\qquad w_s = q_s - kf'(\cdot)$$

and

$$(9)\qquad r_s = f'(\cdot) - \delta,$$

where δ is the depreciation rate on physical capital.

II. Model Calibration

In order to quantify the model, it is necessary to choose particular values for the model's parameters. In this section, we describe the choices that result in our benchmark model and discuss their rationale.

Technology

The simulation exercises reported in section IV assume an aggregate production technology given by

$$(10)\qquad q_s = Ak_s^{\theta},$$

where θ is capital's share in production and A is an arbitrary scale factor. Our benchmark value for θ is 0.36, following Kydland and Prescott (1982). The value of A is chosen to scale steady-state cohort incomes to values consistent with average household income in 1989, the year for which the tax code is calibrated. We discuss this choice in more detail below.

In the benchmark model, we assume that the depreciation rate of physical capital is 10 percent per period, a choice that, again, is motivated by the arguments in Kydland and Prescott. The population growth rate is set to the postwar U.S. average of 1.3 percent per year, and the life-cycle labor efficiency profile $\{\varepsilon_t\}_{t=1}^{55}$ is calculated by interpolating estimates in Hansen (1986).

Preferences

We assume that preferences are isoelastic, specializing equation (1) to

$$(11)\qquad U_b=\sum_{t=1}^{55}\beta^{t-1}\left(\frac{c_{t,b+t-1}^{1-\frac{1}{\sigma_c}}}{1-\frac{1}{\sigma_c}}+\alpha\frac{l_{t,b+t-1}^{1-\frac{1}{\sigma_l}}}{1-\frac{1}{\sigma_l}}\right),$$

where the preference parameters σ_c, σ_l, and α represent the intertemporal elasticities of substitution in consumption and leisure and the utility weight of leisure, respectively. In our benchmark model, we assume $\sigma_c = 1$, so that equation (11) becomes

$$(11')\qquad U_b=\sum_{t=1}^{55}\beta^{t-1}\left(\ln(c_{t,b+t-1})+\alpha\frac{l_{t,b+t-1}^{1-\frac{1}{\sigma_l}}}{1-\frac{1}{\sigma_l}}\right).$$

This form has the special property, not generally exhibited by specification (11), that the capital–labor ratio is invariant to the scale factor A in equation (10).[5] Also, evidence from state-level data reported by Beaudry and van Wincoop (1992) suggests preferences that are logarithmic in consumption.[6]

■ 5 Scale invariance follows from the fact that changes in the level of wages have offsetting wealth and substitution effects on individual labor supply decisions. Since scale invariance also implies that average hours worked will not change with growth, preferences similar in form to those in equation (11′) often appear in the real business cycle literature (see King, Plosser, and Rebelo [1988]).

■ 6 Further, Beaudry and van Wincoop find no evidence supporting either nonseparabilities between consumption and leisure or the absence of time separability in consumption, results that generally support the specification in equation (11). However, it should be noted that their empirical findings are based on a different model of aggregate consumption behavior than the one presented here.

We base the choice of σ_l, the intertemporal elasticity of substitution of leisure, on the extensive empirical literature devoted to estimating the wage elasticity of the labor supply. This elasticity, which we denote η_L, is related to σ_l by

$$(12)\quad \eta_L = \frac{l_{t,s}}{1 - l_{t,s}}\sigma_l \approx 2\sigma_l.$$

MaCurdy's (1981) study of men's labor supply suggests values for η_L in the range of 0.1 to 0.45, a result that is largely confirmed in related studies (see Pencavel [1986]). However, Rogerson and Rupert (1991) argue that, because of corner conditions, estimates of the degree of intertemporal substitution obtained from conventional analyses of male labor supply are likely to be understated. Furthermore, despite greater disparity in estimates obtained from studies of female labor supply, there is broad agreement that the elasticity is higher for women (see Killingsworth and Heckman [1986]). Based on this evidence, in our benchmark model we set $\sigma_l = 0.25$ and choose the parameter α so that steady-state hours worked by an individual at peak productivity are slightly greater than one-third of total time endowment, which we take to be 16 hours per day.

Most empirical studies find values for the subjective discount factor β at annual frequencies to be in the neighborhood of 1.0 — sometimes slightly lower (Hansen and Singleton [1982]), sometimes slightly higher (Eichenbaum and Hansen [1990]). We choose a benchmark value of 0.99. Together with the other parameter choices, this value results in a steady-state real pre-tax interest rate of about 3.7 percent (which corresponds closely to the [apparent] historical average of real pre-tax returns on long-maturity riskless bonds in the United States[7]) and in a steady-state capital output ratio of 2.63 (which corresponds closely to the ratio of total capital to GDP in the United States over the 1959–90 period[8]).

The Tax Code

The benchmark tax code is patterned after the statutory U.S. personal tax code for 1989. Over the income region that is relevant in our simulations, the 1989 schedule was given by

$$(13)\quad T^{Discrete}_{t,s} = \begin{cases} 0.15 & \text{if } y^*_{t,s} \le \$30{,}950, \\ 0.28 & \text{if } y^*_{t,s} > \$30{,}950. \end{cases}$$

We refer to this tax code as the "tax-reform" case.

The income levels obtained from the model are scaled to match those in the 1989 tax code as follows: The scale parameter A in the production function of equation (10) is chosen so that the highest income in the model matches the average income level for the highest-paid age group found in 1988 Census Bureau data.[9] We calculate the average for this group, which consists of persons aged 45–54, to be \$44,217 in 1989 dollars.[10] This value of A is then used in all subsequent simulations. To obtain taxable income, we subtract exemptions and deductions of \$11,206.

III. Welfare Effects

In this section, we examine the effects of shifting to the tax-reform code from an alternative linear-rate code, under the maintained assumption of revenue neutrality. Holding the structure of the discrete code constant, two natural approaches to achieving revenue neutrality are 1) choosing the intercept of the linear-rate code to equalize revenues, and 2) adjusting deductions to equalize revenues.

In each of our experiments, we consider an initial steady state under the linear-rate regime and examine the transition to a new steady state under the tax-reform regime.[11] Thus, under an intercept-adjusted approach, we parameterize the function $\tau(y)$ in equation (3b) as

■ 7 See Siegel (1992), which reports average rates for the 1800–1990 period. We note, for the record, that average real rates appear to differ significantly across particular subperiods. Specifically, real returns to long-term bonds averaged 1.46 percent between 1889 and 1978, but are 5.76 percent outside that interval.

■ 8 The measure used to construct the U.S. capital stock is the constant-cost net stock of fixed reproducible tangible wealth reported in the January 1992 *Survey of Current Business*, compiled by the U.S. Department of Commerce. This measure includes consumer durables and government capital.

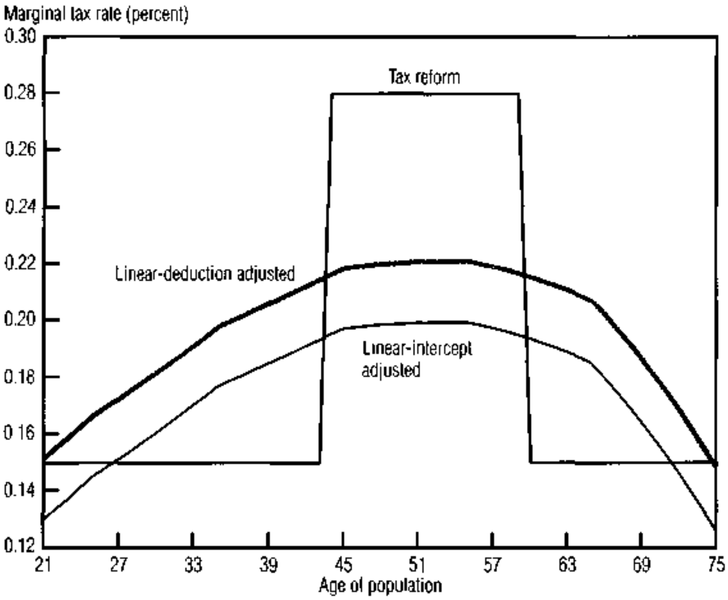
■ 9 Recall from our previous discussion that household utility functions are chosen so that real outcomes are unaffected by the choice of A.

■ 10 The data used in constructing this variable were taken from the Bureau of Labor Statistics' *Current Population Reports*, series P-60, no. 166. The cohort mean is obtained by multiplying the median income of families with household heads aged 45–54 by the ratio of average to median family income for the entire population. All money values in this paper are quoted in 1989 dollars.

■ 11 The experiments we report involve unanticipated changes in the tax regime. We have also conducted analyses (not reported) with anticipated regime shifts and found that our conclusions are robust.

FIGURE 2

Marginal Tax Rates (Benchmark Parameters)



SOURCE: Authors' calculations.

TABLE 2

Average Tax-Rate Comparisons: Steady-State, Benchmark Parameters (percent)

	Low Income	Median Income	High Income
Tax reform code	4.1	10.9	11.8
Linear-rate code, intercept adjusted to equalize revenues	3.3	10.8	11.9
Linear-rate code, deductions adjusted to equalize revenues	0.1	10.7	12.1

SOURCE: Authors' calculations.

$$(14)\quad \tau_{t,s}^{linear}(y) = \psi + 0.0000024 y_{t,s}$$

and choose the intercept ψ so that the present value of income tax revenues generated by the linear-rate code is acceptably close to the present value of revenues generated by the tax-reform transition path and steady state.[12] Under the alternative deduction-adjusted approach, we set $\psi = 0.146$ and choose the deduction to match the revenue levels.[13] For the benchmark model, this approach yields deductions of $14,561 in the initial steady state.

Figure 2 shows the steady-state, life-cycle path of marginal tax rates for the tax-reform and two linear-rate regimes. For the intercept-adjusted linear-rate code, approximately 55 percent of the population, accounting for an equal amount of steady-state income, face lower marginal tax rates than they would under the tax-reform system. The highest marginal tax rate in the linear-rate case is approximately 20 percent, as opposed to 28 percent in the tax-reform regime. For the deduction-adjusted linear-rate code, things are slightly different: Approximately 35 percent of the population, accounting for 42 percent of steady-state income, face lower marginal tax rates than they would in the tax-reform case. Furthermore, the rate reductions are concentrated — and especially pronounced — at high income levels. The highest marginal tax rate in the deduction-adjusted linear-rate scenario is approximately 22 percent.

In addition to the revenue implications, the progressivity of each tax structure is a key element in considering the comparability of the different tax codes. Information on average tax-rate progressivity, provided in table 2, is one convenient way of examining progressivity. Although no more than an informal summary of the nature of a particular tax code, this measure does provide a sense of how average tax liabilities are related to income, highlighting the sort of comparisons often invoked in discussions of alternative tax regimes. As claimed above, the results in table 2 do suggest that in the long run, the tax-reform and linear-rate codes (especially the intercept-adjusted variant) exhibit

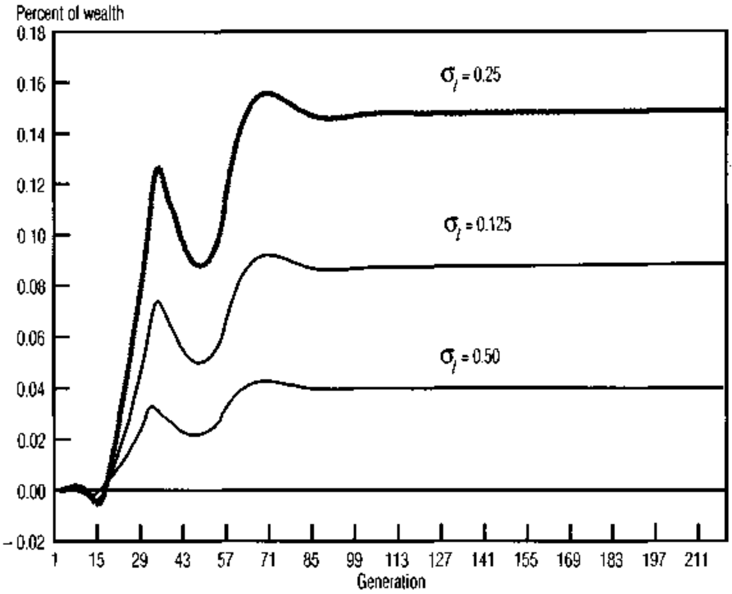
12 By "close," we specifically mean within 0.001 percent. The slope of the function in equation (14) is obtained by fitting a linear regression to the 1965 statutory tax code. The 1965 schedule was chosen as representative of the marginal rate structure in place over much of the 1964–78 period. Over the income range $0–$54,000, which covers the incomes generated by our model, a linear function is a reasonably good approximation of this statutory schedule.

Present values are calculated as the interest rates realized under tax reform, that is, along the transition path and in the new steady state. Measuring revenue neutrality under a fixed assumption about interest rates, while not strictly consistent with ex post neutrality, seems consistent with the fashion in which tax legislation is actually contemplated. Furthermore, because the final, tax-reform steady state is the same in all simulations conducted under a particular parameterization of the model, our choice delivers a common discount factor across like experiments.

13 The choice of 0.146 is motivated by the same regressions used to determine the slope of the linear code. See footnote 12.

FIGURE 3

Welfare Loss Due to Tax Reform: Basic Results



NOTE: Each x on the horizontal axis corresponds to the oldest generation alive x periods after the tax regime change.
SOURCE: Authors' calculations.

similar degrees of progressivity, subject of course to the usual caveats about the validity of the average tax measure.

Armed with these observations, we turn next to examining the welfare implications of shifting from a linear-rate regime to the tax-reform regime. Throughout, we calculate welfare losses as the percentage increase in full wealth that must be *given* to an individual in the tax-reform regime in order to compensate him for the switch to the linear code.[14] Negative numbers therefore represent welfare gains associated with tax reform.

Figure 3 illustrates welfare losses for different age cohorts arising from an unanticipated change from the intercept-adjusted linear-rate regime to the tax-reform regime. Cohorts in figure 3 are identified by year of death. Thus, the welfare number for period 1 of the transition path represents the loss by an individual age 75 (fifty-fifth year of life) at the time the tax-reform regime becomes effective. All cohorts alive in the initial (linear-rate) steady state have died by period 55 of the transition path. The three sets of losses shown in figure 3 are calculated from the benchmark model and from two alternative parameterizations with different choices for the intertemporal elasticity of substitution in leisure.

In the long run, tax reform generates welfare losses, with the magnitude of the loss positively related to individuals' willingness to shift leisure intertemporally. The intuition for this relationship between welfare costs and σ_l can be appreciated by recalling that, because heterogeneity in the steady state is due strictly to life-cycle characteristics, the highest incomes in the model are earned by individuals who are at their peak levels of labor productivity. As shown in figure 2, this is exactly the period of the life cycle for which tax reform implies higher marginal tax rates relative to the linear-rate regime. The distortions on labor supply created by this fact are magnified for higher degrees of willingness to substitute leisure across periods of life. Thus, an apparently important factor in the relative efficiency of the linear-rate structure is that, for roughly the same degree of progressivity, the marginal tax rate faced by the highest-income individuals is lower than in the tax-reform case.

The welfare effects apparent in figure 3 arise primarily from the direct distortions of the tax-reform code vis-à-vis the hypothesized linear-rate code, not from general equilibrium effects associated with changes in interest rates and wages.[15] In figure 4, we compare the welfare effects for the benchmark model with the effects obtained when the entire path of interest rates and wages is held fixed at the initial steady-state values. Although general equilibrium effects mitigate the welfare losses, the picture that emerges is little changed by the partial equilibrium assumption, especially in the long run. Note, however, that general equilibrium effects have a significantly greater impact on older cohorts alive at the time of the regime change.

Finally, we consider the welfare consequences when the linear-rate structure is chosen according to the deduction-based method for equalizing revenues. Figure 5 shows the results of welfare calculations for these experiments. Relative to the intercept-adjusted experiments, the long-run welfare losses of tax reform are

■ **14** Full wealth, Ω, is defined as the present value of wage income when the entire time endowment is allocated to labor. Thus,

$$\Omega = \varepsilon_1 w_b + \sum_{t=2}^{55} \frac{\varepsilon_t w_{b+t-1}}{\prod_{i=2}^{t} (1 + r_{b+i-1})}.$$

■ **15** Recall that for the simulations in this section, we assume that lump-sum taxes and transfers maintain zero net tax payments for every cohort at every point in time. Therefore, wealth effects arise only as a result of changes in the aggregate levels of capital and labor, which are in turn reflected in interest rates and wages.

FIGURE 4

Welfare Loss Due to Tax Reform: Partial versus General Equilibrium

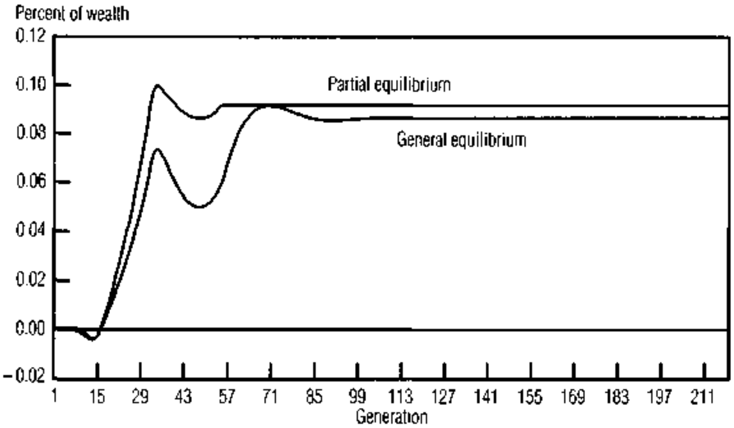


FIGURE 5

Welfare Loss Due to Tax Reform: Deduction-Adjusted Results

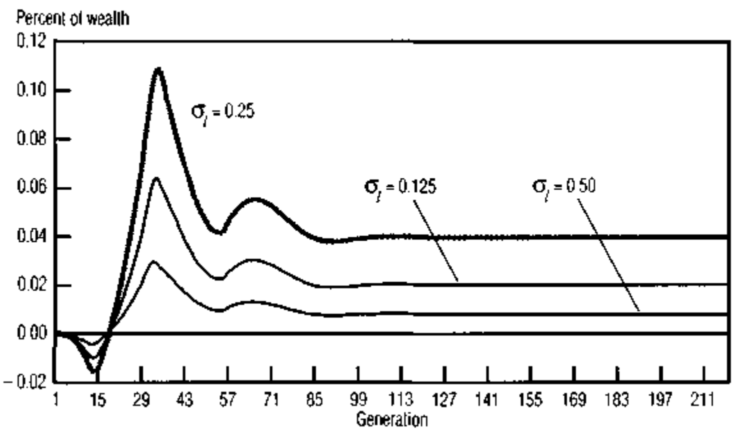
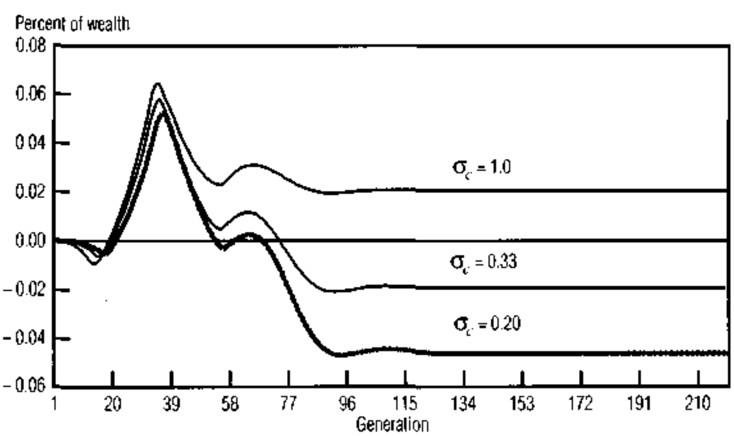


FIGURE 6

Welfare Loss Due to Tax Reform: Alternative Consumption Elasticities



NOTE: Each x on the horizontal axis corresponds to the oldest generation alive x periods after the tax regime change.
SOURCE: Authors' calculations.

somewhat lower when revenues are equalized in the linear-rate code by adjusting deductions. However, as reported in table 2, equalizing revenues by deduction adjustments results in greater average-tax progressivity than does either the intercept-adjusted linear code or the tax-reform code. Essentially, the increase in marginal rates on high-productivity/high-asset cohorts associated with tax reform is smaller when taxes are equalized by increasing deductions in the linear code, resulting in smaller long-run welfare losses.

This last observation underscores a critical point that bears reemphasizing. The relative welfare effects of each of the tax structures we consider are dependent on the relative levels of marginal tax rates necessary to preserve revenue neutrality. The discrete code examined here generates welfare losses because a linear-rate code with similar average-tax progressivity (or less progressivity, for that matter) allows the application of lower rates to the critical high-income cohorts.

Finally, figure 6 presents the same experiments for different degrees of intertemporal elasticity of substitution for consumption.[16] Note especially that as consumers become less willing to substitute consumption across time, tax reform actually generates long-run welfare gains. However, welfare losses persist for the early years following the introduction of tax reform. This observation raises the interesting question of whether, for certain parameter choices, long-run welfare gains are large enough to offset short-run losses. We turn to this issue next.

IV. Efficiency Effects

The pattern of welfare effects in figures 3–5 clearly indicates that the contemplated shifts from the tax-reform regime result in efficiency losses. However, the welfare calculations presented do not provide a simple measure that summarizes the economic cost of such changes. Furthermore, as shown in figure 6, there are long-run welfare *gains* for some plausible alternatives to the benchmark model. For these cases, the question is open regarding whether the shift to the tax-reform regime can be con-

■ **16** Recall that, given the preference specification in equation (11), equilibrium outcomes in the model are not invariant to the scale of the model when $\sigma_c \neq 1$. There are, however, other utility functions that allow more flexibility in the choice of the intertemporal consumption elasticity while preserving scale invariance, albeit at the cost of less flexibility in choosing intertemporal leisure elasticity.

TABLE 3

Efficiency Losses Due to Tax Reform (percent of wealth)

	Revenues Equalized by Adjusting Intercept in the Linear-Rate Code	Revenues Equalized by Adjusting Deductions in the Linear-Rate Code
Benchmark	0.139	0.058
σ_l = 0.17	0.065	0.027
= 0.50	0.235	0.103
β = 1.005	0.080	0.030
= 0.976	0.211	0.088
σ_c = 0.20	0.162	0.074
= 0.33	0.151	0.069
δ = 0.07	0.160	0.066
σ_l = 0.20	0.362	0.165
β = 0.971	0.362	0.165
δ = 0.07	0.362	0.165

SOURCE: Authors' calculations.

structed to maintain positive long-run welfare gains for some generations without diminishing the lifetime utility of any other.

In this section, we develop a measure of the efficiency costs of shifting from the hypothesized linear-rate codes. Furthermore, for cases that generate gains for some generations, we ask whether there exists a set of transfers that preserves positive long-run gains while eliminating all welfare losses of cohorts alive along the post-reform transition path.

To these ends, we calculate an efficiency measure in the spirit of the one introduced in Auerbach, Kotlikoff, and Skinner (1983). Specifically, let $s=1$ be the time at which tax reform is introduced. To obtain our efficiency measure, we ask how much wealth can be taken away from cohorts born on or after $s=1$ following the implementation of a fiscal policy with the following characteristics:[17]

(a) The government first introduces lump-sum taxes and transfers so that the lifetime utility of all generations is maintained at the steady-state level realized in the initial, linear-rate regime. For instance, in figure 6, cohorts experiencing welfare losses would receive transfers while those enjoying welfare gains would be taxed.

(b) Following the policy in (a), the government's long-run budget will be in surplus if the present value of taxes exceeds the present value of transfers, or in deficit if the converse is true. Because the long-run budget must balance, the government must choose a sequence of other transfers (for the surplus case) or taxes (for the deficit case) so that the present value of taxes less transfers equals zero. For the purpose of constructing our efficiency measure, we assume that the budget is balanced by imposing lump-sum taxes, or by granting lump-sum transfers, that are a constant fraction of the full wealth of all generations born after the tax reform.

If, after policy steps (a) and (b), generations along the transition path and in the new steady state are worse off, our efficiency measure is negative and equal to the percentage wealth loss suffered by each. A more detailed sketch of our procedure is offered in the appendix.

Table 3 reports the results of efficiency calculations for alternative parameterizations of the model. Losses are associated with all of the cases considered, even those in which there is a long-run welfare gain from shifting to tax reform. Thus, the short-run losses that occur in figure 6 dominate the long-run gains.

For the benchmark model, the shift to the tax-reform code results in an efficiency loss of 0.14 percent of full wealth when revenues are equalized by adjusting the intercept of the linear-rate schedule. More generally, calculated losses range from 0.08 to 0.36 percent, depending on the chosen parameters. When revenues are equalized by adjusting deductions, the efficiency losses are uniformly smaller, but still range from 0.03 to 0.17 percent of full wealth. As shown, losses increase with individuals' willingness to shift resources intertemporally, again reflecting the fact that high-tax periods correspond to periods of high relative saving rates and high labor productivity.

To put some perspective on the magnitude of the efficiency losses, full wealth for each cohort in the tax-reform steady state is about 63 percent of total output. Thus, a reduction in full wealth of 0.14 percent represents an annual loss equal to about 0.09 percent of output in the model. Converting full wealth in the model to 1989 dollars implies an efficiency loss equivalent to roughly $1,418 per person born (or reaching working age) after the regime change.

17 Auerbach, Kotlikoff, and Skinner refer to the hypothetical government agency that implements these policies as the "Lump Sum Redistribution Authority."

V. Concluding Remarks

Significant reductions in the number of marginal tax-rate brackets — that is, a trend toward structuring systems of personal income taxation such that there exist wide bands of income over which marginal tax rates are flat — have been a striking characteristic of worldwide tax reform over the past decade. In this paper, we argue that this trend is not obviously accounted for by appealing to the efficiency gains inherent in tax codes with just a few brackets separated by discrete-rate jumps. Relative to revenue-neutral linear-rate structures, changing to a simple two-bracket discrete-rate structure creates efficiency losses in all of the numerical experiments we conduct. Furthermore, in most cases welfare gains are uniformly negative, even in the long run.

Two explanations come immediately to mind for the discrepancy between the reality of recent tax reforms and the results of our analysis. First, our analysis is conducted in a purely life-cycle framework. Hence, in steady-state equilibria, all cohorts face exactly the same life-cycle profile of relatively high taxes during periods of peak productivity and saving. The inefficiency of the discrete code that we consider follows in important ways from the fact that, holding average-tax progressivity constant, shifting from an equal-revenue linear code requires marginal tax-rate increases during this phase of the life cycle.

It is reasonable to conjecture that these effects would be mitigated in a more general framework that included intracohort heterogeneity. For instance, suppose that there existed two types of agents, "rich folks" and "poor folks." It is conceivable that the two-bracket tax code could be structured so that the shift from the linear tax would result in poor folks facing only the lower rate and rich folks facing only the higher rate over their entire lives. In this event, the discrete tax code would be equivalent to a flat-tax regime, which would almost certainly create welfare and efficiency gains. In a slightly less extreme case, some portion of each cohort would face the life-cycle pattern of rates on which we have focused, while for others, the poor-folk/rich-folk scenario would be relevant.

We have, however, conducted experiments in which we relax the representative life-cycle agent characteristic of the model presented in this article. In particular, we have replicated several of our welfare experiments in a framework that includes 13 distinct life-cycle agent types with varying degrees of lifetime wealth and income. The qualitative aspects of our results are unchanged by this extension.

A second explanation for the widespread adoption of rate-bracket reductions is that, perhaps for administrative or political reasons, they are a necessary concomitant to lowering the level of tax rates and to the various base-broadening measures that also characterized tax reform in the 1980s. In this case, the approach advocated by Slemrod (1990), which emphasizes the broad institutional framework in which tax policy is chosen, may ultimately be necessary to fully understand the consequences of the income tax systems that have undeniably come to dominate industrialized economies.

Appendix

Notes on Calculating Efficiency Gains

Our efficiency calculations require extending the government sector so that an individual's budget constraint becomes

$$(A1)\quad a_{t,s} = (1+r_s)a_{t-1,s-1} + \varepsilon_t w_s(1-l_{t,s}) + v_{t,s} - T(y^*_{t,s}) + z_{t,s} - c_{t,s}.$$

The only difference between the above equation and equation (2) in the text is the addition of $z_{t,s}$, which represents the net lump-sum transfers (negative numbers represent taxes) in excess of those necessary to offset income tax collections. Given this definition, the per capita level of debt evolves according to the relationship

$$(A2)\quad D_s = (1+r_s)\frac{D_{s-1}}{1+n} - Z_s,$$

where

$$(A3)\quad Z_s = \sum_{t=1}^{55}(1+n)^{55-t} z_{t,s}.$$

Letting $s = 1$ be the first period of the transition path and normalizing the population at $s = 1$ to unity, intertemporal budget balance for the government requires that

$$D_1 = Z_1 + \sum_{s=2}^{\infty} \frac{Z_s(1+n)^{s-1}}{\prod_{i=2}^{s}(1+r_i)} \quad \text{(A4)}$$

The algorithm for obtaining our efficiency measure proceeds in the following steps:

(i) Conjecture a sequence of interest rates for the transition path and the new (tax-reform) steady state.

(ii) Calculate the present value of lump-sum taxes, net of lump-sum transfers, that would be needed to maintain all cohorts at the initial steady-state level of utility. Refer to the resulting number as the "utility-compensation surplus," or UCS. If positive, the UCS determines the present value of transfers that can redistributed by the government while maintaining long-run budget balance. If negative, the UCS determines the present value of taxes that must be raised to maintain budget balance.

(iii) Maintain the utility level of all cohorts alive at the time of the tax regime change, so that the government budget balance is satisfied by solving for the constant tax or transfer (as a percentage of each cohort's full wealth) that can be applied to all subsequent cohorts while just exhausting the UCS.

(iv) Use the path of taxes and transfers from steps (ii) and (iii), along with the associated path of government debt implied by equation (A2), to recalculate the entire problem, as described in section II.

(v) Update interest rates and the UCS until the procedures converge to an equilibrium that satisfies public and private budget constraints, all market-clearing conditions, and the first-order conditions governing individual consumption and leisure choices. Once the problem has converged, the efficiency gain is the percentage of full wealth that is redistributed to (or taken from) all cohorts born after the change in tax regime, as calculated in step (iii).

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