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THE WELFARE EFFECTS OF TAX SIMPLIFICATION: A GENERAL-EQUILIBRIUM ANALYSIS

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ABSTRACT

This paper employs a dynamic general-equilibrium model to analyze various schemes for simplifying the U.S. tax system, such as a uniform tax levied on all types of income regardless of source, and the elimination of specific tax breaks like the depreciation allowance. Under each scheme, the government selects a balanced-budget fiscal policy (consisting of tax rates and the level of public expenditures) which maximizes household welfare given the constraints imposed by the particular tax system. We find that a uniform tax system does almost as well as a system with separate taxes on labor and capital incomes, provided that a depreciation allowance is maintained. Without the depreciation allowance, a uniform tax system significantly reduces household welfare, even though marginal tax rates are lower under this scheme. The welfare differences between the various distortionary tax systems are much smaller than the potential welfare gains from switching to a system of nondistortionary, lump-sum taxes. The various tax systems are also shown to display very different behavior for the movement of tax rates and aggregate economic variables over the business cycle.

1. Introduction

Every year, Congress passes a bill that tinkers in some way with our tax system. During the 1980s however, two major tax bills were enacted that fundamentally altered the structure of the federal income tax: the Economic Recovery Tax Act of 1981 (ERTA) and the Tax Reform Act of 1986 (TRA). Although many changes to the tax code have been made since ERTA and TRA, the current U.S. tax system derives most of its basic structure from these two laws. In this paper, we first review the basic features of these tax laws and then construct a dynamic general-equilibrium model to analyze an issue which is closely linked to tax reform, namely, tax simplification. Our primary finding is that a simplified system which involves a uniform tax levied on all types of income does almost as well as a more complicated system with separate tax rates on labor and capital income, provided that a depreciation allowance is maintained.

In 1981, ERTA imposed a dramatic 23 percent, across-the-board cut in all marginal tax rates, and reduced the top marginal rate for individual income from 70 to 50 percent. Statutory marginal rates were scaled back to levels similar to those that prevailed in 1965. In addition, ERTA introduced new incentives for investment and saving, such as an increased investment tax credit, a generous accelerated depreciation schedule, and an extension to the eligibility rules for Individual Retirement Accounts (IRAs).[1] ERTA also helped to eliminate "bracket creep" by indexing tax brackets, personal exemptions, and the standard deduction for inflation.

In 1986, TRA brought about the most significant overhaul of the federal tax system since its inception in 1913. The act lowered marginal tax rates for individuals and corporations, dramatically reduced the number of tax brackets, broadened the tax base by eliminating or reducing many tax breaks, and helped to "level the playing field" by reducing the dispersion of marginal tax rates across alternative income-producing activities. Also, the lowering of marginal rates reduced the attractiveness of tax evasion and tax avoidance activities. Because of these features, TRA was viewed as taking a significant step toward the goal of achieving a simpler, more efficient federal tax system. An important result of

[1] Some of the investment incentives in ERTA, such as the generous accelerated depreciation schedule, were scaled back somewhat by the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA). See *Economic Report of the President*, 1987 and 1989.

TRA, and one which we will focus on here, was that average marginal tax rates on labor and capital income were brought closer together. The figures in table 1, taken from *Economic Report of the President*, illustrate this point.[2]

Table 1: Average Marginal Tax Rates before and after TRA 1986

Source of Income	Before TRA	After TRA
Labor Income	41.6	38.0
Capital Income	34.5	38.4

Source: *Economic Report of the President*, 1987, Table 2-6, page 91.

TRA also reduced the variation in marginal tax rates within each category of income. In the labor income category, the number of individual income brackets was reduced to only two, set at 15 and 28 percent.[3] In the capital income category, TRA eliminated the investment tax credit (which, under ERTA, had applied to equipment but not structures), eliminated the capital gains preference by taxing gains as ordinary income, decelerated depreciation allowances on real estate, imposed limitations on passive business and real estate losses, and phased out the deductibility of nonmortgage consumer interest. Furthermore, the lowering of personal marginal rates and the top corporate tax rate reduced the attractiveness of tax shelters.

By imposing a more uniform tax on alternative sources of income, TRA attempted to eliminate incentives in the tax code that had directed resources to less productive activities offering high *after-tax* returns. These perverse incentives result in a loss of output and a reduction in economic welfare. In addition, a simpler, more efficient tax system could be expected to contribute to increased compliance and lower administration costs.

In this paper, we examine the issue of tax simplification using a dynamic general-equilibrium model which is calibrated to the U.S. economy. Based on the results of TRA, tax simplification is

[2]For additional description and analysis of TRA 1986, see Slemrod (1991) and the two symposia in *The Journal of Economic Perspectives*, Summer 1987 and Winter 1992.

[3]For high-income individuals, the 15 percent tax bracket and the personal exemption were phased out, creating an implicit third bracket, at 33 percent. Before TRA, there were fourteen tax brackets ranging from 11 to 50 percent. In 1990, the Omnibus Budget Reconciliation Act (OBRA90) created a new statutory bracket at 31 percent. OBRA93, enacted in August 1993, added two statutory brackets for high-income individuals. With OBRA93, there are now five statutory brackets at 15, 28, 31, 36 and 39.6 percent. See *Economic Report of the President*, 1994, Table 1-4, p. 34.

modeled as a system which imposes a uniform tax on all types of income, regardless of source. The more complicated system in our model is one in which capital and labor income are taxed at different rates. A basic principle underlying TRA was to broaden the tax base by eliminating tax breaks, thus allowing revenue requirements to be met with lower marginal rates. We capture this principle by eliminating the model's only tax break, the depreciation allowance. We compare the uniform tax system, with and without the depreciation allowance, to the more complicated tax system. We also compare all three systems to one that employs nondistortionary, lump-sum taxes. The various tax systems are evaluated in terms of economic welfare (as measured by steady-state household utility), output (as measured by steady-state GNP), and business-cycle characteristics (as measured by the relative standard deviations and cross-correlations of aggregate economic variables).

Under each scheme, the government chooses a balanced-budget fiscal policy that maximizes household welfare, given the constraints imposed by the particular tax system. In this way, we endogenize the choice of fiscal policy, which consists of a set of stationary decision rules for tax rates and the level of public expenditures. Our approach differs from that of Cooley and Hansen (1992), who evaluate the welfare effects of various combinations of *exogenous* tax rates.

From the perspective of choosing an optimal fiscal policy, a uniform tax system imposes an additional constraint on the government's decision problem, namely, that the tax rate on capital income must be equal to the tax rate on labor income. Because a policy of equal tax rates is available to the government, but not chosen, under the complicated system, we know that the additional constraint is binding and thus results in a lower level of household utility than in the unconstrained case. Our aim is to quantify this welfare effect and to evaluate the additional impact of the depreciation allowance.

We find that the difference in welfare between the complicated system and the simplified tax system with a depreciation allowance is less than 0.1 percent of GNP, or $23 per person per year in 1993. The steady-state output loss associated with this version of the simplified tax system is slightly less than 1 percent of GNP. These results suggest that a uniform tax system could actually be welfare-improving if sufficient cost saving were realized in the areas of compliance and administration. Without the depreciation allowance, a uniform tax system significantly reduces household welfare and steady-state output, as compared to both the complicated system and a uniform tax system with a depreciation allowance. Household welfare is reduced by approximately 2 percent of GNP or $523 per person per year in 1993. The output loss is over 4 percent of GNP. Eliminating the depreciation allowance reduces household welfare because this tax break operates as an implicit subsidy to capital accumulation, and partially offsets the income tax distortion. This is true even though the marginal tax rate on capital income is lower under a system with no depreciation allowance. Because of the government's desire to tax profits as much as possible, a high tax rate on capital combined with a full depreciation allowance is superior to a low tax rate on capital combined with no depreciation allowance. Our result points out the important role played by the depreciation allowance in encouraging capital accumulation. Thus, the inflation-induced erosion of unused nominal depreciation allowances, which are carried over from year to year in historical cost terms, may impose a significant welfare cost on the U.S. economy.[4]

Moreover, we find that the welfare differences between the various distortionary tax systems are much smaller than the potential welfare gains from switching to a system of nondistortionary, lump-sum taxes. Our calculations indicate that distortionary taxes impose a welfare cost exceeding 14 percent of GNP. Because of distributional issues and concerns over the perceived fairness of the tax code, we do not view the lump-sum tax system as a realistic policy option. However, it does provide a useful benchmark for our analysis.

Finally, we show that the various tax systems have very different implications for the comovement and relative variability of tax rates and aggregate economic variables over the business cycle. Under the complicated tax system, the capital tax moves countercyclically and displays high variability because it is used to absorb shocks to the government's budget constraint. In the model, budget shocks are caused by changes in the size of the tax base due to business-cycle fluctuations. Under the simplified tax system, government expenditures are much more variable because a separate instrument for absorbing budget shocks is not available. Also, for a given variance of the technology shock, we find that output, consumption, and hours worked are more variable under a system of lump-

[4]Judd (1989) emphasizes this point by treating the inflation erosion of unused depreciation allowances as an effective increase in the tax rate on capital. See Altig and Carlstrom (1991) for a business-cycle model that incorporates inflation's effect on the nominal taxation of capital income. Pecorino (1993) examines the growth effects of the depreciation allowance in an endogenous growth model.

sum taxes than under any of the distortionary systems. This occurs because movements in distortionary tax rates tend to offset the effects of technology shocks, thus resulting in lower output variability.

The remainder of this paper is organized in the following manner: Sections 2 and 3 describe the model and the solution method. The choice of parameter values is discussed in section 4. Section 5 presents quantitative welfare comparisons based on steady-state analysis. In section 6, we examine the business-cycle characteristics of the various tax schemes. Section 7 provides concluding remarks.

2. The Model

The model economy consists of many identical, infinitely lived households, identical private firms, and the government. Households derive direct utility from government-provided public goods which are financed by taxes on households and firms. Following Benhabib and Farmer (1994), we assume that firms exert some degree of monopoly power over the production of intermediate goods so that they realize positive economic profits even though the market for final goods is perfectly competitive. The profits are equal to the difference between the value of output and the payments to labor and capital inputs. The purpose of introducing profits is to obtain a positive optimal tax rate on capital, consistent with U.S. observations.[5] As owners of the firms, households receive net profits in the form of dividends, but consider them to be outside their control, similar to wages and interest rates. It is assumed that profits are initially taxed at the firm level, then distributed as dividends and taxed again at the household level. This formulation is intended to capture the double taxation of corporate dividends in the U.S. economy. Furthermore, in the complicated tax system, we assume that the government can distinguish between labor and capital income, but cannot distinguish between the different categories of capital income, such as profits, dividends, and capital rental income. Therefore, the complicated system includes only two types of distortionary taxes: a labor tax and a capital tax.

[5] Jones, Manuelli, and Rossi (1993b) show that the existence of profits and a restriction on the menu of available tax instruments (the absence of a separate profits tax) is one method of obtaining a positive optimal tax rate on capital in the steady state. Without profits, the optimal steady-state tax on capital is zero (see Judd [1985] and Chamley [1986]).

2.1 The Household's Problem

Households maximize a discounted stream of within-period utility functions over consumption and leisure, subject to a sequence of budget constraints. The decision problem can be summarized as

$$\max_{c_t, h_t, k_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln c_t - A h_t + B \ln g_t \right\} \qquad 0 < \beta < 1, \quad A, B \geq 0 \tag{1}$$

subject to

$$c_t + x_t \leq (1-\tau_{ht}) w_t h_t + (1-\tau_{kt})(r_t k_t + \hat{\pi}_t) + \phi \tau_{kt} \delta k_t - T_t, \qquad \phi = \{1, 0\} \tag{2}$$

$$k_{t+1} = (1-\delta) k_t + x_t \qquad 0 < \delta < 1, \qquad k_0 \text{ given.} \tag{3}$$

In the above equations, c_t represents private consumption goods. Households are endowed with one unit of time each period and work h_t hours during period t. Household preferences also include a separable term representing the utility provided by public consumption goods g_t. Examples of public consumption goods that might affect household utility are national defense, police protection, and government provision of food and housing during natural disasters. Public goods are assumed to be non-congestable and free of specific user charges.

Households maximize the utility function in (1) over c_t, and h_t, but view g_t as outside their control. The logarithmic form of the within-period utility function has been chosen for tractability and for comparability with previous business-cycle literature. The separability in c_t and g_t implies that public consumption does not affect the marginal utility of private consumption, a specification supported by parameter estimates in McGrattan, Rogerson, and Wright (1993). The symbol E_t is the expectation operator conditional on information available at time t, and β is the constant household discount factor.

The fact that utility is linear in hours worked reflects "indivisible labor," as described by Rogerson (1988) and Hansen (1985). This means that all variation in economywide hours is due to variations in the number of employed workers, as opposed to variations in hours per worker. Real business cycle models with indivisible labor are better able to match some key characteristics of aggregate labor-market data. Specifically, U.S. data display a large volatility of hours worked relative to labor productivity and a near-zero correlation between hours and productivity.[6]

Equation (2) represents the period budget constraint of the household. The terms x_t and k_t represent gross private investment and private capital, respectively. Households derive income by supplying labor and capital services to firms at rental rates w_t and r_t, and pay taxes on labor and capital income at rates τ_{ht} and τ_{kt}, respectively. The term T_t represents a lump-sum tax. An additional source of income is the firms' net profits $\hat{\pi}_t$, which are distributed to households as dividends and are taxed at the same rate as capital rental income $r_t k_t$. The term $\phi \tau_{kt} \delta k_t$ represents the depreciation allowance, where the parameter ϕ can be set to either 1 or 0, depending on whether this tax break is maintained in the simplified tax system. Equation (3) is the law of motion for private capital, given a constant rate of depreciation δ. Households view tax rates, wages, interest rates and dividends as determined outside their control.

2.2 Household Optimality

The Lagrangian for the households' problem is defined as:

$$\mathfrak{L} = E_0 \sum_{t=0}^{\infty} \beta^t \Big\{ \ln c_t - A h_t + B \ln g_t + \lambda_t \big[(1-\tau_{ht}) w_t h_t + (1-\tau_{kt})(r_t k_t + \hat{\pi}_t) + \phi \tau_{kt} \delta k_t - T_t - k_{t+1} + (1-\delta) k_t - c_t \big] \Big\}. \tag{4}$$

The household first-order conditions with respect to the indicated variables and the associated transversality conditions (TVC) are:

[6]See Hansen (1985), and Christiano and Eichenbaum (1992).

$$
\begin{aligned}
c_t: &\qquad \lambda_t = \frac{1}{c_t} \\
h_t: &\qquad \lambda_t (1-\tau_{ht}) w_t = A \\
k_{t+1}: &\qquad \lambda_t = \beta E_t \lambda_{t+1} \left[(1-\tau_{kt+1}) r_{t+1} - (1-\phi \tau_{kt+1})\delta + 1 \right] \\
TVC: &\qquad \lim_{t \to \infty} E_0 \beta^t \lambda_t k_{t+1} = 0.
\end{aligned}
\tag{5}
$$

The government's problem is solved by finding the set of utility-maximizing allocations c_t, h_t and k_{t+1}, such that the household's first-order conditions (5) and budget constraint (2) are satisfied. Given these optimal allocations, the government uses the household equilibrium conditions to recover the appropriate tax rates τ_{ht} and τ_{kt} that will support these allocations in a decentralized economy.[7]

2.3 The Firm's Problem

The firm's problem is based on the model developed by Benhabib and Farmer (1994). A unique final good y_t is produced out of a continuum of intermediate goods y_{it}, $i \in [0,1]$, using the following constant-returns-to-scale technology: $y_t = [\int_0^1 y_{it}^{\chi} \, di]^{1/\chi}$, $0 < \chi < 1$. We assume that the final goods sector is perfectly competitive, but that intermediate goods producers each exert a degree of monopoly power that is captured by the parameter χ. In the special case when $\chi = 1$, all intermediate goods are perfect substitutes in the production of the final good, and the intermediate sector becomes perfectly competitive. All intermediate goods are produced using the same technology with labor and capital as inputs:

$$
y_{it} = \exp(z_t)\, k_{it}^{\alpha_1} h_{it}^{\alpha_2}, \qquad \text{where} \quad 0 < \alpha_i < 1, \quad \alpha_1 + \alpha_2 \geq 1, \tag{6}
$$

$$
z_{t+1} = \rho_z z_t + \varepsilon_{t+1} \qquad 0 < \rho_z < 1, \quad \varepsilon_t \sim \text{iid}\,(0, \sigma_\varepsilon^2), \quad z_0 \text{ given.} \tag{7}
$$

Notice that equation (6) allows for the possibility of increasing returns to scale in the production

[7] See Chari, Christiano, and Kehoe (1993) for a more complete discussion of this equilibrium concept.

of intermediate goods.[8] The intermediate technology is subject to economywide exogenous shocks (z_t), which are revealed to agents at the beginning of period t. These shocks generate equilibrium business-cycle fluctuations in the model. Due to their monopoly power, producers of intermediate goods earn an economic profit which is taxed at the rate τ_{kt}.

Under the assumption that factor markets are competitive, a *symmetric equilibrium* ($k_{it}=k_t$ and $h_{it}=h_t$ for all i) implies the following expressions for the aggregate production function ($y_t=y_{it}$), the rental rate of capital, and the real wage.

$$y_t = \exp(z_t) k_t^{\alpha_1} h_t^{\alpha_2}, \qquad r_t = \theta_1 \frac{y_t}{k_t}, \qquad w_t = \theta_2 \frac{y_t}{h_t}, \tag{8}$$

$$\text{where} \quad \theta_1 \equiv \chi\alpha_1 \quad \text{and} \quad \theta_2 \equiv \chi\alpha_2.$$

From (8), the aggregate technology can be rewritten as

$$y_t = \exp(z_t)\left[k_t^{\theta_1} h_t^{\theta_2}\right]^{\frac{1}{\chi}}, \qquad \text{where} \quad (\theta_1+\theta_2)\frac{1}{\chi} \geq 1. \tag{9}$$

Depending on the value of χ, the aggregate technology can demonstrate either constant or increasing returns to scale. The after-tax profits, distributed to households in the form of dividends, are

$$\hat{\pi}_t = (1-\tau_{kt})(1-\theta_1-\theta_2)\, y_t. \tag{10}$$

2.4 The Government's Problem

The government chooses an optimal program of taxes and public expenditures in order to maximize the discounted utility of the household. The vector $\mathcal{P}_t = \{ g_t, \tau_{ht}, \tau_{kt}, T_t \}$ summarizes government policy implemented at time t. This is a dynamic version of the Ramsey (1927) optimal tax problem, involving a Stackelberg game between the government and households. To avoid time-consistency problems, we assume that the government can commit to a set of state-contingent, stationary policy rules announced at time zero. Also, to make the problem interesting, we rule out any time-zero

[8]See Benhabib and Farmer (1994) and Farmer and Guo (1994) for more details regarding this formulation.

levies on private-sector assets that might be used to finance all future expenditures. In addition, we assume that the government adheres to a period-by-period, balanced-budget constraint.[9] With these assumptions, the government's problem is

$$\max_{g_t, \tau_{ht}, \tau_{kt}, T_t} E_0 \sum_{t=0}^{\infty} \beta^t \{U(c_t, h_t, g_t)\}$$

subject to:

(i) household first-order conditions and budget constraint,

(ii) firm profit maximization conditions,

$$\begin{aligned} &(iii) \quad g_t = \tau_{ht} w_t h_t + \tau_{kt}(r_t - \phi\,\delta) k_t + \left[1 - (1 - \tau_{kt})^2\right](1 - \theta_1 - \theta_2) y_t + T_t, \\ &(iv) \quad \phi = 1, \quad T_t = 0, \quad \text{for the complicated tax system}, \\ &(v) \quad \tau_{ht} = \tau_{kt} = \tau_t, \quad \phi = \{1, 0\}, \quad T_t = 0, \quad \text{for the simplified tax system}, \\ &(vi) \quad \tau_{ht} = \tau_{kt} = 0, \quad T_t = g_t, \quad \text{for the lump-sum tax system}. \end{aligned} \tag{11}$$

Constraints (i) and (ii) summarize rational maximizing behavior on the part of private agents and constitute "implementability" constraints imposed on the government's choice of policy. Constraint (iii) is a general version of the government budget constraint, where the squared term on the right-hand side reflects the double taxation of firm dividends. Finally, (iv) through (vi) specify the constraints associated with each of various tax systems we intend to analyze. The summation of the household budget constraint (2) and the government budget constraint (iii) yields the following resource constraint for the economy:

$$y_t = c_t + x_t + g_t. \tag{12}$$

Because the resource constraint and the government budget constraint are not independent

[9]Adding government debt to the model introduces complications that we wish to avoid here. Specifically, equilibrium for a model with debt and capital imposes an ex ante arbitrage condition on the expected returns from government bonds and private capital. The steady-state level of debt is thus indeterminate (see Chamley [1985]). Furthermore, in a stochastic environment, the government can vary the ex post combination of the capital tax and the bond interest rate in many different ways to raise needed revenue, yet still satisfy ex ante arbitrage (see Zhu [1992] and Chari, Christiano, and Kehoe [1993]). Excluding government debt allows us to pin down a unique time path for the optimal capital tax.

equations, equation (12) will be used in place of (*iii*) in solving the government's problem.

3. Solution of the Model

The government's problem under commitment can be solved using the recursive algorithm developed by Kydland and Prescott (1980). A recursive structure is obtained by defining the household lagged shadow price λ_{t-1} as a "pseudo-state variable." Including λ_{t-1} in the state vector provides a link to the past by which the policymaker at time t considers the fact that household decisions in *earlier* periods depend on *current* policy by means of expectations. This is the mechanism by which the commitment problem can be solved using dynamic programming. Appendix A describes the procedure for formulating the recursive version of (11) and numerically solving the dynamic programming problem.

4. Calibration of the Model

To obtain quantitative welfare estimates from the model, as many parameters as possible are assigned values in advance on the basis of empirically observed features of postwar U.S. data. Parameter choices are also guided by the desire to obtain steady-state values for key model variables that are consistent with long-run averages in the U.S. economy. Table 2 summarizes the choice of parameter values and is followed by a brief description of how they were selected.

Table 2: Parameter Set

Agent	Parameters and Values			
Households	$\beta = 0.962$	$A = 2.50$	$B = 0.35$	
Firms	$\theta_1 = 0.31$ $\theta_2 = 0.60$	$\chi = 0.91$	$\delta = 0.07$	$\rho_z = 0.85$ $\sigma_\varepsilon = 0.02$
Government	$\phi = \{1, 0\}$			

The time period in the model is taken to be one year. This is consistent with the time frame of most government fiscal decisions and the frequency of available data on average marginal tax rates. The discount factor of β=0.962 implies an annual rate of time preference equal to 4 percent. The household utility parameter A is chosen such that hours worked in the distortionary tax systems is close to 0.3. This is in line with time-use studies, such as Juster and Stafford (1991), which indicate that households spend approximately one-third of their discretionary time in market work. The value of B is chosen to yield a steady-state value of g/GNP near 0.22, the average ratio for the U.S. economy from 1947 to 1992.

The exponents in the Cobb-Douglas production function are chosen on the basis of two criteria. First, the chosen values of θ_1 and θ_2 are in the range of the estimated shares of GNP received by capital and labor in the U.S. economy (see Christiano [1988]). Second, the model's share of GNP devoted to monopoly profits ($= 1 - \theta_1 - \theta_2$) is chosen to yield a reasonable value for the steady-state tax on capital (τ_k) in the complicated tax system. Because a separate profits tax is not available, the government uses the tax on private capital to recapture a portion of these profits. In the model, the steady-state ratio of profits to GNP is 0.09 and the resulting steady-state tax on capital is 0.30. This value of τ_k coincides with the average effective corporate tax rate in the United States from 1947 to 1980, as estimated by Jorgenson and Sullivan (1981).[10] The monopoly power parameter χ is chosen such that the aggregate production technology demonstrates constant returns to scale. The value of $\chi = 0.91$ yields $y_t = \exp(z_t)\, k_t^{0.34}\, h_t^{0.66}$. We also experiment with smaller values of χ, such that the aggregate technology is characterized by increasing returns to scale.

The private capital depreciation rate of $\delta = 0.07$ is based on the value estimated in Braun and McGrattan (1993) and is consistent with values commonly used in the real business cycle literature. Together with the values of β and θ_1, this depreciation rate implies a steady-state ratio of private capital to GNP in the range of 2.27 to 3.11 for the various tax systems, and a ratio of private investment to GNP in the range of 0.16 to 0.22. The corresponding averages for the U.S. economy from 1947 to 1992 are 2.58 and 0.21.

The process governing technology shocks was estimated using annual data from 1947 to 1992. The series for z_t was constructed by computing the changes in output not accounted for by changes in the productive inputs.[11] The estimated parameters, $\rho_z = 0.85$ and $\sigma_\varepsilon = 0.02$, represent values close to

[10] Higher profit levels imply a higher steady-state tax on capital in our model. When profits are zero ($\theta_1 + \theta_2 = 1$), the optimal steady-state tax on capital is zero. If a separate profits tax was available, the government would choose to tax profits at 100 percent and ordinary capital income ($r_t k_t$) at zero percent (see footnote 5).

[11] The production function residual was measured as $z_t = \ln GNP_t - 0.34 \ln k_t - 0.66 \ln h_t$. The private capital stock k_t is defined as fixed private capital + stock of consumer durables + residential capital from *Fixed Reproducible Tangible Wealth in the United States*, U.S. Department of Commerce (1993). Real GNP and the labor input (h_t = LHOURS) are from Citibase.

those estimated by other studies using annual data, such as Benhabib and Jovanovic (1991). In the simulations, the estimated value of σ_ε yields a standard deviation of output in the range of 1.74 to 2.96 percent. The U.S. average over this period is 2.46 percent.

5. Steady-State Welfare Analysis

Based on our choice of parameter values, table 3 shows the steady-state values of key model variables for each of the various tax systems. Of the three distortionary tax systems, the complicated system has the highest level of steady-state utility and the largest output, followed closely by the simplified system with a depreciation allowance. Table 4 indicates that the difference in utility between these two systems is less than 0.1 percent of GNP, which translates to a loss of $23 per person per year in 1993.[12] To put this number in perspective, Cooley and Hansen (1991) estimate the welfare cost of a 5 percent annual inflation to be 0.34 percent of GNP annually.

The simplified tax system could actually be welfare-improving if sufficient cost savings were realized in the areas of compliance and administration. However, the necessary savings represent about 9 percent of the estimated total resource cost of administering the federal tax system.[13] Cost savings of this magnitude would appear to be very difficult to achieve. Also, the simplified system's lack of an explicit capital tax may be undesirable from the standpoint of redistributing resources in an economy where wealth is highly concentrated in the hands of rich taxpayers.[14]

When the depreciation allowance is eliminated from the simplified system, household welfare is reduced by over 2 percent of GNP, or $523 per person per year in 1993. Eliminating the depreciation allowance reduces household welfare because it operates as an implicit subsidy to capital accumulation,

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[12]This figure is based on a nominal GNP of $6,510 billion and a total U.S. population of 258.2 million in 1993.

[13]Rosen (1992, p. 351) estimates the total resource cost of administering the federal tax system to be $35.3 billion in 1982, or 1.11 percent of 1982 GNP. If we assume that the ratio of resource cost to GNP is approximately the same in 1993, and that the necessary cost savings to make the simplified system desirable amount to 0.1 percent of GNP, then the necessary savings represent 9 percent (=0.1/1.11) of the total resource cost.

[14]In the United States, the top 20 percent of households own about 80 percent of total wealth and earn about 42 percent of pretax income. See McDermed, Clark, and Allen (1989), figures 13.1 and 13.2, and Rosen (1992), table 8.1. See Lansing (1994b) for an optimal tax model with rich and poor households.

and partially offsets the income tax distortion. This is true even though the marginal tax rate on capital income (τ_t) is lower under this scheme. Because of the government's desire to tax profits as much as possible (see Jones, Manuelli and Rossi [1993b]), a high tax rate on capital income combined with a full depreciation allowance is superior to a low tax rate on capital income combined with no depreciation allowance.[15]

Table 5 indicates that the welfare effects of tax simplification are much smaller than the potential welfare gains from switching to a system of lump-sum taxation. Under the complicated system, the welfare loss from distortionary taxation translates to $3,533 per person per year in 1993. However, our representative household framework abstracts from any distributional role fulfilled by a system of distortionary taxes. The lump-sum tax system should thus be viewed as a benchmark, but not as a realistic policy option.

[15]When profits are zero ($1-\theta_1-\theta_2=0$) and the government can tax labor and capital income separately, eliminating the depreciation allowance has no effect whatsoever on the steady-state allocations. This can be seen from the government's recursive problem in appendix A, for the complicated tax system ($\tau_h \neq \tau_k$); note that the depreciation allowance parameter ϕ only appears in the profit term of the (transformed) household budget constraint.

Table 3: Steady-State Comparison of Tax Systems

Variable	Complicated	Simplified w/ Depr Allow	Simplified No Depr Allow	Lump-sum	U.S. Economy[a]
Utility	-2.764	-2.766	-2.798	-2.547	n.c.
GNP $= y$	0.488	0.483	0.468	0.734	n.c.
c	0.296	0.292	0.295	0.409	n.c.
h	0.307	0.300	0.306	0.410	n.c.
g	0.107	0.106	0.098	0.166	n.c.
k/y	2.458	2.531	2.279	3.082	2.576
g/y	0.220	0.220	0.209	0.226	0.216
Tax Rate	$\tau_h = 0.22$ $\tau_k = 0.30$	$\tau = 0.25$	$\tau = 0.20$	$T/y = 0.23$	$\tau_h = 0.27, 0.23$ $\tau_k = 0.30, 0.57$ $T/y = 0.28$

[a]n.c. = not comparable. The U.S. values for k/y and g/y represent the 1947-92 averages, from Citibase.

Sources for U.S. tax rates are as follows: The two values for τ_h are averages from Barro and Sahasakul (1986), 1947-83, and McGrattan, Rogerson, and Wright (1993), 1947-87, respectively. The two values for τ_k are averages from Jorgenson and Sullivan (1981, table 11), 1947-80, and McGrattan, Rogerson, and Wright (1993), 1947-87, respectively. The value of T/y is the average of total government receipts (federal, state, and local) as a percentage of GNP, 1947-92, from *Economic Report of the President*, 1994, table B-80, p. 363.

Table 4: Effects of Tax Simplification

	Welfare and Output Loss versus Complicated Tax System[a]	
Tax System	Welfare Loss = $\Delta U/(\lambda y)$	Output Loss = $\Delta y / y$
Simplified w/ Depr Allowance	0.09 %	0.77 %
Simplified No Depr Allowance	2.08 %	4.07 %

[a]ΔU and Δy are normalized using the steady-state values of λ and y from the complicated tax system, where λ is the marginal utility of private consumption (to convert ΔU into consumption units) and y is GNP.

Source: Authors' calculations.

Table 5: Effects of Distortionary Taxes

Tax System	Welfare and Output Loss versus Lump-sum Tax System[a]	
	Welfare Loss = $\Delta U/(\lambda y)$	Output Loss = $\Delta y/y$
Complicated	14.01 %	33.56 %
Simplified w/ Depr Allowance	14.11 %	34.07 %
Simplified No Depr Allowance	16.22 %	36.26 %

[a]ΔU and Δy are normalized using the steady-state values of λ and y from the lump-sum tax system, where λ is the marginal utility of private consumption (to convert ΔU into consumption units) and y is GNP.
Source: Authors' calculations.

The welfare costs in table 4 tend to be higher for an economy with increasing returns to scale. When $\chi = 0.75$, the aggregate production technology is $y_t = \exp(z_t)\, k_t^{0.41}\, h_t^{0.80}$. In this case, the welfare losses in the first column of table 4 become 0.19 percent and 2.69 percent of GNP, respectively, for the two simplified systems.

6. Dynamic Simulation of Business-Cycle Behavior

Our simulation results (table 6 and figures 1 and 2) show that the various tax systems have very different implications for the comovement and relative variability of tax rates and aggregate economic variables over the business cycle. In the model, shocks to the government's budget constraint are caused by changes in the size of the tax base due to business-cycle fluctuations. Because we have imposed a balanced-budget restriction, government debt is not available to help smooth public expenditures when budget shocks occur. In the complicated system, however, the shock absorbing function is performed by a state-contingent capital tax, which moves countercyclically and displays high variability relative to the labor tax. For example, a positive technology shock generates more tax revenue because GNP and household incomes (the tax base) increase. This motivates a reduction in τ_{kt} because government spending requirements can be met using a lower tax rate. Absorbing shocks mainly by changes in τ_{kt}, as opposed to changes is τ_{ht}, is efficient because capital is completely inelastic within a given period, unlike labor supply.[16] The shock absorbing feature of τ_{kt} reinforces the variability of household investment, but allows the government to maintain a very smooth series for g_t / y_t, as compared to the other tax systems (see figure 2). Under the two simplified tax systems, the government prefers to absorb budget shocks mainly by increasing the variability of g_t. Changes in g_t do not affect household decisions due to the additively separable way in which g_t enters the household utility function. The government maintains a low variability in τ_t to reduce fluctuations in household labor supply. Interestingly, the simplified tax systems do a better job of matching the relatively high standard deviation of public expenditures in U.S. data. In the complicated and lump-sum tax systems, the standard deviation of g_t is much lower than the U.S. value. For these tax systems, it appears that an additional shock is needed to increase the variability of government spending.[17]

The labor tax (in the complicated system) and the uniform income tax (in both simplified systems) are procyclical (table 6b). The government uses these taxes to help smooth households' after-tax income from labor. For example, a positive technology shock is accompanied by increases in τ_{ht} and τ_t. This provides households with an implicit insurance mechanism against earnings variability, thus leading to lower standard deviations of household consumption and hours worked in the distortionary tax systems versus those in the lump-sum tax system (table 6a).

The model's prediction that the capital tax should display more variability than the labor tax is consistent with the U.S. tax rate estimates we have chosen for comparison.[18] The model disagrees with the data, however, in predicting a negative correlation between τ_{kt} and τ_{ht}. The U.S. tax rate estimates

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[16]The optimality of using a state-contingent capital tax to absorb budget shocks has been shown previously by Judd (1989) and Chari, Christiano, and Kehoe (1993). Bohn (1988) shows how nominal public debt can be used to absorb budget shocks.

[17]Adding preference shocks to households' demand for public goods (to simulate wars, for example) would increase the variability of g_t in these tax systems. See Lansing (1994a) for an optimal policy model with preference shocks.

[18]Figures 3 and 4 display the tax rate series *before* detrending. For quantitative comparisons (table 6) detrending is necessary because the U.S. labor tax displays a distinct upward trend, while the U.S. capital tax displays a downward trend. These trends have no counterpart in the model. The trend in τ_{ht} is possibly linked to the phenomenon of "bracket creep," which existed before tax schedules were indexed for inflation in 1985. Regarding the trend in τ_{kt}, Auerbach and Poterba (1988) argue that the downward trend is due to increasingly generous investment tax credits and accelerated depreciation schedules.

display a positive correlation.[19] This suggests there may be rigidities in the U.S. tax code (not accounted for in the model) that loosely connect the movement of capital and labor taxes over the business cycle. Explicit modeling of such rigidities is a topic for our future research.

Without a depreciation allowance, the simplified tax system displays wildly counterfactual behavior, predicting negative correlations with output for c_t, h_t, and x_t. This behavior can be traced to the higher variability of τ_t that results from the lack of a separate tax on capital. The variability of τ_t is such that movements in the tax rate can actually override the effects of technology shocks in determining the behavior of household consumption and investment.[20]

For a given variance of the technology shock, output is more variable under the system of lump-sum taxes than under any of the distortionary systems (table 6a). This occurs because movements in the distortionary tax rates partially offset the effects of technology shocks, resulting in lower output variability. The lump-sum tax system does a reasonably good job of matching the relative standard deviations of hours and productivity, a feature typical of indivisible labor models (see Hansen [1985]). In all three distortionary systems, however, the standard deviation of hours relative to productivity is too low, despite the presence of indivisible labor. The insurance features of the optimal tax rates are responsible for the reduced variability of hours in these systems. Similar to the case for government spending, our results suggest that an additional shock is needed in the distortionary tax models to increase the variability of hours worked. Such a specification would be consistent with the position of Aiyagari (1994), who uses a variance decomposition analysis to argue that the behavior of hours in U.S. data is driven by multiple shocks.

[19]In the U.S. data, the correlation coefficient between (detrended) τ_{ht} and τ_{kt} equals 0.41, using the τ_{ht} series from Barro and Sahasakul (1986) and the τ_{kt} series from Jorgenson and Sullivan (1981). The correlation is 0.52 using the τ_{ht} and τ_{kt} series from McGrattan, Rogerson, and Wright (1993).

[20]Except for the double taxation of dividends, the income tax with no depreciation allowance is equivalent to a production tax which takes the form $\hat{y}_t = (1-\tau_t)\exp(z_t)[k_t^{\theta 1} h_t^{\theta 2}]^{1/\chi}$. A tax of this form can be modeled as a negative technology shock. See Abel and Blanchard (1983).

Table 6a: Business-Cycle Statistics for the Various Tax Systems

	Standard Deviation in Percent (all series detrended)[a]				
Series	Complicated	Simplified w/ Depr Allow	Simplified No Depr Allow	Lump-sum	U.S. Economy[b]
GNP $= y_t$	2.32	2.34	1.74	2.96	2.46
c_t	0.63	0.27	0.10	0.77	1.14
g_t	1.66	7.04	9.67	1.54	6.45
k_t	1.21	0.50	0.21	1.33	0.75
x_t	10.78	4.10	1.77	11.78	5.96
h_t	0.89	0.81	0.26	1.81	1.76
y_t/h_t	1.67	1.56	1.83	1.38	1.45
Tax Rates	τ_h 4.12 τ_k 11.31	τ 4.27	τ 7.80	T/y 1.79	τ_h 5.65, 3.65 τ_k 16.4, 4.82 T/y 2.44

Table 6b: Business-Cycle Statistics for the Various Tax Systems (continued)

	Contemporaneous Correlation with Output (all series detrended)[a]				
Series	Complicated	Simplified w/ Depr Allow	Simplified No Depr Allow	Lump-sum	U.S. Economy[b]
c_t	0.64	0.54	-0.55	0.59	0.71
g_t	0.91	0.99	0.99	0.88	0.62
k_t	0.02	-0.07	-0.44	-0.02	-0.12
x_t	0.96	0.99	-0.63	0.97	0.69
h_t	0.83	0.97	-0.30	0.94	0.81
y_t/h_t	0.96	0.99	0.99	0.90	0.71
Tax Rates	τ_h 0.99 τ_k -0.96	τ 0.99	τ 0.99	T/y -0.91	τ_h 0.37, 0.05 τ_k 0.10, 0.32 T/y 0.14

[a]Model statistics are means over 100 simulations, each 46 periods long, after dropping the first 50 periods. Parameter values are from table 2. All series were logged and detrended (except for tax rates which were only detrended) using the Hodrick-Prescott filter (see Prescott [1986]). The filter smoothing parameter was set at $\Lambda = 100$ since all data are at annual frequency.

[b]U.S. data cover the period 1947 to 1992. The following quarterly series from Citibase were annualized before computing statistics: y_t = GNPQ, c_t = GCDQ+GCNQ (nondurables and services), g_t = GGEQ, h_t = LHOURS (household survey), y_t/H_t = GNPQ/LHOURS. The series for x_t is fixed business investment + consumer durables expenditures + residential investment. The series for k_t is fixed private capital + stock of consumer durables + residential capital. Both x_t and k_t are annual series from *Fixed Reproducible Tangible Wealth in the United States*, U.S. Department of Commerce (1993). Sources for U.S. tax rate data are described in the notes to table 3. All series were logged (except tax rates) and detrended as in the model.

7. Concluding Remarks

While our model is admittedly a very abstract and simplified representation of the vastly complex U.S. tax code, we believe that it can be useful for examining key questions about the institutional structure of our tax system. In our view, the strength of the model lies in the ability to capture the general-equilibrium effects of *endogenous* fiscal policy. Using this approach, we find that a uniform tax on all types of income yields almost the same welfare as a more complicated system with separate tax rates on labor and capital income. We also find that the depreciation allowance plays an important role in encouraging capital accumulation. In a related paper (see Guo and Lansing [1994]), we extend our examination of various tax structures to include an analysis of single versus double taxation of firm dividends.

In general, we find that the assumed structure of the tax system can have profound effects on the characteristics of optimal fiscal policy and the resulting behavior of aggregate economic variables over the business cycle. Although our model abstracted from economic growth, we expect that tax structure would continue to have a significant impact in a model where growth is endogenous. Jones, Manuelli, and Rossi (1993a) employ an endogenous growth model to derive optimal fiscal policy with separate taxes on labor and capital, and no depreciation allowance. They also examine a case where tax rates on labor and *human* capital are restricted to be the same, but *physical* capital is taxed separately. In our current research, we are performing tax simplification experiments similar to those done here in the context of an endogenous growth model (see also Pecorino [1993] and Stokey and Rebelo [1993]). Our work thus far agrees with the viewpoint of Slemrod (1990), who argues that selecting an optimal tax structure can often be more important than the setting of optimal tax rates.

APPENDIX A

A.1 Recursive Formulation of the Government's Problem

To formulate the recursive version of the government's problem specified in equation (11), we first substitute the household first-order conditions (5) into the household budget constraint (2), the resource constraint (12), and the utility function $U(\cdot)$ to eliminate τ_{ht}, τ_{kt}, and c_t.[1] The resource constraint (12) can then be used to substitute out g_t. For the lump-sum tax system, we use the household first-order conditions to eliminate r_t, w_t, and c_t; the government budget constraint to eliminate T_t; and the resource constraint to eliminate g_t.[2] The vector of state variables for the government's problem in period t is $s_t=\{z_t, k_t, \lambda_{t-1}\}$. In the transformed problem, the government's decision variables are λ_t, h_t, and k_{t+1}. Using primes ($'$) to denote next-period quantities, the recursive version of the government's problem is shown in (A.1).

The Bellman equation in (A.1) summarizes the recursive nature of the problem. The first two constraints represent two versions of the household budget (after substituting in the first-order conditions), depending on whether distortionary or lump-sum taxes are used. The next constraint imposes the condition of equal tax rates on labor and capital for the simplified tax system. The symbols u_{1t} and u_{2t} represent composite error terms that arise due to the presence of E_t in the first-order condition for k_{t+1}. The remaining constraints define the production technology, the factor prices r_t and w_t, and the law of motion for the exogenous technology shock.

The dynamic programming problem applies for all $t > 0$. The problem at $t = 0$ must be considered separately, as shown by Kydland and Prescott (1980), Lucas and Stokey (1983), and Chamley (1986). At $t = 0$, the stock of private capital is fixed. Optimal policy thus implies a high initial tax on capital to take full advantage of this nondistortionary source of revenue. We assume that this form of lump-sum taxation is insufficient to finance the entire stream of future expenditures. The analysis here will focus

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[1] Due to the presence of the expectation operator in the first-order conditions for k_{t+1} the substitution is accomplished using the expression $E_{t-1} f_t(\cdot) = f_t(\cdot) - u_t$, where $f_t(\cdot)$ is a function of random variables and u_t is the forecast error. The assumption of rational expectations implies $E_{t-1}u_t = 0$.

[2] Due to the presence of monopoly profits in our model, the competitive equilibrium is not Pareto optimal. Therefore, the government's problem with lump-sum taxes must be solved in the same manner as the problem with distortionary taxes.

on policy in stationary stochastic equilibrium, i.e., when t approaches infinity. The linear-quadratic approximation method used to solve (A.1) is accurate only in the neighborhood of the deterministic steady-state. Consequently, we do not solve the $t=0$ problem or compute the transition path to the stationary equilibrium.

$$V(s) = \max_{k',h,\lambda} E_{-1}\left\{U(\cdot) + \beta\left[V(s')|s\right]\right\}$$

$$\text{where} \qquad s = \{z,\ k,\ \lambda_{-1}\} \tag{A.1}$$

$$U(\cdot) = \ln(1/\lambda) - Ah + B\ln\left[y - \frac{1}{\lambda} - k' + (1-\delta)k\right]$$

subject to

$$\frac{Ah}{\lambda} + \frac{\lambda_{-1}}{\beta\lambda}k + (1-\theta_1-\theta_2)y\left[\frac{\frac{\lambda_{-1}}{\beta\lambda} - 1 + \delta(1-\phi)}{r-\phi\delta}\right]^2 - \frac{1}{\lambda} - k' + u_1 = 0 \quad \text{(for the distortionary tax systems)}$$

$$\frac{Ah}{\lambda} + \left[\frac{\lambda_{-1}}{\beta\lambda} - 1 + \delta\right]k - (\theta_1+\theta_2)y + u_1 = 0 \quad \text{(for the lump-sum tax system)}$$

$$\frac{A}{w\lambda} - \left[\frac{\frac{\lambda_{-1}}{\beta\lambda} - 1 + \delta(1-\phi)}{r-\phi\delta}\right] + u_2 = 0 \quad \text{(for the simplified tax system only)}$$

$$y = \exp(z)\left[k^{\theta_1}h^{\theta_2}\right]^{\frac{1}{\chi}}$$

$$r = \theta_1\frac{y}{k}$$

$$w = \theta_2\frac{y}{h}$$

$$z' = \rho_z z + \varepsilon'.$$

Equilibrium is defined as a value function $V(s)$ and an associated set of stationary decision rules that satisfy (A.1). The decision rules dictate a set of household allocations and prices at time t that can be implemented by means of the government's chosen policy. The government's explicit policy rules for tax rates and public expenditures are recovered by substituting the implementable allocations and prices into the applicable first-order conditions and budget constraints.

A.2 Computation Procedure

The dynamic programming problem in (A.1) is solved numerically using a variant of the linear-quadratic approximation technique first used by Kydland and Prescott (1982). An approximate version of (A.1) is obtained by first substituting as many nonlinear constraints as possible into the return function $U(\cdot)$. For constraints that cannot be substituted in, a Lagrange multiplier is used to incorporate the constraint into a redefined return function, and the multiplier is treated as an additional decision variable. A quadratic approximation of the return function is then computed in terms of the *logarithms* of all variables.[3] The solution algorithm exploits the certainty equivalence property of linear-quadratic control problems. The optimal decision rules for the approximated economy can be obtained by solving the deterministic version of the model.[4] An initial guess V_0 is made for the optimal value function $V(s)$ in the quadratic version of (A.1). Sequential candidate value functions V_i are then computed by successively iterating on the Bellman equation until the value function has converged. We verified that the algorithm always converged to the same value function regardless of the initial guess for V_0. Once the process has converged, log-linear decision rules that dictate household equilibrium allocations are computed. Log-linear policy rules for τ_{ht}, τ_{kt} (or τ_t) and g_t can then be computed using the household first-order conditions and the budget constraints, log-linearized around the steady state.

[3]The log-linear version of the Kydland-Prescott method is described in Christiano (1988).

[4]See Sargent (1987, p. 36). Specifically, the stochastic terms ε_t, u_{1t} and u_{2t} are set equal to their unconditional means (zero) in the numerical algorithm. With a quadratic objective, the first-order conditions are linear in all variables. This allows the expectation operator in (A.1) to be passed through the expressions, dropping out any stochastic terms.

FIG 1: SIMULATED SERIES FOR TAX RATES

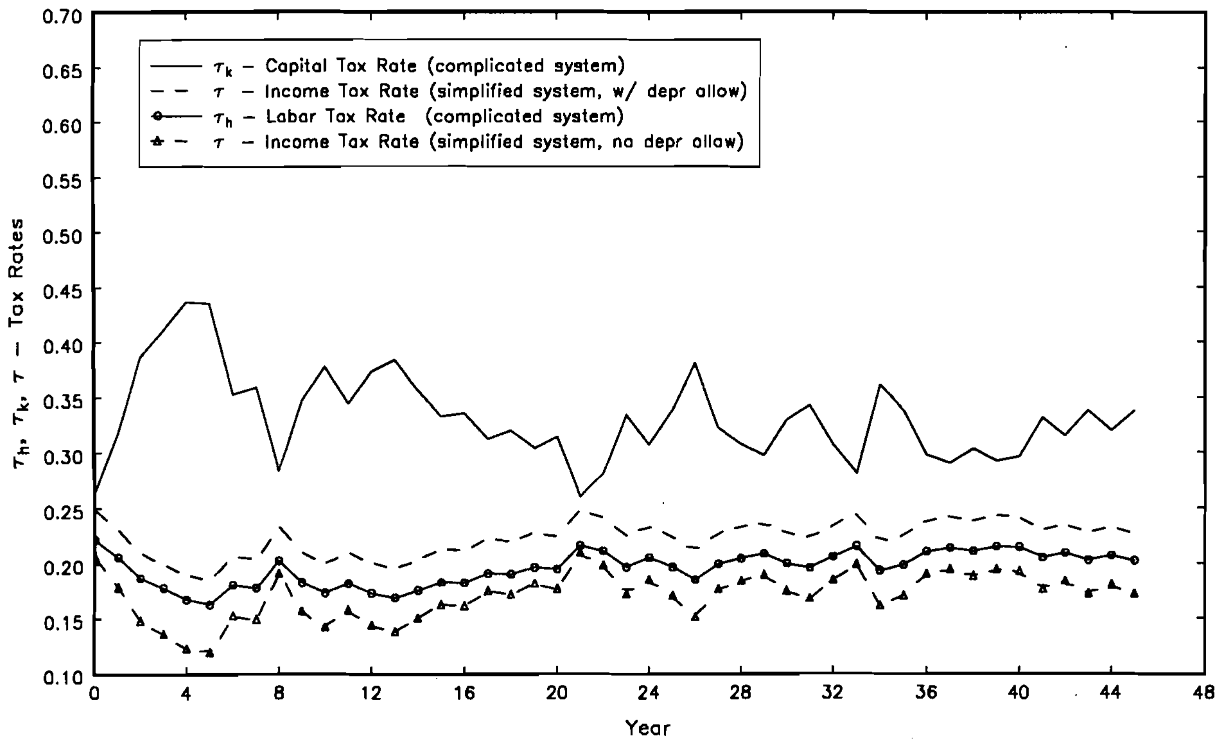


FIG 2: U.S. & SIMULATED SERIES FOR GOVT EXPENDITURES (fraction of GNP)

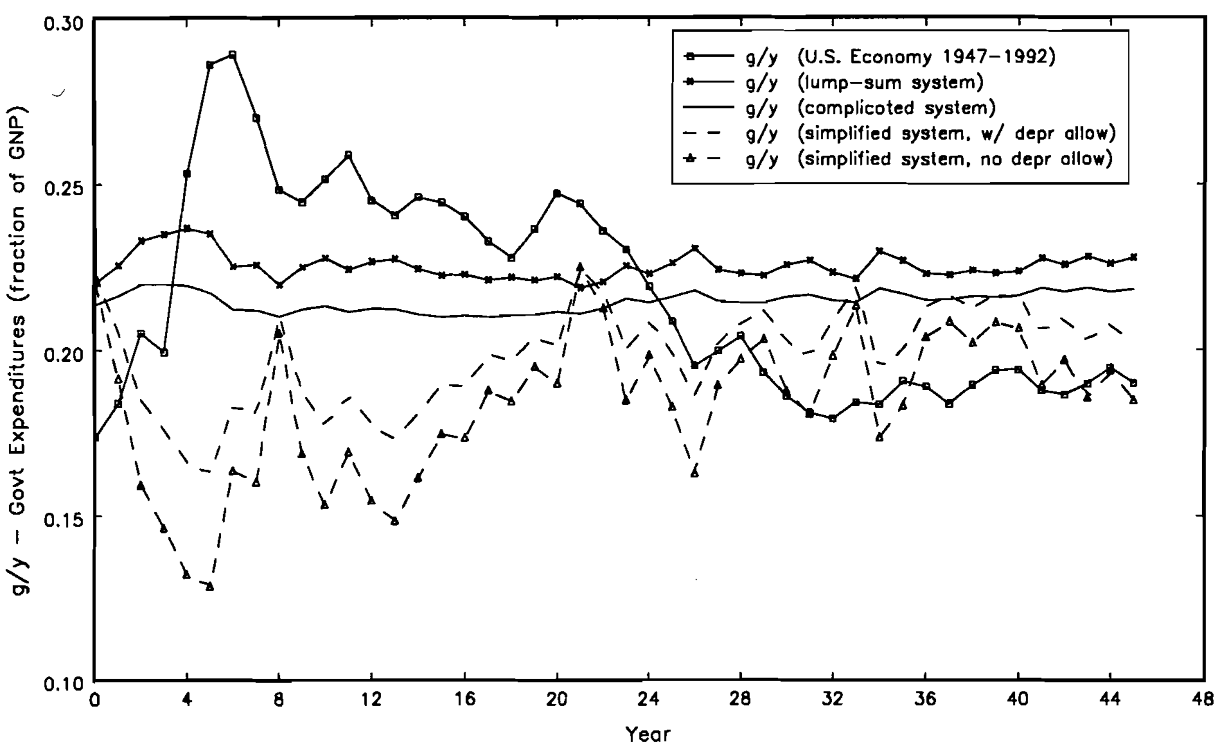


FIG 3: U.S. SERIES FOR CAPITAL TAX RATES

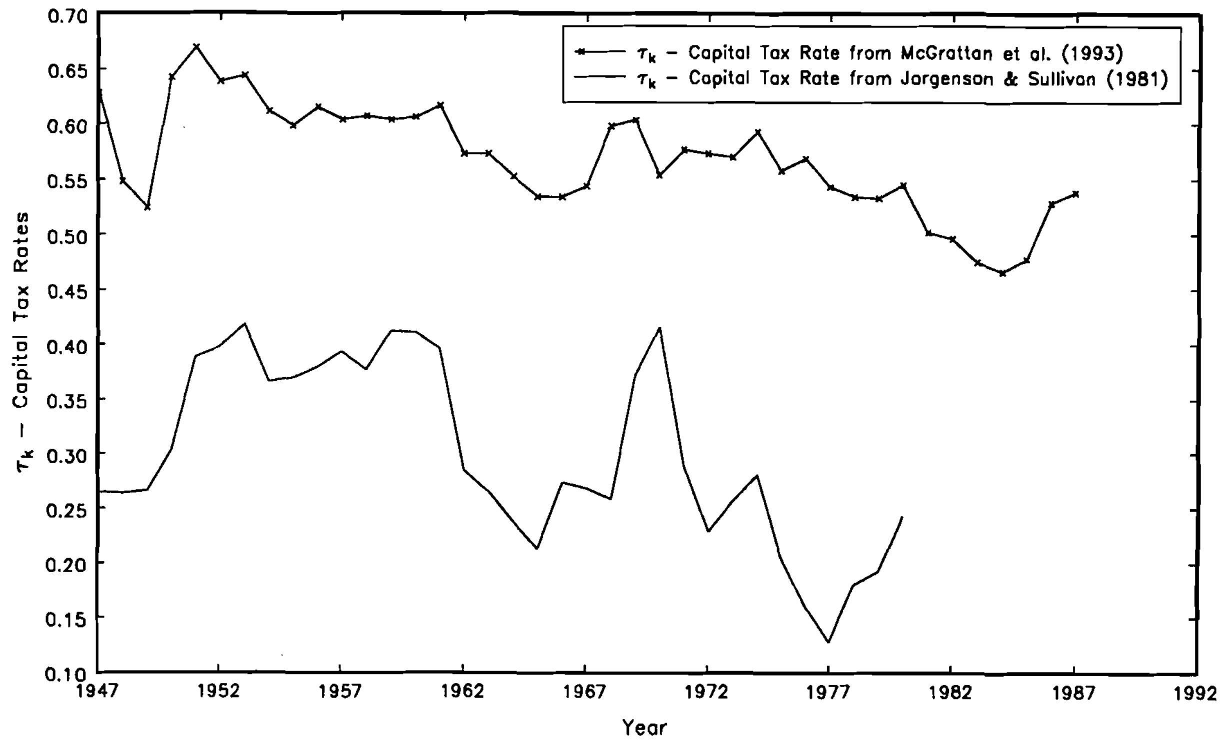
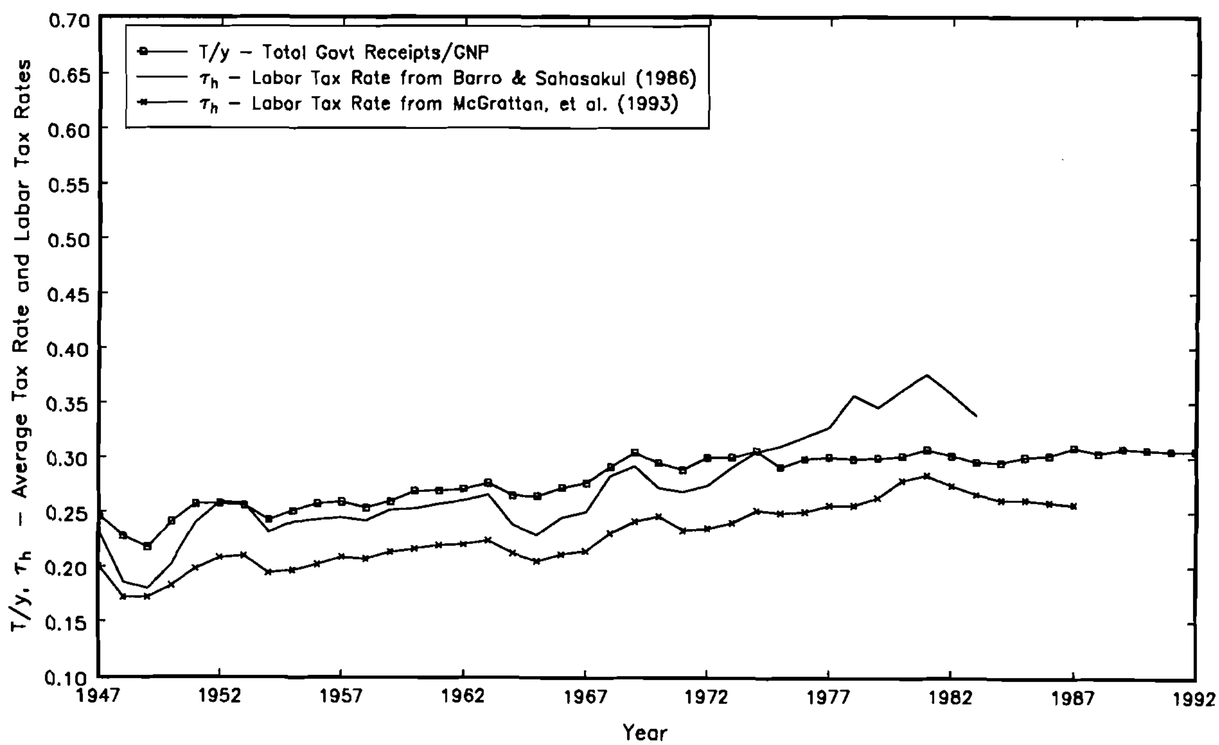


FIG 4: U.S. SERIES FOR AVERAGE AND LABOR TAX RATES



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