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A capital income tax distorts consumer choices along two margins: the intertemporal margin (consuming today versus tomorrow) and the within-period, or "static," margin (consuming durable versus nondurable goods). The static distortion, which the literature has largely ignored, emerges because the income tax base excludes service flows of durable goods. This article decomposes the welfare loss from a capital income tax into its static and intertemporal components. Calculations using a calibrated life-cycle model with a representative consumer suggest that ignoring the static distortion may lead to substantial underestimation of the total welfare loss from a capital income tax. This finding implies that if ending capital income taxation is not feasible because of equity or other considerations, the static excess burden may be eliminated by taxing the purchase of durable goods.

This article examines the welfare implications of some basic structural features of the U.S. tax code. The authors consider the tax deductibility of depreciation and the practice of taxing labor income differently than capital income. Their results show that long-run welfare and output can be improved by a policy of "accelerated depreciation," whereby the depreciation rate for tax purposes exceeds the rate of economic depreciation. This policy increases the tax on pure profits relative to other types of capital income. The authors also find that the benefits of applying separate tax rates to labor and capital income tend to be minimal over a range of typical depreciation tax policies.

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The Welfare Loss from a Capital Income Tax

by Jinyong Cai and Jagadeesh Gokhale

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Introduction

In most countries, the pecuniary return from holding financial assets is taxed because capital income is included in the income tax base. A capital income tax reduces the after-tax rate of return on saving, making future consumption costlier than consuming today. That is, it distorts consumer choice along the "intertemporal" margin. Several studies have investigated the impact of capital income taxation on household saving decisions and evaluated the consequent welfare loss (for example, Levhari and Sheshinski [1972], Feldstein [1978], Chamley [1981], Auerbach, Kotlikoff, and Skinner [1983], and Auerbach [1989]).

However, it is also true that the service flow from holding durable goods like cars, houses, or boats is usually not included in the income tax base, partly because such income is hard to impute. An often underappreciated fact is that with a capital income tax, excluding the imputed value of durable goods' service flows from the tax base produces a second, "static" distortion of consumer choice, namely, that between consuming durable and nondurable goods *within* a period. This distortion occurs because the lower after-tax rate of return reduces the rental cost of holding durable goods. Then, if there is no tax on the service flow from such goods, they gain a relative price advantage over nondurables, causing the distortion. Harberger (1966) and Shoven (1976) focus exclusively on the static excess burden due to resource reallocations in production arising from sector-level differences in capital income taxation. The literature seems to lack comparisons of the static and intertemporal distortions in consumption that arise from a capital income tax.

A number of studies recommend eliminating the capital income tax in order to avoid the welfare loss it causes. Some tax reform plans that call for a shift to a flat tax on wages share this motivation. However, these proposals have been criticized for their probable impact on equity. If they are deemed undesirable because of equity or other considerations, it may nevertheless be possible and desirable to devise tax policies for reducing or eliminating the static component of the welfare loss. Hence, understanding the absolute and relative magnitudes of the two components of welfare loss resulting from capital income taxation is important for setting tax policy: If the static welfare loss is large, a case could be made for taxing durable-goods purchases in order to minimize the total welfare loss from capital income taxation.

To measure the magnitudes of the excess burdens attributable to static and intertemporal distortions, this study uses a representative-agent, life-cycle model of consumption.[1] The agent's preferences are represented by a time-separable utility function with constant elasticity of substitution (CES) in one durable and one nondurable good.

To evaluate the total excess burden and its two components, we use several compensated tax and subsidy experiments. In each of them, we compare the agent's welfare under the no-tax case to that under a compensated tax (or subsidy), where tax (subsidy) revenues are fully rebated (charged) to the consumer in a nondistortionary (lump-sum) manner. Such a rebate of tax revenues is necessary to maintain the agent's budget constraint at the same level as under the no-tax case. Then, with a tax, the agent's consumption choices differ from the no-tax case only because relative prices of durables and nondurables today and in the future are different, not because the consumer's overall budget has changed. To calculate the size of the welfare loss in each case, we measure the percentage reduction in the agent's lifetime budget under the no-tax case that is necessary to generate the same loss of utility as under a compensated tax or subsidy.[2]

The remainder of the paper is organized as follows: Section I describes a life-cycle model of consumption with one durable and one nondurable good. Sections II, III, and IV present the formulations for three different compensated tax schemes used to decompose the total excess burden into its static and intertemporal components. Section V uses results from the previous three sections to show that, under the CES utility specification, the sum of the static and intertemporal components of excess burden closely approximates the total excess burden. Section VI discusses the magnitudes of the excess burdens obtained for the three compensated tax schemes from computations based on a 60-period time horizon, and also examines the sensitivity of the excess burdens to changes in various parameters. Section VII summarizes and concludes.

I. A Simple Model of Consumption

The consumer is assumed to live for T periods and to maximize a time-separable lifetime utility function given by

$$(1)\quad U = \frac{1}{[1-(1/\gamma)]}\Big[\sum_{t=1}^{T}(1+\beta)^{(1-t)}u_t^{\{1-(1/\gamma)\}}\Big],$$

where u_t is given by the CES form:

$$(2)\quad u_t\,[N_t^{\{1-(1/\rho)\}} + \theta S_t^{\{1-(1/\rho)\}}]^{1/\{1-(1/\rho)\}}.$$

Consumption of the nondurable good in period t is denoted by N_t, and the stock of the durable good is denoted by S_t. We assume that the service flow (consumption) from durable goods is proportional to the stock held. Hence, we interpret θ as the product of within-period intensity of preference for the durable good and the ratio of the flow of the durable good's services to its stock.[3] This allows the stock of the durable good—rather than the flow of services—to be used as an argument in the utility function. The parameter γ is the intertemporal elasticity of substitution; ρ is the within-period elasticity of substitution between the nondurable and the durable good; and β is the rate of time preference. These parameters are assumed to be constant over the consumer's lifetime.

The maximization of U in equation (1) is subject to the following budget constraints:

$$(3)\quad D_{t+1} = S_t(1-\delta) \qquad t = 1,\ldots T$$

$$(4)\quad A_{t+1} = [A_t + W_t - N_t - p(S_t - D_t)](1+r) \qquad t = 1,\ldots T$$

$$(5)\quad N_T + p(S_T - D_T) \le A_T + W_T + pS_T[(1-\delta)/(1+r)].$$

1 We should clarify two points: First, the analysis focuses exclusively on the distortions from a capital income tax and does not take into account the fact that mortgage interest on housing is subsidized. Second, our study is not conducted within a general equilibrium framework. General equilibrium feedback effects may alter the final pre- and after-tax interest rates, thereby influencing both components of the excess burden.

2 "Lifetime budget" refers to the amount of money (in present value) necessary to purchase the goods and leisure consumed over one's entire lifetime. This gauge of excess burden is known as the "wealth equivalent" measure.

3 We are indebted to an anonymous referee for pointing out this interpretation of the parameter θ.

In these constraints, A_t represents financial assets and D_t is the stock of the durable good owned by the consumer at the beginning of period t. The durable good's rate of depreciation over one period is given by δ, and its relative price is denoted by p. The consumer is assumed to receive a wage, W (which we set at unity), and purchases of the two goods are assumed to occur at the beginning of each period. The difference, $S_t - D_t$, thus represents the addition to the stock of the durable good in period t. Equations (3) and (4) are asset accumulation conditions that indicate how consumption choice in period t affects the portfolio of assets available at the beginning of period $t+1$. Equation (5) is a terminal-asset-value constraint. It specifies that the total expenditure on the nondurable good and on the net addition to the stock of the durable good at the beginning of the last period cannot exceed the sum of the financial assets held and wages received at the beginning of the period plus the discounted value of the depreciated stock of the durable good that is assumed to be sold at the end of the period. The discount rate is given by r.

Successively substituting equations (3) and (4) for index t into the same equations for index $t+1$, for all t where $1 \le t \le T$, yields the lifetime budget constraint facing the consumer:

$$(6)\quad PVR = \sum_{t=1}^{T} W_t (1+r)^{(1-t)} = \sum_{t=1}^{T} N_t (1+r)^{(1-t)} + \sum_{t=1}^{T} pqS_t (1+r)^{(1-t)},$$

where $q = (r+\delta)/(1+r)$. In terms of units of the nondurable good, N, the rental cost of a unit of the durable good is given by pq; it represents the cost due to forgone interest and depreciation incurred by holding a unit of the durable good for one period. The right side of equation (6) is the present value of total expenditures on the two goods over the agent's lifetime, and the left side is the present value of resources. Thus viewed, the intertemporal maximization problem is isomorphic to a static consumer choice problem. There are $2T$ goods with relative prices that equal their respective coefficients in equation (6). Using familiar techniques, one can obtain the indirect utility function associated with the consumer choice problem described here—that is, utility expressed as a function of the relative price of the durable good, p, its rental cost, q, the present value of resources, PVR, and other parameters of the utility function: $V = V(p, q, PVR; \rho, \gamma, \theta, \delta, \beta)$.

II. A Fully Compensated Capital Income Tax

Now, consider the imposition of a fully compensated capital income tax at rate τ, where $0 < \tau < 1$, which makes the net rate of interest $r_n = r(1-\tau)$. We assume that the collection of revenue from the tax and the compensation both occur at the end of each period. The lifetime budget constraint applicable to this case is

$$(7)\quad PVR = \sum_{t=1}^{T} W_t (1+r_n)^{(1-t)} + \sum_{t=1}^{T} C_t (1+r_n)^{(1-t)} = \sum_{t=1}^{T} N_t (1+r_n)^{(1-t)} + \sum_{t=1}^{T} pq_n S_t (1+r_n)^{(1-t)}.$$

Here, $q_n = (r_n + \delta)/(1+r_n)$, and C_t stands for the lump-sum compensation paid back at the end of period t. Under full compensation, C_t must equal the revenue collected from the capital income tax at the end of period t for all $t = 1,...T$. This implies that the budget constraint is identical to that under no taxation.[4] However, equations (6) and (7) show that the relative prices of the $2T$ goods change when the capital income tax is imposed. Because $\partial q_n / \partial \tau = r(1-\delta)/(1+r_n)^2 < 0$, in any given period the price of consuming the durable good relative to the nondurable good is lower than the same relative price in the no-tax case. This represents the static subsidy to the consumption of the durable good that is implicit in a capital income tax. Further, $\partial[1/(1+r_n)]/\partial\tau = r/(1+r_n)^2 > 0$; that is, the price of consuming either good in any period t is lower relative to the price of consuming the same good in a future period $t+s$, where $s \ge 1$. This represents the intertemporal distortion favoring earlier consumption that a capital income tax introduces.

Using the first-order conditions from maximizing utility subject to equation (7) and the no-tax budget constraint (6), one can obtain the indirect utility, V_c, under the compensated capital income tax case: $V_c = V_c(p, q_n, PVR; \rho, \gamma, \theta, \delta, \beta)$.

4 This can be demonstrated using a simple two-period example with one consumption good N. Assume that the consumer lives for two periods, consumes at the end of both, but earns a wage W only at the end of period 1. The lifetime budget constraint with no capital income tax is $N_1 + N_2/(1+r) = W$. With a compensated capital income tax, it is $N_1 + N_2/[1+r(1-\tau)] = W + C/[1+r(1-\tau)]$, where C is the compensation paid at the end of period 2—which is when the tax revenue on the return on period 1 saving is collected. Note that discounting is now done using the after-tax rate of interest faced by the consumer. Setting C equal to the tax collected at the end of period 2, $C = (W - N_1)r\tau$, and simplifying the expression yields the no-tax budget constraint.

Let λ_c stand for the percentage *reduction* in *PVR* necessary to equate the pre-tax utility, V, with the post-tax utility, V_c. To obtain the analytical formula for λ_c, replace *PVR* in the expression for V with $PVR(1+\lambda_c)$, equate the resultant expression to V_c, and solve for λ_c. The total welfare loss from a capital income tax can then be expressed as[5]

$$(8)\quad \lambda_c = \frac{\{1 + pq\,[\theta/pq\,]^{\rho}\}}{\{1 + pq\,[\theta/pq_n\,]^{\rho}\}} \cdot \frac{\{1 + pq_n[\theta/pq_n\,]^{\rho}\}^{(1/f\,)}}{\{1 + pq\,[\theta/pq\,]^{\rho}\}^{(1/f\,)}} \cdot \frac{\{\sum_{t=1}^{T}[B/R\,]^{\gamma(t-1)}R^{\,(t-1)}\}}{\{\sum_{t=1}^{T}[B/R_n\,]^{\gamma(t-1)}R^{\,(t-1)}\}} \cdot \frac{\{\sum_{t=1}^{T}[B/R_n\,]^{\gamma(t-1)}R_n^{\,\gamma(t-1)}\}^{(1/g)}}{\{\sum_{t=1}^{T}[B/R\,]^{\gamma(t-1)}R^{\,(t-1)}\}^{(1/g)}} - 1.$$

III. The Static Component of Excess Burden

A measure of the static (within-period) component of the excess burden arising from a capital income tax can be obtained by removing the tax and replacing it with an equivalent compensated subsidy on the consumption of the durable good. Removing the capital income tax eliminates both the static and the intertemporal distortions. However, introducing a compensated subsidy on durables consumption reintroduces the static distortion by altering the relative price of durables vis-à-vis nondurables consumption. The subsidy must be levied at a rate equal to that implicit in the capital income tax. This rate of subsidy, σ, can be written as

$$(9)\quad \sigma = 1 - \frac{q_n}{q} = 1 - \frac{(r_n+\delta)/(1+r_n)}{(r+\delta)/(1+r)}.$$

As shown earlier, $\partial q_n/\partial\tau < 0$. Hence, the rate of subsidy, σ, is positive. The lifetime budget constraint relevant to this case is

$$(10)\quad PVR = \sum_{t=1}^{T} W_t(1+r)^{(1-t)} + \Sigma H_t(1+r)^{(1-t)} = \sum_{t=1}^{T} N_t(1+r)^{(1-t)} + \sum_{t=1}^{T} p(1-\sigma)qS_t(1+r)^{(1-t)}.$$

Here, H_t is a lump-sum tax levied at the beginning of period t. It serves as a (negative) compensation against σ, the subsidy on the consumption of the durable good. There are two alternative but equivalent ways to view this subsidy. One can think of it as subsidizing either the rental cost of holding the durable good for one period or the purchase of new stocks of the durable good.

Let $p_\sigma = p(1-\sigma)$ represent the net (post-subsidy) purchase price of new durable goods. Using first-order conditions derived from maximizing utility subject to equation (10), and using the no-tax budget constraint (6), one can obtain the indirect utility under the compensated capital income tax case: $V_s = V_s(p_\sigma, q, PVR;\ \rho, \gamma, \theta, \delta, \beta)$.

Following the same procedure as that used for obtaining λ_c in equation (8), the excess burden due to the static distortion, λ_s, can be evaluated as

$$(11)\quad \lambda_S = \frac{\{1+pq\,[\theta/pq]^{\rho}\}\{1+p_\sigma q\,[\theta/p_\sigma q]^{\rho}\}^{(1/f\,)}}{\{1+pq\,[\theta/p_\sigma q]^{\rho}\}\{1+pq\,[\theta/pq]^{\rho}\}^{(1/f\,)}} - 1.$$

Note that the static excess burden depends on the elasticity of substitution between durables and nondurables consumption, ρ, but not on the intertemporal elasticity of substitution, γ.

IV. The Intertemporal Component of Excess Burden

To isolate the intertemporal distortion in the relative price of current versus future consumption resulting from a capital income tax, the compensated capital income tax is retained and, in addition, a compensated tax on the consumption of the durable good is imposed. Retention of the capital income tax maintains the static and intertemporal distortions. However, the additional tax on durables consumption neutralizes the static distortion, leaving only the intertemporal distortion in place. As in the previous case, the tax must be levied at a rate equivalent to the rate of subsidy on durables consumption that is implicit in the capital income tax. The equivalent tax rate, μ, on the durable good is given by

$$(12)\quad \mu = \frac{q}{q_n} - 1 = \frac{(r+\delta)/(1+r)}{(r_n+\delta)/(1+r_n)} - 1.$$

5 Details of the derivations are available from the authors upon request.

Again, since $\partial q_n / \partial \tau < 0$, the tax rate, μ, is positive. The agent's lifetime budget constraint now becomes

$$(13) \quad PVR = \sum_{t=1}^{T} W_t (1+r_n)^{(1-t)}$$
$$+ \sum_{t=1}^{T} C_t (1+r_n)^{(1-t)} + \sum_{t=1}^{T} G_t (1+r_n)^{(1-t)}$$
$$= \sum_{t=1}^{T} N_t (1+r_n)^{(1-t)}$$
$$+ \sum_{t=1}^{T} p_t (1+\mu) q_n S_t (1+r_n)^{(1-t)}.$$

Here, G_t stands for a lump-sum transfer made at the beginning of each period to compensate for the tax, μ, levied on consumption of the durable good in each period. Because the capital income tax is maintained in this case, C_t, the corresponding end-of-period compensation for each period t, also enters the budget constraint. As in the case of the subsidy, the tax on the durable good can be viewed either as a tax on the rental cost of holding the good for one period or as a tax on the purchase of new stocks of durables.

Let $p_\mu = p(1 + \mu)$ represent the gross price of new stocks of durable goods. Following the same procedure of maximizing utility subject to the budget constraint (13), and using the first-order conditions with the no-tax budget constraint (6), we can obtain the indirect utility function for this case: $V_m = V_m(p_\mu, q_n, PVR;$ $\rho, \gamma, \theta, \delta, \beta)$. Note that $p_\mu q_n = pq$. Hence, the relative prices of the two goods within any period are restored to those prevailing under the no-tax budget constraint (6).

Using the same procedure as earlier, the excess burden due to the intertemporal distortion, λ_m, becomes

$$(14) \quad \lambda_m = \frac{\{\sum_{t=1}^{T} [B/R]^{\gamma(t-1)} R^{(t-1)}\}}{\{\sum_{t=1}^{T} [B/R_n]^{\gamma(t-1)} R^{(t-1)}\}} \cdot \frac{\{\sum_{t=1}^{T} [B/R_n]^{\gamma(t-1)} R_n^{(t-1)}\}^{(1/g)}}{\{\sum_{t=1}^{T} [B/R]^{\gamma(t-1)} R^{(t-1)}\}^{(1/g)}} - 1.$$

Note that λ_m depends on the intertemporal elasticity of substitution, γ, but not on the within-period elasticity of substitution between durables and nondurables consumption, ρ.

V. Does the Total Excess Burden Equal the Sum of Its Parts?

It is possible to show that under the CES specification of consumer preferences used here, the sum of the static and intertemporal components of excess burden is *almost* equal to the combined excess burden from a capital income tax. Rewrite equations (11) and (14) in abbreviated fashion as $\lambda_s = (X - 1)$ and $\lambda_m = (Y - 1)$, where X is the term in equation (11) involving p, p_σ, q, θ, and ρ; and Y is the term in equation (14) involving B, R, R_n, and γ. Noting that $p_\sigma q = pq_n$, equation (8) can be written as

$$(15) \quad \lambda_c = (XY - 1).$$

However, adding equations (11) and (14) in abbreviated form yields

$$(16) \quad \lambda_s + \lambda_m = (X-1) + (Y-1)$$
$$= [(XY-1) - (X-1)(Y-1)]$$
$$= \lambda_c - \lambda_m \lambda_s .$$

Because the product $\lambda_m \lambda_s$ becomes negligibly small when λ_m and λ_s are small, one can conclude that the total excess burden from a capital income tax is closely approximated by the sum of its static and intertemporal components.

VI. Welfare Loss: Results with a 60-Period Time Horizon

Calibration

To obtain the wealth equivalent measure of excess burden, it is necessary to make assumptions about the utility parameters ρ, γ, δ, θ, and β, the pre-tax rate of interest r, the relative price of the durable good p, and the rate of capital income taxation τ. To do this, we select base-case values for the different utility parameters, drawing on the findings of other empirical studies. We then examine the magnitude of the wealth equivalent measure of excess burden and analyze its sensitivity to changes in different parameters for each of the three compensated tax schemes.

Empirical evidence on the value of ρ is sparse. Mankiw's (1982) study establishes a range of between 0.77 and 1.23, but the

FIGURE 1

Response of Excess Burden to Changes in γ

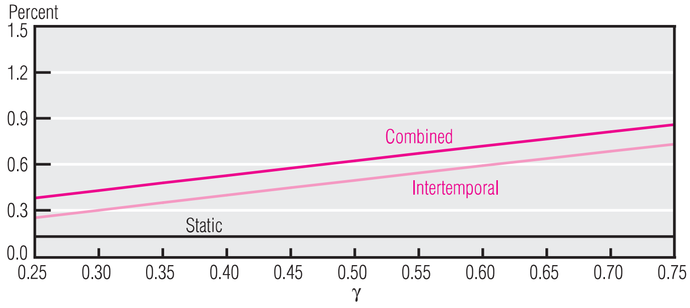


FIGURE 2

Response of Excess Burden to Changes in ρ

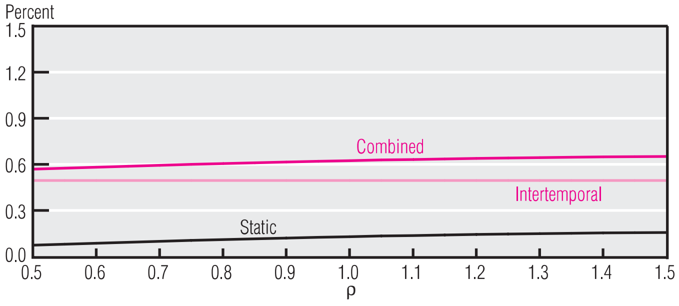
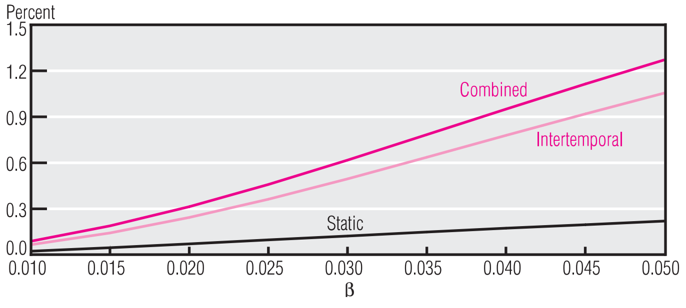


FIGURE 3

Response of Excess Burden to Changes in β



SOURCE: Authors' calculations.

hypothesis that ρ equals unity cannot be rejected. For the purposes of this study, the base-case value is set at unity.

For γ, values of 0.28 (Ghez and Becker [1975]), 0.25 (Grossman and Shiller [1981]), and < 0.1 (Hall [1988]) have been reported. However, recent studies analyzing labor–leisure choices suggest that intertemporal substitution elasticities are much larger, ranging from 0.3 (Mulligan [1995]) to 0.9 (Rupert, Rogerson, and Wright [1996]). Therefore, the base-case value selected for γ in our study is 0.5.

The base-case value chosen for θ is 2.5, which makes the expenditure on nondurable goods and services equal to 40 percent of the stock of the durable good when the rate of capital income taxation is 30 percent.[6] The base-case values of both r and β have been set at 0.03. The relative price of the durable good, p, has been chosen so that the cost of holding one unit of the durable good for one period equals the cost of purchasing one unit of the nondurable good in the no-tax case; that is, $pq = 1$.

A reasonable depreciation rate on major durable goods such as housing is 3 percent annually, but the rate on durable appliances is much higher. Hence, 0.05 has been used as the base-case value of δ.

Results and Sensitivity Analysis

The base-case parameters yield values of 0.13 percent for the static component, 0.50 percent for the intertemporal component, and 0.62 percent for the combined excess burden.[7] Thus, under our chosen base-case values, the total excess burden due to a capital income tax is sizable, with the static component about 26 percent as large as the intertemporal component. This implies that focusing exclusively on the intertemporal source of welfare loss would likely underestimate the welfare loss from a capital income tax by about 26 percent!

■ 6 This parameterization is based on 1994 data on personal consumption expenditures of $4,120 billion and outstanding stock of residential real estate (housing and land) and consumer durable goods of $9,956 billion. These figures are taken from the *Economic Report of the President,* 1997, and the Federal Reserve System's *Balance Sheets of the U.S. Economy,* 1945–94. The ratio of nondurable expenditures and durable goods stock turns out to be 41 percent. Because these figures are based on an economy with a capital income tax, our calibration of $\theta = 2.5$ is made in the presence of a 30 percent tax rate.

■ 7 The numbers do not add up because of rounding and because the sum of the components is greater than the total excess burden. See equation (16), keeping in mind that λ_s, λ_m, and λ_c are all negative.

FIGURE 4

Response of Excess Burden to Changes in δ

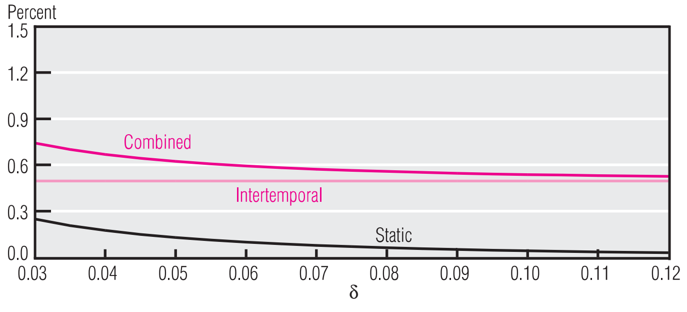


FIGURE 5

Response of Excess Burden to Changes in τ

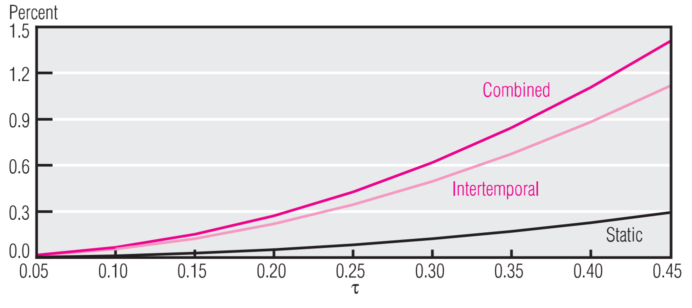
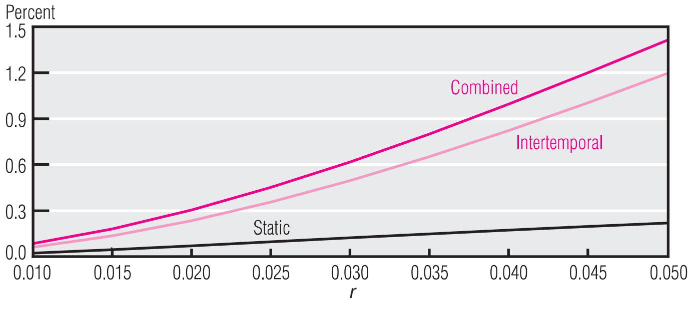


FIGURE 6

Response of Excess Burden to Changes in *r*



SOURCE: Authors' calculations.

Figures 1 through 6 show the response of excess burden to changes in various parameters. The numbers plotted represent the percentage reduction in *PVR* required under the no-tax case to obtain the same utility level as under the relevant compensated tax/subsidy scheme. In each instance, all parameters except the one under consideration are set at their base-case levels.

Figure 1 shows the response of excess burden to changes in γ. The combined excess burden increases from about 0.38 percent to about 0.86 percent when γ is raised from 0.25 to 0.75. As expected, the static component is not responsive to changes in the value of γ. Figure 2 shows that the combined excess burden from a capital income tax goes from 0.57 percent to 0.65 percent in response to a change in ρ from 0.5 to 1.5. Again, as expected, the intertemporal component does not change when the value of ρ is altered.

Figure 3 indicates that simultaneously increasing the rates of interest and time preference while maintaining equality between them results in larger excess burdens. However, the rate of increase of the intertemporal component is greater than that of the static component.

The expression for λ_m (equation [14]) does not involve δ. Hence, the intertemporal component is not responsive to changes in the depreciation rate. The static and the combined excess burdens, on the other hand, are negatively related to δ. This can be shown by differentiating equation (11) with respect to δ:

$$(17)\qquad \frac{\partial\sigma}{\partial\delta} = -\frac{(1+r)(1+r_n)(r-r_n)}{(1+r_n)^2(r+\delta)^2} < 0.$$

Figure 4 shows that the combined excess burden declines from about 0.74 percent to 0.53 percent when δ is increased from 0.03 to 0.12. The static component is almost 50 percent smaller than the intertemporal component for very low values of δ. This implies that the static distortion could be particularly substantial for major durable goods (such as housing), which have low depreciation rates.

Figure 5 plots the responses of the combined excess burden and its components to changes in the capital income tax rate, τ. In conformity with the rule that excess burdens increase with the square of the tax rate, the figure shows all three curves rising at an increasing rate. For example, a 50 percent reduction in the tax rate (from 30 to 15 percent) would result in a 76 percent reduction in the excess burden—from 0.62 to 0.15 percent. Based on a

GDP of $7,254 billion (its 1995 value), this would amount to a gain of about $34 billion.

The size of the welfare loss is also sensitive to the assumed rate of interest. Figure 6 shows that the combined excess burden increases from 0.62 percent to 0.99 percent when r is raised by just 100 basis points from its base-case value of 3 percent.

Neutralizing the Static Distortion

As mentioned earlier, ignoring the static distortion would result in substantial underestimation of the welfare loss from a capital income tax. Taking GDP at its 1995 value of $7,254 billion, the total welfare loss from a capital income tax under our base-case parameters is estimated at $45 billion annually. The implicit *subsidy* to durable goods consumption induces a higher lifetime consumption of durables and a lower consumption of nondurables. Under our base-case parameters, we estimate that the demand for holding durable-goods stocks rises by 3.4 percent and the demand for nondurables declines by 7.5 percent.

It follows, then, that eliminating the capital income tax would be a desirable goal for tax reform. Indeed, this is the motivation of recent proposals for replacing the income tax with a flat tax on wages. The flat-tax proposals have been criticized, however, because of their likely impact on equity. If such objections make eliminating the capital income tax infeasible, our analysis suggests that it may nevertheless be possible to reduce or eliminate the static component of the welfare loss. This could be done by imposing a tax on the purchase of durable goods. The appropriate rate of taxation can be calculated as $\mu = 1 - (q/q_n)$. Under our base-case parameters, the rate of additional tax on durables purchases turns out to be about 11.7 percent. This would reduce the welfare loss by about $9 billion annually.

VII. Conclusion

Our theoretical analysis shows how the total excess burden from a capital income tax can be decomposed into its static and intertemporal parts by using a CES utility specification. Under this specification, the sum of the static and intertemporal components closely approximates the combined excess burden. We also show that the static component of the excess burden arising from capital income taxation may be sizable. Under reasonable assumptions about elasticities of substitution and other parameters, ignoring this source of distortion causes an underestimation of the welfare loss by as much as 26 percent.

Furthermore, our analysis indicates that the static distortion caused by capital income taxation can be substantial for major durable goods such as housing, which have relatively low rates of depreciation. The total distortion from the capital income tax is estimated to be $45 billion annually. Shifting from the income tax to a flat-tax system would eliminate this welfare loss. However, if such a reform is infeasible because of equity or other reasons, it may be desirable to impose a tax on the purchase of durable goods, thereby eliminating the static component of excess burden.

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Tax Structure and Welfare in a Model of Optimal Fiscal Policy

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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 (ERTA81) and the Tax Reform Act of 1986 (TRA86). Although many changes to the tax code have been made since then, a number of important structural features of the current U.S. tax system can be traced to these two laws.

ERTA81 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 approximating those that prevailed in 1965. To help eliminate "bracket creep," tax brackets, personal exemptions, and the standard personal deduction were all indexed to inflation. Another important feature of ERTA81 was the introduction of new incentives for investment and saving. For the purposes of this paper, the most noteworthy of these was the introduction of generous accelerated depreciation schedules.[1]

TRA86 brought about the most significant overhaul of the federal tax system since its inception in 1913. It lowered marginal rates for individuals and corporations, dramatically reduced the number of income brackets, broadened the tax base by eliminating or reducing many tax breaks, and substantially lowered the dispersion of marginal rates across alternative income-producing activities. These changes were viewed as a significant step toward achieving a simpler, more efficient system. Another important element of the legislation was that average marginal tax rates on labor and capital income were brought closer together. The data in table 1, taken from the 1987 *Economic Report of the President,* illustrate this point.

TRA86 also reduced the dispersion of marginal tax rates within each category of income. For labor income, the number of individual tax brackets was reduced to only two: 15 percent and 28 percent. Before TRA86, there were 14

■ 1 Other incentives included an increase in the investment tax credit and an extension of the eligibility rules for Individual Retirement Accounts. The generous depreciation schedules were partially scaled back by the Tax Equity and Fiscal Responsibility Act of 1982. For more details, see *Economic Report of the President,* 1987 and 1989.

TABLE 1

Average Marginal Tax Rates before and after TRA86

	Before TRA86	After TRA86
Labor income	41.6	38.0
Capital income	34.5	38.4

SOURCE: *Economic Report of the President,* 1987, table 2-6, p. 91.

tax brackets, ranging from 11 to 50 percent.[2] In the category of capital income, the legislation eliminated the investment tax credit (which, under ERTA81, had applied to equipment but not structures), wiped out the capital gains preference by taxing gains as ordinary income, decelerated the depreciation schedule for real estate, imposed limits on passive business and real estate losses, and phased out the deductibility of non-mortgage consumer interest. By imposing a more uniform tax on alternative sources of income, TRA86 was designed to eliminate incentives in the tax code that had directed resources to less productive activities offering high after-tax returns. Moreover, a simpler, more efficient tax system could be expected to increase taxpayer compliance and reduce administrative costs.[3]

In economics, a benchmark for the study of tax policy is the approach pioneered by Ramsey (1927). He considered the problem faced by a benevolent government policymaker who is asked to choose a set of welfare-maximizing tax rates in order to finance some level of public expenditures.[4] In our paper, we adopt such an approach, but introduce another dimension to the problem. That is, we study the welfare implications of two features of the tax code highlighted by ERTA81 and TRA86: 1) the degree to which depreciation expenses are tax deductible, and 2) the differential tax treatment of labor and capital incomes. We formulate the government's problem as one in which the policymaker selects an optimal program of taxes, borrowing, and public expenditures to maximize the discounted utility of an infinitely lived representative household. In comparison to the standard Ramsey problem, we introduce one new parameter and one additional constraint that govern the structural features of the tax code. The parameter controls the degree to which depreciation expenses are tax deductible. The constraint controls whether labor and capital income may be taxed differently. We solve the government's problem over a range of structural combinations and compute the resulting long-run allocations.

The inputs to the model's production technology are per capita quantities of labor, private capital, and public capital. This setup is motivated by an expanding body of recent theoretical and empirical research which suggests that public capital may play an important role in the dynamics of economic growth.[5] Our specification of constant returns to scale across all three inputs implies that competitive firms realize positive economic profits equal to the difference between the value of output and the payments made to the private inputs. Ideally, the government would like to tax these profits at a rate of 100 percent, because profits do not affect agents' decisions at the margin. However, if (as we assume) the government cannot distinguish between profits and other types of capital income, then the capital tax also functions as a tax on profits, but one with an endogenous upper bound.

We find that in such an environment, long-run household welfare (as measured by steady-state utility) can be improved by a policy of "accelerated depreciation," whereby the depreciation rate for tax purposes exceeds the rate of economic depreciation. Accelerated depreciation, combined with a positive tax rate on all capital income, serves to increase the effective tax rate on pure profits relative to other types

2 Under TRA86, the 15 percent tax bracket and the personal exemption were phased out, creating an implicit third bracket for high-income individuals at 33 percent. The Omnibus Budget Reconciliation Act of 1990 (OBRA90) created a new statutory bracket at 31 percent. OBRA93, enacted in August 1993, created two additional statutory brackets for high-income individuals, making a total of five: 15, 28, 31, 36, and 39.6 percent. See *Economic Report of the President,* 1994, table 1-4, p. 34.

3 For additional description and analysis of TRA86, see Slemrod (1991) and the two symposia in *Journal of Economic Perspectives,* summer 1987 and winter 1992.

4 Examples of this approach in the context of dynamic general equilibrium models include Kydland and Prescott (1980), Lucas and Stokey (1983), Judd (1985), Chamley (1986), Lucas (1990), Zhu (1992, 1995), Bull (1993), Chari, Christiano, and Kehoe (1994, 1995), Roubini and Milesi-Ferretti (1994), Coleman (1996), and Jones, Manuelli, and Rossi (1993, 1997).

5 The idea that public capital may represent an important productive input is not new (see Arrow and Kurz [1970]). Some recent papers that explore the theoretical implications of productive public expenditures include Barro (1990), Barro and Sala-i-Martin (1992), Baxter and King (1993), Glomm and Ravikumar (1994), Corsetti and Roubini (1996), Judd (1997b), Lansing (1997), and Cassou and Lansing (1997). Some recent empirical applications include Finn (1993), Ai and Cassou (1995), and Kocherlakota and Yi (1996, 1997). See Sturm, Kuper, and de Haan (1997) for an extensive review of the empirical evidence regarding the productive effects of public capital.

of capital income. In this way, accelerated depreciation helps undo the restriction that prevents the government from imposing a separate tax on profits.

We also examine the effects of imposing separate tax rates on labor and capital income versus applying a uniform tax rate to all income. This portion of our analysis is motivated not only by TRA86 (which partially closed the gap between labor and capital tax rates), but also by recently proposed versions of the so-called "flat tax," which calls for a uniform tax rate on all taxable income.[6] Since tax rates in our model are endogenous, the government adjusts both the labor tax and the capital tax in response to any change in the depreciation allowance. The use of a uniform income tax imposes an additional constraint on the government's decision problem, namely, that the tax rate on labor income must equal the tax rate on capital income. If the additional constraint is binding, household welfare will be lower relative to the unconstrained case.

In the calibrated version of our model, however, we find that the optimal steady-state tax rates on labor and capital income are numerically close for a range of typical depreciation tax policies. Thus, the additional constraint under the uniform income tax is not severely binding in the steady state. This means that the benefits from separate tax rates on labor and capital income tend to be small.

The remainder of this paper is organized as follows. Section I describes the model. The computation procedure and choice of parameter values are discussed in section II. Section III presents our quantitative results, and section IV concludes. An appendix provides technical details regarding the solution of the government's problem.

I. The Model

The model economy consists of a private sector that operates in competitive markets and a benevolent optimizing government. The private sector is typical of macroeconomic models with agents behaving optimally, taking government policy as a given. In formulating its policy, the government takes into account the rational responses of the private sector. Below, we describe each of these features in more detail.

The Private Sector

The private sector consists of a large but fixed number of identical households, each of which owns a single firm that produces output y_t according to the technology

$$(1) \quad y_t = k_t^{\theta_1} h_t^{\theta_2} k_{gt}^{\theta_3},$$

where $\theta_1 + \theta_2 + \theta_3 = 1$.[7] This technology is characterized by three factors of production: the per capita stock of private capital k_t, per capita labor hours h_t, and the per capita stock of public capital k_{gt}. Here, k_{gt} is specified as a per capita quantity so that no scale effects are associated with the number of firms.[8] We assume that firms operate in competitive markets and maximize profits. The firm's decision problem can be summarized as

$$(2) \quad \max_{k_t,\, h_t} \left(k_t^{\theta_1} h_t^{\theta_2} k_{gt}^{\theta_3} - r_t k_t - w_t h_t\right),$$

where r_t is the rental rate on private capital and w_t is the real wage. Since $\theta_1 + \theta_2 + \theta_3 = 1$, the firm earns an economic profit equal to the difference between the value of output and the payments made to the private inputs. Our assumptions about firm ownership imply that all households receive equal amounts of total profits. The market-clearing input prices and the resulting firm profits are given by

$$(3) \quad r_t = \theta_1 y_t / k_t$$

$$(4) \quad w_t = \theta_2 y_t / h_t$$

$$(5) \quad \pi_t = (1 - \theta_1 - \theta_2) y_t .$$

The infinitely lived representative household maximizes a stream of discounted utilities:

$$(6) \quad \max \sum_{t=0}^{\infty} \beta^t (\ln c_t - A h_t + B \ln g_t), \; A, B > 0,$$

6 For details regarding the flat tax, see Hall and Rabushka (1995). For a theoretical analysis of the growth effects of a flat tax, see Cassou and Lansing (1996).

7 Empirical work by Aschauer (1989), Munnell (1990), and Ai and Cassou (1995) supports a technology specification with $\theta_1 + \theta_2 + \theta_3 = 1$.

8 This setup can be viewed as incorporating an implicit congestion effect related to the number of firms (which is equal to the number of households here). See Glomm and Ravikumar (1994) and Judd (1997b) for models in which an explicit congestion effect is linked to levels of the private-sector inputs k_t and h_t.

where $\beta \in (0,1)$ is the household discount factor, c_t is private consumption, and h_t is hours worked. The fact that utility is linear in hours worked draws on the formulation of indivisible labor described by Rogerson (1988) and Hansen (1985). This implies that all fluctuations in total labor hours are due to the number of workers employed, rather than to variations in hours per worker.[9] Household preferences also include a term representing the utility provided by per capita public consumption goods g_t. The specification of additive separability in g_t is supported by parameter estimates in McGrattan, Rogerson, and Wright (1997) using postwar U.S. data. This setup simplifies the computations, because the term involving g_t can be ignored when deriving the household optimization conditions.

The household faces the following within-period budget constraint:

$$(7) \qquad c_t + x_t + b_{t+1} \leq (1 - \tau_{ht}) w_t h_t + (1 - \tau_{kt})(r_t k_t + \pi_t + r_{bt} b_t) + \tau_{kt} \phi \delta k_t + b_t,$$

with k_0 and b_0 given. Here, x_t is private investment and b_t represents one-period, real government bonds that earn interest at rate r_{bt}. We assume that the government levies taxes on two categories of income. Labor income, given by $w_t h_t$, is taxed at rate τ_{ht}. Capital income, given by $r_t k_t + \pi_t + r_{bt} b_t$, is taxed at rate τ_{kt}.[10] Households view τ_{kt}, τ_{ht}, w_t, r_t, r_{bt}, and π_t as determined outside their control.

A few words about the model's assumed tax structure are in order. Here, as is typically the case in Ramsey problems, the government's menu of available tax instruments is artificially restricted, first by ruling out lump-sum taxes, second by ruling out consumption taxes, and third by ruling out a separate tax on profits. Since profits do not affect household decisions at the margin, the government would want to tax profits as much as possible to obtain nondistortionary revenue. If a separate tax on profits were available, the government would set the tax rate equal to 100 percent, and the model would behave in much the same way as one having no profits to begin with. In particular, the optimal steady-state tax on capital income would equal zero.

For our purposes, this is not a desirable result because we are interested in formulating a model that can capture some important observed features of U.S. tax policy. So that our model may capture positive capital taxation, we postulate that the government cannot distinguish between profits and other types of capital income. In such an environment, the capital tax also serves as a tax on pure profits, but one with an endogenous upper bound.[11]

The term $\tau_{kt} \phi \delta k_t$ represents a depreciation allowance, where $\delta \in [0,1]$ is the capital depreciation rate, and $\phi \geq 0$ is a tax-structure parameter that controls the degree to which depreciation expenses are tax deductible. The effective depreciation rate for tax purposes can be viewed as $\phi\delta$. When $\phi > 1$, the effective depreciation rate exceeds the rate of economic depreciation δ. We refer to this case as a policy of "accelerated" depreciation. In reality, accelerated depreciation implies $\phi > 1$ in the early years of an asset's life, but $\phi < 1$ in later years. In our model, however, ϕ can be interpreted as a weighted-average value over the asset's entire life. The law of motion for the private capital stock is

$$(8) \qquad k_{t+1} = (1 - \delta) k_t + x_t.$$

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

$$(9a) \qquad c_t: \quad \lambda_t = 1/c_t$$

$$(9b) \qquad h_t: \quad \lambda_t (1 - \tau_{ht}) w_t = A$$

$$(9c) \qquad k_{t+1}: \quad \lambda_t = \beta \lambda_{t+1} [(1 - \tau_{kt+1}) r_{t+1} - (1 - \phi \tau_{kt+1}) \delta + 1]$$

$$(9d) \qquad b_{t+1}: \quad \lambda_t = \beta \lambda_{t+1} [(1 - \tau_{kt+1}) r_{bt+1} + 1]$$

$$(9e) \qquad \text{TVC}: \quad \lim_{t \to \infty} \beta^t \lambda_t k_{t+1} = 0$$

$$(9f) \qquad \text{TVC}: \quad \lim_{t \to \infty} \beta^t \lambda_t b_{t+1} = 0,$$

9 In post–World War II U.S. data, about two-thirds of the variance in total labor hours over the business cycle is due to changes in the number of workers. See Kydland and Prescott (1990).

10 An alternative decentralization, which is equivalent to the one used here, combines the household and firm problems such that after-tax capital income is $(1 - \tau_{kt})(y_t - w_t h_t + r_{bt} b_t)$, where y_t is given by equation (1).

11 The zero-tax result is discussed by Arrow and Kurz (1970), pp. 195–203, and has been further elaborated on by Judd (1985), Chamley (1986), and Jones, Manuelli, and Rossi (1993, 1997). Besides profits, other mechanisms for overturning the zero-tax result include borrowing constraints, monopoly power, externalities, alternative specifications of the capital accumulation technology, and untaxed factors of production. For details, see Aiyagari (1995), Judd (1997a, 1997b), Zhu (1995), Guo and Lansing (1995), and Correia (1996).

where λ_t is the Lagrange multiplier associated with the budget constraint (7). The transversality conditions ensure that (7) can be transformed into an infinite-horizon, present-value budget constraint.

The Government

The government chooses a program of taxes, borrowing, and public expenditures to maximize the representative household's discounted utility. To avoid time-inconsistency problems, we assume that the government can commit to a sequence of policies announced at $t = 0$. Following the approach of Chari, Christiano, and Kehoe (1994, 1995), we further assume that τ_{k0} and r_{b0} are specified exogenously such that tax revenue collected at $t = 0$ cannot finance all future expenditures. Otherwise, an initial levy on private-sector assets may allow the government to choose $\tau_{ht} = \tau_{kt} = 0$ for some $t > \hat{t}$. This case is not very interesting because after period $\hat{t}$, the model looks identical to one with lump-sum taxes.

In per capita terms, the government's budget constraint is

$$(10) \quad g_t + x_{gt} + b_t(1 + r_{bt}) - b_{t+1}$$
$$= \tau_{ht} w_t h_t + \tau_{kt}[(r_t - \phi\delta)k_t + \pi_t + r_{bt} b_t].$$

Government expenditures on the left side of (10) include public consumption g_t, public investment x_{gt}, and outlays associated with government borrowing. The law of motion for the stock of public capital is

$$(11) \quad k_{gt+1} = (1 - \delta_g)k_{gt} + x_{gt},$$

with k_{g0} given. The depreciation rate of public capital is δ_g. The summation of the household budget constraint (7) and the government budget constraint (10) yields the following per capita resource constraint for the economy:

$$(12) \quad y_t = c_t + g_t + x_t + x_{gt}.$$

Since the resource constraint and the government budget constraint are not independent equations, (12) will be used in place of (10) in formulating the government's problem.

As a condition for equilibrium, government policy must consider the rational responses of the private sector, as summarized by (3)–(5), (7), and (9a)–(9e). It is convenient to use these constraints to eliminate some variables, so that the government's problem is formulated as one in which the policymaker directly chooses a sequence of optimal allocations $\{c_t, h_t, g_t, k_{t+1}, k_{gt+1}\}_{t=0}^{\infty}$. Once known, this sequence can be used to recover a sequence of optimal tax rates and government debt that will support the allocations as a decentralized equilibrium. The appendix provides technical details concerning the formulation and solution of the government's decision problem.

Up to this point, our model has allowed for differential tax treatment of labor and capital income. However, as noted in the introduction, an important consequence of TRA86 was that average marginal tax rates on these two sources of income were brought closer together. We investigate the welfare implications of this sort of tax structure by further restricting the menu of available tax instruments such that $\tau_{ht} = \tau_{kt} = \tau_t$ for all t. In this case, equations (3), (4), and (9a)–(9c) are used to derive the following additional constraint on the government's choice of allocations:

$$(13) \quad \frac{Ah_t c_t}{\theta_2 y_t} - \left[\frac{c_t/(\beta c_{t-1}) - 1 + \delta(1 - \phi)}{\theta_1 y_t/k_t - \phi\delta}\right] = 0.$$

At $t = 0$, the above constraint takes the form $\frac{Ah_0 c_0}{\theta_2 y_0} - (1 - \tau_{k0}) = 0$, where τ_{k0} is given.

II. Computation and Calibration

Because our focus is on the long-run stationary equilibrium, we use the steady-state level of the household's within-period utility function as our basic welfare measure. The change in steady-state utility from one tax structure to another can be readily translated into an annual cost and expressed as a percentage of total output. This welfare measure provides a rough estimate of the available gains or losses that might be realized by changing the tax code according to the options we consider. To gauge the magnitude of these welfare effects, we compare them to the available gains from switching to a system of nondistortionary lump-sum taxes.

A more comprehensive welfare analysis would need to take into account the dynamic transition between steady states. However, during the initial phase of the transition, the government in our model has a strong incentive to impose $\tau_{kt} = 1$, since the beginning stock of household assets (k_0 and b_0) is fixed. Indeed, Coleman (1996) shows that the welfare gain from this initial period of heavy capital taxation tends to dominate any differences between final steady states. Although this scenario provides

TABLE 2

Baseline Parameter Values

Parameter	Value
β	0.962
A	2.430
B	0.293
θ_1	0.3570
θ_2	0.5905
θ_3	0.0525
δ	0.084
δ_g	0.049
$\bar{b}$	0.190

SOURCE: Authors' calculations.

an interesting motivation for tax reform, it is doubtful that confiscatory taxes of this kind are politically feasible.

An alternative approach to transitions assumes that shifts in tax rates between steady states are given by some exogenously specified pattern. Using this approach, Lucas (1990), Cooley and Hansen (1992), and Laitner (1995) find that transitions involve a welfare loss that reduces the available gains from moving to a more desirable steady state. Coleman (1996) shows that these kinds of welfare calculations are strongly influenced by the starting tax-rate levels and the pattern of taxes allowed during the transition.

Given the many ways in which transitions can be modeled, we have chosen to compare tax structures on the basis of steady-state welfare analysis. Our results should thus be qualified to the extent that transitions between steady states produce significant benefits or costs. Our computation procedure holds the steady-state level of debt, $\bar{b}$, constant across tax structures. Additional details are contained in the appendix.

To perform the quantitative welfare analysis, we must first assign values to the model parameters. In doing so, we adopt a baseline tax structure defined as one where the depreciation rate for tax purposes coincides with the rate of economic depreciation ($\phi = 1.0$), and where labor and capital incomes are taxed separately ($\tau_{ht} \neq \tau_{kt}$). Parameters are then assigned values based on empirically observed features of the postwar U.S. economy.[12] The time period in the model is taken to be one year, consistent with the frequency of most government fiscal decisions. The discount factor $\beta = 0.962$ is chosen to yield a real after-tax interest rate of 4 percent.

The parameter A in the household utility function is chosen such that the fraction of time spent working is equal to 0.3 in the steady state. This is consistent with time-use studies, which indicate that households spend approximately one-third of their discretionary time in market work (see, for example, Juster and Stafford [1991]). The value of B is chosen to yield a steady-state ratio $\bar{g}/\bar{y} = 0.17$, the average value for the U.S. economy from 1954 to 1992.[13]

The exponents θ_1 and θ_3 in the Cobb–Douglas production function are chosen such that the model's steady-state capital-to-output ratios, $\bar{k}/\bar{y}$ and $\bar{k}_g/\bar{y}$, coincide with the postwar U.S. averages of 2.61 and 0.61, respectively. The exponent θ_2 is then given by $\theta_2 = 1 - \theta_1 - \theta_3$. The resulting values of θ_1 and θ_2 are within the range of the estimated shares of GNP received by private capital and labor in the U.S. economy.[14] The depreciation rates δ and δ_g are chosen such that the model's steady-state investment-to-output ratios, $\bar{x}/\bar{y}$ and $\bar{x}_g/\bar{y}$, coincide with the postwar U.S. averages of 0.22 and 0.03. The steady-state level of government debt, $\bar{b}$, is held constant at a value of 0.190 for each tax structure. For the baseline tax structure, this level of debt implies a steady-state ratio of $\bar{b}/\bar{y} = 0.37$, which matches the average level of U.S. federal debt held by the public as a fraction of GNP from 1954 to 1992. Table 2 summarizes the parameter values used in the computations.

12 The sample period begins in 1954. Data sources are as follows: The capital and investment series are in 1987 dollars from U.S. Department of Commerce, *Fixed Reproducible Tangible Wealth in the United States,* 1993. The series for k_{gt} and x_{gt} include nonmilitary government-owned equipment, structures, and residential components. The series for k_t and x_t include business equipment and structures, consumer durables, and residential components. The "capital input" version of the net stock series (which measures the remaining productive services available) was used for all capital data. Annualized series for the following variables were constructed using the indicated quarterly series from Citibase: $y_t = GNPQ$, and $g_t = GGEQ - x_{gt}$ – military investment. The series for b_t/y_t is federal debt held by the public as a fraction of GNP, where the debt series is from U.S. Congressional Budget Office, *Federal Debt and Interest Costs,* 1993, table A-2.

13 In computing this average, public consumption was estimated by subtracting total public investment (including military investment) from the annualized series for government purchases of goods and services, *GGEQ*. This was done to reduce double counting, since the *GGEQ* series does not distinguish between consumption and investment goods.

14 See Christiano (1988). The range of direct empirical estimates for θ_3 at the aggregate national level is quite large. Aschauer (1989) and Munnell (1990) estimate values of 0.39 and 0.34, respectively. Finn (1993) estimates a value of 0.16 for highway public capital. Aaron (1990) and Tatom (1991) argue that removing the effects of trends and taking account of possible missing explanatory variables (such as oil prices) can yield point estimates for θ_3 that are not statistically different from zero.

FIGURE 1

Effects on Steady-State Welfare

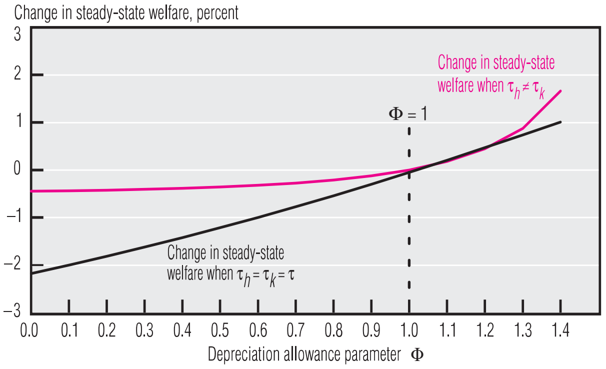


FIGURE 2

Effects on Steady-State Output

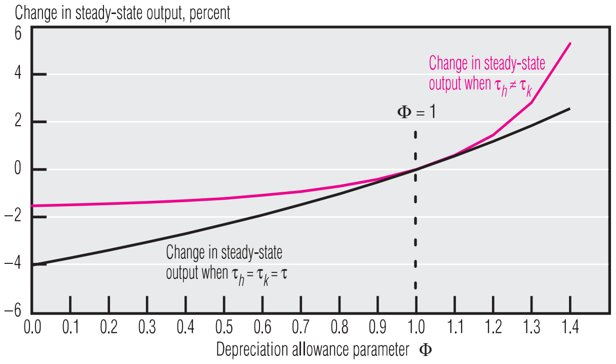


FIGURE 3

Effects on Optimal Steady-State Tax Rates

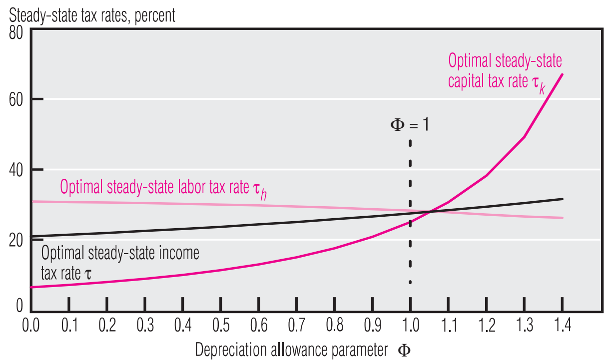
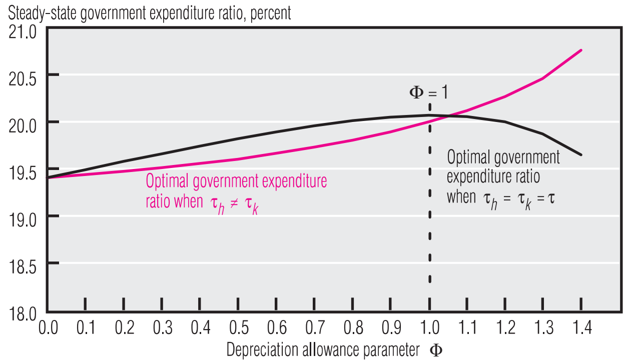


FIGURE 4

Effects on Optimal Steady-State Government Expenditures



SOURCE: Authors' calculations.

III. Quantitative Results

Figures 1 and 2 plot the depreciation allowance parameter ϕ versus the corresponding changes in steady-state welfare and output, relative to the baseline tax structure ($\phi = 1.0$ and $\tau_{ht} \neq \tau_{kt}$). Figures 3 and 4 show the effects of ϕ on the optimal steady-state tax rates and the optimal ratio of government expenditures to output. Tables 3 and 4 provide the quantitative results for two particular cases: $\phi = 1.0$ and $\phi = 1.2$. In all cases, the model parameters are held constant at the values shown in table 2.

Two general observations about the effects of changes in tax structure can be made. First, steady-state welfare and output are both increasing in ϕ. Second, the welfare and output effects of switching to a uniform income tax are extremely small when in the vicinity of $\phi = 1.0$, a typical value in models of dynamic fiscal policy.

The intuition for these results is straightforward. Recall that the government prefers to tax profits at a rate of 100 percent, because profits do not distort household decisions at the margin. A higher value of ϕ, combined with a positive tax rate on all capital income, serves to increase the effective tax rate on profits relative to other types of capital income. In this way, a policy of accelerated depreciation helps to undo the restriction that prevents the government from imposing a separate tax on profits. Figure 3 shows that as ϕ increases, the optimal steady-state tax on capital income, $\bar{\tau}_k$, also rises. At higher values of ϕ, the capital tax takes on more of the character of a profits tax. The increase in $\bar{\tau}_k$ allows for a lower distortionary tax on labor income $\bar{\tau}_h$ and, as shown in figure 4,

TABLE 3

Welfare and Output Comparison for Selected Cases (percent)

	ϕ = 1.0	
	$\tau_{ht} \neq \tau_{kt}$	$\tau_{ht} = \tau_{kt} = \tau_t$
Steady-state welfare change	0[a]	−0.053
Steady-state output change	0[a]	−0.012
	ϕ = 1.2	
	$\tau_{ht} \neq \tau_{kt}$	$\tau_{ht} = \tau_{kt} = \tau_t$
Steady-state welfare change	0.446	0.470
Steady-state output change	1.449	1.172

a. Baseline.
NOTE: The steady-state welfare change is defined as $100\Delta\bar{U}/(\bar{\lambda}\bar{y})$, where $\Delta\bar{U}$ is the change in steady-state utility relative to the baseline tax structure (ϕ = 1.0 and $\tau_{ht} \neq \tau_{kt}$), where $\bar{\lambda}$ and $\bar{y}$ are maintained at the values associated with the baseline tax structure. We divide by the Lagrange multiplier $\bar{\lambda}$ in order to convert $\Delta\bar{U}$ into units of consumption goods. The steady-state output change is defined as $100\Delta\bar{y}/\bar{y}$, where $\bar{y}$ is again maintained at the value associated with the baseline tax structure.
SOURCE: Authors' calculations.

TABLE 4

Tax-Rate Comparison for Selected Cases (percent)

	ϕ = 1.0	
	$\tau_{ht} \neq \tau_{kt}$	$\tau_{ht} = \tau_{kt} = \tau_t$
Steady-state tax rates	$\bar{\tau}_h$ = 28.3 $\bar{\tau}_k$ = 25.0	$\bar{\tau}$ = 27.5
	ϕ = 1.2	
	$\tau_{ht} \neq \tau_{kt}$	$\tau_{ht} = \tau_{kt} = \tau_t$
Steady-state tax rates	$\bar{\tau}_h$ = 27.2 $\bar{\tau}_k$ = 38.2	$\bar{\tau}$ = 29.4

SOURCE: Authors' calculations.

a higher ratio of government expenditures to output $(\bar{g} + \bar{x}_g)/\bar{y}$. Quantitatively, however, the effect of ϕ on the government expenditure ratio is very small.

When tax rates on labor and capital income are chosen separately, the values of $\bar{\tau}_h$ and $\bar{\tau}_k$ turn out to be numerically very close when in the neighborhood of ϕ = 1.0 (see figure 3 and table 4). As a result, the Lagrange multiplier μ_t associated with (13) is near zero in the steady state, and the constraint has only a minor impact on long-run allocations. Notice that in some instances, the steady-state utility under a uniform income tax can actually be higher than in the unconstrained case (figure 1). This is because the government's objective is to maximize a discounted stream of within-period utility functions, as opposed to maximizing a steady-state utility expression. Note also that the value of the uniform income tax rate $\bar{\tau}$ is always between the values of $\bar{\tau}_h$ and $\bar{\tau}_k$ (figure 3).

Table 3 shows that a policy of accelerated depreciation, with ϕ = 1.2, will increase steady-state welfare by almost 0.5 percent relative to the baseline case. To help gauge the magnitude of this effect, we can compare it to the available gain from switching to a system of nondistortionary lump-sum taxes. We find that the latter is 10.85 percent.[15] Thus, the welfare effects associated with changing from one distortionary tax structure to another are much smaller than the effects associated with eliminating distortions altogether. As another comparison, the welfare effects in table 3 are of the same order of magnitude as the steady-state welfare cost resulting from a 5 percent annual inflation rate as computed by Cooley and Hansen (1991, table 1), who obtain a value of 0.63 percent of output.

IV. Conclusion

We have examined the welfare implications of some basic structural features of the U.S. tax code, specifically, the tax deductibility of depreciation and the practice of taxing labor income differently from capital income. Our principal finding is that a policy of accelerated depreciation can help mimic the features of a profits tax and thereby improve welfare. We also find that the long-run welfare consequences of separate tax rates on labor and capital income tend to be small in the range of typical depreciation tax policies. Although our model is admittedly an abstract and simplified representation of the vastly complex U.S. tax code, we believe it may offer a possible justification for some observed features of recent tax reforms.

15 As in table 3, the change in steady-state utility $\Delta\bar{U}$ is converted into consumption units and expressed as a percentage of steady-state output relative to the baseline tax structure.

APPENDIX

Formulation and Solution of the Government's Decision Problem

Formulation of the Government's Problem

As noted in the text, the government must take into account the rational responses of the private sector, as summarized by equations (3)–(5), (7), and (9a)–(9e). These equations can be conveniently summarized by the following "implementability constraint":

$$\text{(A1)}\quad \sum_{t=1}^{\infty}\beta^t\left\{1-Ah_t-\frac{1}{c_t}\left[\frac{c_t/(\beta c_{t-1})-1+\delta(1-\phi)}{\theta_1 y_t/k_t-\phi\delta}\right](1-\theta_1-\theta_2)y_t\right\}+$$

$$1-Ah_0-\frac{1}{c_0}(1-\tau_{k0})(1-\theta_1-\theta_2)y_0-\frac{1}{c_0}(R_{k0}k_0+R_{b0}b_0)=0,$$

where

$$R_{k0}=(1-\tau_{k0})\theta_1 y_0/k_0-(1-\phi\tau_{k0})\delta+1$$

$$R_{b0}=(1-\tau_{k0})r_{b0}+1.$$

Equation (A1) is obtained by substituting the first-order conditions of the household and firm into the present-value household budget constraint. More specifically, it is obtained as follows: Multiply both sides of the household budget constraint (7) by $1/c_t$, substitute in (3)–(5) and (9a)–(9d), iterate the resulting expression forward and sum over time, and then apply the transversality conditions (9e) and (9f).

Government policy must also satisfy the condition $\tau_{kt}\leq 1$, so that households have an incentive to rent their capital stock to firms instead of simply letting it depreciate and writing off the depreciation against their tax bill. Using (9a) and (9c), this condition can be written as

$$\text{(A2)}\quad \frac{1}{c_t}-\frac{\beta}{c_{t+1}}[1-\delta(1-\phi)]\geq 0,\qquad \text{for } t\geq 0,$$

which is imposed as an additional constraint on the government's problem.

Since τ_{k0} and r_{b0} are specified exogenously, the government's problem amounts to choosing a set of allocations $\{c_t, h_t, g_t, k_{t+1}, k_{gt+1}\}_{t=0}^{\infty}$ to maximize household utility (6) subject to the implementability constraint (A1), the resource constraint (12), and the tax-rate constraint (A2). Given the optimal allocations, both the appropriate sequence of factor prices r_t and w_t and the policy variables τ_{ht}, τ_{kt}, r_{bt}, and b_{t+1} that decentralize the allocations can be recovered from the private-sector equilibrium conditions. For example, the optimal allocations define w_t and λ_t from equations (4) and (9a). Given w_t and λ_t, equation (9b) defines the government's optimal choice for τ_{ht}.

The general version of the government's problem can be written as

$$\text{(A3)}\quad \max_{\substack{c_t,\,h_t,\,g_t,\\ k_{t+1},\,k_{gt+1}}}\ \sum_{t=1}^{\infty}\beta^t\Bigg\{\ln c_t-Ah_t+B\ln g_t+$$

$$\Lambda\left[1-Ah_t-\frac{1}{c_t}\left[\frac{c_t/(\beta c_{t-1})-1+\delta(1-\phi)}{\theta_1 y_t/k_t-\phi\delta}\right](1-\theta_1-\theta_2)y_t\right]\Bigg\}+$$

$$\ln c_0-Ah_0+B\ln g_0+$$

$$\Lambda\left[1-Ah_0-\frac{1}{c_0}(1-\tau_{k0})(1-\theta_1-\theta_2)y_0-\frac{1}{c_0}(R_{k0}k_0+R_{b0}b_0)\right],$$

subject to

$$R_{k0} = (1 - \tau_{k0})\theta_1 y_0 / k_0 - (1 - \phi\tau_{k0})\delta + 1$$

$$R_{b0} = (1 - \tau_{k0}) r_{b0} + 1$$

$$g_t = y_t - c_t - k_{t+1} + k_t(1 - \delta) - k_{gt+1} + k_{gt}(1 - \delta_g)$$

$$y_t = k_t^{\theta_1} h_{gt}^{\theta_2} k_{gt}^{\theta_3}$$

$$\frac{1}{c_t} - \frac{\beta}{c_{t+1}} [1 - \delta(1 - \phi)] \geq 0$$

$$\frac{A h_t c_t}{\theta_2 y_t} - \left[\frac{c_t / (\beta c_{t-1}) - 1 + \delta(1 - \phi)}{\theta_1 y_t / k_t - \phi\delta} \right] = 0, \text{ when } \tau_{ht} = \tau_{kt} = \tau_t,$$

with k_0, k_{g0}, b_0, τ_{k0}, and r_{b0} given. The Lagrange multiplier Λ associated with (A1) is determined endogenously at $t = 0$ and is constant over time.

In general, the tax-rate constraint (A2) will bind for a finite number of periods $0,1,2 \ldots \bar{t}$, and then become slack for $t > \bar{t}$. For $t > \bar{t}$, the solution to (A3) can be characterized by a set of stationary decision rules: $c_t(s_t, \Lambda)$, $h_t(s_t, \Lambda)$, $g_t(s_t, \Lambda)$, $k_{t+1}(s_t, \Lambda)$, $k_{gt+1}(s_t, \Lambda)$, where $s_t = \{k_t, k_{gt}, c_{t-1}\}$.[16] Given these rules, a stationary decision rule for the government bond allocation $b_{t+1}(s_t, \Lambda)$ can be computed as the solution to the following recursive equation:

$$\text{(A4)} \quad \frac{1}{c_t}(k_{t+1} + b_{t+1}) = \beta \left\{ \frac{1}{c_{t+1}}(k_{t+2} + b_{t+2}) + 1 - A h_{t+1} - \frac{1}{c_{t+1}} \left[\frac{c_{t+1} / (\beta c_t) + \delta(1 - \phi)}{\theta_1 y_{t+1} / k_{t+1} - \phi\delta} \right] (1 - \theta_1 - \theta_2) y_{t+1} \right\}.$$

Equation (A4) is the household budget constraint at $t + 1$ after substituting in the first-order conditions for the private sector. For $t \leq \bar{t}$, the optimal allocations are determined using the government's first-order conditions with respect to c_t, h_t, g_t, k_{t+1}, k_{gt+1} and η_t, where η_t is the Lagrange multiplier associated with (A2). The computation works backward in time starting from $t = \bar{t}$, and imposes the stationary decision rules for $t > \bar{t}$ as boundary conditions. The entire sequence of allocations, together with the initial conditions, determines Λ such that the implementability constraint (A1) is satisfied. Notice that when $\Lambda = \eta_t = 0$, the government's problem (A3) collapses to a social planner's problem. The planner's allocations can be decentralized when the government has access to lump-sum taxes.

The Optimal Steady-State Capital Tax

The government's first-order condition with respect to k_{t+1} is

$$\text{(A5)} \quad \frac{-B}{g_t} + \frac{\beta B}{g_{t+1}} [\theta_1 y_{t+1} / k_{t+1} + 1 - \delta] + \beta\Lambda \frac{\partial W_{t+1}}{\partial k_{t+1}} + \beta\mu_{t+1} \frac{\partial F_{t+1}}{\partial k_{t+1}} = 0,$$

where μ_t is the Lagrange multiplier associated with (13). If labor and capital incomes can be taxed separately, then $\mu_t = 0$ for all t. To conserve space, W_t and F_t are defined as follows:

16 Including c_{t-1} in the state vector at time t is the mechanism by which the commitment assumption is maintained in the recursive version of (A3). See Kydland and Prescott (1980).

$$\text{(A6)}\quad W_t \equiv \frac{1}{c_t}\left[\frac{c_t/(\beta c_{t-1}) - 1 + \delta(1-\phi)}{\theta_1 y_t/k_t - \phi\delta}\right](1-\theta_1-\theta_2)y_t$$

$$\text{(A7)}\quad F_t \equiv \frac{Ah_t c_t}{\theta_2 y_t} - \left[\frac{c_t/(\beta c_{t-1}) - 1 + \delta(1-\phi)}{\theta_1 y_t/k_t - \phi\delta}\right].$$

The steady-state version of (A5) can be written as

$$\text{(A8)}\quad \frac{B}{\bar{g}}\,[\theta_1\bar{y}/\bar{k} - \delta - \rho] + \Lambda W_k + \bar{\mu}F_k = 0,$$

where $\rho = 1/\beta - 1$ and W_k and F_k represent the steady-state values of the derivatives $\frac{\partial W_{t+1}}{\partial k_{t+1}}$ and $\frac{\partial F_{t+1}}{\partial k_{t+1}}$, respectively. If profits are zero, then $1 - \theta_1 - \theta_2 = 0$, and (A6) implies $W_k = 0$. If labor and capital income can be taxed separately, then $\bar{\mu} = 0$. If both of these conditions hold, then (A8) simplifies to

$$\text{(A9)}\quad \bar{r} - \delta - \rho = 0,$$

where $\bar{r} = \theta_1\bar{y}/\bar{k}$. The steady-state version of (9c) is

$$\text{(A10)}\quad (1-\bar{\tau}_k)\bar{r} - (1-\phi\bar{\tau}_k)\delta - \rho = 0.$$

Equation (A10) can be rearranged to obtain $\bar{\tau}_k = \frac{\bar{r}-\delta-\rho}{\bar{r}-\phi\delta}$. Combining this expression with (A9) yields $\bar{\tau}_k = 0$, which confirms the result obtained by Judd (1985) and Chamley (1986). When $1 - \theta_1 - \theta_2 > 0$ or $\bar{\mu} > 0$, however, (A8) and (A10) imply $\bar{\tau}_k > 0$.[17]

Computation Procedure

The optimal long-run allocations in the model depend on the Lagrange multiplier Λ, which is computed as follows. First, we use the constraints in (A3) to substitute out g_t and y_t. The tax-rate constraint (A2) can be ignored in this computation because it can later be verified that $\bar{\tau}_k \leq 1$, where $\bar{\tau}_k$ is the optimal steady-state tax on capital income. Next, we obtain the first-order conditions of (A3) with respect to c_t, h_t, k_{t+1}, k_{gt+1}, and for the uniform income tax structure μ_t, where μ_t is the Lagrange multiplier associated with (13). If labor and capital income can be taxed separately, then $\mu_t = 0$ for all t.

Given an initial guess for Λ, we compute the steady state from the first-order conditions. We then use the steady-state version of (A4) to compute the steady-state level of government debt $\bar{b}$. We repeat this procedure, adjusting Λ for each tax structure so that all tax structures have the same level of steady-state debt. Our computation procedure implies a set of initial conditions $\{k_0, k_{g0}, b_0, \tau_{k0}, r_{b0}\}$ and allocations $\{c_t, h_t, g_t, k_{t+1}, k_{gt+1}, \eta_t, \mu_t\}_{t=0}^{\bar{t}}$ for each tax structure such that the implementability constraint (A1) is satisfied for the values of $\bar{b}$ and Λ that we obtain.[18]

With lump-sum taxes, the steady state is obtained from the first-order conditions of (A3) with respect to c_t, h_t, k_{t+1}, and k_{gt+1}, with $\Lambda = \mu_t = 0$ for all t.

17 See Jones, Manuelli, and Rossi (1997) for a general proof of this result.

18 Alternatively, we could assume that there exists a uniform set of initial conditions for all tax structures, but allow for a lump-sum tax at $t = 0$ to satisfy the implementability constraint. See Chari, Christiano, and Kehoe (1995) for a more detailed discussion of this point.

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