JOURNAL OF ECONOMIC THEORY 58, 290–316 (1992)

Tax Distortions in a Neoclassical Monetary Economy

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Received January 29, 1991; revised September 24, 1991

In this paper we use the common perspective provided by the neoclassical growth model to evaluate the size of the distortions associated with different monetary and fiscal policies designed to finance a given sequence of government expenditures. We calibrate a neoclassical monetary economy to match important features of the U.S. economy and use it to provide a quantitative assessment of the welfare costs of government policies involving different combinations of taxes on capital and labor income, consumption, and money holdings. In addition we evaluate the welfare gains from tax reforms designed to replace the tax on capital income with other forms of taxation. *Journal of Economic Literature* Classification Numbers: B22, E62

1. INTRODUCTION

The U.S. fiscal system (at least at the federal level) relies primarily on the taxation of labor and capital income and very little on the taxation of consumption or real balances. While there has been considerable research on the efficiency of capital and labor income taxes and many studies of the welfare costs of the inflation tax, there have been few attempts to look at these sources of revenue together. In this paper we use the common perspective provided by the neoclassical growth model to evaluate the size of the distortions associated with different monetary and fiscal policies

* We have benefitted from the comments and suggestions of Eric Engen, Teresa Garcia-Mila, Thomas Sargent, Charles Stuart, participants in the 1990 Northwestern University summer workshop, and two anonymous referees. This research was supported by NSF Grant SES-8921346. The first author also acknowledges support from the Olin Foundation.

0022-0531/92 $5.00

designed to finance a given sequence of government expenditures. We construct an artificial neoclassical monetary economy, calibrate it to match important features of the U.S. economy, and use it to provide a quantitative assessment of the welfare costs associated with government policies involving different combinations of taxes on capital and labor income, consumption, and holdings of money. We then consider the welfare gains from tax reforms that are designed to replace the tax on capital income with other forms of taxation.

Measurement of the welfare costs associated with different ways of financing government expenditures is a central issue for economists and has important implications for economic policy. There is a very large public finance literature that has addressed this topic and a number of authors, notably Chalmley [5], Judd [19], and Lucas [24], have attempted to quantify the welfare costs of factor taxation in very simple dynamic general equilibrium models. The current paper is in the spirit of these studies. Here we attempt to quantify the welfare costs of alternative forms of taxation in a model economy where the government can raise revenue through an inflation tax and a consumption tax as well as by the taxation of factor incomes. We assume that the government must finance an exogenous stream of expenditures either through distorting taxes or a combination of taxes and bonds that keep the present value of government revenues equal to the present value of government expenditures. We capture the magnitude of the pure distortions associated with alternative taxes by computing the percentage change in consumption required to give agents in an economy where government spending is financed with distorting taxes the same utility level they would receive if lump sum taxes were used.

The economy we study is a perfect foresight version of a stochastic growth model of the sort used in real business cycle studies combined with the cash-in-advance framework of Lucas and Stokey [25, 26]. This economy incorporates a distinction between "cash goods" and "credit goods," a specification that permits sensitivity of real money balances to changes in the interest rate. In addition, this specification creates a distinction between the inflation tax and a consumption tax. This is because a consumption tax will distort some choices, such as the labor–leisure decision, while the inflation tax will distort along these same margins and, in addition, will distort the cash good–credit good decision.

We use this model economy to address three issues. First, we want to provide a quantitative assessment of the size of the distortions associated with different taxes. We examine how the steady state welfare of an economy is affected when different combinations of taxes on labor income, capital income, consumption and money holdings are used to produce a given amount of revenue. Second, using as an initial starting point an economy in which all revenue is raised with taxes on labor and capital income, we assess the welfare consequences of tax reforms designed to replace the tax on capital income with taxes that are less distorting. Our interest in this question is motivated by the fact that our steady state experiments indicate that economies that do not make use of a capital tax enjoy significantly higher welfare. In addition, the optimal tax literature argues that the tax on capital income is a bad tax.[1] However, unlike the policies that emerge from the optimal tax literature, the tax reforms we consider are changes in taxes that occur at one point in time. It may be that welfare is improved significantly by considering tax reforms that occur in stages, that is, policies which involve tax rates that change over time. Although we do not directly solve an optimal taxation problem we do study experiments which involve initial policies that are different from policies in the limit. Our goal is to assess the potential magnitude of the welfare gains from nonstationary tax policies.

In the next section of the paper we describe in detail the model economy we are going to study and describe the equilibrium concept to be used. In Section 3 we discuss the computational methods used to solve for a competitive equilibrium, to simulate the transitions from one policy to another, and to compute the welfare costs associated with various policies. Section 4 describes how the model is calibrated to features of the U.S. economy.

The quantitative results are presented in Section 5. In the first set of experiments we compare the steady state welfare costs across economies characterized by different mixes of taxes designed to raise the same total revenue. Our base for comparison is a model economy where all revenue is raised by the taxation of labor and capital income at rates close to those observed in the U.S. economy. Our results suggest that the welfare costs are slightly lower in economies that substitute inflation or consumption taxes for the tax on labor income, but dramatically lower for economies that substitute any tax for the tax on capital income. In particular, the welfare cost associated with an economy that uses consumption taxes in place of capital taxes is about half that in an economy where capital taxes are used (6.6% of GNP vs 13.3%). We then consider the welfare consequences and the dynamic behavior of the economy under policies that involve a transition from capital income taxation to other forms of taxation designed to yield the same present value of revenue. We find welfare benefits from these tax reforms are much smaller than might be expected from the steady state comparisons because of the costs associated with the

[1] Some recent papers that study optimal taxation, in the sense of Ramsey [28], in the context of dynamic economies include Chamley [6], Judd [20], Chari *et al.* [7, 8], Jones *et al.* [18], King [21], Lucas [24], and Zhu [32].

transition. A tax reform that replaces capital income taxation with a consumption tax reduces welfare costs from 13.3% of GNP to 10.5%. The final set of experiments considers nonstationary policies that involve a transition to a temporary policy followed by a new steady state policy, again designed to support the same sequence of government expenditures. These results show that nonstationary tax policies can improve welfare compared to stationary policies, but the improvement associated with the policies we consider is not large.

2. A Cash-in-Advance Economy with Taxes

The model economy we study is populated with a continuum of identical infinitely lived households endowed with k_0 units of capital in period 0 and one unit of time each period that is allocated between work and leisure. The households receive income from capital and labor which is used to finance consumption, investment in additional capital, or held in the form of money or government bonds. Some consumption goods, however, can only be purchased with previously accumulated cash balances. This feature ensures that money is valued in equilibrium. Output is produced from capital and labor by a single competitive firm with access to a constant return to scale technology. In addition, the government in our model economy finances a given sequence of expenditures by issuing currency, taxing labor and capital income, taxing consumption expenditures, and issuing bonds. There is no uncertainty in this economy; agents are assumed to have perfect foresight.

An important feature of this model is that asset trading is permitted only at the beginning of the period, before the goods market is open. Households obtain at that time the currency needed to purchase a type of consumption good called "cash goods." In the beginning of any period t, a representative household has currency holdings equal to $m_t + (1 + R_t) b_t$, where m_t is currency carried over from the previous period and the second term is principle plus interest from government bond holdings, b_t. Households then acquire bonds that they carry into the next period, b_{t+1}. This leaves the household with $m_t + (1 + R_t) b_t - b_{t+1}$ units of currency for purchasing goods; the household has no access to additional currency after this point. Thus, purchases of cash goods, denoted c_1, must satisfy the cash-in-advance constraint,

$$(1 + \tau_{ct}) P_t c_{1t} \leqslant m_t + (1 + R_t) b_t - b_{t+1}, \tag{2.1}$$

where P_t is the price level in period t and τ_{ct} is the consumption tax rate in period t. It turns out that this constraint will hold with equality as long as the nominal interest rate is positive. This requirement will be satisfied throughout our analysis.

In addition to the cash good, households obtain utility from consuming a "credit good," denoted c_{2t}, and leisure, $1-h_t$, where h_t is hours worked. Previously accumulated currency is not required to purchase credit goods; they can be purchased with contemporaneously earned income. Preferences are summarized by the following utility function:

$$\sum_{t=0}^{\infty} \beta^t(\alpha \log c_{1t} + (1-\alpha) \log c_{2t} - Bh_t), \qquad 0<\beta<1,\ 0<\alpha<1. \quad (2.2)$$

An important aspect of this utility function is that hours worked enters linearly. This feature follows from the following three assumptions as shown in Rogerson [29]: (1) labor is indivisible: people can either work some given number of hours or not at all; (2) the utility function is separable in consumption and leisure; and (3) agents trade employment lotteries rather than hours of labor. We have incorporated these assumptions because an indivisible labor economy is consistent with the fact that most changes in hours worked are due to changes in the number of workers, not in average hours worked per person. In addition, a model with this feature has been shown to more closely mimic features of aggregate time series data, in particular, the response of hours worked to a change in productivity, than a similar model without indivisible labor (see Hansen [14]).

Households maximize (2.2) subject to the following sequence of budget constraints[2]:

$$(1+\tau_{ct})(c_{1t}+c_{2t}) + x_t + \frac{m_{t+1}}{P_t} + \frac{b_{t+1}}{P_t}$$
$$\leqslant (1-\tau_{ht})\, w_t h_t + (1-\tau_{kt})\, r_t k_t + \tau_{kt}\, \delta k_t + \frac{m_t}{P_t} + \frac{(1+R_t)\, b_t}{P_t}. \quad (2.3)$$

The household expenditures include purchases of the two consumption goods, investment (x_t), money to be carried into the next period (m_{t+1}),

[2] This budget constraint incorporates the fact that both consumption goods and the investment good sell at the same price even though one is a cash good and the others are credit goods. This is because all goods are produced using the same technology and, from the point of view of the seller, sales of both credit goods and cash goods result in cash that will be available for spending at the same time in the following period. Although cash good sales in a given period result in cash receipts in the same period, this cash cannot be spent until the next period.

and government issued bonds. The funds available for these purchases include after-tax labor income, where τ_{ht} is the labor tax rate and w_t is the wage rate, and after-tax capital income, where τ_{kt} is the capital tax rate, k_t is the capital owned by the household, and r_t is the rental rate of capital. The third term on the right side of (2.3) reflects the depreciation allowance built into the tax code.[3] The last two terms are the currency carried from the previous period and the principle and interest from holdings of government bonds.

Investment in period t becomes productive capital in period $t+1$ according to the law of motion,

$$k_{t+1} = (1-\delta)\, k_t + x_t, \qquad 0 < \delta < 1. \tag{2.4}$$

The firm in this economy produces output, Y_t, using the constant returns to scale technology[4]:

$$Y_t = K_t^{\theta} H_t^{1-\theta}, \qquad 0 < \theta < 1. \tag{2.5}$$

The firm seeks to maximize profit, which is equal to $Y_t - w_t H_t - r_t K_t$. The first-order conditions for the firm's problem yield the following functions for the wage rate and rental rate of capital:

$$w(K_t, H_t) = (1-\theta)\left(\frac{K_t}{H_t}\right)^{\theta} \tag{2.6}$$

$$r(K_t, H_t) = \theta\left(\frac{H_t}{K_t}\right)^{1-\theta}. \tag{2.7}$$

The role of the government is to raise revenue to finance a sequence of government expenditures, $\{G_t\}_{t=0}^{\infty}$. Its monetary policy is to issue money according to the rule,

$$M_{t+1} = (1+\mu_{t+1})\, M_t, \tag{2.8}$$

[3] The depreciation allowance in our model is measured in real terms while the depreciation allowance in the U.S. tax code is based on nominal schedules. Therefore we do not capture the effect of inflation on the size of these allowances (and hence total government revenue) that has been stressed by Judd [20].

[4] We are employing the convention of using capital letters (such as K and H) for per capita variables that are determined in equilibrium but not chosen by the individual households and small letters (k and h) for variables under the direct control of the households. Of course, $K=k$ and $H=h$ in equilibrium. This convention will be particularly useful when we describe a recursive formulation of this economy in Section 2.2.

where $\{\mu_t\}_{t=1}^{\infty}$ is a sequence of money growth rates and M_0 is given. It follows that the amount of revenue raised by the government through money creation in period t is equal to $\mu_{t+1} M_t / P_t$.

The fiscal policy of the government consists of the sequence of government expenditures and a sequence of taxes on capital income, labor income, and consumption, $\{\tau_{kt}, \tau_{ht}\ \tau_{ct}\}_{t=0}^{\infty}$. These sequences must satisfy the requirement that the present value of the sequence of government expenditures equals the present value of the sequence of revenues. We refer to such a policy as a *feasible* government policy. To implement this policy, the government must issue bonds each period to satisfy the budget constraint,

$$G_t = \tau_{ht} w_t H_t + \tau_{kt}(r_t - \delta) K_t + \tau_{ct} C_t + \frac{\mu_{t+1} M_t}{P_t} + \frac{B_{t+1} - (1 + R_t) B_t}{P_t}, \tag{2.9}$$

where $C_t = C_{1t} + C_{2t}$. We assume that the initial stock of bonds, B_0, is equal to zero.

To facilitate solving for an equilibrium, we transform variables so that the household's problem is stationary. In particular, we define $\hat{m}_t \equiv m_t / M_t$, $\hat{P}_t \equiv P_t / M_{t+1}$, $\hat{b}_t \equiv b_t / M_t$, and $\hat{B}_t \equiv B_t / M_t$. This has the effect of eliminating M from the model. We now define an equilibrium for this economy:

Given $k_0 = K_0$, $\hat{b}_0 = \hat{B}_0 = 0$, $\hat{m}_0 = 1$, and a feasible fiscal and monetary policy $\{G_t, \tau_{ht}, \tau_{kt}, \tau_{ct}, \mu_{t+1}, \hat{B}_{t+1}\}_{t=0}^{\infty}$ satisfying (2.9), a *competitive equilibrium* is a set of sequences for the price level $\{\hat{P}_t\}_{t=0}^{\infty}$, interest rates $\{R_t\}_{t=0}^{\infty}$, factor prices $\{w_t, r_t\}_{t=0}^{\infty}$, household allocations $\{c_{1t}, c_{2t}, h_t, x_t, \hat{m}_{t+1}, \hat{b}_{t+1}, k_{t+1}\}_{t=0}^{\infty}$, and per capita quantities $\{C_{1t}, C_{2t}, H_t, X_t, K_{t+1}\}_{t=0}^{\infty}$ such that

(i) Given the sequence of price levels, interest rates, and factor prices, the sequence of quantities maximizes (2.2), subject to (2.1), (2.3), and (2.4);

(ii) $\hat{m}_{t+1} = 1$, $\hat{b}_{t+1} = \hat{B}_{t+1}$, $c_{1t} = C_{1t}$, $c_{2t} = C_{2t}$, $h_t = H_t$, $x_t = X_t$, $k_{t+1} = K_{t+1}$ for all t;

(iii) factor prices satisfy Eqs. (2.6) and (2.7).

2.1. *Solving for a Competitive Equilibrium*

Given that the cash-in-advance constraint holds with equality, equilibrium sequences for C_{1t}, C_{2t}, H_t, K_{t+1}, $\hat{B}_t$, $\hat{P}_t$, and R_t must satisfy the following set of equations for $t \geqslant 0$:

$$\text{(i)}\quad (1+R_t)=\frac{(1+\mu_t)\,C_{1t}(1+\tau_{ct})\,\hat{P}_t}{\beta C_{1t-1}(1+\tau_{ct-1})\,\hat{P}_{t-1}}$$

$$\text{(ii)}\quad \frac{(1+R_t)\,\hat{B}_t-(1+\mu_{t+1})\,\hat{B}_{t+1}}{\hat{P}_t}$$

$$=[(1-\theta)\,\tau_{ht}+\theta\tau_{kt}]\,K_t^{\theta}H_t^{1-\theta}-\delta\tau_{kt}\,K_t+\frac{\mu_{t+1}}{\hat{P}_t}+\tau_{ct}C_t-G_t$$

$$\text{(iii)}\quad (1+\tau_{ct})\,C_{1t}=[(1-\theta)\,\tau_{ht}+\theta\tau_{kt}+\tau_{ct}]\,K_t^{\theta}H_t^{1-\theta}-\delta\tau_{kt}\,K_t+\frac{1+\mu_{t+1}}{\hat{P}_t}$$

$$-\tau_{ct}(K_{t+1}-(1-\delta)\,K_t)-(1+\tau_{ct})\,G_t \qquad (2.10)$$

$$\text{(iv)}\quad (1+\tau_{ct})\,C_{2t}=[(1-\theta)(1-\tau_{ht})+\theta(1-\tau_{kt})]\,K_t^{\theta}H_t^{1-\theta}$$

$$+\delta\tau_{kt}\,K_t-\frac{1+\mu_{t+1}}{\hat{P}_t}-K_{t+1}+(1-\delta)\,K_t$$

$$\text{(v)}\quad (1-\alpha)(1+\mu_{t+1})\,\hat{P}_{t+1}(1+\tau_{ct+1})\,C_{1t+1}=\alpha\beta\hat{P}_t(1+\tau_{ct})\,C_{2t}$$

$$\text{(vi)}\quad (1+\tau_{ct})\,C_{2t}=\frac{(1-\alpha)(1-\theta)(1-\tau_{ht})}{B}\left(\frac{K_t}{H_t}\right)^{\theta}$$

$$\text{(vii)}\quad (1+\tau_{ct+1})\,C_{2t+1}=\beta\left[1+(1-\tau_{kt+1})\left(\theta\left(\frac{H_{t+1}}{K_{t+1}}\right)^{1-\theta}-\delta\right)\right]$$

$$\times(1+\tau_{ct})\,C_{2t}$$

The first of these equations is obtained from the first-order condition with respect to $\hat{b}_t$: for the household's optimization problem. Equation (ii) is obtained by substituting (2.6) and (2.7) into (2.9). The third equation is the per capita version of the cash-in-advance constraint, (2.1), with (ii) used to eliminate the last two terms. The per capita versions of the budget constraint, (2.3), and the cash-in-advance constraint, (2.1), were used to obtain the fourth equation. Equations (v) through (vii) are obtained from the first-order conditions with respect to $\hat{m}_{t+1}$, h_t, and k_{t+1}, respectively. Together, these seven equations, along with a feasible government policy, initial conditions $(K_0, \hat{B}_0)$, and terminal conditions that have not yet been specified, determine the equilibrium sequences for C_{1t}, C_{2t}, H_t, K_{t+1}, $\hat{B}_t$, $\hat{P}_t$, and R_t. In the remainder of this section we describe how the terminal conditions necessary for solving these equations are obtained.

In this paper we restrict our discussion to policies under which government expenditures, tax rates, and money growth rates are eventually constant. That is, there will always exist some date such that $G_t=G$, $\tau_{ct}=\tau_c$, $\tau_{ht}=\tau_h$, $\tau_{kt}=\tau_k$, and $\mu_{t+1}=\mu$ for all t beyond this date. The tax rates and money growth rate may differ from these values previous to this date. However, in the limit, all variables (exogenous and endogenous) will converge to a constant steady state. Our method involves approximating the equilibrium behavior of the economy in a neighborhood of the steady state with a set of linear rules that express H_t, $\hat{P}_t$, and K_{t+1} as functions of K_t. We will define these functions precisely in the next subsection using a recursive formulation of the model. These linear rules, evaluated at K_T, are used as the terminal conditions for solving the system of Eqs. (2.10) for the sequence of per capita quantities and prices for period 0 to $T-1$. Period T is chosen to be sufficiently large to ensure that the economy has converged close enough to the steady state for these linear functions to be accurate approximations.

More precisely, these functions enable one to express H_T, $\hat{P}_T$, and K_{T+1} as $H_T = H(K_T)$, $\hat{P}_T = P(K_T)$, and $K_{T+1} = K(K_T)$. These functions are used in Eqs. (iii) and (iv) of (2.10) for $t = T$ to obtain C_{1T} and C_{2T} as functions of K_T. These, in turn, are used to eliminate C_{1T} and C_{2T} in Eqs. (v) and (vii), for $t = T-1$. After these substitutions, Eqs. (iii)–(vii), for $0 \leqslant t \leqslant T-1$, comprise $5T$ equations in $5T$ unknowns, $\{C_{1t}, C_{2t}, H_t, K_{t+1}, \hat{P}_t\}$. Once this sequence has been obtained, Eqs. (i) and (ii) can be used to solve for the sequence of interest rates and bond holdings.

2.2. *A Recursive Formulation with Constant Taxes*

We now describe a recursive formulation of our model under the assumption that government expenditures, tax rates, and money growth rates are constant over time. With this formulation we are able to define precisely the functions determining H_T, $\hat{P}_T$, and K_{T+1}. The computational techniques used to obtain linear approximations of these functions will be described in Section 3.

Assuming that nominal interest rates are determined according to Eq. (2.10)(i), guaranteeing that the household's first-order condition for bond holdings is satisfied in equilibrium, (2.10)(ii) can be substituted into (2.1) and (2.3) to eliminate bonds from the households optimization problem. This is equivalent to replacing government bonds with a particular sequence of lump sum taxes and transfers that leaves household decisions the same as they would be if bonds were issued. Under this interpretation, a household enters a given period with k units of capital, when the per capita capital stock is K, and currency, expressed as a fraction of per capita money holdings, equal to $\hat{m}$. The function $V(K, k, \hat{m})$ denotes the equilibrium maximized present value of the utility stream of the representative household as a function of his beginning of period state. This function V must satisfy Bellman's equation (primes denote next period values):

$$V(K, k, \hat{m}) = \max\{[\alpha \log c_1 + (1-\alpha) \log c_2 - Bh] + \beta V(K', k', \hat{m}')\}$$

subject to

$$\begin{aligned}
(1+\tau_c)\, c_1 &= \frac{\hat{m}}{\hat{P}} + TR \\
(1+\tau_c)(c_1 + c_2) + x + \frac{(1+\mu)\,\hat{m}'}{\hat{P}} &= (1-\tau_h)\, w(K, H)\, h + (1-\tau_k)\, r(K, H)\, k \\
&\quad + \tau_k\, \delta k + \frac{\hat{m}}{\hat{P}} + TR \\
TR &= [(1-\theta)\,\tau_h + \theta\tau_k]\, K^\theta H^{1-\theta} \\
&\quad - \tau_k\, \delta K + \frac{\mu}{\hat{P}} + \tau_c C - G \\
C &= K^\theta H^{1-\theta} - X - G \\
K' &= (1-\delta)\, K + X \\
X &= X(K),\ H = H(K),\ \hat{P} = P(K)
\end{aligned} \tag{2.11}$$

and (2.4), (2.6), (2.7), c_1, c_2, x, $\hat{m}'$ non-negative and $0 < h < 1$.

For this problem G, τ_h, τ_k, τ_c, and μ are assumed to be known constants. The first constraint in (2.11) is the cash-in-advance constraint and the second is the household's budget constraint. The third expression gives the size of the lump sum transfer (TR) required to equate government expenditures and revenues. This is followed by the resource constraint which is used to determine per capita consumption. The next expression is the law of motion for the per capita capital stock. The final line of (2.11) gives the perceived functional relationship between the per capita state, K, and per capita investment, per capita hours worked, and the price level. These perceptions are necessary if the household's problem is to be well defined. Our definition of equilibrium will require that these perceptions be consistent with aggregate outcomes.

A *recursive competitive equilibrium* consists of a set of decision rules for the household, $c_1(s)$, $c_2(s)$, $x(s)$, $\hat{m}'(s)$, and $h(s)$ (where $s = (K, k, \hat{m})$); a set of per capita decision rules, $X(K)$ and $H(K)$; a pricing function $P(K)$; and a value function $V(s)$ such that

(i) the functions V, X, H, and P satisfy (2.11) and c_1, c_2, x, $\hat{m}'$, and h are the associated decision rules;

(ii) Given the pricing function, P, individual decisions are consistent with aggregate outcomes:

$$x(K, K, 1) = X(K), \qquad h(K, K, 1) = H(K), \qquad \hat{m}'(K, K, 1) = 1.$$

Linear approximations of the functions $H(K)$, $P(K)$ and the function obtained by substituting the function $X(K)$ into the law of motion for the per capita capital stock are the functions used to determine H_T, $\hat{P}_T$, and K_{T+1} as described in the previous subsection.

3. Computational Issues

In Section 5 of this paper we will evaluate the welfare consequences of various tax reforms using our model economy. This requires that we first simulate the equilibrium transition from the steady state under the initial policy to the new steady state. The computational steps involved in doing this are described in Section 3.1. Second, once we have simulated the transition we are able to evaluate the welfare consequences of the reform. Our welfare measure is described in Section 3.2.

3.1. *Computing the Transition Following a Tax Reform*

Simulating the effects of a tax reform involves three steps. First, we compute linear approximations of the per capita decision rules for H and X (and hence K') and the pricing function, P, that satisfies the definition of a recursive competitive equilibrium. In computing these functions, we set the tax rates and the money growth rate equal to the (constant) values they have been assigned in the new steady state. The second step is to use these functions and Eqs. (2.10) to solve for the equilibrium transition path for the various prices and quantities, as described in the previous section, using as initial conditions the steady state under the initial (or base) policy. Finally, we check whether the new government policy is feasible, that is, whether the present value of revenue is equal to the present value of government expenditures.

In much of the literature on the neoclassical growth model, the real business cycle literature in particular, it is possible to compute decision rules satisfying the requirements of a recursive competitive equilibrium indirectly by solving a planning problem. However, in our case distortions force us to solve for an equilibrium using direct (fixed point) methods. The method we use to compute equilibrium decision rules is the approximation method employed in Cooley and Hansen [15].

This method, which we will not discuss in detail here, involves substituting the nonlinear constraints in problem (2.11) into the utility function, eliminating c_1 and c_2. A quadratic approximation of the resulting objective function is formed around the steady state, using the method described in Kydland and Prescott [22]. Next, an initial quadratic function, V_0, is chosen as a candidate for V and a sequence of approximations, $\{V_i\}$, is computed by successive iterations using the quadratic version of (2.11). At each iteration, linear candidates for the functions X, H, and P are formed, making it possible to solve the maximization problem in (2.11). This process is continued until successive approximations are sufficiently close. The procedure used to form the linear candidates for X, H, and P, and to obtain successive approximations of the value function is described in detail in Hansen and Prescott [16].

Given the linear decision rules and pricing function, the second step of our procedure is to use a nonlinear equation solver to solve for prices and quantities for periods from zero to $T-1$ exactly as described in the previous section. In practice, to ensure that the economy has converged close enough to the new steady state so that the linear decision rules and pricing function are accurate approximations, T is chosen so that the constant (steady state) government policy has been in effect for at least 50 periods. The equilibrium decision rules and pricing function are also used to simulate the economy beyond period T since very long time series are desirable for evaluating the welfare consequences of a tax reform.

Finally, it is necessary to check that the government policy chosen is in fact feasible. In the experiments that we study, there is always one revenue source that can be adjusted until the present value of government revenue is equal to the present value of government expenditures. We start with some guess for that particular tax rate and compute an equilibrium sequence of prices and quantities of at least 2000 periods in length. Next, we evaluate the present value of government revenues and compare it with the present value of government expenditures. Depending on the outcome, we continue to adjust the tax rate until the policy is feasible.

3.2. *Calculating Welfare Changes*

To compute the welfare costs of distorting taxation, we calculate the percentage increase in consumption that an individual would require to be as well off as under the equilibrium allocation where all distorting taxes are eliminated, the growth rate of money is set to zero and revenue is raised only with lump sum taxes.[5] To obtain a measure of the welfare loss associated with a particular government policy in the steady state, we solve for x in the equation

$$\bar{U}=\alpha \log[c_1^*(1+x)]+(1-\alpha)\log[c_2^*(1+x)]-Bh^*. \tag{3.1}$$

In this equation, $\bar{U}$ is the level of utility attained (in the steady state) under the lump sum tax allocation ($\mu=\tau_h=\tau_k=\tau_c=0$), and c_1^*, c_2^*, and h^* are the steady state consumption and hours associated with the

[5] The allocation we use for our welfare comparisons is not the Pareto optimal allocation. Negative inflation is required for the Pareto optimal allocation to be a competitive equilibrium allocation for this economy.

government policy in question. From the value of x that satisfies this equation, we compute $\Delta C = x(c_1^* + c_2^*)$. Here, ΔC is the total change in consumption required to restore an individual to the level of utility obtained under the lump sum tax allocation. The welfare measure we report is ΔC expressed as a percentage of steady state output (GNP) produced under the government policy being considered.

In order to evaluate tax reforms, as opposed to simply measuring the welfare costs associated with a set of distorting taxes, we need to take into account the transition from one policy to another. In these cases, we simulate the economy for at least 2000 periods using the steps described above. In particular, we obtain time series for c_1, c_2, and h, beginning with the first period that the new policy is put into effect. The welfare costs are calculated by solving the following equation for x, where $\bar{U}$ is the same as in (3.1):

$$\sum_{t=1}^{2000} \beta^t[\alpha \log(c_{1t}(1+x)) + (1-\alpha)\log(c_{2t}(1+x)) - h_t - \bar{U}] = 0. \quad (3.2)$$

The welfare cost measure we typically report is the present value of $x(c_{1t} + c_{2t})$ over the 2000-period simulation expressed as a percentage of the present value of GNP over the same simulation.

4. Calibration of the Model

In this section we describe how values are assigned to the parameters of technology, preferences, and the policy variables. We follow the procedure of choosing values based on observed features of the data. This calibration procedure has been widely applied in business cycle studies based on models similar to ours.[6] The fact that there are distorting taxes in our model has led us to change some of the parameter values from those used in previous work. We first describe the values of the policy variables used in calibrating the model and then the parameters of technology and preferences.

Since the inflation rate has been quite low on average in the United States during the postwar period, we chose to calibrate the model assuming a zero inflation rate, which implies setting μ equal to zero. Similarly, we chose to set the tax on consumption expenditures equal to zero ($\tau_c = 0$). A number of authors have computed the average marginal tax rates on labor

[6] This procedure became popular in business cycle analysis beginning with the work of Kydland and Prescott [22]. An alternative would be to estimate the parameters using maximum likelihood as is done in Christiano [9] or Hansen *et al.* [15]. Christiano and Eichenbaum [10] discuss a procedure that is somewhat intermediate, using the data to estimate key moments while specifying other parameters.

and capital income. Auerbach [1], Joines [17], Seater [30, 31], Barro and Sahasakul [4], among others, have estimated these average taxes. In the simulations reported below we assume the tax rate on labor income is 23% and the tax rate on capital income is 50%, values which were determined by taking the average of the time series reported in Joines [17].[7] In the remainder of the paper, we refer to this policy ($\mu = 0$, $\tau_h = 0.23$, $\tau_k = 0.5$ and $\tau_c = 0$) as the *base policy*. Government expenditures, G, under the base policy are equal to the steady state revenue obtained each period with this set of taxes.

We now turn to the parameters of technology, θ and δ. The share of total output that represents payments to capital, θ in our model, is set equal to 0.36. Christiano [9] points out that, depending on how proprietors income is assigned, θ can range from 0.25 to 0.43 when measured using postwar U.S. national income accounts. We have chosen 0.36, which is in the middle of this range, because it is the value most commonly used in these studies, including our previous work.

The quarterly depreciation rate, δ, is commonly set equal to 0.025, which corresponds to a 10% annual rate. However, we were led to assign a different value to this parameter in order for the investment–output ratio to match that observed in the U.S. economy. Since in this paper, the tax on capital corresponds to a tax on the income from producer's structures and equipment (not residential capital or consumer durables), the appropriate component of the national income accounts corresponding to investment in the model is fixed nonresidential investment. In addition, the appropriate measure of total output is gross domestic product of corporate business. Using these series, the average investment–output ratio is 0.17 over the postwar period. By setting δ equal to 0.02 (corresponding to an 8% annual depreciation rate), the investment–output ratio for the model economy matches that for the U.S. economy.

The preference parameters, β, B, and α, remain to be set. The discount factor, β, is set equal to 0.99, which implies an annual real interest rate of 4%. The parameter B, which appears in Eq. (2.2), is chosen so that, on average, households spend one-third of their substitutable time working. This implies a value for B equal to 2.6.

The parameter α, which determines the relative importance of the cash and credit good in the utility function, is calibrated by considering two kinds of evidence. First, we take an approach similar to that in Lucas [23]. He considers a cash-in-advance model and shows how the parameters of

[7] Many authors distinguish between the direct tax on capital income and the additional tax that operates through the income tax. The tax rate of 0.50 is intended to incorporate both of these effects. In addition, this is the tax rate on capital income *before* depreciation allowances have been deducted.

conventional money demand functions are related to the parameters of preferences. To illustrate this, Eqs. (2.10)(i) and (v) can be used to obtain the expression

$$\frac{C_t}{C_{1t}} = \frac{1}{\alpha} + \frac{(1-\alpha)}{\alpha} R_{t+1}, \tag{4.1}$$

where $C_t = C_{1t} + C_{2t}$. Per capita real money balances held during period t are equal to $(1+\tau_{ct})\, C_{1t}$, given that the cash-in-advance constraint (2.1) holds with equality. This implies that the velocity of money with respect to consumption (VEL) is

$$\text{VEL}_t = \frac{1}{\alpha(1+\tau_{ct})} + \frac{1-\alpha}{\alpha(1+\tau_{ct})} R_{t+1}. \tag{4.2}$$

To give empirical content to (4.2) one must identify the appropriate measure of consumption and the appropriate measure of money from which to construct the velocity. For consumption we use consumption of non-durables and services taken from Citibase. Choosing a measure of money presents problems. Conventional monetary aggregates that one might use to capture quantities subject to the inflation tax—the monetary base, or the non-interest-bearing portion of $M1$—have the drawback that they are too large. They imply velocities less than unity which is inconsistent with the model. Instead, we use the portion of $M1$ that is held by households.[8] To obtain a value for α, we compute the regression implied by (4.2) using these data.[9] For the sample period from 1970–1986, the estimated equation is

$$\begin{aligned} \text{VEL} = \; & 1.1392 \; + \; 0.1165 \; * \text{RTB} \\ & (0.0265) \quad (0.0133) \\ & D - W = 0.297, \qquad R^2 = 0.549, \end{aligned}$$

where RTB is the rate on three-month Treasury bills stated on a quarterly basis. The intercept of this regression implies an estimate of $\alpha = 0.88$. But,

[8] These data are obtained from the flow-of-funds accounts. Unfortunately these data are also flawed because of the way they treat currency. Currency held by households is treated as the residual of total currency outstanding and currency held by businesses and governments. The resulting figure is undoubtedly way too high.

[9] The data reveal a strong trend in velocity. For this regression to be valid it would have to be matched by a trend in interest rates. We test the null hypothesis that velocity and nominal interest rates are cointegrated. We cannot reject the null hypothesis that velocity and interest rates are cointegrated at the 5% level using Park's [27] test. Unfortunately there is also evidence of a remaining spurious trend in the residuals of this regression.

it must be noted that the conclusions of this regression analysis are sensitive to the choice of sample period.

An alternative way to approach this calibration problem is to estimate α from survey studies of how people actually make their transactions. In 1984, and again in 1986, the Federal Reserve commissioned surveys of consumer transactions (Avery *et al.* [2, 3]). The purpose of these surveys was to determine how people use cash and other means of payment in making their transactions. The proportions for 1984 and 1986 are virtually identical. We take as our estimate of the "cash goods" transactions, those purchases made with cash, main checking, other checking, and money orders. This constitutes 84% of all transactions. If we denote this percentage by υ then the relation between the preference parameter α and this percentage υ is given by the expression:

$$\alpha = \frac{(1+\mu)\,\upsilon}{\beta(1-\upsilon)+(1+\mu)\,\upsilon}. \tag{4.3}$$

This expression is obtained from the steady state version of Eq. (2.10)(v). Using $\beta = 0.99$, $\mu = 0$, and $\upsilon = 0.84$ implies an estimate of $\alpha = 0.84$. Since 0.84 is close to the number obtained from the regression above, this is the number we will use in our experiments. However, for some of the experiments we also report results for $\alpha = 0.5$.

We summarize our parameter choices in the following table:

β	B	α	θ	δ	μ	τ_h	τ_k	τ_c
0.99	2.60	0.84	0.36	0.02	0.00	0.23	0.50	0.00

5. Quantitative Analysis of Alternative Government Policies

5.1. *Steady State Analysis*

In this section we provide a comparison of the welfare costs associated with alternative tax policies designed to raise a given amount of revenue. By holding revenue constant and calculating the steady state welfare costs associated with different mixes of capital taxes, labor taxes, inflation taxes, and consumption taxes we can quantitatively assess the differences in the long run distortions associated with each of these revenue sources. The results of these steady state experiments are summarized in Fig. 1 and Table I.[10]

[10] We have also conducted the same set of experiments for an economy in which the indivisible labor assumption is replaced by a divisible labor assumption. The results are quantitatively and qualitatively very similar.

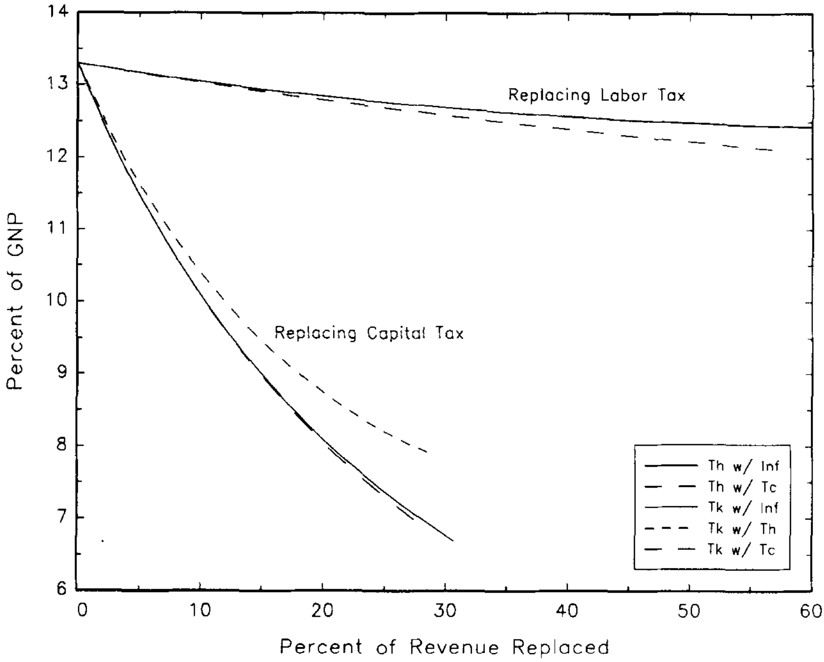

FIG. 1. Steady state welfare comparisons ($\alpha = 0.84$).

The columns of Table I show the tax rates (for the inflation tax we show the money supply growth rate, which is the steady state quarterly inflation rate) and the welfare cost as a percent of GNP associated with several different policies. The first row of Table I shows the welfare cost of the base

TABLE I

Steady State Welfare Consequences of Alternative Policies

Policy	τ_h	τ_k	μ	τ_c	τ	Welfare cost (% of GNP)
Base policy	0.23	0.50	0.0	0.0	0.0	13.30
Replace all taxes with						
Lump sum	0.0	0.0	0.0	0.0	0.263	0.0
Replace labor tax with						
Lump sum	0.0	0.50	0.0	0.0	0.142	8.10
Inflation tax	0.0	0.50	0.293	0.0	0.0	12.43
Consumption tax	0.0	0.50	0.0	0.234	0.0	12.07
Replace capital tax with						
Lump sum	0.23	0.0	0.0	0.0	0.065	4.07
Labor tax	0.343	0.0	0.0	0.0	0.0	7.77
Inflation tax	0.23	0.0	0.145	0.0	0.0	6.09
Consumption tax	0.23	0.0	0.0	0.119	0.0	6.60

policy to be 13.3% of GNP. This number measures the increase in consumption required to provide agents with the same utility level as in an economy where revenue is raised using only lump sum taxation. Therefore, this is an estimate of the pure distortion associated with the tax policy. The second line of Table I shows the size of the lump sum taxes required to raise the same revenue as in the base case.

We next consider policies that replace the tax on labor income, either in whole or in part, with other sources of revenue. The third row of Table I shows what happens when the labor tax is completely replaced by lump sum taxes. The welfare cost falls to 8.1% of GNP, a substantial improvement over the base policy. When the labor income tax is replaced by an inflation tax (row 4) the required inflation rate is 29% per quarter (180% per year) and the welfare cost is 12.43%, an improvement on the base policy of less than 1% of GNP. When the labor tax is replaced by a consumption tax of 23% (row 5) the welfare cost is 12.07% of GNP, a slightly larger improvement. It is not possible to reduce labor taxation to zero by increasing capital taxation in this economy. The consequences of these extreme policies, as well as various mixes of labor taxation and inflation or consumption taxation, are illustrated in the top part of Fig. 1. Overall, the welfare consequences of these policy variations are small. The distortions resulting from the labor income tax are similar to those resulting from an inflation tax or a consumption tax designed to raise the same amount of revenue.

Policies which avoid taxing capital income lead to much lower welfare costs than the base policy. Rows 6 through 9 of Table I show the welfare consequences of such policies. Replacing the capital income tax with lump sum taxation lowers the welfare cost of distorting taxation to 4.07% of GNP, a decrease of more than 9% of GNP compared with the base policy. Replacing the capital tax with the labor income tax would require that the labor income tax rate be increased from 23% to 34.3% to keep revenue constant, but the welfare cost would decline to 7.77% of GNP. Replacing the capital income tax with the inflation tax would require a quarterly inflation rate of 14.5%, or over 70% annually, and the welfare cost would decline to 6.69% of GNP. Finally, replacing the revenue from capital taxation by implementing a consumption tax of 11.9% would reduce the welfare cost to 6.6% of GNP, a dramatic decline in welfare costs over the base policy. Figure 1 shows the welfare consequences of various mixes of capital income taxes and these other taxes designed to raise the same revenue as in the base policy.

One important issue here concerns the sensitivity of these results to the assumed preference parameters. One of the most difficult parameters to pin down is that governing the preferences for cash goods, α. We calibrated α to be 0.84 as described in the previous section. This has the effect of making the inflation tax almost identical to a consumption tax in the steady state. To illustrate the sensitivity to α, Fig. 2 shows the welfare consequences of various mixes of taxes under the assumption that $\alpha = 0.5$. For the most part, the results are very similar to the results for $\alpha = 0.84$. The notable exception is that policies designed to replace the labor tax by inflation taxation appear to first improve welfare, but as the percentage of revenue contributed by inflation is increased, welfare eventually decreases relative to the base case. In the limit, if the labor income tax were replaced completely by the inflation tax, the welfare cost of the policy would rise to 14.2% of GNP. In addition, compared with the $\alpha = 0.84$ case, a much higher inflation rate, $\mu = 0.617$ (almost 600% annual inflation), is required to replace the lost revenue. This is because agents consume fewer cash goods in this case. Similarly, replacing completely the capital tax with the inflation tax would require an annual inflation rate of 160%, which is much higher than the rate required for the economy studied in Table I. However, the welfare cost associated with such a policy is 7% of GNP, which is similar to the welfare cost of the same policy when $\alpha = 0.84$.

These results suggest that there are likely to be major differences in economic welfare across different economies resulting from their use of

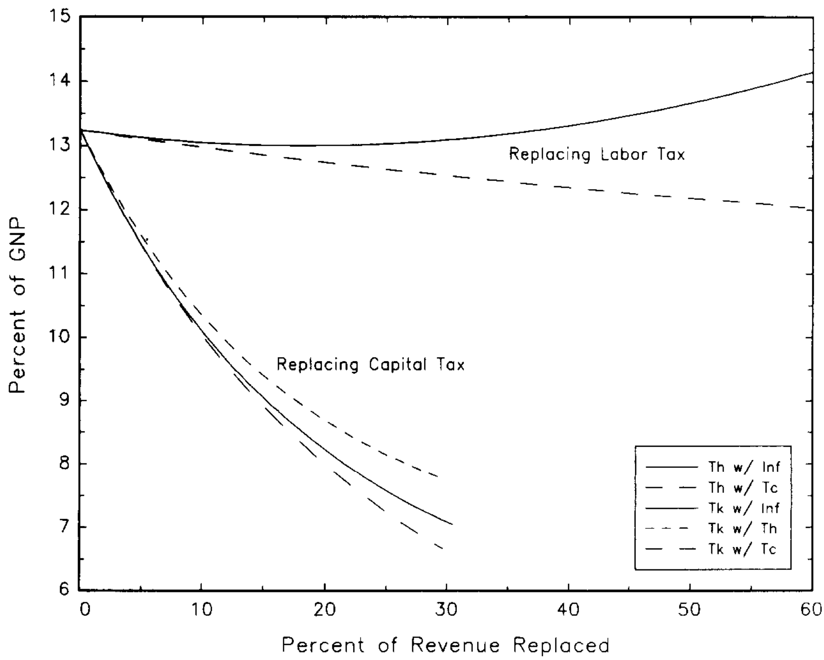

FIG. 2. Steady state welfare comparisons ($\alpha = 0.5$).

TABLE II

Welfare Gains from Replacing Capital Income Tax Using One-Step Reform Including Transition from Steady State

	Welfare cost (% of GNP)	Capital stock in new steady state
Original policy, $\tau_k = 0.5$, $\tau_h = 0.23$	13.299	9.903
Replacing τ_k with:		
Inflation tax, $\mu = 0.152$	10.633	14.742
Consumption tax, $\tau_c = 0.125$	10.532	14.742
Labor income tax, $\tau_h = 0.342$	11.229	14.327

capital income taxation. Controlling for this, there are likely to be only minor differences associated with how revenue is raised between labor, inflation, and consumption taxation. These conclusions seem to indicate that an economy which is currently following the base policy might enjoy significant welfare gains by eliminating capital taxation in favor of one of these other sources of revenue. We explore this possibility in the next section by studying an economy that is initially in the steady state under the base policy and makes an unanticipated transition to a policy regime where there is no taxation of capital income.

5.2. *Stationary Policies*

The policy changes we consider in this section are assumed to be unanticipated, but agents have perfect foresight once the changes are implemented. We focus on the welfare gains from replacing, in one step, the capital income tax with either an inflation tax, a consumption tax, or a labor income tax, taking into account the transition from the steady state under the base policy to the new steady state. The policies considered are designed to keep the present value of the revenue stream equal to the present value of government expenditures. Government expenditures are held constant across all experiments and are equal, period by period, to the government expenditures in the base policy ($G_t = 0.263$ for all t). The welfare gains from these alternative policies are reported in Table II. The transition paths of consumption, hours, utility, and the capital stock under the alternative policies are displayed in Figs. 3 and 4.[11]

[11] We do not include a figure showing the transition path associated with switching to an inflation tax because it looks identical to the consumption tax case (Fig. 3).

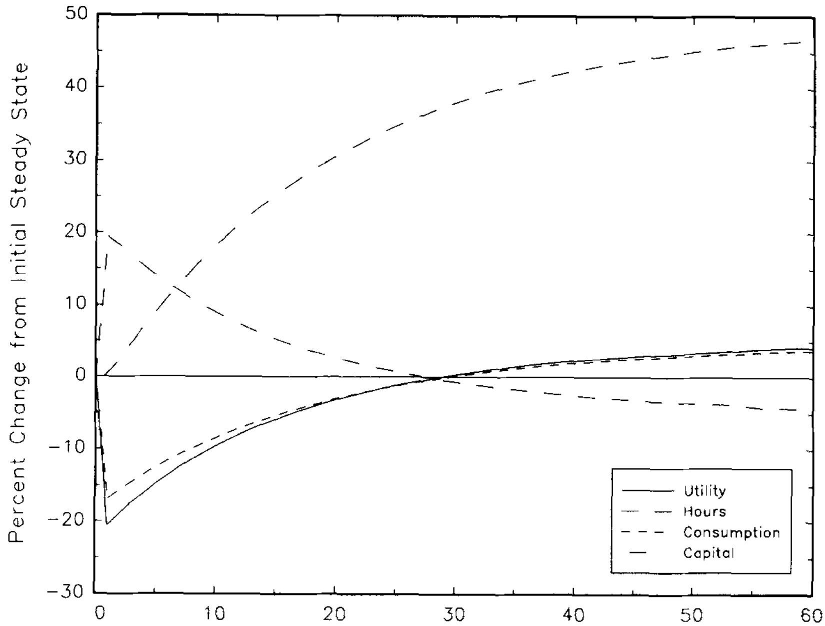

FIG. 3. Replacing capital tax with consumption tax.

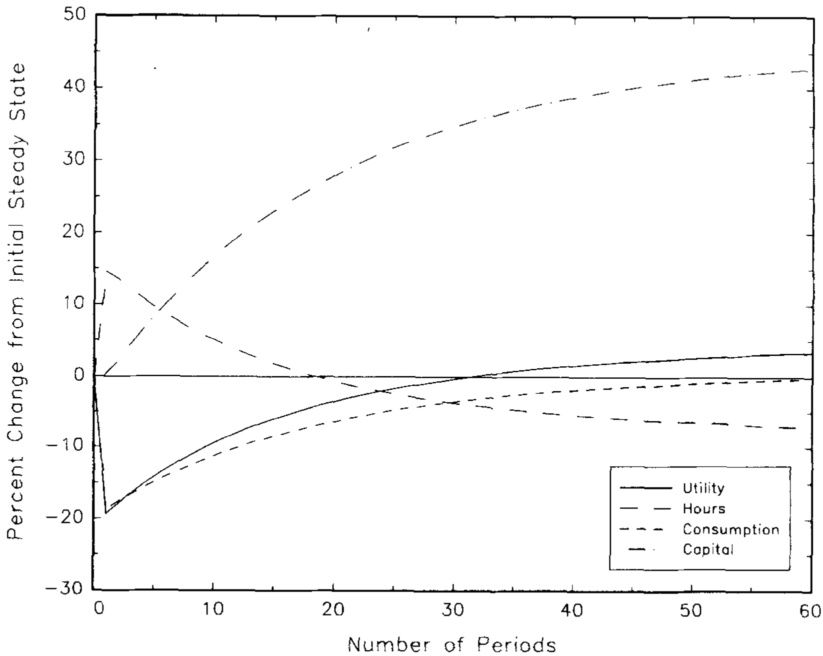

FIG. 4. Replacing capital tax with labor tax.

The results in Table II are quite different from those based on comparing different steady states. Replacing the revenue from the capital income tax with an inflation tax requires a monetary growth rate (and therefore an inflation rate in the new steady state) of 15.2% per quarter. This is somewhat higher than the 14.5% from the steady state experiment reported on in Table I and the welfare cost of this policy is 10.633% of GNP, which is considerably higher than the welfare cost of the corresponding steady state policy. Similarly, replacing the revenues from the capital income tax with the consumption tax requires a tax rate of 12.5% and leads to a welfare cost of 10.532% of GNP. That these results are different from those reported in Table I is accounted for by the fact that both revenue and utility fall initially and then converge to the new steady state from below. The last line of Table II shows that increasing the labor income tax is the least efficient way to replace these revenues. It requires that the tax rate on labor income jump to 34.2% and results in welfare costs of 11.229% of GNP, an improvement over the base policy of only 2% of GNP. The third column of Table II shows the steady state capital stock associated with each of the policies. The alternative tax policies have a dramatic impact on the capital stock. Replacing the capital income tax increases the capital stock in the new steady state by as much as 50%. These estimates are consistent with those reported by Lucas [24].

Figures 3 and 4 show how these policies affect several variables of interest. The initial impact of both the consumption and inflation taxes is to cause households to consume less and to work and invest more. Utility falls initially, but the resulting increase in the capital stock permits consumption to be higher and hours of work lower in the long run. The increase in the labor income tax has effects that are much the same. Compared with Fig. 3, hours of work increase somewhat less and consumption decreases somewhat more in the short run while in the long run, hours decrease more and consumption increases less. Again, it is the dramatic increase in the capital stock that improves welfare in the long run, but the costs of making the transition are very high.

These experiments confirm the result shown in Table I that replacing the capital tax with a consumption tax is the most desirable of the tax reforms considered. However, we have found that the costs incurred during the transition are quite high and have a significant effect on the welfare benefits to be obtained from this tax reform. Next, we consider some two-step tax reforms that are designed to reduce the utility costs incurred during the transition to a zero capital tax and increase the utility enjoyed in the new steady state.

5.3. *Nonstationary Policies*

One of the important insights to be derived from the literature on optimal taxation in dynamic economies is that the tax rates employed in the limit under an optimal policy may be very different from the tax rates employed during the transition to the new steady state. This particular feature is a consequence of the fact that optimal taxation is characterized by two principles: goods in inelastic supply should be taxed heavily and consumption at different dates should be taxed evenly. Reconciling these two principles requires policies that are nonstationary. As Chamley [6] and Lucas [24] have pointed out, this implies heavy initial taxation of capital and zero taxation in the limit. In a monetary economy this may imply high initial inflation rates followed by lower ones in the limit (see Chari *et al.* [8]). In this section, although we do not compute an optimal tax policy, we illustrate how welfare can be improved by considering non-stationary versions of policies designed to eliminate capital taxation. In particular, we consider policies that replace capital taxation with consumption taxation in two stages: there is one set of tax rates that are effective for the first four quarters followed by a different set of taxes effective from the fifth period on.[12] As before, the policy change is unanticipated but agents have perfect foresight once the policy has been implemented. In particular, the agents are aware of how the tax rates will change over time.

Table III shows the welfare consequences of replacing the capital tax using two different nonstationary policies. These policies were designed by first constructing a new stationary policy, ($\mu = 0.0$, $\tau_h = 0.23$, $\tau_k = 0.0$, $\tau_c = 0.111$), such that an unanticipated change from the base policy to this policy would replace 90% of the revenue lost by eliminating the capital tax. This policy is implemented starting in period 5 in both experiments in Table III. For the first experiment, the capital tax rate for the initial four periods is set to replace the remaining 10% of revenues—that is, so that the present value of the revenue stream is equal to the present value of government expenditures. This required setting $\tau_k = 0.631$, as shown in the first column of Table III. Columns three and four show the welfare cost of the nonstationary policy and the capital stock associated with the new steady state. These results indicate that a policy which sets the capital income tax rate very high initially, followed by a zero capital tax combined with a consumption tax improves welfare slightly and leads to a higher steady state capital stock than the corresponding stationary policy described in the third row of Table II. Thus the steady state under this policy yields greater utility than the steady state associated with the corresponding stationary policy. Figure 5 illustrates the transition path associated with this policy. Note that the dip in utility during the transition path is attenuated somewhat relative to Fig. 3.

[12] We have chosen the length of the first stage to be four quarters as this seems to be a realistic interval between tax rate changes.

TABLE III

Welfare Gains from Replacing Capital Income Tax Using Two Step Reform
(Original Policy: $\tau_h = 0.23$ and $\tau_k = 0.50$)

Policy to replace τ_k			
First four periods	Period five and after	Welfare cost (% of GNP)	Capital stock in new steady state
$\tau_c = 0.111$ $\tau_k = 0.631$	$\tau_c = 0.111$ $\tau_k = 0.0$	10.348	14.873
$\tau_c = 0.111$ $\mu = 0.404$	$\tau_c = 0.111$ $\mu = 0.0$	10.420	14.873

The second policy illustrated in Table III differs from the first in that an inflation tax during the first four periods (rather than a capital tax) is used to replace the remaining revenue. This requires a very high growth rate of money, 40.4% per quarter for four quarters. Again, we see that this nonstationary policy leads to a slight improvement in economic welfare compared to the corresponding stationary policy. Using the inflation tax to capture the initial revenue seems slightly inferior to using the capital income tax. The transition path associated with this policy is shown in Fig. 6.

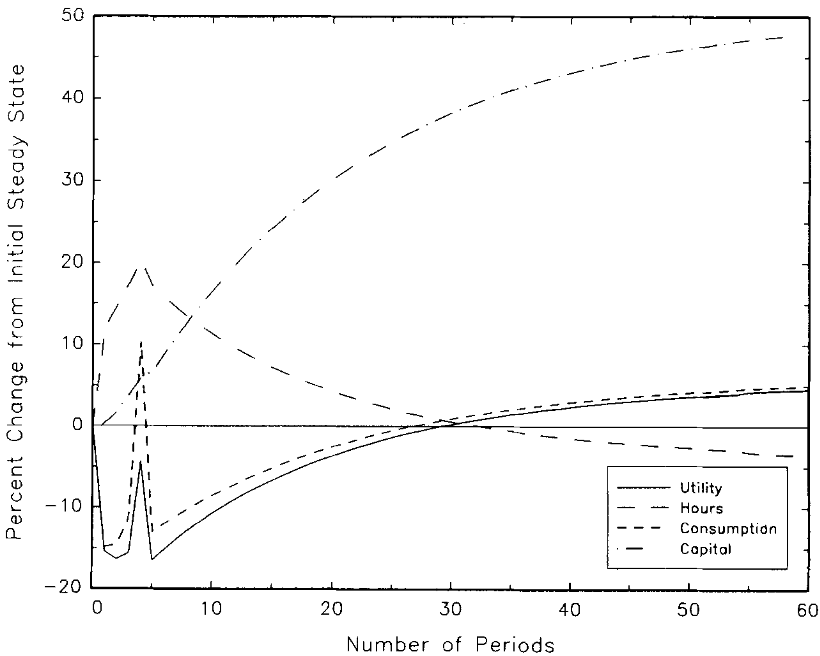

FIG. 5. Transition path for first experiment in Table III.

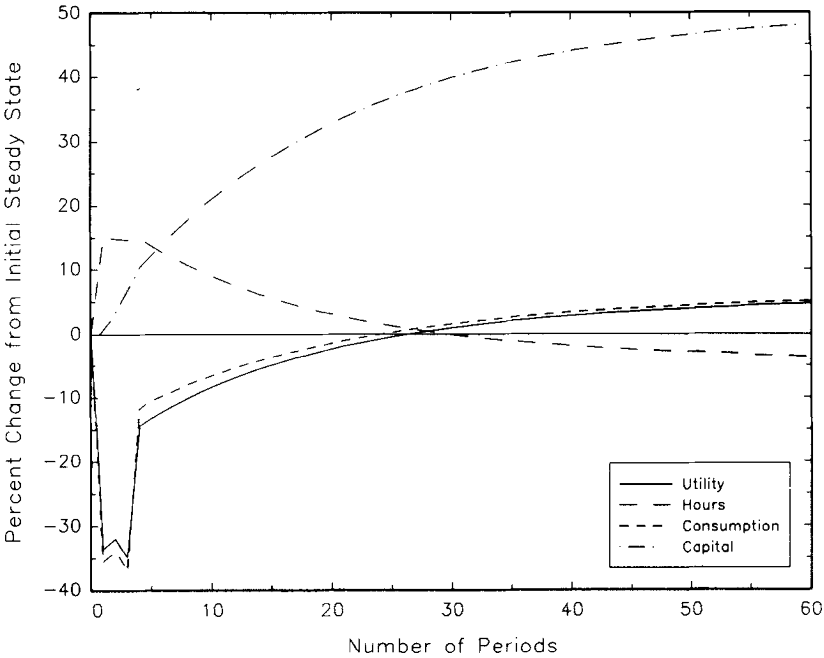

FIG. 6. Transition path for second experiment in Table III.

6. CONCLUSIONS

This paper has quantified the welfare costs of monetary and fiscal policies designed to support an exogenous level of government spending in a neoclassical monetary economy. To address this issue we have put aside a number of very real issues including the effects of uncertainty and the possibility of strategic behavior by the government and households.[13] We have provided a quantitative assessment of the distortions associated with the inflation tax, the consumption tax, the labor income tax, and the capital income tax in a simple neoclassical economy. Taxes levied against consumption goods, either through the inflation tax or the consumption tax, are the least distorting. Taxing the income from labor has distortions that are larger but quantitatively similar to taxing consumption or real balances. The taxation of income from capital produces the greatest distortions, 9% of GNP at a 50% tax rate. These results suggest that significant improvements in economic welfare follow from a change in the tax structure of an economy that taxes the income from capital heavily.

[13] Many others are discussed in Judd [20].

Nevertheless, the costs of the transition are also quite high. Replacing the capital income tax by a consumption tax eliminates only one-third of the distortion due to the former because of the high cost of making the transition. Our experiments show exactly how the welfare improvements would come about. When the tax on capital income is replaced by an alternative tax, consumption would be lower, and work effort and investment higher for an extended period, resulting ultimately in a higher level of the capital stock.

Fiscal policies that are efficient in the sense of Ramsey [28] have the feature that the initial policy may be quite different from the policy that is converged to in the long run. This implies that a nonstationary sequence of policies may produce lower distortions. Our quantitative results confirm this basic principle. Nevertheless, for the policies we considered, we find that the welfare consequences of these changes in the timing and pattern of taxes are very small, compared with the gains from policies that replace the capital tax in one step. However, in future work we hope to compute the welfare gain from switching from our base policy to a Ramsey policy in order to check the robustness of this finding.

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