Capital Taxation and Accumulation in a Life Cycle Growth Model

By LAWRENCE H. SUMMERS*

Almost all of the serious economic work on savings decisions within the past decade has relied on some variant of the life cycle hypothesis in which savings arise out of individual choices of an optimum lifetime consumption path. This paper reexamines the incidence and welfare consequences of capital income taxes within a realistic life cycle model. The results suggest that the elimination of capital income taxation would have very substantial economic effects. For example, a complete shift to consumption taxation might raise steady-state output by as much as 18 percent, and consumption by 16 percent. The long-run welfare gain from such a shift would for plausible parameter values exceed $150 billion annually. Stated somewhat differently, shifting to consumption taxation would raise the lifetime utility of the representative consumer by the equivalent of about six years' income in the new steady state. These estimates dwarf estimates of the static welfare cost of taxation, and significantly exceed even extreme previous estimates of the dynamic loss.

This study departs from earlier analyses of the effects of taxes on capital income in several respects. Probably the most important difference between this treatment and most preceding ones lies in the assumptions about the interest elasticity of saving. It is shown below that the common two-period formulation of saving decisions yields quite misleading results. A more realistic model of life cycle savings demonstrates that, for a wide variety of plausible parameter values, savings are very interest elastic. This implies that shifting away from capital income taxation would significantly increase capital formation, making possible long-run increases in consumption.

Many studies of the welfare effects of capital income taxation have ignored the general equilibrium effects of increased capital formation. In an economy with life cycle savings, there is no presumption that the undistorted growth path corresponds to any sort of social optimum. As Peter Diamond has shown, life cycle savings can lead to a steady-state capital intensity either greater or less than the Golden Rule level. More generally, it is clear that there is no reason to believe that a life cycle economy will maximize any particular intertemporal social welfare function. A fundamental tenet of welfare evaluation is that preexisting distortions must be considered in evaluating the consequences of tax changes. The results presented in this paper take explicit account of the nonoptimal character of the no-tax steady state. This explains in large part why such a sizeable welfare effect of capital taxes is found. In an economy far from the Golden Rule level of capital intensity, there are substantial gains in steady-state consumption achievable through increased capital formation.

Section I of the paper examines the aggregate savings function in a continuous-time life cycle framework. The second section clarifies the differences between wage and consumption taxes. An aggregate production function is added to complete the model in the third section. The effects of changes in capital taxes on both steady-state incidence and welfare are considered within a general equilibrium framework. The final section of the paper discusses some implications of the results and suggests areas which appear to warrant further study.

*Assistant professor of economics, Massachusetts Institute of Technology, and research analyst, National Bureau of Economic Research. I am grateful to Alan Auerbach, Martin Feldstein, Laurence Kotlikoff, to the participants in the NBER Workshop on Business Taxation, and to the Harvard Public Finance Seminar for useful discussions. James Poterba and James Buchal performed the numerical calculations.

I. The Aggregate Savings Function

In all studies of the effects of capital income taxation, the interest elasticity of the aggregate savings rate emerges as a key parameter. This parameter is also central to questions ranging from the potency of monetary policy to the appropriate discount rate on public investments projects.[1] Both empirical and theoretical considerations have led most economists to conclude that the interest sensitivity of aggregate savings is likely to be quite small. This section examines the implications of the well-known life cycle hypothesis for the interest elasticity of aggregate savings. It is shown that the theory when formulated realistically implies interest elasticities well in excess of unity.

Most commonly, the impact of capital income taxes has been considered within a two-period framework, in which all income is received within the first period.[2] That is, the representative individual is assumed to maximize an intertemporal utility function of the form $U(C_1, C_2)$ subject to a lifetime budget constraint:

$$C_1 + \frac{C_2}{1+r} = W_1 \tag{1}$$

where W_1 represents labor income in the first period. It can be shown[3] that the interest elasticity of savings depends on the elasticity of substitution between present and future consumption. If the elasticity is greater than one, savings respond positively to the interest rate, while an elasticity less than one implies a negative savings response. In the knife-edge Cobb-Douglas case where the elasticity of substitution is one, savings are independent of the interest rate. Since the last case seems reasonable, and theory does not offer an unambiguous verdict on the sign of the interest effect, it is frequently held that savings are likely to be interest insensitive. This notion is supported by verbal reference to conflicting substitution and income effects. Martin Feldstein (1978) has shown that in a two-period setting, savings may be usefully viewed as expenditure on future consumption. The case where savings are insensitive to the interest rate occurs when the price elasticity of demand for future consumption is one.

The usual two-period formulation of the savings decision obscures two important aspects of reality. In all modern theories, saving is carried on to provide for future consumption. All savings are eventually dissaved. Net positive savings arise only because the young who save are more affluent and numerous than retired dissavers. In order to realistically model the determination of net savings, it is necessary to take account of the dissaving of older generations. This is not usually done in two-period formulations of the problem which treat the savings decision as equivalent to the choice of C_1.

The second difficulty with the usual two-period formulation is that it obscures the role of future labor income. In a multiperiod setting, the endowment W_1 in equation (1) represents the present value of future labor income. When the interest rate rises, this endowment declines as future income is more heavily discounted. Even in the Cobb-Douglas case where the consumption propensity out of wealth is independent of the interest rate, consumption will fall as the interest rate rises through what might be called a human wealth effect.[4] With income constant, an increase in savings is implied. Since savings represent only a small fraction

[1] Michael Boskin discusses the implications of the interest elasticity of savings for several aspects of capital accumulation. He finds that even an elasticity of .4 can have an important impact. The analysis below suggests .4 is likely to be a significant underestimate of the true elasticity.

[2] Exceptions include David Levhari and Eytan Sheshinski, and Robert Hall. Levhari and Sheshinski's analysis is confined to a partial equilibrium framework. Hall's study parallels this one in many respects but reaches radically different conclusions about the welfare consequences of capital taxes. Using a life cycle model without retirement, he does conclude that aggregate savings are likely to be quite interest elastic on grounds quite similar to those considered here.

[3] The two-period consumption savings decision is extensively discussed in Martin Feldstein and S. C. Tsiang.

[4] This terminology may be somewhat misleading. Increases in the interest rate to reduce the value of consumers' endowment measured in terms of first-period consumption. However, in general, they broaden the set of feasible consumption paths and raise welfare.

of income, even a small effect on consumption can translate into a large effect on savings.

In order to realistically take account of human wealth and the difficulties of aggregation, it is necessary to formulate a model in which many generations coexist at any instant. This is most easily done in continuous time. Models of the type outlined below have been used by James Tobin, Hall, M. J. Farrell and Laurence Kotlikoff to explore various aspects of life cycle savings. Let us first consider individual and then aggregate savings.

Individuals choose a consumption plan to maximize an intertemporal utility function, subject to a lifetime budget constraint.

$$\max \int_0^T U(C_t)e^{-\delta t}\,dt \tag{2}$$

subject to

$$\int_0^T C_t e^{-rt}\,dt = \int_0^{T'} W_t e^{-rt}\,dt$$

where T represents the certain date of death,[5] T' the age of retirement, δ is a discount factor, and W represents labor income. In order to render the problem tractable, I adopt a constant elasticity utility function,[6] and assume that at any instant all workers receive the same wage which rises exponentially at rate g.[7] With these assumptions the Lagrangian for the individual maximization problem becomes

$$\int_0^T C_t^{\gamma} e^{-\delta t}\,dt - \lambda\left[\int_0^T C_t e^{-rt}\,dt - \int_0^{T'} W_0 e^{(g-r)t}\,dt\right] \quad \text{if } \gamma \neq 0 \tag{3}$$

$$\int_0^T \log C_t e^{-\delta t}\,dt - \lambda\left[\int_0^T C_t e^{-rt}\,dt - \int_0^{T'} W_0 e^{(g-r)t}\,dt\right] \quad \text{if } \gamma = 0$$

where γ is the elasticity of the marginal utility function. The expression $1/(1-\gamma)$ corresponds to the intertemporal elasticity of substitution in consumption. Solving the individual maximization problem (3) yields the conditions:

$$C_t = C_0 e^{[(r-\delta)/(1-\gamma)]t} \tag{4a}$$

$$C_0 = \frac{W_0\left(e^{(g-r)T'} - 1\right)\left[\left(\frac{r-\delta}{1-\gamma}\right) - r\right]}{\left(e^{((r-\delta)/(1-\gamma)-r)T} - 1\right)(g-r)} \tag{4b}$$

It is clear from (4) that the slope of the age-consumption profile rises with the interest rate, with the sensitivity depending on γ. In order to find aggregate consumption, it is necessary to aggregate over the consumption of all persons alive at a point in time. Using equations (4) the consumption of persons of each age can be calculated as a function of their initial wage. The relative number of persons of each age depends on the population growth rate n. The larger is n, the greater the fraction of the population which is young. By adding up consumption at each age, weighted by relative population size, and initial wage W_0, total consumption of the population may be calculated.

From aggregate consumption, it is possible to calculate the savings rate out of labor income using the steady-state assumption. Steady-state growth implies that

$$(n+g)K = wL + rK - C = S \tag{5}$$

where n is the rate of population growth.

[5] In this paper, perfect certainty is assumed throughout. Robert Merton has demonstrated in a continuous-time framework that allowing for uncertainty does not alter the character of the optimal intertemporal consumption plan. However, it might importantly affect the analysis of tax changes, which alters both the return and risk from savings.

[6] The constant elasticity utility function with a constant discount rate is capable of generating smooth consumption paths with any slope. It is not clear that the additional range of behavior admitted by more general utility functions is very plausible. In any event a "smooth" consumption stream is a central assumption of all life cycle theories of savings.

[7] It would be desirable to explicitly incorporate an instantaneous age earnings profile. However, Alan Blinder argues that because the profile rises and then declines after about age 50, the approximation adopted here is not likely to be too inaccurate.

Solving equation (5) it is apparent that

$$(6)\qquad \frac{S}{WL}=\frac{(n+g)\left(\dfrac{C}{WL}-1\right)}{r-n-g}$$

Substituting for C/WL in (6) yields the aggregate savings function:

$$(7)\qquad \frac{S}{WL}=\left(\frac{r-\delta}{1-\gamma}-r\right)\left(e^{(g-r)T'}-1\right)$$

$$\times\left(e^{\left(\left(\frac{r-\delta}{1-\gamma}\right)-g-n\right)T}-1\right)(n)(n+g)$$

$$\div\left(\left[\frac{r-\delta}{1-\gamma}-n-g\right](g-r)\left(e^{\left(\frac{r-\delta}{1-\gamma}-r\right)T}-1\right)\right.$$

$$\left.\times\left(1-e^{-NT'}\right)(r-n-g)\right)-\frac{n+g}{r-n-g}$$

It is noteworthy that (7) shows that the life cycle hypothesis gives rise to a steady-state aggregate savings function which may be represented by a variable propensity to save out of labor income, and a zero-savings propensity out of capital income. The life cycle hypothesis thus gives rise to a savings function which is quite different than that usually assumed in growth models which allow different savings propensities out of different types of income.

It is clear from (7) that the relationship between savings and the interest rate is complex and depends on all of the other parameters in the model. In Table 1 the savings rate, defined as S/WL, and interest elasticity of aggregate savings η_r, evaluated at various values of the interest rate, are reported for plausible parameter values. It is assumed that population grows at a 1.5 percent per annum, productivity increases by 2 percent per annum, and that individuals live fifty-year economic lives with retirement at age 40. Somewhat arbitrarily, a 3 percent utility discount factor was chosen.

TABLE 1—THE INTEREST ELASTICITY OF AGGREGATE SAVINGS

	Value of r		
	.04	.06	.08
$\gamma=.5$			
η_r	3.71	2.26	2.44
S/WL	.121	.274	.451
$\gamma=0$			
η_r	3.36	1.89	1.87
S/WL	.068	.142	.210
$\gamma=-.5$			
η_r	3.09	1.71	1.54
S/WL	.049	.096	.135
$\gamma=-1$			
η_r	2.87	1.59	1.37
S/WL	.038	.073	.099
$\gamma=-2$			
η_r	2.38	1.45	.122
S/WL	.028	.048	.063
$\gamma=-5$			
η_r	.741	1.09	1.18
S/WL	.014	.019	.025

Note: The calculation assumes $n=.015$, $g=.02$, $T'=50$, $T=40$, and $\delta=.03$. The savings rate is measured as a fraction of labor income.

The results universally support a high interest elasticity. In the plausible logarithmic utility case, the interest elasticity of the savings rate varies from 3.36 at 4 percent to 1.87 at 8 percent. This case also generates the most reasonable values for the aggregate savings rate. The table demonstrates the unimportance of the elasticity of substitution between present and future consumption. For example, at an interest rate of .06, the elasticity of saving varies only from 2.26 when $\gamma=1/2$ to 1.09 when $\gamma=-5$. The insensitivity of the elasticity to the level of γ reflects the fact that the "reduction in human wealth" effect is much more important that the substitution effect of interest changes. The basic conclusion, a significant long-run interest elasticity of aggregate savings, is quite robust to changes in all of the parameter values. While very low values of γ could generate low or even negative savings elasticities, they would also give rise to unrealistic savings propensities, unless the other parameter values are set to implausible levels. Almost any plausible life cycle formulation is likely to imply a high long-run elasticity of savings with respect to the interest rate. It seems fair to conclude that two-period analyses of the effects of capital taxes are likely to be quite misleading. Efforts to use empirical savings elasticities to estimate elasticities of substitution between present and future consumption are very misguided, unless the "human wealth effect" is explicitly considered.

So far it has been assumed that saving is motivated only by the desire to provide for retirement consumption. This assumption has been challenged by Kotlikoff and myself (1979). We suggested that the life cycle hypothesis could account for only a relatively small fraction of total savings. Our results indicate that a significant fraction of capital formation is motivated by a desire to leave bequests. Assuming that consumers bequeath a constant proportion of lifetime income would not have any important impact on the results. Robert Barro has shown that if bequests arise from maximization of a utility function in which the utility of future generations appears as an argument, the intertemporal decision problem is radically altered. Essentially, this case is equivalent to treating each consumer as if he had an infinite horizon, since he internalizes the welfare of future generations. Miguel Sidrauski has shown that, in this case, the long-run savings rate is infinitely interest elastic as the capital stock is always driven to a "modified Golden Rule" level. Thus allowing for such bequests would strengthen the conclusions reached here.

Interest elasticities of savings as high as those reported in Table 1 appear at first blush to be flatly contradicted by the available empirical studies which have found only small interest rate effects. Beyond the standard problems of errors in variables,[8] and specification error,[9] there is an important reason to expect interest rate effects in usual empirical specifications to differ from those calculated here. At issue here is the change in the savings rate out of income when the interest rate changes. Usually, in empirical work, wealth is held constant. Since interest rate changes exert their effect in part through changes in wealth, this procedure is likely to obscure the impact of interest rates. The importance of this question is apparent in Boskin's careful study of the interest elasticity of savings. Its results imply a direct savings elasticity of about .4, with respect to interest rate changes, and about 2.8 with respect to changes in wealth. Thus, if the interest elasticity of wealth is .5, the "full effect" interest elasticity of savings is 1.9, which is within the range suggested here.[10]

The discussion in this section establishes a prima facie theoretical case for a high interest elasticity of savings. This conclusion appears to follow almost ineluctably from a realistic life cycle formulation.[11] This implies that the frequent assumption of a constant savings rate in analyses of economic growth may be quite inaccurate. It also indicates that the case where savings depend negatively on the interest rate, which yields pathological results in many models, can legitimately be ruled out. A high interest elasticity of savings has important implications for almost all questions bearing on capital accu-

[8]Typically, studies have used the nominal interest rate as a measure of the return on savings. Only Boskin has used the more appropriate real after-tax rate. Even this series is flawed because the long-term interest rate accurately reflects the return on only a small part of savings. Satisfactory measures of the expected return on equity, homes, and durable goods are nonexistent. Since the interest rate has been fairly highly correlated with income and wealth over the past forty years, even small errors in interest rate measures could cause very significant underestimation of interest rate effects.

[9]Life cycle theories imply that the age structure of the population, the rate of growth of output, life expectancy, and expected retirement age all affect the savings rate. None of these variables has been included in time-series savings equations.

[10]If all wealth were held in the form of consols, the elasticity would be one; if it were all held in short assets, it would be zero. Common stock fluctuations which account for most of the variation in wealth are known to be caused by interest rate changes. The simplest valuation model in which the *P-E* ratio is set equal to the interest rate would imply an elasticity of one. Of course, with changes in taxes, and pretax profitability the actual situation is much more complex. The assumption of a .5 elasticity seems conservative.

[11]A fuller effort to reconcile the theoretical calculations with the empirical evidence may be found in my earlier paper which treats issues surrounding the short-run response of savings to both transitory and permanent changes in the interest rate.

mulation. Its impact on estimates of the incidence and welfare consequences of capital taxation are examined in some detail in succeeding sections of this paper.

II. Alternatives to Capital Taxation

It is widely believed that taxation of labor income is equivalent to consumption taxation as long as there are no bequests. This section demonstrates the extremely restricted sense in which this proposition is correct, and shows that wage and consumption taxation in a general equilibrium setting have different effects in both the short and long run.[12] It follows that even if consumption taxation is optimal, replacing capital taxes with taxes on labor income may not be desirable.

The sense in which consumption and labor income taxation are equivalent is easily demonstrated by specifying the individual's budget constraint in each case. With wage taxation the budget constraint is

$$(8)\quad \int_0^T C_t e^{-rt}\,dt - \int_0^{T'} W_t(1-t_L)e^{-rt}\,dt = 0$$

The budget constraint with consumption taxation takes the form

$$(9)\quad \int_0^T \frac{C_t}{1-t_c} e^{-rt}\,dt - \int_0^{T'} W_t e^{-rt}\,dt = 0$$

where t_c is the ad valorem tax rate on consumption. It is apparent that if $t_c = t_L$, the two tax regimes offer consumers equivalent choice sets, and, in a present value sense, raise equal revenues. Since consumers have the same opportunity set, they will choose the same optimal consumption path under each regime. It is in this restricted sense that wage and consumption taxes may be said to be equivalent.

In a life cycle setting, savings arise because the desired consumption stream does not match the path of income. Since the timing of tax collection is very different under wage and consumption taxes, they have very different effects on savings. Savings at an instant t are the difference between income and consumption. Hence with consumption taxation savings may be written as

$$(10)\quad S_t = W_t + rA_t - \frac{C_t}{1-t_c}$$

while under wage taxation savings are

$$(11)\quad S_t = (1-t_L)W_t + rA_t - C_t$$

Quite clearly there is no reason why these expressions need be equal period by period. Consumption taxation extracts revenue later in the individual's lifetime than does wage taxation and so causes more savings in the younger years. The difference in the aggregate savings rate between the two types of taxes depends on the age structure of the population. But it is clear from (10) and (11) that there is no a priori reason to expect equal savings rates.

Equations (9) and (10) illustrate an important property of consumption taxation. It is completely neutral with respect to the savings rate. It is clear from (9) that for any homothetic utility function along the optimal path $C_t/1-t_c$ will be the same for any value of t_c. This implies, using (10), that savings at all ages and hence aggregate savings are also unaffected by the tax rate. Equation (11) shows that this property does not hold for taxes on wage income, since the time path of savings is altered. In fact, as the results in the next section demonstrate, wage taxation significantly reduces capital intensity relative to consumption taxation.

A second important difference between wage and consumption taxation lies in the government budget constraint. The usual argument demonstrating the equivalence of wage and consumption taxation assumes that the government raises the same present value of revenue from each individual under both regimes. A somewhat plausible requirement is that in each period the government raises

[12] Feldstein (1978b) has examined the transition away from capital taxation. His analysis underscores the importance of compensating the older generation in shifting to consumption taxation, but does not emphasize the different effects of consumption and wage taxation in the long run.

the same amount of revenue from the total population under each tax.[13] If G is the government's revenue requirement, the budget constraint under wage taxation is

$$\int_0^{T'} e^{-ns} W(1-t_L)\,ds = G \tag{12}$$

while under consumption taxation the constraint is

$$\int_0^{T} e^{-ns} C_s \frac{t_c}{1-t_c}\,ds = G \tag{13}$$

These equations do not imply that $t_c = t_L$. The reason for this is straightforward. The individual is discounting at rate r in calculating the present value of taxes paid at different ages. On the other hand, the government in steady states implicitly discounts at n, the rate of population growth. As long as $r>n$, the government can meet its budget constraint, and reduce the present value of the taxes each individual must pay by postponing the extraction of taxes. As noted above, consumption taxes postpone tax payments relative to wage taxes. Hence, with consumption taxation it is possible to reduce the steady-state present value of taxes paid by the representative individual.

Feldstein (1978b) has observed that wage and consumption taxes involve quite different transition paths. To see this, consider the sudden imposition of a consumption tax. Consumers of all ages are equally affected. On the other hand, imposition of a wage tax has no effect on the retired segment of the population. Loosely speaking, the consumption tax is less burdensome on workers in the steady state, because it taxes more heavily those who are alive at the moment when it is imposed.

The analysis in this section indicates that it is inappropriate in either the short or long run to regard consumption and labor income taxation as equivalent even in the absence of bequests. Since they give rise to different age-savings patterns, they do not have the same effect on steady-state capital intensity. Of equal importance, the rates which are necessary to meet a constant government budget constraint will differ between the two taxes. In the next section, both wage and consumption taxes are considered as alternatives to capital income taxation.

[13] David Bradford emphasizes the importance of this "balanced budget" requirement. He argues that without such a requirement the government by running surpluses or deficits can control the level of the capital stock given any tax structure. The "real world" feasibility of this sort of policy seems unclear.

III. Steady-State Comparisons of Tax Alternatives

In this section, the effect of replacing capital income taxes with wage and consumption taxes is examined by comparing steady states. In order to make a general equilibrium comparison of tax alternatives, it is necessary to join a production side to the life cycle savings model examined in the first section. James Tobin and Robert Hall have shown this can be done diagramatically.

Above, it was shown that life cycle savings gives rise to a savings-labor income ratio which is a function of the interest rate. Under the steady-state assumption, this can be readily converted into a capital-labor income ratio by dividing by the growth rate. This is represented by the SS curve in Figure 1. The production function also implies a relationship between the capital-labor income ratio and the interest rate. This is plotted as PP in Figure 1. (In the Cobb-Douglas case it is a rectangular hyperbola.) In the no-capital tax case, equilibrium occurs where the curves cross. Now consider the effect of imposing a tax on capital income. This drives a wedge between the gross interest rate determined by the production function and the net rate received by savers. The new equilibrium occurs where the difference between the interest rate along the PP and SS curves is equal to the tax. It is clear from the figure that as long as savings respond positively to the interest rate, imposition of a capital tax raises the gross return and reduces the net return on capital. Hence capital taxes will be partially but not completely shifted.

The characteristics of a steady state can be calculated numerically by finding the value

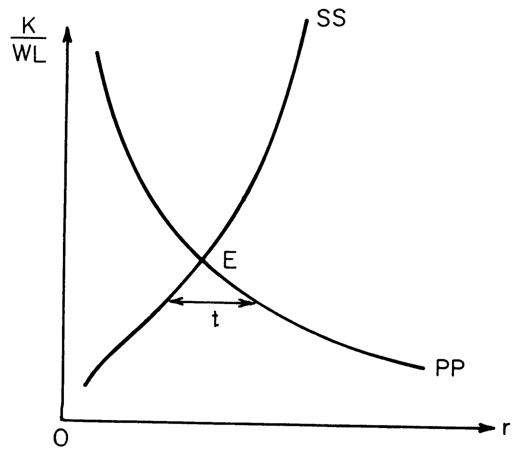

FIGURE 1

of K for which

$$(14) \qquad \frac{S(F_L(1-t_L), F_K(1-t_K))}{n+g} = \frac{K}{F_L L}$$

where $S(\cdot)$ represents the aggregate savings function provided in (7). Once the steady-state value of K is found, the levels of output and consumption as well as factor prices can be found from the steady-state condition (5) and the production function.

In calculating the effects of tax changes, it is necessary to make assumptions about parameter values. The parameters of the savings function are the same as those assumed above. In the results reported below, logarithmic utility ($\gamma=0$) is assumed. As will be shown, the main conclusions are not sensitive to this assumption. Tax changes are analyzed with elasticities of substitution in production of 1 and 1/2.[14] In each case, parameters of the production function were chosen so that the capital share was .25. The appropriate value of the tax rates is not easy to determine. The capital tax is presumed to represent the combined effect of corporate taxes, individual income taxes on dividends and interest income, and property taxes. Recent evidence (see the 1980 paper by Feldstein and myself) suggests that inflation has substantially raised the effective rate of all these taxes. A value of .5 for the capital income tax rate seems conservative on the basis of these considerations.[15] A tax rate of .2 on labor income is also assumed. These assumptions imply that government revenues equal 27.5 percent of GNP, which is within the empirically reasonable range.

The model was solved for the steady state under this tax regime. The steady state was then recalculated with the capital tax replaced by a wage tax with exactly equal revenue yield and with both the interest and labor income taxes replaced by a consumption tax. Thus, all the analysis here is carried out within a differential incidence framework, in which alternative sources of the same amount of government revenue are contrasted. Representative results are presented in Table 2.

It is interesting to note that the base calculation shown in column 1 corresponds quite accurately to the actual American economy. The gross of tax return on capital in both cases mirrors the average return on capital of 11 percent estimated by Feldstein and myself (1977). The savings rate of about 8.5 percent is close to the historical rate.

The shift away from capital taxation has very substantial effects. In the Cobb-Douglas case, steady-state income rises by about 14 percent if wage taxation is used and 18 percent with consumption taxation. The increase in income occurs because the high interest elasticity of savings leads to a large increase in capital intensity. Indeed the capital-output ratio rises by almost 75 percent in the consumption tax solution. This increase drives down the gross return on capital from 10.5 to 6.1 percent. Consequently the owners of capital do not benefit greatly from the removal of the capital tax. On the other hand, the increase in capital intensity raises the gross wage. The increase

[14]These numbers represent bounds on the true elasticity. Cross-section estimates typically imply that σ is close to 1, while time-series estimates suggest an elasticity close to 1/2. Robert Lucas, after contrasting these approaches, concludes that the time-series estimates are to be preferred.

[15]It is the effective marginal rate which is at issue here. This will depend critically on the method of financing of marginal investment. Joseph Stiglitz has argued that complete debt financing at the margin would imply a zero effective rate. This view has been challenged by Feldstein, Jerry Green, and Sheshinski, among others.

TABLE 2—COMPARISON OF STEADY STATES: INCOME, PAYROLL, AND CONSUMPTION TAXES

	Current System		Payroll Tax		Consumption Tax		Percent $\Delta(1-2)$		Percent $\Delta(1-3)$	
	$(\sigma=1)$	$(\sigma=1/2)$	$(\sigma=1)$	$(\sigma=1/2)$	$(\sigma=1)$	$(\sigma=1/2)$	$(\sigma=1)$	$(\sigma=1/2)$	$(\sigma=1)$	$(\sigma=1/2)$
R_G	0.105	0.112	0.069	0.066	0.061	0.056	−42.4	−51.9	−53.7	−66.3
R_N	0.053	0.056	0.069	0.066	0.061	0.056	26.1	16.2	14.3	0.4
W_G	1.000	2.018	1.155	2.420	1.202	2.526	14.4	18.1	18.3	22.4
W_N	0.800	1.614	0.788	1.604	1.202	2.526	−1.6	−0.6	40.0	44.0
Y/L	1.334	2.841	1.541	3.111	1.604	2.179	14.4	9.1	18.3	11.2
C/L	0.856	1.769	0.977	1.928	1.004	1.955	13.1	8.6	15.9	10.0
K/Y	2.373	2.589	3.652	3.375	4.117	3.653	42.4	26.4	53.7	34.1
S/Y	0.083	0.091	0.128	0.118	0.144	0.128	42.4	26.4	53.7	34.1

Note: These calculations assume $n=0.015$, $g=0.02$, $\gamma=0.001$, and that $t_W=0.2$ and $t_r=0.5$ in the current system.

is large enough to almost completely offset higher taxes on labor income. The net wage falls by less than 1 percent when capital taxes are replaced by the payroll tax.

Since the gross rate of return in the equilibrium with capital taxes is well above the Golden Rule level, steady-state consumption is increased as capital intensity rises. When capital taxes are replaced by wage taxes, consumption rises by 14.2 percent, while it rises by 17.1 percent with consumption taxes. Of course these gains cannot be interpreted as a measure of the steady-state welfare increment from eliminating capital taxes. The appropriate criterion is the utility of the representative individual.

The steady-state change in the welfare of the representative individual can be expressed as a fraction of lifetime income as follows. In a steady state, individual welfare V is given by

$$V=\int_0^T C^{\gamma}e^{-\delta t}\,dt \tag{15}$$

Substituting using equation (4) yields an expression for lifetime utility as a function of lifetime income, H, and the net interest rate.

$$V(H,r_N)=H^{\gamma}\left[\frac{(r_N-\delta)}{\left(e^{\frac{(r_N-\delta)T}{\gamma-1}}-1\right)}\right]^{\gamma} \times\left[\frac{\left(e^{\frac{r_N-\delta}{\gamma-1}}-1\right)(\gamma-1)}{\gamma(r_N-\delta)}\right] \tag{16}$$

where $r_N=r(1-t_K)$ the net interest rate, and human wealth H is given by

$$H=\frac{W(1-t_L)(e^{(\delta-r_N)T'}-1)}{(g-r_N)} \tag{17}$$

Welfare V can be compared across alternative steady-state paths. However, in order to yield a meaningful result, it is necessary to express the welfare difference in operational units. This may be done most easily by calculating the percentage change in lifetime earnings in the base steady state which would be necessary to yield the welfare level reached in the altered steady state. To do this, it is necessary to solve the equation:

$$V\big(H^1(1+L),r_N^1\big)=V\big(H^2,r_N^2\big) \tag{18}$$

for L, which is a measure of the welfare difference between the two steady states. Unlike most welfare loss calculations this approach does not rely on differential approximations. It is accurate for changes of any size.[16]

Table 3 presents the steady-state welfare gains from the tax changes, outlined above for alternative utility and production functions. The results indicate the potential for large gains from eliminating capital taxes. In the intermediate case, where $\gamma=0$, instituting a payroll tax would raise welfare by the

[16]Green and Sheshinski have demonstrated the danger of extrapolating differential approximation to tax effects over large ranges.

TABLE 3—THE STEADY-STATE WELFARE COST OF CAPITAL INCOME TAXATION

	$\gamma=0.5$	$\gamma=0.001$	$\gamma=-1$
	Percentage Change in Steady-State Consumption		
		$(\sigma=1)$	
Payroll Taxation	12.7	13.1	13.3
Consumption Taxation	14.0	15.9	17.4
		$(\sigma=\frac{1}{2})$	
Payroll Taxation	6.1	8.6	12.9
Consumption Taxation	6.5	10.0	17.2
	Welfare Gain (expressed as a percentage of lifetime income)		
		$(\sigma=1)$	
Payroll	7.0	4.9	1.4
Consumption	11.2	11.7	11.6
		$(\sigma=\frac{1}{2})$	
Payroll	3.8	3.5	1.1
Consumption	6.2	9.4	16.2

Note: Calculated assuming that $n=0.015$, $g=0.02$, and that $t_w=0.2$ and $t_r=0.5$ in the current system.

equivalent of almost 5 percent of lifetime income, while consumption taxes would raise welfare by about 12 percent, or almost five years' earnings. Applying these figures to American aggregates yields huge annual flows, about $80 billion in the former case and approximately $200 billion in the latter.

These large gains are smaller than the gains in steady-state consumption shown in the top half of the table. This is because the increase in the net interest rate leads individuals to consume later in their lifetimes, reducing the increases in welfare. There are two reasons why the welfare gain tends to be smaller for lower values of γ. First, a lower value of γ implies a lower savings elasticity, and hence less gain from approaching the Golden Rule. Second, a small γ implies only a small distortion of the shape of the consumption path.

A very surprising feature of the results is the large difference in steady state welfare between consumption and wage taxes. For example, in the Cobb-Douglas $\gamma=0$ case, the steady-state gain in welfare arising from shifting from labor to consumption taxation approaches $100 billion a year. The greater welfare under consumption taxes occurs for two reasons. As noted in the previous section, capital intensity is higher with consumption taxes, which raises welfare by making possible a higher level of steady-state consumption. The second reason is probably more important. Consumption taxation reduces the present value of the taxes each individual pays during his lifetime. This occurs because the tax burden is increased on those alive during the transition to consumption taxation. Hence the steady-state comparison may be a poor indicator of the efficiency advantages of consumption taxation.

The calculations presented here indicate that partial equilibrium calculations of the welfare consequences of capital taxes are likely to be very misleading. Such calculations focus on the welfare loss which takes place because the taxation of interest distorts the shape of the consumption profile. The results here indicate this effect is of only minimal importance. Since in a realistic life cycle model, savings are very interest elastic, changes in capital taxes have only a small effect on the net interest rate. Thus partial-equilibrium analysis by assuming a constant *gross* interest rate greatly overstates the importance of intertemporal substitution effects.

The important effect of removing capital taxes on welfare is not captured in partial-equilibrium analyses. The large increase in capital which results raises real wages and leads to a larger level of sustainable consumption. It is the interaction of increased capital intensity with the preexisting distortion of a significant divergence from the Golden Rule, which causes the removal of capital taxes to lead to such large gains in these calculations.

There are two potentially important difficulties with the analysis. First, no allowance is made for variable labor supply. The distortion of the labor-leisure choice is not considered in evaluating the welfare consequences of wage taxation. It seems unlikely that relaxing the assumption of inelastic labor supply would alter the results in an important way. The general equilibrium effects described above imply that shifting to wage taxation changes real wages only slightly. Hence, labor supply is likely to be little affected. Allowing for intertemporal variation in labor supply might actually increase the estimated gain from reducing capital taxes. Similar conclusions apply to consumption taxation.

Second, the analysis here is confined to steady-state comparisons. Higher steady-state consumption is achieved only at the expense of consumption during the transition to the new steady state. Hence, the costs of transition must be weighed against the long-term gain. This issue is considered in my 1979 paper where the transition path following the elimination of capital income taxation is simulated numerically. It is shown there that convergence to a new steady state is quite rapid, and that at plausible discount rates, the gain far exceeds the transition cost. It is also demonstrated that it is possible to reform taxes in a Pareto-superior way; that is, so that all those alive on or after the day of the changeover are made better off.

IV. Conclusions

The results in this paper suggest that the welfare cost of capital income taxation may have been seriously underestimated. For reasonable parameter values, the annual welfare gain from a shift to consumption taxation is conservatively estimated at 10 percent of *GNP*. This surprising conclusion emerges from an examination of tax effects in the context of a realistic life cycle growth model. The large estimates reported here differ from previous estimates for two main reasons. First, the multiperiod model used here suggests that a very high interest elasticity of savings is likely to obtain for almost any reasonable parameter values. Second, the estimates in this paper incorporate the general equilibrium effects of tax changes. The most important of these is the increase in gross wages which results from the increased capital intensity arising from eliminating capital taxation.

The model used in this study, while more realistic than the conventional two-period formulation, could usefully be extended in several directions. The discussion in this paper ignores the financing of investment. In effect it assumes that all investment is equity financed at the margin. Recently Joseph Stiglitz has suggested that the corporate tax may in reality be a lump sum tax, as corporate investment is completely debt financed at the margin. If this controversial conclusion is correct, it is clear that the analysis here greatly overestimates the welfare cost of capital taxes. The results in this paper underscore the importance of empirical and theoretical research bearing on the effective marginal tax rate on capital income.

This analysis has not considered differential taxation of different types of capital. Alan Auerbach has shown that optimality does not dictate uniform tax rates if overall capital intensity is not at the Golden Rule level. It would be useful to extend the current analysis by examining a corporate tax which falls on only some of the capital used in production.

While these extensions would be valuable, it is unlikely that the basic conclusion of this analysis would be altered. Capital income taxes are likely to appear very undesirable in any sort of realistic life cycle formulation. A question of central importance is the realism of the life cycle hypothesis. While its implication of a high interest elasticity of savings may seem implausible, it is the only framework currently available for evaluating competing tax policies. Examining its realism and/or devising an alternative to it seems a necessary prerequisite to a fuller understanding of the effects of capital taxation.

REFERENCES

A. Auerbach, "Optimal Taxation of Heterogenous Capital," unpublished paper, Harvard Univ. 1978.

R. Barro, "Are Government Bonds Net Wealth?," *J. Polit. Econ.*, Nov./Dec. 1974, *82*, 1095–117.

Alan Blinder, *Toward an Economic Theory of Income Distribution*, Cambridge, Mass. 1974.

M. J. Boskin, "Taxation, Saving and the Rate of Interest," *J. Polit. Econ.*, Apr. 1978, *86*, S3–S27.

D. F. Bradford, "The Economics of Tax Policy Towards Savings" in George von Furstenberg, ed., *The Government and Capital Formation*, 1980.

P. A. Diamond, "National Debt in a Neoclassical Growth Model," *Amer. Econ. Rev.*, Dec. 1965, *55*, 1126–50.

A. Drazen, "Government Debt, Human Capital, and Bequests in a Life Cycle Model," *J. Polit. Econ.*, June 1978, *86*, 505–16.

M. J. Farrell, "The Magnitude of 'Rate-of-Growth' Effects on Aggregate Savings," *Econ. J.*, Dec. 1970, *80*, 873–94.

M. Feldstein, "Taxation in a Growing Economy with Variable Factor Supply," *Quart. J. Econ.*, Nov. 1974, *88*, 551–73.

——, (1978a) "The Welfare Cost of Capital Income Taxation," *J. Polit. Econ.*, Apr. 1978, *86*, S29–S51.

——, (1978b) "The Rate of Return, Taxation and Personal Savings," *Econ. J.*, Sept. 1978, *88*, 482–87.

——, **J. Green, and E. Sheshinski,** "Inflation and Taxes in a Growing Economy with Debt and Equity Finance," *J. Polit. Econ.*, Apr. 1978, *86*, S53–S70.

—— **and L. Summers,** "Is the Rate of Profit Falling?," *Brookings Papers*, Washington, 1977, *1*, 211–28.

—— **and** ——, "Inflation, and the Taxation of Capital Income in the Corporate Sector," *Nat. Tax J.*, Dec. 1980, *32*, 445–70.

—— **and S. C. Tsiang,** "The Interest Rate Taxation, and the Personal Savings Incentive," *Quart. J. Econ.*, Aug. 1968, *82*, 419–34.

J. Green and E. Sheshinski, "Approximating the Efficiency Gain of Tax Reform," unpublished paper, Harvard Univ. 1976.

R. Hall, "Consumption Taxes Versus Income Taxes: Implications for Economic Growth," *Proc. Nat. Tax Assn.*, 1968, 125–45.

L. Kotlikoff, "Social Security and Capital Accumulation," unpublished paper, Univ. California-Los Angeles 1977.

—— **and L. Summers,** "Tax Incidence in a Life Cycle Model with Variable Labor Supply," *Quart. J. Econ.*, Nov. 1979, *93*, 705–18.

—— **and** ——, "The Role of Intergenerational Transfers in Aggregate Capital Accumulation," *J. Polit. Econ.*, forthcoming.

D. Levhari and E. Sheshinski, "Lifetime Excess Burden of a Tax," *J. Polit. Econ.*, Jan./Feb. 1972, *80*, 139–47.

R. Lucas, "Labor-Capital Substitution in U.S. Manufacturing," in Arnold Harberger and Martin Bailey, eds., *The Taxation of Income from Capital*, Washington 1969, 223–74.

R. C. Merton, "Lifetime Portfolio Selection Under Uncertainty: The Continuous-Time Case," *Rev. Econ. Statist.*, Aug. 1969, *51*, 247–57.

F. Modigliani and R. Brumberg, "Utility Analysis and the Consumption Function: An Interpretation of Cross-Section Data," in Kenneth K. Kurihara, ed., *Post-Keynesian Economics*, New Brunswick 1954.

M. Sidrauski, "Rational Choice and Patterns of Growth in a Monetary Economy," *Amer. Econ. Rev. Proc.*, May 1967, *57*, 534–44.

J. Stiglitz, "Taxation, Corporate Financial Policy, and the Cost of Capital," *J. Publ. Econ.*, Feb. 1973, *2*, 1–34.

L. Summers, "The Interest Elasticity of Aggregate Savings: Theory and Evidence," unpublished paper 1980.

——, "Tax Policy and a Life Cycle Model," Nat. Bur. Econ. Res. working paper, no. 302, 1979.

J. Tobin, "Life Cycle Saving and Balanced Growth," in William Fellner, ed., *Ten Economic Studies in the Tradition of Irving Fisher*, New York 1967.