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Optimal Fiscal Policies under Distortionary Taxation

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1. Introduction:

This paper studies second-best tax and fiscal policies when agents have infinite lives. This line of research follows recent studies of dynamic taxation by Auerbach and Kotlikoff [1987], Chamley [1985], [1986], and Judd [1985]. Like the present one, all these studies use a general equilibrium framework to analyze the impact of government policy upon private incentives. Auerbach and Kotlikoff, and Judd have studied the welfare effects of arbitrary changes in the time paths of various distortionary taxes. Chamley, and to some extent, Judd have addressed the issue of second-best tax rates based upon explicit welfare maximisation by a social planner. A rather strong result derived by both authors was that the steady-state tax rate on interest income should be zero, even under policies which seek to redistribute income from capitalists to workers. This result is controversial on several grounds.

Firstly, as the authors themselves have noted, a policy resulting in zero taxes on capital income is time inconsistent because of the lump-sum nature of unanticipated levies on capital. Thus, future planners would always be tempted to surprise the private sector with positive taxes on capital income in order to lower the distortionary burden of other taxes.

Secondly, the zero tax result is derived under the condition that private and social discount rates are equal at the steady state. This condition follows from the assumption that agents have variable discount rates which increase with wealth (a condition that has been referred to as "increasing marginal impatience" in the literature). Under this assumption, a unique, stable steady state arises where all agents have the same discount rate, and this rate is used by the social planner in determining steady state taxes.

However, as Jafarey [1986] shows in the context of two agents, if discount rates decrease with wealth (which is equally, if not more, appealing from the intuitive point of view as increasing marginal impatience), the distribution of wealth asymptotically approaches a steady state where only one agent holds any wealth and the other only consumes wage income. At such a steady state, the wealthy agent has a lower discount rate. In this situation, the optimal tax rate on capital income depends upon the welfare function used by the social planner.

Thirdly, the ability of government to run deficits or surpluses bears some implications for optimal policies with respect to tax rates. Indeed, one of the means by which a time consistent policy resulting in zero tax rates on interest may be supported at a steady state is if the government owns some capital (or claims to it), and can finance its revenue requirements from interest earnings. As Brock and Turnovsky [1980] have shown, an unanticipated appropriation of productive assets equal to the present value of the stream of revenue requirements makes possible a time-consistent steady state with no taxes on any distortionary instrument. At the same time, the lump-sum nature of the initial appropriation results in a first-best outcome. A similar (though substantially different in details) argument may be found in Meade [1958].

The question then arises as to whether a policy of gradually building up government assets could be optimal in the second-best, i.e. when the initial appropriation is ruled out as a possibility for the planner. While steady state welfare would certainly be higher in this case, the transition period would require taxes high enough to run surpluses, and the distortionary effects of these taxes would counteract the gains in steady state welfare.

A study relevant to this question is by Pestieau [1974]. Using a life cycle model with direct public investment, Pestieau showed that the role of government fiscal (i.e. borrowing and lending) policy should be to equalize the rates of return on public and private capital at each point in time, and to equate both to the social discount rate in the steady state. The divergence of private and social discount rates implicit in the life-cycle framework (without operative bequests) meant that tax rates on interest income would not be zero. However, if such an equality existed (as in the case of an infinitely-lived, representative agent) the implied tax on interest income would be zero (since the marginal product of capital would equal the private discount rate in that case).

The present paper studies some of the questions raised above about the zero tax on interest income. Section 2 examines optimal redistributive taxation in the steady state of an economy where one agent owns capital, and the government maximises the welfare of the other. It is found that the optimal redistributive tax on capital income is not zero if the agents have different discount factors. Somewhat surprisingly, the optimal tax may be a *subsidy* in certain cases.

Section 3 focuses on capital taxation in a representative-agent context to study whether running initial surpluses in order to achieve a zero-tax steady state could be optimal. For the admittedly restrictive case of linear utility, Section 4 shows that such a policy is Pareto-optimal.

2. Redistributive Taxes with Heterogeneous Discount Rates.

In this section, we study how the heterogeneity of discount factors can lead to positive redistributive taxes on capital income, depending upon the welfare function used by the social planner. The model assumes a linear

homogeneous production function of capital and labor. Labor is provided inelastically by a representative worker, while capital belongs solely to a representative capitalist whose private optimization governs the accumulation program.

The capitalist faces a path of taxes on interest which are used to finance transfers to the worker. This implies an after tax interest rate

$$r(t) = (1-\tau(t))f'(k(t))$$

where τ is the tax rate and $f'(k)$ denotes the marginal product of the capital-labor ratio. There is no depreciation. The capitalist's accumulation program seeks to:

$$\text{Max} \quad \int_0^\infty e^{-\rho_c t} u(c(t))dt$$

where: $u(.)$ = capitalist's utility function.
$c(t)$ = capitalist's consumption.
ρ_c = capitalist's discount rate.

subject to:

$$\dot{k}(t) = r(t)k(t) - c(t).$$

The *current-value* Hamiltonian for this problem is

$$\mathcal{H} = u(c) + \nu(rk-c).$$

which gives rise to the following equations of motion:

(1) $$\dot{\nu} = \rho_c \nu - \frac{\partial \mathcal{H}}{\partial k} = (\rho_c - r)\nu$$

(2) $$\dot{k} = rk - c.$$

where $\nu = u'(c)$ is the shadow price of capital from the capitalist's point of view.

The social planner is assumed to maximise the worker's utility by choosing a path of taxes on the capitalist's income that can be used to

finance transfers to the worker. Under this scheme, the worker's consumption $w(t)$ is given by (dropping time subscripts)

$$\begin{aligned} w &= f(k) - f'(k)k + \tau f'(k)k \\ &= f(k) - (1-\tau)f'(k)k \\ &= f(k) - rk \end{aligned}$$

The planner's problem is

$$\text{Max} \int_0^\infty e^{-\rho_w t} v(w(t))dt$$

where : $v(.)$ = worker's utility function.
ρ_w = worker's discount factor.

subject to the equations of motion (1) and (2). Defining the *current-value* Hamiltonian for the planner problem as

$$\mathcal{H} = v(f(k)-rk) + \lambda_1 \nu(\rho_c - r) + \lambda_2(rk - c)$$

the first-order conditions and equations of motion are

(3) $\partial\mathcal{H}/\partial r = - v'(w)k - \lambda_1 \nu + \lambda_2 k = 0$

(4) $\dot{\nu} = \nu(\rho_c - r)$

(5) $\dot{k} = rk - c$

(6) $\dot{\lambda}_1 = \rho_w \lambda_1 - \partial\mathcal{H}/\partial\nu = (\rho_w + (\rho_c - r))\lambda_1 + u''(c)^{-1}\lambda_2$

(7) $\dot{\lambda}_2 = \rho_w \lambda_2 - \partial\mathcal{H}/\partial k = \rho_w \lambda_2 - v'(w)(f'(k)-r) - \lambda_2 r$

PROPOSITION 1: *At the steady state, the optimal tax rate on capital is*

$$\tau = \frac{(\rho_w - \rho_c)\ \rho_w . \mu}{f'(k)(\rho_w . \mu - \rho_c)}$$

where $\mu = -\frac{u''(c)c}{u'(c)}$ *is the capitalist's elasticity of marginal utility evaluated at the steady state.*

Proof: At a steady state, all variables satisfying (3)-(7) are stationary, and denoted by ($\bar{\ }$). Setting the time derivatives of state and costate variables to zero, equation (4) implies that

$$\rho_c = \bar{r} \tag{8}$$

This confirms that the steady state capital stock is perfectly elastic at the capitalist's constant discount factor. Solving for the steady state values of λ_1 and λ_2 from (6) and (7):

$$\bar{\lambda}_1 = \frac{\bar{\lambda}_2}{\rho_w u''(\bar{c})} \tag{9}$$

$$\bar{\lambda}_2 = \frac{u'(\bar{w})(f'(\bar{k})-\bar{r})}{\rho_w - \bar{r}} \tag{10}$$

Plugging (9) and (10) into the static optimality condition (3)

$$- u'(\bar{w})\bar{k} + \left[\frac{u'(\bar{w})(f'(\bar{k})-\bar{r})}{(\rho_w-\bar{r})\rho_w}\right]\left[\frac{u'(\bar{c})}{u''(\bar{c})\bar{c}}\right].\bar{c} + \frac{u'(\bar{w})(f'(\bar{k})-\bar{r})}{\rho_w - \bar{r}}.\bar{k} = 0$$

which, after substituting for μ, and simplifying terms, reduces to

$$- \bar{k} - \frac{f'(\bar{k})-\bar{r}}{\rho_w-\bar{r}}.\frac{\bar{c}}{\rho_w\mu} + \frac{f'(\bar{k})-\bar{r}}{\rho_w-\bar{r}}.\bar{k} = 0.$$

Noting that (5) implies that $\bar{c} = \bar{r}\bar{k}$, and using (8), we can rearrange the above to

$$f'(\bar{k}) - \bar{r} = \frac{(\rho_w-\rho_c)\rho_w\mu}{\rho_w\mu - \rho_c}$$

which given that $f'(k)-r = \tau f'(k)$ yields the tax rate claimed in the proposition.

From the above formula, the optimal redistributive tax is indeed zero when $\rho_w = \rho_c$, i.e. the agents share a common discount rate. Otherwise, it is non-zero. Interestingly, if $\rho_w > \rho_c$ but μ is "small", the optimal tax would require a *subsidy* to the capitalist. The reason for this seeming paradox is the implicit capital market imperfection required by the assumption that workers consume their entire income.

3. Efficient steady state taxation.

In this section, we switch to a discrete-time framework in order to study second-best efficient taxation when there is a representative household that supplies capital endogenously, but labor exogenously. The household has a time-separable utility function

$$\sum_{t=0}^{\infty} \beta^t u(c_t) \qquad u'>0, \ u''<0$$

where: c_t= consumption at time t.

$\beta \in (0,1)$ = discount factor.

Social production is characterized by a linear homogenous production function of labor and capital, the proceeds of which are divided between consumption, capital accumulation, and exogenously specified government expenditures. The household faces the following period wise budget constraints:

$$c_t + (a_{t+1} - a_t) \leq r_t a_t + w_t. \qquad t \geq 0.$$

where $a_t = k_t + b_t$ is the total level of assets held by the household, consisting of capital and government-issued bonds, r_t is the

after-tax rate of interest, while w_t is the gross wage on the one unit of labor provided by the household. The absence of a tax on wages can be justified by appeal to exogenous constraints. Equivalently, it can be assumed that there is an exogenously set positive lower bound on the after-tax wage, and that the level of government spending is high relative to that bound, so that taxes on capital are necessitated.

The level of b_t can be positive or negative; if it is negative the government is a net creditor owning claims to part of society's capital stock. Furthermore, equilibrium requires that if the level of public debt is positive, the after-tax rate of interest on capital would have to also be payed on bonds in order to induce the household to include both in its portfolio.

The household maximises its utility subject to the above budget constraint, leading to the first-order conditions

$$(11) \quad u'(c_t) - \beta(1+r_{t+1})u'(c_{t+1}) \leq 0. \qquad t \geq 0.$$

The government chooses a path of taxes on capital in order to meet an exogenous revenue requirement g. Its problem is to choose this path while taking into account the distortionary choices of capital that will follow from (11). In addition, its chosen path of taxes must lead to the agent's choosing consumption and accumulation paths that remain socially feasible, i.e. that satisfy

$$(12) \quad f(k_t, l_t) \geq (k_{t+1} - k_t) + c_t + g.$$

and budgetary balance

$$(13) \quad b_{t+1} - b_t = [g + r_t b_t] - [f(k_t, l_t) - r_t k_t - w_t l_t]$$

which only requires that the excess of expenditures over tax revenues be covered by borrowing. There is no constraint on the overall level of the debt because, in the present framework, bonds are part of net worth and therefore any attempt to roll over debt indefinitely will swamp household savings. Furthermore, a policy of rolling over debt is not the only way for the government to avoid imposing taxes. An initial appropriation of private capital which endows the government with the present value of its future revenue requirements can also lead to zero taxes. This is shown in the following lemma.

PROPOSITION 2: *Suppose the government can choose the level of* b_1. *Then, provided that it is feasible, the optimal policy is to impose a capital levy large enough to set* $b_1 = -\sum_{t=1}^{\infty} \frac{g}{\Pi_{s=1}^{t}(1+r_s)}$.

Proof: The Lagrangean of the infinite-horizon problem is:

$$\mathcal{L} = \sum_{t=0}^{\infty} [\beta^t u(c_t) + \lambda_t^s(f(.,.) - (k_{t+1} - k_t) - c_t - g)$$
$$+ \lambda_t^g(b_{t+1} - b_t - g - r_t(b_t + k_t) + f(.,.) - w_t)$$
$$+ \lambda_t^r(u'(c_t) - \beta(1 + r_{t+1})u'(c_{t+1}))$$

which has first order conditions (assuming interiority for all variables):

(14): (k_{t+1}) $\quad -\lambda_t^s + (1 + f'(k_{t+1}))\lambda_{t+1}^s + \lambda_{t+1}^g(f'(k_{t+1}) - r_{t+1} = 0.$

(15) (b_{t+1}) $\quad \lambda_t^g - \lambda_{t+1}^g(1 + r_{t+1}) = 0.$

(16) (r_0) $\quad \lambda_0^g(k_0 + b_0) = 0.$

(17) (r_{t+1}) $\quad \lambda_{t+1}^g(k_{t+1} + b_{t+1}) - \lambda_t^r\beta u'(c_{t+1}) = 0.$

(15) implies $\lambda_0^g = 0$. Then, (16) implies that $\lambda_1^g = \lambda_2^g = \ldots = 0$. From (17) this implies that $\{\lambda_t^r\}_{t=0}^{\infty} = 0$. (14) then reduces to :

$$(18) \qquad \lambda_t^s - (1 + f'(k_{t+1}))\lambda_{t+1}^s = 0.$$

Define the current value multipliers $\tilde{\lambda}_\tau^s = \beta^\tau \lambda_\tau^s$, the FOC with respect to c_t can be written

$$u'(c_t) - \tilde{\lambda}_t^s = 0 \qquad \text{since } \lambda_t^r = 0 \ \forall \ t.$$
$$\therefore u'(c_t) = \tilde{\lambda}_t^s$$

Using the definition of the current-value multipliers, and substituting the above into (18)

$$(19) \qquad u'(c_t) - \beta(1 + f'(k_{t+1}))u'(c_{t+1}) = 0$$

But since, the agent's private optimization implies

$$u'(c_t) = \beta(1+r_{t+1})u'(c_{t+1})$$

(19) can only hold if $r_{t+1} = f'(k_{t+1}) \ \forall \ t \geq 0$. Thus there are no taxes at all in the future. Note that since b_0 and k_0 are given, the ability to pick b_1 implies that the government does not face a binding constraint upon the minimum level of r_0. (Otherwise, it's first period borrowing, and therefore, b_1 would trivially follow from the first-period budgetary constraint.)

If there are no taxes being collected, the household's disposable income exhausts national product (due to the assumption of CRS). Therefore, the government budgetary constraint implies

$$b_t = -\frac{g}{(1+r_t)} + \frac{b_{t+1}}{(1+r_t)}$$

which, after repeated substitution starting from $b_t = b_1$ results in the level of b_1 claimed. ■

Given the fact that initial capital is fixed, a large enough tax upon it can allow the government to build up its own claims on this capital.[1] These claims take the form of lending to the private sector. The government's interest earnings from these claims constitute a form of lump-sum taxation made possible by the initial transfer of assets. As far as the problem of the second-best is concerned the government's ability to pick b_1 enables the economy to "jump" to a tax-free path. Given the monotonic convergence implicit in this model, the economy approaches a first-best steady state characterized by $f'(\bar{k}) = \bar{r} = \rho$ where ρ is the household's discount rate given by $\beta = 1/(1-\rho)$. At this steady state, household net wealth is $\bar{k} + \bar{b}$, and the government's claims upon the household are $\bar{b} = -g/\bar{r}$.

The use of b_1 to support the no-tax path could also arise from a policy of continually rolling over government debt. However, even if such a policy is ruled out by an explicit constraint on the level of the debt, the capital levy would still allow a zero-tax path.

Allowing the government to pick its initial net worth is equivalent to allowing it to choose a first-best steady state. The question then arises as to whether a first-best steady state (i.e. with zero taxes) would still be chosen if the government could not pick its initial net worth in a nondistortionary way, i.e. if there was a constraint ruling out initial levies on capital. In that case, the policy would require accumulating

[1]This result is also discussed in Brock and Turnovsky [1980] and Chamley [1986].

surpluses through higher taxes in the short-run, and thus the long-run gains in welfare at the untaxed steady state would have to be weighed against the distortionary effects of the transition. Intuition suggests that, even if the initial level of capital is large enough relative to the initial indebtedness and the revenue requirements of the government, the optimal path of taxes would depend upon the preferences and discount rates involved.

IV. An Example with Linear Utility.

We now assume that the agent's period-wise utility function is linear in consumption, in order to show that the optimal policy in this case is to run initial surpluses leading to an untaxed steady state. Specifically we assume that the utility function has the form $U = \Sigma_{t=0}^{\infty} \beta^t c_t$, which reflects a constant marginal utility equal to 1. The first-order condition governing the consumption-savings tradeoff for the agent [i.e. equation (11)] modifies to the following inequality:

(20) $1 \leq \beta(1+r_{t+1})$.

Noting that the discount factor can be expressed as $\beta = 1/(1 + \rho)$ where $\rho \in (0,\infty)$ is the associated <u>rate</u> of time-preference, the above condition implies that if:

(21.a) $r_{t+1} > \rho$, then $c_t = 0$.

(21.b) $r_{t+1} < \rho$, then $c_t = (1+r_t)a_t + w_t$.

(21.c) $r_{t+1} = \rho$, then $c_t = r_t a_t + w_t$.

The implications of the above cases are, respectively, that all income is

saved, all income plus all wealth is consumed, and that all disposable income is consumed leaving the level of wealth unchanged.

In a model of optimal capital growth with no government, assuming an economy that starts off with a low enough capital stock, for some initial interval of time $(0,1,\ldots\ldots,t_1-1)$, (21.a) will hold and the entire output will be devoted to capital accumulation. At t_1 itself, the inequality will generally be reversed (i.e. (21.b) will hold) if the entire output is once again invested. Thus, only part of the output will be invested and the consumption path will jump to the steady state level implied by (21.c). Algebraically, the capital path can be characterized by the equation $k_{t+1}-k_t=f(k_t)$ for $0\le t<t_1$, and $k_{t+1}=k_t=\bar{k}$ for $t\ge t_1$. The associated consumption path is given by $c_t=0$ for $0\le t<t_1$, and $c_t=\bar{c}=f(\bar{k})$ for $t\ge t_1$.

In the case of positive government expenditure g which can be financed with lump-sum taxes, and assuming no initial government debt (to rule out initial debt servicing), the time path from any initial capital stock will take longer to reach the steady state (which will result i the same level of capital as in the untaxed case). Although the agent will face the same inequalities along the way, as he did in the untaxed case, and will therefore save his entire income again, the lump-sum tax will leave the agent with less income to invest in each period. Thus the capital path will be described by $k'_{t+1}-k'_t=f(k'_t)-g$ for $0\le t<t_2$ (where $t_2>t_1$), and $k'_{t+1}=k'_t=\bar{k}$ for $t\ge t_2$. The associated consumption path is $c'_t=0$ for $0\le t<t_2$ and $\bar{c}'=f(\bar{k})-g$ for $t\ge t_2$. Figure 1 compares the untaxed case with case of a positive expenditure financed with lump-sum taxes.

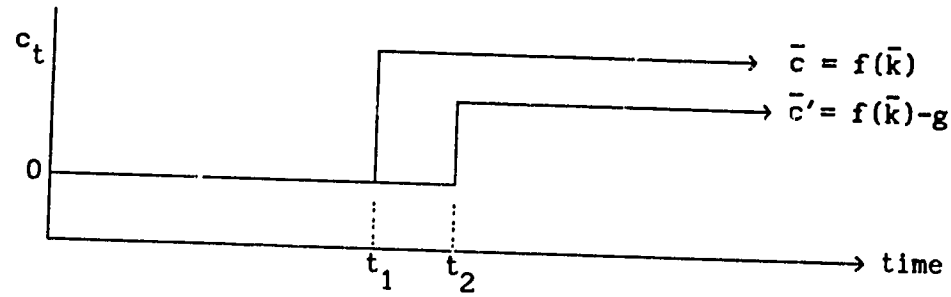

Figure 1: Consumption paths under (i) no taxes and (ii) lump-sum taxes.

Consider now the case where *a priori* lump-sum taxes are ruled out. In this case, the government has to levy taxes upon interest payments. In a policy that generates initial surpuses adding up to the net present value of the stationary stream of government expenditures, the steady state will imply zero taxes. The level of the agent's consumption at this steady state will equal that at the steady state with lump-sum taxes. This is because the government will own just enough capital to finance its expenditures, while the economy as a whole will sustain just enough capital to have its untaxed marginal product equal to ρ. This implies that the economy wide level of capital will exactly equal that of the lump-sum case. Thus steady state consumption can once again be characterized by $\bar{c}' = f(\bar{k})-g$. In the following lemma, we show that the time at which the economy jumps to this steady state is also the same as in the lump-sum tax case, making the present policy equivalent to the lump-sum tax one.

LEMMA 1: *Consider a stream of tax rates* $\{\tau_0, \tau_1, \ldots \tau_T, 0, 0, 0, \ldots\}$ *which satisfies:*

(i) $$\sum_{t=0}^{T} \frac{(\tau_t f' k_t - g)}{\Pi_{s=1}^{t}(1+r_s)} = \sum_{t=0}^{\infty} \frac{g}{\Pi_{s=1}^{t}(1+r_s)} \quad \text{(NPV of surplus = NPV of } g\text{)}$$

(ii) $\tau_0 = \bar{\tau}_0$. *(initial constraint on capital levy is binding)*

(iii) $(1-\tau_t)f'(k_t) > \rho \ \forall \ 1 \leq t < \tau$. *(net return on capital exceeds ρ)*

(iv) $\tau < t_2$. *(surpluses can be generated prior to reaching the s.s.)*

For such a path of taxes, the optimal path of consumption jumps to the untaxed steady state at t_2.

Proof: Condition (iii) implies that the agent will save his entire income. Denoting private capital by k^p and government capital by k^g, the equation governing private accumulation will be given by

$$k^p_{t+1} - k^p_t = (1-\tau_t)f'(k_t)k^p_t + w_t$$

At the same time, the government is reinvesting its surplus, so that the rate of growth of government capital is defined by

$$k^g_{t+1} - k^g_t = \tau_t f'(k_t)k^g_t - g.$$

Since total capital is given by $k_t = k^p_t + k^g_t$, adding the above two equations gives

$$k_{t+1} - k_t = f'(k_t) - g$$

which is the same as in the case with lump-sum taxes. Thus, starting from the same initial capital stock, the two paths reach the steady-state at exactly the same time.

Since the policy of running surpluses to reach an untaxed steady state is equivalent to lump-sum taxation, it is optimal and first-best. At the same time, any policy that does not generate enough surpluses to reach an untaxed steady state is sub-optimal because it implies positive taxes on interest,

and therefore lower capital and consumption, in the steady state. Thus, the optimal policy is to generate surpluses large enough to reach the untaxed steady state.

The maximum revenue that the government can collect in taxes during each of the transitional periods is given by an upper bound

$$\tau_t f'(k_t)k_t = (f'(k_t) - \rho)k_t$$

Thus, the maximum level of government expenditures $\bar{g}$ which can be financed by a policy of surpluses must have a present value just equal to the present value of the above revenue stream evaluated between t=0 and $t=t_2$. This implies the inequality

$$\sum_{t=0}^{t_2} \frac{[f' - \rho]k_t - \bar{g}}{\Pi_{s=1}^{t}(1+r_s)} \geq \sum_{t=0}^{\infty} \frac{\bar{g}}{\Pi_{s=1}^{t}(1+r_s)}$$

which defines the maximum level of government expenditures (given an initial capital stock and the production technology) which can allow for a feasible policy of generating surpluses that lead to an untaxed steady state.

Leaving aside the special case of linear utility, the general problem of welfare comparisons between a policy of generating surpluses to reach an untaxed steady state and a policy that balances the government's budget each period (a benchmark case) can be illustrated on the following diagram. The path labelled A arises from the former policy, while the path labelled B arises from the latter.

The steady state level of consumption is higher along A than along B, because of the absence of distortionary taxes in the former as opposed to the latter. At the same time, given the same initial capital stock, short-run consumption levels are higher along A than along B, reflecting the larger

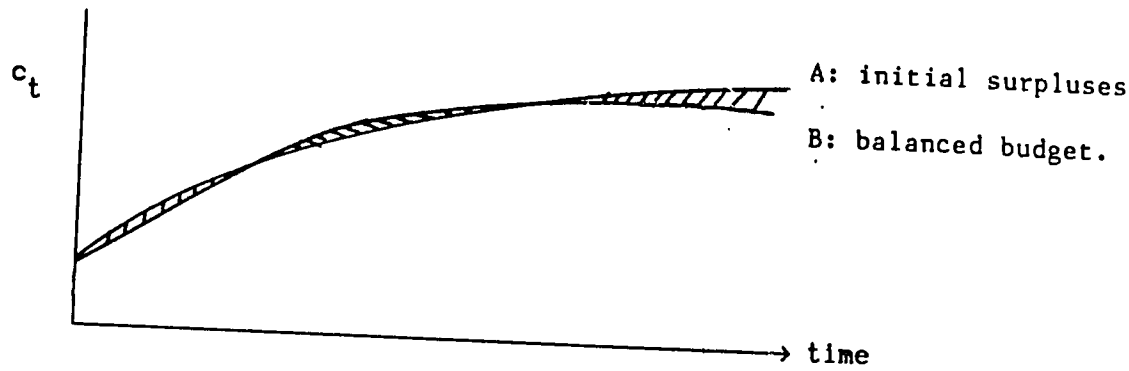

Figure 2: Consumption paths under different policy regimes.

substitution effects (towards consumption and away from savings) of the higher taxes needed to generate surpluses. During the medium run, however, consumption levels along A fall below those along B. This reflects the transition from lower short-run capital stocks (induced by the surpluses) to higher long-run capital stocks (at the untaxed steady state). It is because of these intersections that welfare comparisons become ambiguous.

A comparison of welfare between the two policy regimes will depend upon the relative weights given to the medium- and the long-run (i.e. on the rate of time preference), and upon the magnitudes of the initial substitution effects engendered by the surplus-generating policy relative to the balanced-budget policy. These effects will in turn depend upon the degree of concavity of the agent's period-wise utility. In the case of linear utility, these effects are equal to zero, and therefore, the long-run gains dominate all short- and medium-run considerations. It is likely that the result for this case may extend to cases with low discounting and "almost linear" utility functions.

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