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This paper analyzes the intertemporal allocation effects of anticipated tax-rate changes, reconsidering the recommendations of the Meade Committee in a perfect foresight general equilibrium model of economic growth. We show that the R-base (or consumption) tax can be more distortionary than an income tax and that a revenue-neutral integration of corporate and personal taxation may lower social welfare. Moreover, we argue that a dividend tax dominates the R-base tax because it places its distortions on the financial rather than on the real side of the economy.

After a period of intensive study of optimal indirect taxation, there has been a renewed interest in recent years in the problem of optimal direct taxation, with particular emphasis on capital income taxation and economic growth. A number of authors and tax committees have proposed replacing the current tax system with various forms of cash-flow taxation, and there is an ongoing debate on the problem of double taxation of dividends.

While the discussion has clarified many of the advantages and disadvantages of the various taxes, it has not paid much attention to the question of how sensitive the results are to the assumption of tax-rate stability: nearly the whole theoretical literature on tax reform assumes unforeseen sudden changes in tax rates and a constancy of these rates thereafter.

A typical example is the report of the Meade Committee (1978) on the reform of direct taxation, one of the most careful and voluminous studies on direct taxation ever done. In his introductory remarks to this report, Dick Taverne, the Director of the Institute of Fiscal Studies, expressed the expectation "that the Committee would adopt a practical approach: to aim at those reforms which would be able to command the widest possible support in the hope that political argument might in the future be concerned with rates of tax rather than the structure." Although this statement is clearly based on the assumption of continuing tax-rate adjustments, no attempt is made in the report to address the problems that would arise if people anticipated such adjustments.

Exceptions to the general disinterest are some remarks by Stephen Nickell (1977, pp. 57–58) and a note by Agnar Sandmo (1979). These authors considered the tax on the real cash flow of the firm which the Meade Committee called the *R*-base tax. They showed that this tax is nonneutral when the tax rate is subject to change, and that the equivalence with a tax on pure profit, previously proved by Sandmo (1974) for the case of a constant tax rate, does not hold for a variable rate.

There are at least three reasons why the analysis of non-constant capital income tax rates begun by Nickell and Sandmo merits further attention. First, government forecasts of tax revenues often prove wrong, and a revision of tax rates turns out to be necessary to balance the budget. Second, to mitigate redistributive losses, tax reforms are often phased in over an extended adjustment period. Third, and perhaps most important, there is no presumption that a time-consistent policy will be compatible with a constant tax rate, even if the government may

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wish to announce a constant tax rate for efficiency reasons.[1]

The basic tasks of this paper are to extend the Nickell-Sandmo type of partial analytic result to other taxes and to provide a consistent framework for a synthesis and systematic coverage of the economic effects of anticipated tax-rate changes in general. This framework is built on a perfect-foresight general equilibrium model of economic growth similar to those of Hans-Werner Sinn (1981, 1987). The model satisfies the two main theorems of welfare theory and thus allows for a Paretian welfare evaluation of the taxes to be considered.

I. Idealized Capital Income Taxes

We study three idealized forms of capital income taxation which share the property of tax neutrality with regard to the firm's real, and to a considerable extent also with regard to its financial decisions, when applied with a constant rate: the *R*-base tax, a dividend tax, and a uniform Schanz-Haig-Simons (SHS) tax on all kinds of capital income. Each tax is assumed to be levied at a single uniform rate at any one time. The paper centers around the question of to what extent neutrality persists when these rates are anticipated to change.

The *R*-base tax is a real-base cash-flow tax that allows for immediate write-off of real investment projects, but disallows deduction of debt interest. It was first analyzed by Cary Brown (1948) and has since received much attention in the literature. It has never been implemented, but the Meade Committee seriously considered it and, in a kind of minority vote to the Committee's report, John Kay and Mèrvyn King (1978) recommended it as a practical alternative to the present U.K. capital income tax system.

The Meade Committee did not favor the *R*-base because it leaves financial institutions untaxed. Instead it advocated the so-called *S*-base tax which taxes a firm's financial cash flow in addition to its real cash flow. This means in particular that debt interest is deductible in addition to real investment outlays and that, in exchange, the firm's inflow of borrowed funds is included in the tax base. If endowed with a limited loss-offset, the *S*-base tax is a genuine dividend tax of the type we will analyze in this paper.[2]

Unlike the two cash-flow taxes, the SHS tax on capital incomes is based on accrual accounting and is imposed on both firms and households. The tax base includes company profits and personal interest income where debt interest and true economic depreciation are deductible. The SHS tax is the capital income tax par excellence and, except for the treatment of corporations, it can be interpreted as the theoretical ideal underlying the capital income tax systems employed in the OECD countries.[3] Taken together, the SHS tax and the dividend tax can be seen as an approximation to a tax system with an imperfect integration between corporate and personal taxation like that of the United States. The SHS tax stands for the corporate tax *and* the personal tax on interest income, and the dividend tax represents the personal tax on dividends sometimes referred to as the "double tax" on corporate income. It goes without saying that this approximation is still very crude in that it neglects accelerated depreciation, progressive taxation, and the divergence between corporate and personal tax rates.

The tax rates corresponding to the *R*-base, the dividend, and the SHS taxes are labeled τ_i, where $i = R, D, S$. Each tax rate will be assumed throughout the analysis to be a differentiable function of time whose value is nonnegative, strictly less than unity, and constant beyond some arbitrarily distant point in time t^*. For each tax, let Θ_i denote the *tax factor*: $1-\tau_i$, and let Θ_i^* be the target level reached at t^*. We consider the effects of these taxes on a firm that produces a homogeneous output using capital and la-

[1] See Finn Kydland and Edward Prescott (1977).

[2] See Howitt and Sinn (1986, Sec. 5) for the details of the relationship between the *S*-base tax and a dividend tax.

[3] See Richard Goode (1977) for the details of the historical development of this form of tax.

bor according to the linearly homogeneous production function $f(K,L)-\delta K$, where f is output gross of depreciation and δ the percentage rate of physical decay of the capital stock. The analysis abstracts from commodity price changes. It is therefore assumed that there is just one malleable capital-consumption good whose price is normalized to unity. By way of contrast, the wage rate w and the interest rate r are allowed to change; the time paths of these factor prices will be determined endogenously in the model.

The real cash flow of the firm, the R-base, is the firm's revenue f net of its wage cost wL and net of gross investment, where gross investment is the sum of depreciation δK and net investment $\dot{K}$:

$$(1) \quad R \equiv f(K,L) - wL - (\delta K + \dot{K}).$$

The R-base tax is a firm-based consumption tax with an exemption of wage incomes. It does not apply to interest income.

When no other tax is levied, the base of the SHS tax is: $f(K,L)-\delta K - wL - rB$ where $B \gtreqless 0$ is the firm's level of outstanding debt and δK is both physical and true economic depreciation.[4] When the R-base tax is also levied, the effective net revenue of the firm is $\Theta_R f(K,L)$, and the net wage cost is $\Theta_R wL$. The value of the firm's stock of capital is $\Theta_R K$ since, if the firm decided to sell this capital stock, it would have to pay a tax equal to $\tau_R K$. True economic depreciation is accordingly[5] $(\delta - \hat{\Theta}_R)\Theta_R K$. Thus the base of the SHS tax on the firm is

$$(2) \quad S \equiv \Theta_R\left[f(K,L) + \left(\hat{\Theta}_R - \delta\right)K - wL\right] - rB.$$

This formulation gives due recognition to the government's fractional ownership of the capital via the R-base tax. Define the firm's equity capital as

$$(3) \quad E \equiv \Theta_R K - B.$$

Then S can be rewritten as

$$(4) \quad S = \Theta_R\left[f(K,L) + \left(\hat{\Theta}_R - \delta - r\right)K - wL\right] + rE,$$

which is economic profit plus the normal return on equity. Recall that the SHS tax is levied not only on the firm's profit, but also on its shareholders' interest income.

Dividends, D, equal the firm's pretax real cash flow minus debt interest, minus R-base and SHS tax liabilities, plus new issues of debt $\dot{B}$ and shares Q:

$$(5) \quad D \equiv f(K,L) - wL - (\delta K + \dot{K}) - rB - \tau_R R - \tau_S S + \dot{B} + Q.$$

Inserting (1) and (2) into this equation gives

$$(6) \quad D = \Theta_S S - \pi,$$

where π is the firm's level of retained profits defined as

$$(7) \quad \pi \equiv \Theta_R \dot{K} + \dot{\Theta}_R K - \dot{B} - Q.$$

The dividend, net of all taxes, received by the firm's shareholders is $\Theta_D D$.

In reality, firms have considerable scope for manipulating the tax bases through changing their real and financial decisions, but this scope is limited. Mervyn King (1974a, 1977) has taken the view that gov-

[4] The production function used here avoids any ambiguities in defining true economic depreciation. In line with the neutrality concept of Sven-Erik Johansson (1961) and Paul Samuelson (1964), true economic depreciation is more generally defined as the decline over time in the present value of an asset's remaining cash flow where the market rate of interest net of the SHS tax serves as the discount rate. See Sinn (1987, ch. 5) for a discussion of this concept with explicit reference to the above production function.

[5] The circumflex "^" denotes a proportional rate of change with respect to time; a "dot" denotes a time derivative.

ernment authorities tend to impose constraints on firms' decisions whenever a provision of the tax system leads to excessive arbitrage reactions. For his analysis of existing tax systems he thus assumed that dividends cannot exceed the firm's profits and cannot be negative, and he disallowed share repurchases and debt redemptions. Except for the last, these same constraints are assumed in this paper. They prevent the firms' choice variables from becoming infinite and ensure the existence of a solution.

Not all of these constraints seem equally reasonable in the light of existing regulations in OECD countries, but they do have empirical counterparts. First, negative dividends are usually excluded since they would imply a negative dividend tax revenue. Second, in most countries share repurchases are illegal, since they constitute a form of corporate distribution that evades the dividend tax. Even the United States, which seems to be comparatively generous in this regard, does not formally allow share repurchases in lieu of dividend payments.[6] Third, most countries have provisions that impose upper bounds on a firm's dividend payments to ensure that its equity base stays intact. We model these provisions through the constraint $D \leq \Theta_S S$ which, according to (6), means that profit retentions are nonnegative: $\pi \geq 0$.[7]

[6]See Alan Auerbach (1979, p. 439). It is the subject of ongoing debates, however, whether the legal proscriptions are sufficient to explain why companies pay dividends instead of repurchasing shares. The United States recently experienced a strong increase in the volume of share repurchases and acquisitions but, as was argued by John Shoven (1986), this increase was primarily debt-financed and did not crowd out ordinary dividend payments. Compare also David Bradford (1980, pp. 53–58; 1986, ch. 6) for discussions of the repurchase problem and Sinn (1987, ch. 6) for a formal analysis of debt- and profit-financed acquisitions.

[7]The constraint would not be reasonable for firms that make losses for it would then obviously contradict the assumption that $D \geq 0$. However, as shown in Appendix 1 (expressions (A8) and (A9)), the equilibrium analyzed in this model excludes such a possibility. For an overview of the restrictions on the declaration of dividends that are in use in the United States, see Robert Hamilton (1980, § 16.3 and § 16.4). It would perhaps be more accurate to represent these constraints with the stock restriction $E(t) \geq E^o$ rather than the flow restriction $\pi(t) \geq 0$. However, this modification would require us to allow jumps in the state variable E when it was profitable for the firm to pay a measurable fraction of its equity out in dividends. The modified analysis can be conducted using the techniques discussed by Morton Kamien and Nancy Schwartz (1981, pp. 215–32) but is formally cumbersome. It results in no change in the conditions (11) and (12) below governing the firm's real decisions, and minor changes in the firm's financial decisions, which are described in our research report (Howitt and Sinn, 1986, fn. 11).

II. Optimal Employment of Capital with Varying Tax Rates

In line with Fisher's separation theorem, the firm is assumed to maximize the market value M of its shares knowing the characteristics of a capital market equilibrium and expecting time paths $\{r\}$ and $\{w\}$ for the two factor prices. Assume $r, w > 0$ and let $M = mz$, where z is the number of shares and m is the price per share. Assume that new shares are sold at their market price, $m\dot{z} = Q$, and that market equilibrium is characterized by an equality of the net-of-tax returns on shares and bonds as perceived by shareholder households:

$$(8) \qquad \dot{m}z + \Theta_D D = r\Theta_S M.$$

Here $\dot{m}z$ is the capital gain on existing shares, $\Theta_D D$ the net dividend, and $r\Theta_S M$ the opportunity cost of holding shares in terms of foregone interest income net of the personal component of the SHS tax. It follows from (8) that $\dot{M} = \dot{m}z + m\dot{z} = r\Theta_S M - \Theta_D D + Q$. Upon integration, this differential equation yields the unique solution

$$(9) \quad M(t) = \int_t^{\infty} [D(u)\Theta_D(u) - Q(u)] \times \left[\exp \int_t^u - \Theta_S(v) r(v)\, dv\right] du,$$

where it is assumed that the integrals exist and that $M = 0$ if the firm never issues new shares and never pays out any dividends.

The formal optimization problem of the firm can be written down as follows:

$$(10)\quad \max_{\{K,L,Q,\pi\}} \int_0^\infty \Big\{ \Theta_D\Theta_S\Theta_R\big[f(K,L) + \big(\hat{\Theta}_R - \delta - r\big)K - wL\big] - \Theta_D\pi + \Theta_D\Theta_S rE - Q \Big\}\Delta\, dt$$

$$\text{s.t.}\quad \dot{E} = \pi + Q,$$

$$E(0) = E^o > 0,$$

$$K, L, Q, \pi \geq 0,$$

$$(D=)\Theta_S\Theta_R\big[f(K,L) + \big(\hat{\Theta}_R - \delta - r\big)K - wL\big] + r\Theta_S E - \pi \geq 0,$$

where $\Delta(t) \equiv \exp\int_0^t - \Theta_S(\nu)r(\nu)\,d\nu.$

The firm's control variables are capital K, labor L, new share issues Q, and profit retentions π; and the single-state variable is the stock of equity E. We have used (4) and (6) to eliminate D as a separate control variable. The stock of debt could be introduced as an additional control variable, but as revealed by (3), it is redundant, being uniquely determined by E and K. Other combinations of state and control variables would be equally feasible. The one we chose may have the advantage of minimizing computational efforts. The equation of motion for the state variable, $\dot{E} = \pi + Q$, follows from (3) and (7). It says that equity capital can be built up through profit retentions and new share issues.

In line with the discussion of Section I, the firm is constrained to keep all its controls and its flow of dividends nonnegative. We will assume that this constraint is never binding on the real controls K and L. But it will often be binding on one or both of the financial controls Q and π.

The current-value Hamiltonian of problem (10) can be written as

$$\mathscr{H} = (\Theta_D + \mu_D)\big\{\Theta_S\Theta_R\big[f(K,L) - wL - \big(r + \delta - \hat{\Theta}_R\big)K\big] + r\Theta_S E - \pi\big\} - Q + q(\pi + Q) + \mu_\pi\pi + \mu_Q Q,$$

where the μ's are Kuhn-Tucker multipliers and q is the costate variable associated with equity ("Tobin's q"). As $\Theta_D > 0$ and $\mu_D \geq 0$, it is obvious that a maximization of the Hamiltonian with regard to the controls implies, among other things, that

$$(11)\qquad f_K(K,L) - \delta + \hat{\Theta}_R = r,$$

$$(12)\qquad f_L(K,L) = w.$$

Further conditions of an optimum that reveal the underlying financial decisions of the firm and are more difficult to obtain are analyzed in Appendix 1.[8]

Because of their myopic nature and the fact that only one of the three tax rates appears, conditions (11) and (12) are surprisingly simple. Note, however, that the simplicity is not an assumption but a result of our approach, part of which comes from the fact that the firm's financial decisions are forward looking and fully optimal. The important aspect of the two conditions is not how much, but how little the tax rates interfere with the firm's real decisions, and this is what we now try to explain.

Consider first condition (12). This condition excludes any tax influence on the firm's employment of labor for the simple reason that all three tax bases allow for a deduction of wage cost. ((Compare (1), (2), and (5).) Thus, no tax burden is imposed on the marginal worker and the decision about his employment is not affected.

[8]Our selection of control variables minimizes the effort of deriving (11) and (12), but not necessarily that of analyzing the financial decisions.

Turn now to the more important condition (11). It is obvious from this condition that the R-base tax affects the firm's real investment decision if and only if the tax rate is subject to change. With a constant tax rate ($\hat{\Theta}_R = 0$), the R-base tax is neutral since the tax authority acts as a fair, dormant partner of the firm who, because of the immediate write-off, contributes to a real asset's purchase in the same terms as it participates in its returns. With a variable tax rate, however, the neutrality breaks down as the partnership is no longer that fair. For example, in an introductory phase with a gradually rising tax rate ($\hat{\Theta}_R \leq 0$), the government participates more in the returns than it contributes to the purchase, so investment is discriminated against. By its very nature, the R-base tax is fully neutral with regard to the firm's financial decisions.

That the SHS tax does not show up in (11) may at first sight seem surprising. After all, we interpreted this tax as the corporate tax on the company side where no accelerated depreciation was allowed. The reason for the neutrality, however, is simply that the SHS tax base includes personal interest income and that, as shown by (8) and (9), the tax burden on this income enters the market valuation of the firm through the shareholders' discount rate. While the corporate component of the SHS tax discriminates against real and financial investment within the firm relative to a personal capital market investment outside the firm, the personal component of this tax has the opposite effect. Thus, when the tax rate for both components is the same, the two effects just cancel each other and the tax is neutral both with regard to the firm's real and financial decisions. The neutrality of the SHS tax includes the case of changing tax rates since, unlike the R-base tax, it is not the equality in tax rates across time, but one across assets that matters.[9] Note that the neutrality is partial analytic and refers to the case of a given time path of the market rate of interest. Section III will allow for endogenous changes in this time path due to a tax influence on private savings decisions.

Consider now the dividend tax. This tax has been modeled here in line with the "trapped equity" view put forward by Mervyn King (1974b), Alan Auerbach (1979), and David Bradford (1980, 1981).[10] Once equity has been injected into the firm there is no way for the shareholders to enjoy their returns other than through capital gains on their shares or through dividends paid out by the firm. Share repurchases, in particular, have been excluded. Under these circumstances, the dividend tax discriminates against new share issues, one of the three elementary sources of finance, but apart from that it has important neutrality properties. When applied with a constant rate, it does not affect the choice between debt and equity capital built up through profit retentions and therefore is neutral with regard to the firm's dividend policy. Moreover, as (11) reveals, it is also neutral with regard to the firm's real investment decisions. The explanation for this general neutrality is obvious from (9) and (10). When $Q = 0$, the dividend tax factor can be put in front of the integral of the right-hand side of (9) and hence disappears from the maximization problem (10). For each decision strategy, as represented by the time paths of K, L, and π, the dividend tax reduces the present value of dividends by the same percentage and hence does not affect the ranking of the strategies.

When the tax rate is constant, the dividend tax can be seen as giving the government a dormant partnership in the company's share capital which is similar to the partnership in the firm's stock of real assets with the R-base tax. The government may not have received this partnership at fair terms originally, but once it is established through the tax law, the government participates in all further debt- and profit-financed

[9] Basically, our neutrality result for the SHS tax is a variant of the Johansson-Samuelson theorem of taxation theory. (Compare Sinn, 1987, ch. 5.) It extends this theorem by explicitly considering a corporate firm, including financial decisions, and allowing for varying tax rates.

[10] See James Poterba and Lawrence Summers (1983) for a criticism of the trapped equity model and Sinn, (1987, p. 217) for a criticism of Poterba and Summers.

investments of the corporation in the same terms as shareholders do. When dividends are paid out, the government receives a fixed fraction of them as if it owned a fraction of the share capital, and when no dividends are paid, it postpones its claims as the shareholders do. The single shareholder perceives the partnership of the government like the partnership of other shareholders, and, except for the reduced incentive to buy newly issued shares, there is no reason for him to vote for a policy of his company other than the one he would have chosen without the dividend tax.

When the tax rate is subject to change, the partnership interpretation becomes invalid as with the R-base tax and it seems natural to expect similar distortions in the firm's investment behavior. This expectation, however, is not confirmed by equation (11). Unlike the R-base tax, the neutrality of the dividend tax persists despite anticipated tax-rate changes.

The key for understanding this is the way a non-constant tax rate affects the firm's financial decisions. There is little change with regard to external equity finance. The firm continues not to issue new shares because a dollar injected into the firm generates a market value of less than one dollar except in the case where it is expected that the dividend tax will ultimately be abolished. However, a variable dividend tax rate affects the choice between debt and retentions. A rising tax rate discriminates against profit retentions relative to debt and induces the firm to pay out all its profits as dividends. Debt is the cheapest source of finance and it is chosen to finance marginal increments of capital. A falling tax rate, on the other hand, favors profit retentions over debt, and induces the firm not to distribute any dividends.[11] Under these circumstances, debt is not the cheapest source of finance, but nevertheless it is chosen at the margin. This is obvious if the firm's net investment in real capital exceeds its profit, but it is also true in the reverse case where some of the profit remains available for a capital market investment by the firm. Each additional dollar of real investment reduces this capital market investment and is therefore, in effect, debt-financed.

Given that debt is always a marginal source of finance—even when the firm's net investment is fully equity-financed—the neutrality of the dividend tax is rather obvious. In the absence of taxation, the last unit of capital employed just generates enough return to cover its interest cost but not enough to generate any present or future dividends. Obviously, when there is a dividend tax, this same unit stays the marginal unit and continues to satisfy the first-order condition (11) because it does not contribute to paying this tax.[12]

The section concludes with a proposition that summarizes the bare essentials of the tax influence on the firm's real investment decision.

PROPOSITION 1: *While a rising R-base tax rate drives a wedge between the market rate of interest and the net-of-depreciation marginal product of capital, the dividend tax and the Schanz-Haig-Simons tax do not, even when the tax rates are subject to change.*

III. The Decision Problem of the Household and the Conditions for an Intertemporal General Equilibrium

We now attempt to close the model by constructing the market counterpart of the neoclassical one-sector model of optimal growth and allowing for a government sector. The firm is assumed to be a representative firm, and there is a representative household who owns this firm, supplies loans and labor, and buys part of the firm's output for consumption. The government collects the tax revenue and redistributes it to the house-

[11] This is the frequently cited lock-in effect which is usually attributed to the existence of a dividend tax as such. (Compare Sinn, 1987, ch. 4, for an extensive discussion.)

[12] The neutrality of profit taxes in the case of debt financing has been demonstrated by Alois Oberhauser (1963, pp. 67ff.) and Joseph Stiglitz (1973) in different contexts.

hold sector in the form of lump-sum transfers. The government is allowed to hold debt, but Ricardian equivalence prevents this from affecting real economic behavior.

The household is concerned about his and his heirs' utility, whose present value is given by

$$\bar{U}(t) = \int_t^\infty e^{-\rho(\nu-t)} N(\nu) \times U(C(\nu)/N(\nu))\, d\nu,$$

where $\rho > 0$ is the rate of utility discount, N the population or family size, and U the period utility function that is assumed to be characterized by a constant elasticity of marginal utility, $\eta \equiv -U''C/(U'N) =$ const. > 0. For simplicity, labor supply is assumed to be inelastic. This is a non-trivial assumption that would not be suited for an analysis of reforms such as the transition from a capital income tax to a wage tax or from a comprehensive income tax to a consumption tax. For the purposes of this paper, which is exclusively concerned with structural aspects of capital income taxation, the assumption seems less restrictive though.[13] Let $L = NG$ be the number of efficiency units of labor supplied, where G is an efficiency factor and N and G grow at the constant rates n and g, respectively.

The household takes the time paths of N, r, w, and the SHS tax factor Θ_S as given and chooses the path of C to maximize $\bar{U}(0)$ subject to the intertemporal budget constraint

$$\int_0^\infty C(u)\left[\exp\int_0^u -\Theta_S(\nu) r(\nu)\, d\nu\right] du = V(0),$$

where $V(0)$ is the historically given (from the household's point of view) initial value of the household's net wealth, which consists of the sum of government debt, the firm's debt and shares, and the present value of government transfers and wage income discounted at the after-SHS-tax rate $r\Theta_S$.

[13]See Sinn (1984) for a comparison of three cash-flow taxes in a variant of this model that has constant tax rates but elastic labor supply.

By standard arguments the solution to this problem must satisfy the equation

$$\rho + \eta(\hat{C} - n) = r\Theta_S. \tag{13}$$

Equation (13) shows the well-known result that the SHS tax drives a wedge between the market rate of interest and the consumers' rate-of-time preference (the LHS of (13)). This wedge adds to the wedge that a rising R-base tax will drive between the market rate of interest and the marginal product of capital according to (11), and we will see that it produces similar intertemporal distortions. Note that the size of the wedge produced by the SHS tax depends only on the current *level* of the tax rate τ_S and, unlike the R-base tax, not on its *rate of change*.

In an intertemporal general equilibrium, the time paths of the market rate of interest $\{r\}$ and the wage rate $\{w\}$ are such that the plans of households and firms are compatible with one another under perfect foresight. To investigate the properties of equilibrium it is useful to redefine the aggregates relative to L. Thus $c \equiv C/L$, $k \equiv K/L$, $\varphi(k) \equiv f(k,1)$. Note that $\varphi'(k) = f_K(K,L)$ and $\hat{L} = n + g$. We can then reduce the definition of equilibrium to a pair of first-order differential equations. The first is the condition for the output market to clear:

$$\dot{k} = \varphi(k) - (\delta + n + g)k - c. \tag{14}$$

This is the familiar equation of motion of capital intensity with labor-augmenting technological progress.

The second equation combines (11) and (13) from the firm's and the household's decision problems:

$$\dot{c} = \frac{c}{\eta}\left(\Theta_S\left[\hat{\Theta}_R + \varphi'(k) - \delta\right] - (\rho + \eta g)\right). \tag{15}$$

Unlike (14), this differential equation is non-autonomous for $t \leq t^*$, when the tax factors are approaching their long-run target levels.

The market equilibrium path implied by (14) and (15) can be studied by use of Figure

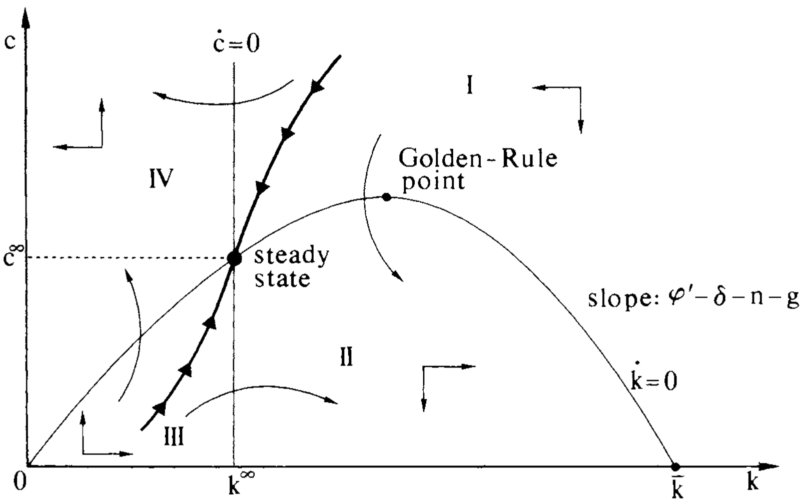

FIGURE 1. THE INTERTEMPORAL GENERAL EQUILIBRIUM WITH TAXATION (FOR $t \geq t^*$)

1 which shows the familiar (c, k) diagram known from the central planning literature. As usual, there is the $(\dot{k} = 0)$ line whose maximum indicates the Golden-Rule point where the marginal product of capital, $\varphi' - \delta$, equals the natural rate of growth, $n + g$. In addition, there is a $(\dot{c} = 0)$ line valid for $t \geq t^*$. Because of (15) and since $\Theta_S = \Theta_S^* =$ const. and $\hat{\Theta}_R = 0$ for $t \geq t^*$, this line is vertical and satisfies the condition

$$\varphi'(k^{\infty}) - \delta = \frac{\rho + \eta g}{\Theta_S^*}, \tag{16}$$

where k^{∞} is the steady-state capital intensity. The intersection point between this line and the $(\dot{k} = 0)$ line is the steady-state point. Accordingly, the steady-state level c^{∞} of the standardized consumption is: $c^{\infty} = \varphi(k^{\infty}) - (\delta + n + g)k^{\infty}$.

The arrows in regions I through IV and those on the $(\dot{k} = 0)$ and $(\dot{c} = 0)$ lines indicate the movements compatible with the two differential equations when the tax rates are constant; that is, after t^*. The heavy line that connects the steady-state point with regions I and III indicates the *stable branch* among the possible paths. As in the central planning literature the equilibrium is unique given any initial k, and it coincides with the stable branch for $t \geq t^*$.[14]

To ensure that solutions to the planning problems of the agents exist on this branch it is necessary that

$$\lim_{t \to \infty} \hat{X}(t) < \lim_{t \to \infty} \left[r(t) \Theta_S(t) \right] \quad \text{for } X = C, K, \tag{17}$$

or, equivalently, that

$$n + g < \rho + \eta g, \tag{18}$$

where $\rho + \eta g$ is the steady-state rate-of-time preference. Condition (18) is a well-known existence condition for central planning models with the same technology and preferences as those assumed in this paper.[15] It follows from (16) and (18) that $\varphi'(k^{\infty}) - \delta > (n + g)/\Theta_S$. Thus, with or without taxation, only steady-state points to the left of the Golden-Rule point are compatible with a market equilibrium.

[14] Paths above the stable branch become infeasible in finite time, paths below it approach the point $(c = 0, k = \bar{k})$ as time goes to infinity and violate condition (17).

[15] See Kenneth Arrow and Mordecai Kurz (1970, ch. III).

Before t^*, the non-autonomous part of (15) as represented by $\Theta_S(t)$ and $\hat{\Theta}_R(t)$ will affect the market equilibrium path, and in general this path will not coincide with the stable branch. The next section analyzes some of the more interesting possibilities.

IV. Tax Reforms and Economic Growth

Unlike static equilibrium models, intertemporal equilibrium models often do not satisfy the two main theorems of welfare economics: even in the absence of a government activity the models generate a growth path that cannot, in any meaningful way, be considered as socially optimal. This is not so for the present model. If we maximize the representative household's utility function subject to the "law of motion" (14) then we clearly get the equilibrium growth path for $\Theta_D = \Theta_S = \Theta_R = 1$. The solution is well-known from the work of Kenneth Arrow and Mordecai Kurz (1970).

The advantage of the coincidence between the social optimum and the *laissez faire* solution is that the latter can serve as a benchmark for evaluating the tax distortions. Figure 2 depicts the *laissez faire* path. It intersects the ($\dot{k}=0$) line at a point where (16) reduces to the Modified Golden Rule: $\varphi'(k_g^\infty)-\delta=\rho+\eta g$.

The steady state of an economy that has an SHS tax (and, possibly, other taxes) is on the ($\dot{k}=0$) curve to the left of the Modified Golden-Rule point (because $\Theta_S^* < 1$ in (16)). For the following analysis we assume that the economy is initially in such a steady state. An optimal tax reform would be one that drops consumption suddenly and makes the economy move along the *laissez faire* path.[16] Admittedly, such an optimum optimorum may be an unrealistic standard of

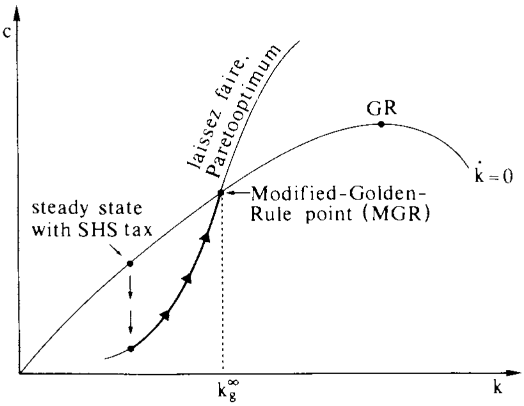

FIGURE 2. THE "OPTIMAL" TAX REFORM

perfection for policy analysis, and we do not claim that this standard can ever be reached with realistic tax reforms. Nevertheless, it will turn out to be a useful point of reference for comparing less than optimal reforms.

For this comparison, we make use of the following proposition, which is proved in Appendix 2. Specifically, suppose that $\{c(t), k(t)\}$ is the equilibrium path resulting from a given path of tax parameters where $\hat{\Theta}_R \le 0$ and $k(t) \le k_g^\infty$ (the Modified Golden-Rule stock) for all $t \ge 0$. Then any other solution $\{c'(t), k'(t)\}$ to (14) that starts with the same capital and never has more:

$$k'(t) \le k(t) \quad \text{for all } t \ge 0$$
$$\text{with equality for } t=0$$

yields strictly lower lifetime utility to the household. Because the proof uses a revealed preference argument involving a surrogate decision problem characterizing the equilibrium path we shall refer to this proposition as our revealed-preference proposition.

Our welfare criterion, the lifetime utility of the representative household, is strictly Paretian and does not incorporate distributional aspects other than the intergenerational preferences implicit in the infinitely lived household's utility function.[17] Admit-

[16]At first glance, it may seem strange that the optimal transition to the *laissez faire* path is independent of the social discount rate. Note, however, that this path itself describes an optimal transition to a steady state and depends on the social discount rate implicitly through (15). ($\varphi'(k)-\delta$ equals the social discount rate in the absence of taxation.) Our model does not allow the social rate-of-time preference to determine an optimal transition path to a transition path.

[17]Compare Robert Barro's (1974) discussion of the intertemporal utility function in the case of an operative bequest motive.

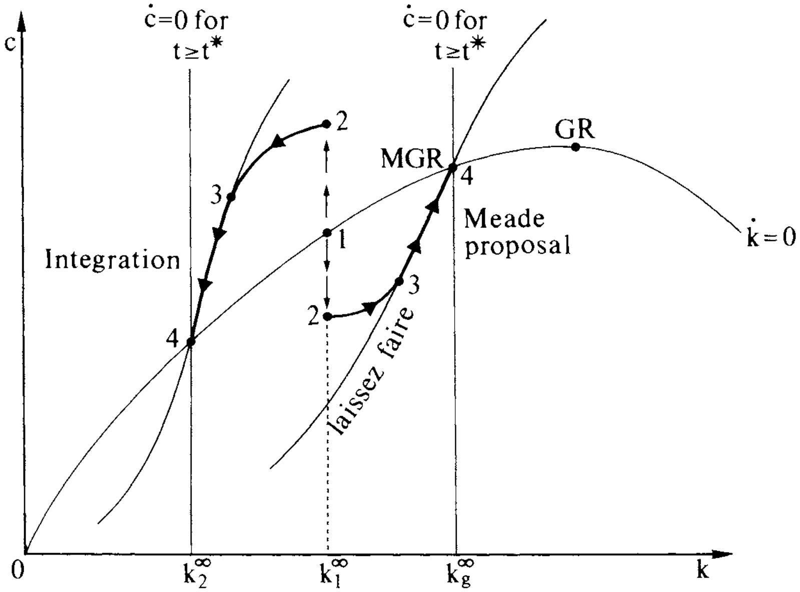

FIGURE 3. A REVENUE-NEUTRAL INTEGRATION OF CORPORATE AND PERSONAL INCOME VS. PROPOSAL OF MEADE COMMITTEE

tedly, this leaves out of consideration the intragenerational distribution effects that motivate much of the public debate over tax reform.

A. *The Dividend Tax and the Schanz-Haig-Simons Tax*

Phasing out the dividend tax and increasing the Schanz-Haig-Simons tax rate approximates what generations of economic advisors have had in mind when arguing for an integration of corporate and personal income taxation that would reduce the degree of double taxation of dividends. West Germany, for example, one of numerous countries that has followed this advice, has raised the corporate and (maximum) personal tax rates and completely removed the corporate tax burden on dividends paid to domestic residents in exchange.[18] The United States may be among the next candidates for a similar reform.

It is clear from (15) that the removal of the dividend tax in itself produces no substitution effects that affect economic growth. Instead, all model reactions are driven through the change in the SHS tax factor. Assume that $\hat{\Theta}_S < 0$ for $t < t^*$. Because of the decrease of Θ_S to Θ_S^* the $(\dot{c} = 0)$ locus defined by (16) will move to the left of the initial steady state in the (c, k) plane, and accordingly, when $t \geq t^*$, the equilibrium point must move along the stable branch leading through the intersection point between this locus and the $(\dot{k} = 0)$ locus. If Θ_S were lowered in a one-step reform, the equilibrium point would immediately jump upward to the stable branch and would then follow it, gradually drifting southwest toward the new steady state. However, since Θ_S is falling gradually, there is a less rapid decline in c in the period before t^* and hence a smaller initial upward jump. As shown by the leftward motion in Figure 3, the equilibrium point will move along a flatter path below the stable branch which, because of the continuity in $\Theta_S(t)$, is tangent to the stable branch at $t = t^*$. Paths that start at or above the stable branch and paths

[18]We refer to the joint effect of the 1975 and 1977 German tax reforms.

that start at or below the ($\dot{k}=0$) line will never lead to the stable branch and can thus be excluded. In Figure 3 and the following figures, points 1 and 2 characterize the situations before and immediately after the reform, point 3 refers to $t=t^*$ where the tax rates reach their target levels, and point 4 is the new steady state.

Note that the economy's reaction to the tax reform illustrated in Figure 3 is the opposite to that of an optimal tax reform. Instead of steering the economy closer to the socially optimal growth path, it makes it drift even further away, exacerbating the distortion of capital income taxes. This is in striking contrast to the efficiency gains claimed by proponents of integrating corporate and personal taxes.

Not only does this reform steer k away from its optimal growth path, it also reduces welfare. By our revealed preference proposition the post-reform equilibrium path will be inferior to the pre-reform steady state, because it involves less capital at each date, because the initial steady state is at or below k_g^∞, and because $\hat{\Theta}_R=0$.

The following proposition summarizes the economy's reactions.

PROPOSITION 2: *In comparison to the growth path that would have prevailed without a reform, a substitution of the Schanz-Haig-Simons tax for the dividend tax causes an initial rise in consumption at the expense of a long-run decline in the levels of both consumption and capital; it also reduces social welfare. The qualitative aspects of this result are independent of whether the reform is sudden or gradual, but when it is gradual, the initial rise in consumption is less extreme and so the capital intensity does not decline as quickly.*

Instead of the reform described, a more useful reform would be to phase out the SHS tax, substituting in its place an increased dividend tax; that is, to carry out the reform recommended by the Meade Committee (1978). Deriving the implications of such a reform is analogous to the previous argument, and we leave it to the reader to verify the result depicted in Figure 3 for the case of a gradual reform. Clearly this reform approximates the optimal reform shown in Figure 2. The reform increases social welfare, whether it is carried out gradually or implemented immediately. This is because along the post-reform equilibrium path, where $\hat{\Theta}_R=0$, k is less than or equal to k_g^∞, and k is always greater than or equal to the initial steady-state value k_1^∞. Therefore, the pre-reform steady state yields less social welfare than the post-reform equilibrium path.

Figure 3 reveals that the less gradual the reform the more closely will it approximate the optimal tax reform. Immediate implementation would make it exactly optimal.

B. *The Dividend Tax and The R-Base Tax*

Suppose that double taxation of dividends were eliminated by substituting the R-base tax rather than by increasing the SHS tax. If this were done immediately, with a surprise reform and a credible commitment not to alter rates in the future, then the neutrality of the R-base tax and the dividend tax in the case of constant rates would prevent any change in the growth path. If the economy was initially at the steady state k^∞ in Figure 4 it would remain there because equation (15) would remain unchanged.

If, however, the replacement of the dividend tax with the R-base tax were phased in gradually, then, over the period before t^*, the term $\hat{\Theta}_R$ in (15) would be negative and growth would be affected. Figure 4 shows what would happen in the case where $\hat{\Theta}_R$ was constant over the interval $(0,t^*)$. The ($\dot{c}=0$) locus would temporarily shift leftward to $\tilde{k}$ defined by

$$\varphi'(\tilde{k})-\delta=\frac{\rho+\eta g}{\Theta_S}-\hat{\Theta}_R$$

$$>\frac{\rho+\eta g}{\Theta_S}=\varphi'(k^\infty)-\delta,$$

but at t^* this locus would shift back to its initial position.

Consumption would jump up immediately after the reform is announced, and the equilibrium point would drift away, first to the southwest then, after crossing the ($\dot{k}=0$)

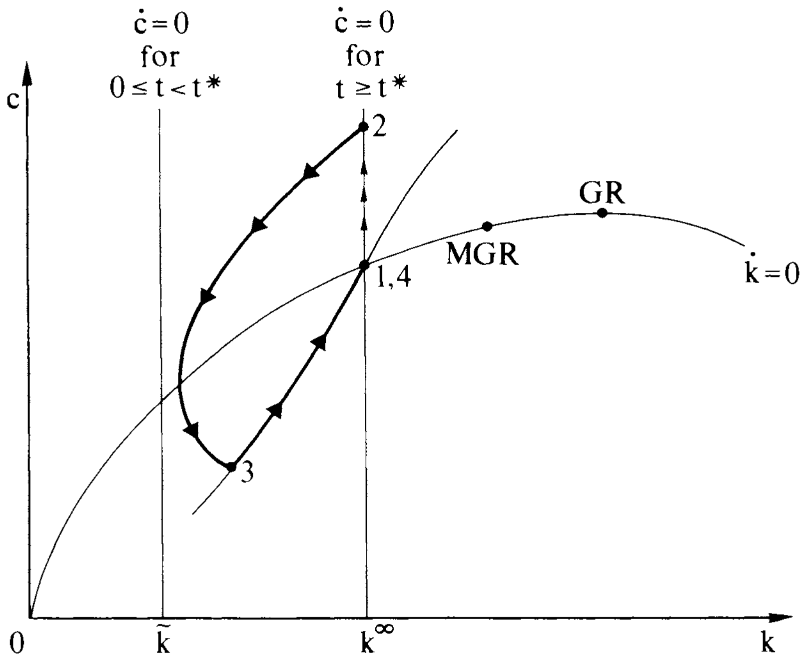

FIGURE 4. REPLACING THE DIVIDEND TAX WITH THE R-BASE TAX

locus, to the southeast until meeting the stable branch at t^*. Note that c could not initially stay the same or fall because the equilibrium point would then begin immediately drifting southeast and could never meet the stable branch. Our revealed preference proposition implies that the post-reform welfare is lower than in the initial steady state.

PROPOSITION 3: *A revenue-neutral gradual replacement of the dividend tax with the R-base tax causes a cyclical movement of consumption, beginning with an upswing, around the path it otherwise would have followed. Capital accumulation undergoes a period of deceleration followed by a period of acceleration, with a recouping of the initial growth path in the long run. The reform reduces welfare.*

The economic reason for the perverse effects of this reform is the asymmetry noted above between the R-base tax and the dividend tax when rates are changing. The former affects only real and the latter only financial decisions. The prospect of a rising R-base tax imposes capital losses on the firm and discourages investment. A quick and courageous reform rather than a gradual one would minimize the damage; in the extreme case, a sudden once-over switch to the R-base tax with no phase-in period would give firms no time in which to avoid capital losses by reducing investment.

C. *The Schanz-Haig-Simons Tax and the R-Base Tax*

Consider now a substitution of an R-base tax for an SHS tax, the reform which—albeit as a one-step move—John Kay and Mervyn King (1978) recommended for Britain. This substitution will gradually remove the wedge which the SHS tax drives between the market rate of interest and the consumer rate-of-time preference. But, with a gradually rising R-base tax rate, it will also create a new wedge between the market rate of interest and the marginal product of capital. The combined effect of these two wedges makes it difficult to give a general assessment of the kind of reactions the substitution will provoke.

Equation (15) reveals that eventually the $(\dot{c}=0)$ line and the stable branch will lead through the Modified Golden-Rule point (when $t \geq t^*$ and $\Theta_S = \Theta_S^* = 1$, $\hat{\Theta}_R = 0$). Thus, the economy must eventually converge to the optimal growth path. But there is a rich menu of possible adjustment paths that connect the initial steady state with the stable branch. We confine attention to the two cases where the "sum" of the two wedges is constant at or above the wedge that existed before the reform was initiated or, in other words, where during the transition phase $[0, t^*)$ the $(\dot{c}=0)$ locus is constant, either (a) at its pre-reform position, or (b) to the left of it. From (15) it follows that during the transition phase:

$$(19)\quad \frac{\rho+\eta g}{\Theta_S(t)} - \hat{\Theta}_R(t) = \frac{\rho+\eta g}{\Theta_S^o} + \sigma,$$

where Θ_S^o is the pre-reform value of Θ_S and σ is a constant, equal to zero in case (a) and positive in case (b). Integration of (19) reveals that for all $t \in [0, t^*]$:

$$(20)\quad \Theta_R(t) = \Theta_R(0) \times \exp \int_0^t \left[(\rho+\eta g) \times \left(\frac{1}{\Theta_S(u)} - \frac{1}{\Theta_S^o} \right) - \sigma \right] du.$$

Note that for any given value of $\sigma \geq 0$, (20) is well-defined and remains between zero and one no matter how large t^* is, and that, while Θ_S is increasing, Θ_R is decreasing on $[0, t^*)$.

Consider first case (a). (This case is similar to a pre-announced abolition of the SHS tax at $t = t^*$.) As indicated in Figure 5 by the solution $1 \sim 4$, the adjustment path is characterized by a downward jump in c and a subsequent southeast motion toward the stable branch. An initial upward jump in c can be excluded since the equilibrium point would then gradually drift to the northwest and would never meet the stable branch.

While the adjustment path in case (a) more or less resembles the one that was derived above for the substitution of the SHS tax with the dividend tax, it may look completely different in case (b). Here it is still possible that there is an initial downward jump in c. However, with a sufficiently large value of t^*, there will be an initial upward jump in consumption followed by a gradual movement along a path that passes near the transitional steady state (c_2^∞, k_2^∞) and eventually joins with the ultimate stable branch below the $(\dot{k}=0)$ locus.[19]

We do not claim that case (b) is particularly plausible or even necessary. On the other hand, it is certainly not a remote case that can easily be dismissed as irrelevant. Note that, as $\hat{C} - n = g$ in a steady state, (13) implies $\rho + \eta g = r^o \Theta_S^o$ where r^o is the pre-reform interest rate. Hence (19) can be rewritten as $\hat{\Theta}_R = r^o[(\Theta_S^o/\Theta_S) - 1] - \sigma$. This equation shows that initially, when Θ_S is only slightly above Θ_S^o, the requirement $\sigma > 0$ is compatible with a very low "shrinkage rate" of Θ_R, far below the level of r^o. Over time Θ_S increases and so does the "shrink-

[19]More specifically, it is clear from Figure 5 that if c did not increase initially then k would stay forever above k_1^∞. But then for all $t \in [0, t^*]$:

$$\begin{aligned}(\dot{c}/c) &= (1/\eta)\left[\Theta_S\left[\hat{\Theta}_R + \varphi'(k) - \delta\right] - (\rho+\eta g)\right] \\ &= (\Theta_S/\eta)\left[\varphi'(k) - \delta - \sigma - (\rho+\eta g)/\Theta_S^o\right] \quad \text{[by (19)]} \\ &\leq (\Theta_S/\eta)\left[\varphi'(k_1^\infty) - \delta - \sigma - (\rho+\eta g)/\Theta_S^o\right] \quad \text{(because } \varphi'' < 0) \\ &= -\Theta_S\sigma/\eta \\ &\leq -\Theta_S^o\sigma/\eta \quad \text{(because } \Theta_S \text{ is increasing on } [0, t^*])\end{aligned}$$

Therefore $\ln c(t^*) - \ln c(0) \leq -t^*\Theta_S^o\sigma/\eta$. By assumption, $c(0) \leq c_1^\infty$. Furthermore, Figure 5 makes it clear that $c(t^*) \geq \underline{c}$. Therefore $t^* \leq (\ln c_1^\infty - \ln \underline{c})\eta/\sigma\Theta_S^o$. For any larger t^*, c would therefore have to increase initially.

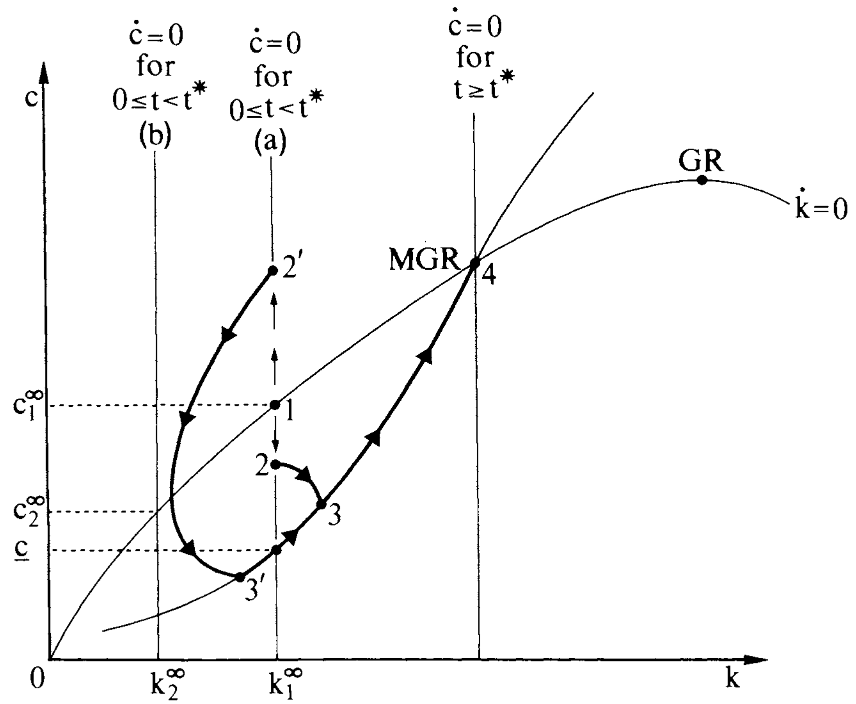

FIGURE 5. SUBSTITUTING THE R-BASE TAX FOR THE SHS TAX: THE PROPOSAL OF KAY AND KING

age rate." However, as $\Theta_S \leq 1$ and $\Theta_S^o > 0$, it is obviously compatible with $\sigma > 0$ that $\hat{\Theta}_R > -r^o$ throughout. Thus, Θ_R never has to shrink at a rate equal to a greater than the initial interest rate.

To investigate the welfare implications of case (b), consider the specific example in which $\Theta_S(t) = 1 + (1 - t/t^*)^2(\Theta_S^o - 1)$ during the transition. Then, as $t^* \to \infty$, the differential equation (15) on any finite interval will approximate the equation

$$\dot{c}/c = (1/\eta)\{\Theta_S^o[\varphi'(k) - \delta] - [\rho + \Theta_S^o\sigma + \eta g]\},$$

that would apply if the only tax were a constant SHS tax and if the rate of utility discount were $\rho + \Theta_S^o\sigma$ instead of ρ. Thus, over any finite interval the equilibrium path will converge upon the stable branch defined by this artificial problem, which converges on the transitional steady state.

Our revealed preference proposition shows that the pre-reform steady state yields higher social welfare than this limiting path, which has $k \leq k_1^\infty$. But as $t^* \to \infty$ the social welfare on the post-reform equilibrium path will converge on that of the limiting path. Therefore the substitution of the R-base tax for the SHS tax can actually reduce welfare if it is implemented too slowly. Too slow a reform will discourage investment for so long that the reform is welfare-reducing, whereas immediate implementation would yield the optimal tax reform.

PROPOSITION 4: *A gradual substitution of the R-base tax for the SHS tax will in the long run, when the tax rates have reached their target levels, induce an acceleration of economic growth and a movement toward the Modified Golden-Rule point. However, since during the reform period the overall wedge between the marginal product of capital and the consumer rate-of-time preference may well be above its pre-reform level, an initial period* *of decline in the level of capital per efficiency unit of labor cannot be excluded. The reform may lower social welfare.*

We conclude the analysis by adding a remark on the consumption tax. It is easily seen from equation (1) that a consumption tax is an R-base tax plus a wage tax. When labor supply is inelastic, it is therefore clear that the allocative implications of a consumption tax are indistinguishable from those of an R-base tax. For the reasons explained, the consumption tax, also, may not be an attractive candidate for tax reform when the government is unable to commit itself to a policy of tax-rate stability.

V. Conclusion

The present paper can be interpreted as a theoretical amendment to the report of the Meade Committee (1978), focusing on basically the same taxes as the Committee did. It lends support to the Committee's recommendation to replace the present capital income tax system by a cash-flow tax system and it helps establish a counterposition against the widespread view that a stronger integration of corporate and personal taxation would stimulate economic growth and create dynamic efficiency gains. It also supports the Committee's choice of a dividend tax (S-base tax) instead of the R-base tax. However, concentrating on the growth effects of anticipated tax-rate changes, it does so for reasons that have little in common with those put forward by the Committee.

The analysis showed that the SHS tax distorts the economy's growth path regardless of whether or not it is applied with a constant rate. The R-base (or consumption) tax is growth neutral when the tax rate is constant, but with anticipated variations in the tax rate, this tax can create more severe distortions than the SHS tax. Only the dividend tax turned out to be growth neutral irrespective of anticipated changes in its rate.

Given that both the R-base tax and the dividend tax are cash-flow taxes, the difference in the performance of these taxes is worth noting. Basically it can be attributed to the implicit inclusion of the financial cash flow in the base of the dividend tax. While the R-base tax is fully neutral with regard to the firm's financial decisions and places all distortions on the real side of its activity, the dividend tax places the distortions on the financial side and leaves the firm's real decisions untouched. With the dividend tax, the financial reactions of the firm serve as a kind of buffer that cushions its real decisions against the blows imposed by tax-rate changes.

In the kind of neoclassical equilibrium framework used in this paper, financial distortions in themselves are unimportant. Only real distortions matter, and this is why the dividend tax performed so well in our welfare analysis. However, financial distortions may be important in other frameworks of analysis. The tax on equity imposed by a dividend tax is a disincentive to the formation of new firms, an activity not considered in our analysis. Excessive debt financing that results from a rising dividend tax rate may also weaken the firm's ability to withstand economic crises, and may therefore have a destabilizing effect on the economy that is more harmful than the Paretian welfare losses that the other taxes cause in a situation of market equilibrium. Moreover, as explained before, financial distortions make it necessary for the government to impose constraints on the firm's decision making. These constraints are unlikely to be costless to administer and may even have efficiency costs of their own in a more complex model. Hopefully future research will be able to shed more light on these issues.

This research may also address allocative distortions other than the intertemporal ones analyzed here. These include the choice of asset life, the intersectoral allocation of capital (the Harberger problem), and potential distortions in international capital flows and credit contracts. In principle, the partial analytic results of Section III should be applicable to an analysis of at least some of these issues, but a detailed analysis has yet to be done.

Other problems that we have not addressed in this paper relate to distributional aspects. Unlike the typical economist's interest in efficiency, the public is normally more concerned about the redistributional effects of a tax reform. Our approach does have implications for the functional distribution of income, and it may be useful to analyze them. Many questions will have to be answered before a broad agreement on the optimal reform of capital income taxation can possibly be expected.

APPENDIX 1

This appendix briefly sketches the essentials of the firm's financial decisions implicit in (10). By the Maximum Principle, the Hamiltonian implies the following necessary optimality conditions in addition to (11) and (12):

$$-1+q+\mu_Q=0 \tag{A1}$$

$$q-\Theta_D-\mu_D+\mu_\pi=0 \tag{A2}$$

$$r\Theta_S(q-\Theta_D-\mu_D)=\dot{q} \tag{A3}$$

$$Q\geq 0,\quad \mu_Q\geq 0,\quad \mu_Q Q=0 \tag{A4}$$

$$\pi\geq 0,\quad \mu_\pi\geq 0,\quad \mu_\pi\pi=0 \tag{A5}$$

$$D\geq 0,\quad \mu_D\geq 0,\quad \mu_D D=0 \tag{A6}$$

$$\lim_{t\to\infty}\left[q(t)E(t)\exp\int_0^t-\Theta_S(u)r(u)\,du\right]=0 \tag{A7}$$

The second-order conditions of this problem are satisfied as the Hamiltonian is a concave function of the controls K, L, π, and Q and is linear in the state variable E.

Note first that the constraints $\dot{E}=\pi+Q$, $\pi, Q\geq 0$, $E(0)=E^o>0$ from (10) imply

$$E(t)\geq E^o>0\quad \text{for all } t\geq 0 \tag{A8}$$

and that, because of Euler's theorem, (11), (12), and (4) imply

$$S(t)=r(t)E(t)\quad \text{for all } t\geq 0. \tag{A9}$$

Together with (6), these pieces of information reveal that

$$D(t)>0 \text{ or } \pi(t)>0\quad \text{for all } t\geq 0. \tag{A10}$$

It follows from (A2), (A5), (A6), and (A10) that:

$$\begin{cases} (i) & \text{If } q-\Theta_D>0, \\ & \quad\text{then } \mu_\pi=D=q-\Theta_D-\mu_D=0. \\ (ii) & \text{If } q-\Theta_D=0, \\ & \quad\text{then } \mu_\pi=\mu_D=0. \\ (iii) & \text{If } q-\Theta_D<0, \\ & \quad\text{then } \pi=\mu_D=0. \end{cases} \tag{A11}$$

Thus (A3) can be rewritten as

$$\dot{q}=r\Theta_S\min(0,q-\Theta_D). \tag{A12}$$

The following argument shows that

$$q=\Theta_D^*\quad \text{for } t\geq t^*. \tag{A13}$$

Suppose, on the contrary, that (a) $q<\Theta_D^*$ or (b) $q>\Theta_D^*$ for some $t\geq t^*$. In case (a), (A12) implies that $\dot{q}/q\to r\Theta_S^*$ as $t\to\infty$. This and (A8) contradict (A7). In case (b), (A12) implies $q-\Theta_D=\text{const.}>0$ for all $t\geq t^*$. Together with (6), (A4), (A9), and (A11(i)) this implies: $\dot{E}=Q+\pi\geq\pi=\Theta_S S-D=\Theta_S S=\Theta_S rE$ for all $t\geq t^*$, which, because $q=\text{const.}>0$, again contradicts (A7).

The first-order condition (11) shows that debt is always a marginal source of finance. By (A1) and (A4), new shares will be a marginal source if and only if $q=1$. By (A11), retentions will be a marginal source if and only if $q=\Theta_D$. If $q<1$, no shares are issued, and if $q<\Theta_D$, no profits are retained. If $q>\Theta_D$, retentions are fixed at the level of profits and so cannot be a marginal source. Obviously, the financial behavior of the firm is determined by q and Θ_D.

After t^*, (A13) implies that retentions will always be a marginal source, and that new shares will be a marginal source if and only if $\Theta_D^*=1$: the same is true before t^* if $\dot{\Theta}_D=0$ everywhere on $[0,t^*)$. If $\dot{\Theta}_D>0$ everywhere on $[0,t^*)$, (A12) and (A13) imply that $q=\Theta_D^*>\Theta_D$ forever. In this case, before t^* new shares continue to be a marginal source if and only if $\Theta_D^*=1$, but retentions are no longer a marginal source as all profits are retained. If $\dot{\Theta}_D<0$ everywhere on $[0,t^*)$ then neither retentions nor new shares will be a marginal source before t^* because in this case (A12) and (A13) imply that $\Theta_D>q>\Theta_D^*$ on $[0,t^*)$.

Thus in all cases where the dividend tax rate is a monotonic function of time, which source of finance may be used in equilibrium depends only upon the behavior of Θ_D. In this sense, both the R-base tax and the SHS tax are neutral with respect to the firm's financial decisions. (In Howitt and Sinn, 1986, we analyze the case of non-monotonic Θ_D.)

APPENDIX 2

This appendix proves the revealed preference proposition stated in Section IV of the text.

First, note that $\{c(t),k(t)\}$ solve the surrogate decision problem of choosing $\{\tilde{c}(t),\tilde{k}(t)\}$ to maximize $\overline{U}(0)$

subject to the distorted law of motion:

$$(14') \quad \dot{\tilde{k}} \le \varphi(\tilde{k}) - (\delta + n + g)\tilde{k} - \tilde{c}$$
$$+ \left(\Theta_S \hat{\Theta}_R + \delta \tau_S\right)(\tilde{k} - k) - \tau_S\left[\varphi(\tilde{k}) - \varphi(k)\right],$$

and the initial condition: $\tilde{k}(0) = k(0)$. [The solution to this problem is the unique convergent solution to (14′) and (15) starting at $k(0)$. Because $\{c(t), k(t)\}$ satisfies (14) and (15), converges, and starts at $k(0)$, it is that solution.]

Next, because $\{c'(t), k'(t)\}$ satisfies (14) it must also satisfy (14′) if $(\Theta_S \hat{\Theta}_R + \delta\tau_S)(k' - k) - \tau_S[\varphi(k') - \varphi(k)] \ge 0$. This condition is indeed satisfied because:

$$\left(\Theta_S \hat{\Theta}_R + \delta\tau_S\right)(k' - k) - \tau_S\left[\varphi(k') - \varphi(k)\right]$$
$$\ge \left\{\Theta_S \hat{\Theta}_R + \tau_S\left[\delta - \varphi'(k)\right]\right\}(k' - k) \qquad (\text{because } \varphi'' < 0)$$
$$\ge \left[\Theta_S \hat{\Theta}_R - \tau_S(\rho + \eta g)\right](k' - k) \qquad (\text{because } \varphi'(k) - \delta \ge \rho + \eta g \text{ and } k' \le k)$$
$$\ge 0 \qquad \left(\text{because } \hat{\Theta}_R \le 0 \text{ and } k' \le k\right).$$

Since $\{c'(t), k'(t)\}$ also satisfies the initial condition $k'(t) = k(0)$ it satisfies all the constraints of the surrogate decision problem, and hence yields strictly less welfare than the unique solution $\{c(t), k(t)\}$ to that problem.

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