IMF WORKING PAPER

WP/94/92

INTERNATIONAL MONETARY FUND

Middle Eastern Department

Government Spending, Taxes, and Economic Growth

Prepared by Paul Cashin 1/

Authorized for Distribution by Henri Ghesquiere

August 1994

Abstract

This paper develops an endogenous growth model of the influence of public investment, public transfers, and distortionary taxation on the rate of economic growth. The growth-enhancing effects of investment in public capital and transfer payments are modeled, as is the growth-inhibiting influence of the levying of distortionary taxes which are used to fund such expenditure. The theoretical implications of the model are then tested with data from 23 developed countries between 1971 and 1988, and time series-cross sectional results are obtained which support the proposed influence of the public finance variables on economic growth.

JEL Classification Numbers:

E62, O41

1/ An earlier version of this paper appears as Chapter 1 of my Ph.D. dissertation completed at Yale University. I thank Xavier Sala-i-Martin, T.N. Srinivasan, Gustav Ranis, Willem Buiter, William Brainard, Ken Kletzer, Malcolm Knight and Sena Eken for their comments and suggestions. The financial support of a Doctoral Dissertation Fellowship from the Alfred P. Sloan Foundation is gratefully acknowledged.

Contents

Summary

This paper develops an endogenous growth model of the influence of public investment, public transfers, and distortionary taxation on the rate of economic growth. Rather than use the flow of publicly provided private goods to proxy for government services, as in current models in the literature, the model introduces increments in the stock of congested public capital as a positive influence on economic growth. The growth-enhancing effects of both intragenerational and intergenerational transfer payments are also modeled, again differing from current models in the literature, which typically view transfers as having a negative effect on growth.

Transfers are argued to raise the marginal product of private capital by reducing the negative externalities flowing from (1) poor enforcement of private property rights, and (2) workers with a below-average stock of human capital. The model also highlights the growth-inhibiting effects of the levying of the distortionary taxes necessary to finance the provision of public transfers and public capital. A trade-off exists between the growth-enhancing provision of public capital and transfers and the growth-diminishing influence of distortionary taxes. For small government (where public spending is low), the growth-enhancing effect is likely to dominate; for large government (where public spending is high), the growth-diminishing effect is likely to dominate.

The theoretical implications of the model are then tested with data from 23 developed countries between 1971 and 1988, using a time-series cross-sectional model to take into account the potential influence of unobserved country heterogeneity. The empirical results offer support for the theoretical implications of the model, as the three public finance variables are significant and enter with signs consistent with a priori expectations of their respective influences on economic growth. Productive government spending, in the form of public investment and transfer payments, is demonstrated to enhance economic growth. In addition, distortionary taxation is shown to have a detrimental effect on economic growth. The convergence implications of the neoclassical growth model are also borne out in this data set, as initial incomes are significant and negatively correlated with subsequent growth rates.

I. Introduction

The relationship between government spending, taxation, and economic growth has been one of the most important (and most studied) issues in economics. However, while it was clear that distortionary taxation and government spending could affect the level of gross domestic product in a given country, the theoretical link between them and the rate of growth had not been clearly established in the standard neoclassical model. 1/ That is, because the source of long-run growth in the early neoclassical models of Solow (1956) and Swan (1956) was exogenous technical change, the effect of fiscal policy on the rate of capital accumulation was irrelevant in affecting the long-run rate of growth. 2/

However, the contributions of the recent endogenous growth (EG) and government literature have emphasized the role of fiscal policy in influencing the rate of economic growth, with government spending directly affecting private production functions (see Easterly 1989, 1990, Barro 1990, and Barro and Sala-i-Martin 1992). The common element linking all EG models is that the marginal returns to the factors which can be accumulated are bounded away from zero. Unlike the early neoclassical growth models, steady-state growth in EG models is not determined exogenously by technological innovations or population growth, but is determined by the parameters of the model, in particular the savings rate. 3/ Recent key papers in the EG literature were contributed by Romer (1986), Lucas (1988), King, Plosser and Rebelo (1988), Grossman and Helpman (1989), Barro (1990), and Rebelo (1991).

1/ More accurately, the standard neoclassical growth model assumes that the marginal product of each factor goes to zero as use of that factor increases, holding all other factors constant (that is, the Inada conditions hold).

2/ In the traditional optimal growth models of Ramsey (1928), Cass (1965), and Koopmans (1965), time-varying savings rates were derived from the optimization of an intertemporal social welfare function. In this normative (or planning) use, these models were designed to calculate the required savings rate to be attained to achieve a given target rate of growth, rather than provide guidance for the appropriate role for government in promoting growth.

3/ In the Solow-Swan neoclassical growth model, fiscal policies (taxation and government spending) can affect the rate of growth only during the transition to steady state, as the steady-state rate of growth is determined by the exogenous rate of technological progress. This is also the case in the Arrow-Kurz (1970) model of the influence of public investment on growth, where as in this paper the stocks of private and public capital enter into the private production function, but unlike this paper they assume diminishing returns to scale in private and public capital inputs for a given exogenous population. As in Solow-Swan, for Arrow-Kurz exogenous technical progress drives the rate of growth, and the marginal returns to public and private capital are not bounded away from zero.

One of the goals of this paper is to examine the long-run effects of government spending and taxation in an endogenous growth setting, using a model in which government spending and taxation can have effects on the rate of growth of output. The model has the advantage of allowing for two state goods (the stock of private physical capital and the stock of public physical capital), rather than contemporaneous flows of government spending as an input to private production, as in Barro (1990). This innovation overcomes the awkward dichotomy in existing endogenous growth models of public finance (Barro 1990, Barro and Sala-i-Martin 1992), where the stock of private physical capital and the flow of government-provided services from public goods comprise the inputs to private production. The model is also innovative in arguing that public transfer payments enter as productive inputs in private production functions. Transfers are productive in that they raise the marginal product of private capital, by improving the enforcement of private property rights in the economy, and by inducing relatively unproductive agents to leave the workforce.

Another important contribution of the model is to highlight the rivalrous nature of the consumption of the stock of public capital by private individuals and firms, and of the consumption of transfer payments. This approach also overcomes the need in earlier models of growth and public finance (such as Barro 1990) for the goods provided by government to be essentially publicly provided private goods. By introducing congestion in the consumption of publicly provided capital and transfers, (as first suggested by Barro and Sala-i-Martin 1992), the present model reflects the view that many of the goods provided by government are rivalrous and nonexcludable in nature.

A further goal of the paper is to estimate the empirical relationship between public investment, transfers, distortionary taxation, and the rate of economic growth. The formulation used is an improvement over previous empirical studies of the influence of fiscal policies on growth, which have predominantly concentrated on the effects of government consumption spending and have largely ignored the effects of distortionary taxes. Moreover, by using a time series-cross sectional (TSCS) framework for the analysis, this paper goes beyond the traditional empirical tests found in this literature, which most often use cross-sectional estimation alone. Levine and Renelt (1991, 1992) and Levine and Zervas (1993) point out that such cross-sectional studies are prone to yield misleading results, given that they cannot account for persistent unobserved heterogeneity across countries.

The plan of this paper is as follows. Sections II and III outline an endogenous growth model of the effects of public investment, transfers, and distortionary taxes on economic growth. The data used in the empirical analysis is described in Section IV. Section V presents the results obtained from the TSCS models, then compares and contrasts them with the findings of previous research into public finance variables and growth. Finally, Section VI gives some concluding comments.

II. Endogenous Growth Models Involving Public Investment, Transfers, and Taxes

Consider a model with infinitely-lived agents endowed with perfect foresight, which allows for productive government spending in which both the growth of private and public capital stocks are endogenously determined. In this model the government levies two constant marginal taxes on the final goods sector to fund its provision of public capital and transfer payments. In assuming productive government spending, the model departs from the traditional framework of analysis for examining the effects of taxation in the neoclassical growth model, where typically revenue raised from taxation is used to finance the provision of goods which neither enter into firms' production possibilities nor affect the marginal utilities of agents' consumption (Feldstein 1974, Judd 1985).

It is assumed that a given population of identical economic agents maximizes a constant intertemporal elasticity of substitution utility function of the form:

$$U = \int_0^\infty u(c(t))e^{-\rho t}\, dt \tag{1}$$

where c is consumption per person, and ρ is the constant subjective rate of time preference. It is assumed that the utility function is of the form:

$$u(c(t)) = (c(t)^{1-\sigma} - 1)/\ (1-\sigma) \tag{2}$$

where σ^{-1} is the constant intertemporal elasticity of substitution coefficient. Each household-producer (given that there are the same number of people and firms) has access to a production function for per capita final output of the form:

$$y(t) = Ak(t)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} \tag{3}$$

where: A is a parameter which represents the level of technology, k(t) is the per capita stock of private sector physical capital in the economy, G(t)/K(t) is the ratio of the aggregate public capital stock (G(t)) to the aggregate private capital stock (K(t)), α is the output elasticity of G(t)/K(t), T(t)/K(t) is the ratio of aggregate public transfer payments (T(t)) to the aggregate private capital stock (K(t)), β is the output elasticity of T(t)/K(t), and K(t) = Nk(t), where N is the constant number of household-producers (firms) in the economy. The production function (3) is homogeneous of degree one in k(t), for a given state of congestion in the use of publicly provided capital and transfers (that is, for given ratios of G(t)/K(t) and T(t)/K(t)), and exhibits increasing returns to scale if the three inputs (k(t), G(t)/K(t), and T(t)/K(t)) are considered together. 1/

1. Describing the production function: public capital goods

The model follows the suggestion of Barro and Sala-i-Martin (1992) by introducing the real-world feature of congestion in the consumption of publicly provided goods (both physical capital and transfer payments) by individual household-producers (firms), as here (as is the case for a substantial share of government productive expenditures) public goods are rivalrous but not excludable. In this model of congested public goods, every producer reaps the benefits from the provision of public capital. However, for a given stock of public capital (G(t)), the benefits to producers decline as they raise their individual k(t), and hence their output (and accordingly, aggregate K(t)). This is the nature of the congestion existing in the consumption of public capital. G(t) can represent, for example, the miles of highways provided, the number and size of airports, and law and order, and K(t) can represent highway traffic, air traffic, and the number of legal disputes.

Barro and Sala-i-Martin (1992) argue that national defense and domestic security services (police and prisons), which are often deemed to be prototypical nonrival and nonexcludable public goods, can also be considered to be subject to a form of congestion, using the argument set forward by Thompson (1974). The state of both national and local security depends on expenditures on defense and police services, G(t), in relation to the level of the perceived external threat, where that threat is a function of the "prize" potentially attainable by aggression, which is proportional to the private domestic capital stock, K(t). Hence, it can be argued that G(t)/K(t) represents the effective level of national and domestic security.

2. Describing the production function: transfers

In the traditional public finance literature, the role for government in affecting economic growth is limited. In those models where it is discussed, the government is usually required to decide the rate at which capital or output is taxed, and the distribution of the resulting revenue between productive expenditure on public investments and unproductive expenditure on government consumption or lump-sum transfer payments (see Alesina and Rodrick 1991, Lee 1992). A typical theoretical result is that for a given tax rate, economic growth is adversely affected by an increase in redistribution through public transfers. Running counter to the received

---

1/ Equivalently, aggregate production, Y(t)=Ny(t), exhibits constant returns with respect to K(t)=Nk(t), G(t) and T(t), yet diminishing returns to K(t) for given G(t) and T(t) due to increases in congestion from the use of public capital and the consumption of transfers.

theoretical wisdom are some cross-sectional empirical results which test the above finding and find the converse: that public transfers actually raise economic growth (Barro 1989, Sala-i-Martin 1992a).

The model of equation (3) includes productive public transfers as an input to private production functions. It is not argued here that transfers are a direct input to private production (as is public investment), but that they do raise the after-tax private return to capital by reducing the implicit "taxation" of output due to: (i) poor enforcement of private property rights, and (ii) workers possessing below average stocks of human capital (see below). Notwithstanding the possibility of overlaps, public transfer payments are argued to be of two broad types: intragenerational (such as from rich to poor) and intergenerational (such as from young to old), and both types raise economic growth by raising the marginal product of private capital.

Sala-i-Martin (1992a) provides a rationale for productive public transfers in arguing that intragenerational transfers assist in better enforcing private property rights, which reduces the extent of aggregate distortions in the economy, such as criminal activities. An increase in such transfers raises the probability of a household/producer receiving the marginal product of capital, and maintaining ownership of his capital stock. This in turn provides an incentive for households to accumulate capital and produce. Sala-i-Martin (1992a) also presents empirical evidence from cross-sectional (Summers and Heston 1991) data for a set of 75 countries, and finds that holding constant the overall size of government, public transfers are positively related to growth in per capita income.

Intergenerational transfers can also be regarded as positively affecting economic growth in that they induce relatively unproductive agents in the economy (typically the old) to leave the workforce, thus reducing the negative externalities produced by these relatively unproductive old on the productive young, raising the productivity of private capital, and so raising the rate of growth of output (see Sala-i-Martin 1992). The argument is that, given externalities in the average stock of human capital (such as those introduced by Lucas (1988)), and because skills deteriorate with age, these externalities produced by the old (with lower than average skills) have a detrimental effect on the productivity of the young (with higher than average skills). When the difference between the skill levels of the young and the old is large enough, it will be beneficial for the old to be induced to retire, as then aggregate output will be higher than if they remained in the workforce. Intergenerational transfers, in almost all countries paid on condition of retirement, are the means to achieve this end.

Both types of transfers can be thought of as a public input to private production which is subject to congestion, for much the same reasons as those outlined earlier for defense and domestic security. When an economic agent engages in more production, the protective role of a given level of transfer payments (improving the enforcement of private property rights and inducing workers with low human capital stocks to leave the workforce) is diminished by the associated increase in $K(t)$.

III. A Model of Public Finance and Economic Growth

In this section a model of the influence of public finance variables on economic growth is set out. Here the levying of distortionary taxes on output (which lower the incentive for economic agents to save and invest and so adversely affect economic growth) will be balanced against the growth-enhancing effects of expenditure on public capital (as a durable good) and transfers (as a nondurable good), both of which raise the marginal product of private capital. The production function (3) is used, with congested public capital and transfer payments entering private production functions of household-producers.

Resource constraints in this model are:

$$\dot{k}(t) = (1-\tau_1-\tau_2)Ak(t)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} - c(t) \tag{4}$$

$$\dot{G}(t) = \tau_1 ANk(t)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} \tag{5}$$

$$T(t) = \tau_2 ANk(t)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} \tag{6}$$

where: $\dot{k}(t)$ is investment in private capital, $\dot{G}(t)$ is investment in public capital, $T(t)$ is the flow of aggregate transfer payments, τ_1 and τ_2 are the constant marginal (and average) tax rates on output used to fund the provision of public capital and transfers, respectively, and $(1-\tau_1-\tau_2)$ is the (assumed constant) fraction of private output that remains after taxation. The two taxes, τ_1 and τ_2, are levied to fund the sectors of government producing public capital and transfers, respectively. Each sector of government therefore has its own budget constraint, and neither sector of government can borrow from other agents in the economy nor from one another; that is, each sector's budget constraint is contemporaneously satisfied. It is assumed that there is neither depreciation of capital stocks, nor any adjustment costs.

Growth is achieved in this model through the actions of government, as when individual household-producers forego consumption and increase their private capital, then, in order to maintain a given ratio of $\dot{G}(t)/Y(t)$ and a given ratio of $T(t)/Y(t)$ the government is compelled to invest in public capital ($\dot{G}(t)$) and to increase transfers ($T(t)$); at the margin, for an extra unit of output τ_1 goes for $\dot{G}(t)$ and τ_2 for $T(t)$. Thus investment by households to produce private output generates growth through $\dot{G}(t)$ and $T(t)$

because the two together prevent the marginal product of capital from falling. In this model output can be either consumed, invested, or used as transfers. 1/

The innovation in this paper, which builds on the models of Barro (1990) and Barro and Sala-i-Martin (1992), is that these earlier formulations had private production being dependent on the stock of private capital and the flow of purchased publicly-provided services, while the formulation given here has private production being a function of the stock of private capital goods and the stock of public capital goods, in addition to public transfers. 2/ This contribution is particularly important for empirical estimation and testing of the hypotheses suggested by the theory, as data exists on the share of public investment in gross domestic product, and in this model the variable of interest matches the available data. Previous empirical research (Barro 1989, 1990, 1991) did not have a model linking public investment to the rate of economic growth, yet proceeded to use data on public investment to empirically test a theory which emphasized the public provision of private goods.

The model presented here is similar to that of Rebelo (1991), with production linear in k(t) for a given G(t)/K(t) and a given T(t)/K(t), although unlike Rebelo here there are two capital goods, K(t) and G(t). As noted by Mulligan and Sala-i-Martin (1993), this condition satisfies one of their necessary and sufficient restrictions on the type of private technology that is required to generate growth endogenously. In this model

1/ Competitive producers take τ_1, τ_2, G(t)/K(t), T(t)/K(t) and $\dot{G}(t)$ as given, because each agent is small relative to the aggregate, and so do not believe their actions affect the behavior of government. Accordingly, they do not take into account the externality arising when, as described above, higher private output raises the revenue obtained by the government from its constant tax rates (τ_1 and τ_2), thus raising public investment and transfers, and so the marginal product of private capital of all producers.

2/ It can also be argued that by including the flow of services from publicly provided goods as an input to private production functions, the Barro and Sala-i-Martin formulations are implicitly assuming full depreciation of the existing stock of public capital at the end of each production period. Alternatively, Barro (1990, at p.s107) argues that in his set up the government can be envisaged as carrying out no production and owning no capital, but acts as a middleman in purchasing a flow of output from the private sector and redistributing it to private firms.

it is assumed that consumption and the accumulation of private capital are perfect substitutes, while public capital is produced and accumulated using revenue obtained from the taxation of private production. 1/

Steady-state solutions are sought where consumption and the production of both kinds of capital are growing at constant rates, the shadow prices of the two kinds of capital are falling at constant rates, and given constant τ_1 and τ_2. In the present model the optimal consumption-capital accumulation path is always on the steady-state or balanced growth path (given the initial G(t)/K(t) at t=0 is at the steady-state level), and thus there are no transitional dynamics. 2/ Alternatively, sectoral imbalances in the relative stocks of capital can be seen as being corrected by investing at an infinite rate in the relatively scarce capital, so the economy would "jump" to its steady state.

It is assumed that private individuals maximize utility (1) subject to (4), taking τ_1, τ_2, T(t)/K(t), G(t)/K(t), and $\dot{G}(t)$ as given. Accordingly, the Hamiltonian is:

$$(7) \qquad H(k(t),\lambda(t),c(t),t) = e^{-\rho t}[(c(t)^{1-\sigma} - 1)/(1-\sigma)] + \lambda(t)[(1-\tau_1-\tau_2)Ak(t)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} - c(t)]$$

where $k(0) = k_0$, $(G(0)/K(0)) = (G/K)_0$, $(T(0)/K(0)) = (T/K)_0$ are the initial conditions, $\tau_1,\tau_2 \in [0,1]$, and $c(t)\geq 0$, $k(t)\geq 0$, $(G(t)/K(t))\geq 0$, $(T(t)/K(t))\geq 0$. There is one control variable c(t) and one state variable k(t), with $\lambda(t)$ the shadow price used to value increments to private capital. The first-order conditions of this problem are:

1/ The assumption that the accumulation of private capital is a perfect substitute for consumption differs from the models proposed by Srinivasan (1964) and Kurz (1968), where different production processes for consumption and capital goods were assumed. The present model resembles that of Jones and Manuelli (1990), where a single production process is used for consumption and capital goods, as here public and private capital are basically the same good.

2/ Mulligan and Sala-i-Martin (1993) discuss transitional dynamics in two-capital good models of endogenous growth, and argue that if there are initial imbalances among any of the sectors in an economy (due perhaps to a war or large price shock), then there may be a transitional period when these variables do not behave as would be predicted by steady-state analysis. For example, a war may have destroyed a large fraction of the private capital stock, leaving public capital relatively unaffected, and so the economy will have to get back to the steady-state ratio of G/K by higher (lower) than steady-state rates of growth for the private (public) stock of capital. Such issues do not arise in one capital good (or AK) models of growth (Barro 1990, Rebelo 1991), which do not exhibit transitional dynamics and are always in steady-state.

(8) $$e^{-\rho t}\, c(t)^{-\sigma} = \lambda(t)$$

(9) $$-\dot{\lambda}(t) = \lambda(t)[(1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta}], \text{ and}$$

(10) the transversality condition, $\lim_{t\to\infty} \lambda(t)k(t) = 0$.

Taking logarithms and derivatives of (8) and using (9) yields the growth rate of consumption ($\gamma_c = \dot{c}(t)/c(t)$) as a function of the growth rate of the shadow price of private capital ($\dot{\lambda}(t)/\lambda(t)$):

(11) $$\rho+\sigma\gamma_c = (1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta}.$$

This is the usual consumption Euler equation which requires that the return to consumption ($\rho+\sigma\gamma_c$) equals the return to saving ($\dot{\lambda}(t)/\lambda(t)$), which is here the marginal product of private capital. 1/ Dividing (4) by k(t) gives:

(12) $$\gamma_k = \dot{k}(t)/k(t) = (1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} - c(t)/k(t)$$

where γ_k is the rate of growth of the stock of private capital. In steady state γ_k will be constant, and given that the first part of the right-hand side of (12) is a constant, if logs and derivatives are taken of both sides then $\gamma_c = \gamma_k$.

Manipulation of (6) yields:

(13) $$T(t)/K(t) = [\tau_2 A(G(t)/K(t))^{\alpha}]^{1/(1-\beta)},$$

which can then be substituted in (5) and that expression divided by G(t) to give:

(14) $$\dot{G}(t)/G(t) = \gamma_G = \tau_1 A^{1/(1-\beta)}(K(t)/G(t))^{(1-\alpha-\beta)/(1-\beta)}\tau_2^{\beta/(1-\beta)}.$$

1/ For linear homogenous production functions, a steady-state equilibrium will be attained only if the utility function features constant intertemporal elasticity of substitution, and the technology for capital, A(.), exhibits constant returns to scale. These requirements yield a constant elasticity of marginal utility of $-\sigma=-[c(t)U''(c(t))/U'(c(t))]$ and $\sigma\gamma_c=\dot{\lambda}/\lambda$.

Again, given that in steady state γ_G will be constant, and that τ_1, τ_2, A, and N are constant, then taking the logs and derivatives of both sides gives $\gamma_k = \gamma_G = \gamma_c = \gamma_Y = \gamma$, where γ is the common growth rate. Manipulation of (14) yields:

(15) $$G(t)/K(t) = [\gamma\tau_1^{-1}A^{-1/(1-\beta)}\tau_2^{-\beta/(1-\beta)}]^{(\beta-1)/(1-\alpha-\beta)}.$$

Accordingly, (13) can be rewritten as:

(16) $$T(t)/K(t) = \tau_2^{(1-\alpha)/(1-\alpha-\beta)}A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\tau_1^{\alpha/(1-\alpha-\beta)}.$$

1. Comparative statics of public finance variables and growth

Substituting (15) and (16) into (11) yields, after manipulation:

(17) $$\rho+\sigma\gamma = (1-\tau_1-\tau_2)A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\tau_1^{\alpha/(1-\alpha-\beta)}\tau_2^{\beta/(1-\alpha-\beta)}.$$ 1/

The left-hand side of (17) is the return to consumption, which is upward-sloping and linear in γ. The right-hand side of (17) can be rewritten as:

(18) $$A^{1/(1-\alpha-\beta)}.\psi(\tau_1,\tau_2).\gamma^{-\omega} \equiv J(\gamma,A,\tau_1,\tau_2)$$

where $\omega=\alpha/(1-\alpha-\beta)$. Since $A^{1/(1-\alpha-\beta)} > 0$, and $\psi(.) > 0$, then $J(.) > 0$. Accordingly, $\partial J/\partial\gamma = -\omega(J(.)/\gamma)$ and $\partial^2 J/\partial\gamma^2 = \omega(\omega+1)(J(.)/\gamma^2)$. We also know that $(\omega+1)=(1-\beta)/(1-\alpha-\beta)$, and it is assumed that $0 < \alpha,\beta < 1$ and that $\alpha+\beta < 1$.

1/ In this model $\gamma_c = \sigma^{-1}[(1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} - \rho]$ and $\gamma_k = (1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} - c(t)/k(t)$. It is assumed that: $A(1-\tau_1-\tau_2)(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta} > \rho$ (for positive steady-state growth of consumption, private capital, public capital, and income) and that the parameters of $\tilde{\gamma}$ (namely A, ρ and σ), where $\tilde{\gamma}$ is the growth rate implicit in (17), are such that U(0) is bounded. Given that we have constant intertemporal elasticity of substitution in utility, for bounded utility we require that the expression inside the integral of (1) tend to zero as $t\to\infty$, that is, we require $\rho > \tilde{\gamma}(1-\sigma)$.

While in this set up there is always a solution to $\tilde{\gamma}$, the steady state growth rate, there are two cases to consider, depending on whether $(1-\alpha) \gtrless \beta$:

Case A $(1 > (1-\alpha) > \beta)$: $\omega>0$, $(\omega+1)>0$ and so $\omega.(\omega+1)>0$, and $\lim_{\gamma\to 0} J(\gamma)=\infty$; and

$\lim_{\gamma\to\infty} J(\gamma)=0$, with $\partial J/\partial\gamma<0$ and $\partial^2 J/\partial\gamma^2>0$;

Case B $(1 > \beta > (1-\alpha))$: $\omega<0$, $(\omega+1)<0$ and so $\omega.(\omega+1)>0$, and $\lim_{\gamma\to 0} J(\gamma)=0$ and

$\lim_{\gamma\to\infty} J(\gamma)=\infty$, with $\partial J/\partial\gamma>0$ and $\partial^2 J/\partial\gamma^2>0$.

Case A is shown in Figure 1, and Case B in Figure 2. In both cases the $\rho+\sigma\gamma$ and J(.) lines always cross. An important implication of these Figures is that an increase in the marginal product of capital (a shift up in the J(.) locus) will increase (decrease) growth depending on whether $(1-\alpha)$ is greater (less) than β. Similarly, a fall in ρ or a fall in σ will increase (decrease) growth depending on whether $(1-\alpha)$ is greater (less) than β.

Recognizing that $\tau_1 = \dot{G}/Y \equiv$ IGOV, $\tau_2 = T/Y \equiv$ SOCSEC and that $(1-\tau_1-\tau_2) \equiv$ (1-CURREV), where IGOV is the ratio of public investment to gross domestic product (GDP), SOCSEC is the ratio of transfer payments to GDP, and CURREV is a measure of the ratio of current tax revenue to GDP (see Section IV and the Appendix for further details), then (17) can be rewritten as:

$$(17') \qquad \rho+\sigma\gamma = (1-\text{CURREV}).A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\text{IGOV}^{\alpha/(1-\alpha-\beta)}\text{SOCSEC}^{\beta/(1-\alpha-\beta)}.$$

By the arguments given above, for $(1-\alpha)>\beta$ then: (i) $\partial\tilde{\gamma}/\partial$(1-CURREV) > 0, where $\tilde{\gamma}$ is the steady-state growth rate implicit in (17'); (ii) $\partial\tilde{\gamma}/\partial$(IGOV) > 0; and (iii) $\partial\tilde{\gamma}/\partial$(SOCSEC) > 0.

For $(1-\alpha)>\beta$, $\tilde{\gamma}$ is also an increasing function of the willingness to forego consumption by saving (that is, a lower ρ (the more patient a society is) or higher σ^{-1} (the more willing society is to substitute intertemporally) raises $\tilde{\gamma}$). Here $\tilde{\gamma}$ is also increasing in A, the productivity parameter of production technology. Linear panel regression equations, as an approximation to the nonlinear growth equation of (17') will be run in Section V, using CURREV, IGOV and SOCSEC as explanatory variables, among others, and are expected to have the above signs.

Figure 1
Case A: $[(1-\alpha)>\beta]$

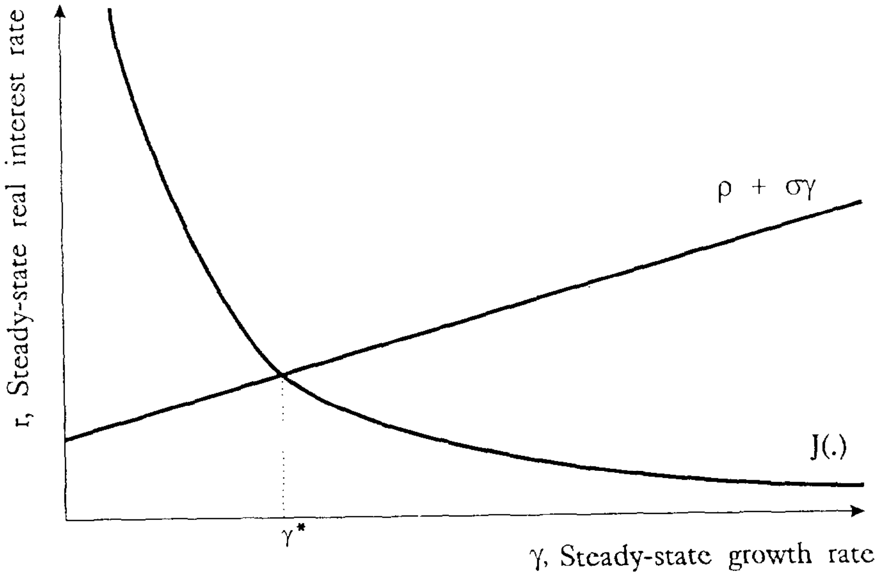
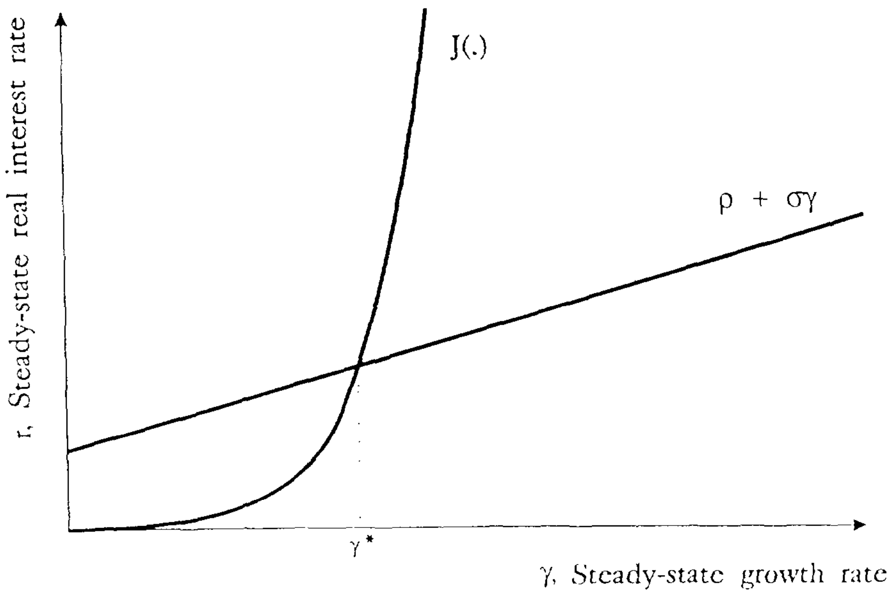


Figure 2
Case B: $[(1-\alpha)<\beta]$



2. Optimal growth and public finance variables

The optimal growth rate can also be calculated from (17). Using the implicit function theorem, where $\tilde{\gamma}$ is the steady-state growth rate implicit in (17), gives:

$$(19) \qquad \partial\tilde{\gamma}/\partial\Lambda = -f_{\Lambda}/f_{\tilde{\gamma}}$$

where $f((1-\tau_1-\tau_2),\tau_1,\tau_2,\tilde{\gamma})=0$ is the implicit function, and Λ is one of $(1-\tau_1-\tau_2),\tau_1,\tau_2$. Examining first $\partial\tilde{\gamma}/\partial(1-\tau_1-\tau_2)$ for given τ_1 and τ_2 gives:

$$(20) \qquad -f_{(1-\tau 1-\tau 2)} = A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\tau_2{}^{\beta/(1-\alpha-\beta)}\tau_1{}^{\alpha/(1-\alpha-\beta)} \text{ , and}$$

$$(21) \qquad f_{\tilde{\gamma}} = \sigma-(-\alpha/(1-\alpha-\beta))\gamma^{(\beta-1)/(1-\alpha-\beta)}A^{1/(1-\alpha-\beta)} \\ .\tau_1{}^{\alpha/(1-\alpha-\beta)}\tau_2{}^{\beta/(1-\alpha-\beta)}(1-\tau_1-\tau_2),$$

and so the numerator of $\partial\tilde{\gamma}/\partial(1-\tau_1-\tau_2)=-f_{(1-\tau 1-\tau 2)}/f_{\tilde{\gamma}}$ is positive, and given that from (21) $f_{\tilde{\gamma}}>0$, then unambiguously $\partial\tilde{\gamma}/\partial(1-\tau_1-\tau_2)>0$. Accordingly, as τ_1 and τ_2 fall, that is, the taxes levied to fund the provision of public capital and transfers fall, then $(1-\tau_1-\tau_2)$ rises and so does $\tilde{\gamma}$.

Examining $\partial\tilde{\gamma}/\partial\tau_1$ for given τ_2 and $(1-\tau_1-\tau_2)$, gives:

$$(22) \qquad -f_{\tau 1} = -A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\tau_2{}^{\beta/(1-\alpha-\beta)}\tau_1{}^{\alpha/(1-\alpha-\beta)} \\ .[1-(1-\tau_1-\tau_2)(\alpha/(1-\alpha-\beta))\tau_1{}^{-1}],$$

and again from (21) we know $f_{\tilde{\gamma}}>0$, so $\partial\tilde{\gamma}/\partial\tau_1 = -f_{\tau 1}/f_{\tilde{\gamma}} \gtrless 0$ for $\tau_1 \lesseqgtr \alpha$. Examining $\partial\tilde{\gamma}/\partial\tau_2$ for given τ_1 and $(1-\tau_1-\tau_2)$ yields:

$$(23) \qquad -f_{\tau 2} = -A^{1/(1-\alpha-\beta)}\gamma^{-\alpha/(1-\alpha-\beta)}\tau_1{}^{\alpha/(1-\alpha-\beta)}\tau_2{}^{\beta/(1-\alpha-\beta)} \\ .[1-(1-\tau_1-\tau_2)(\beta/(1-\alpha-\beta))\tau_2{}^{-1}],$$

and again from (21) we know that $f_{\tilde{\gamma}}>0$, so $\partial\tilde{\gamma}/\partial\tau_2 = -f_{\tau 2}/f_{\tilde{\gamma}} \gtrless 0$ for $\tau_2 \lesseqgtr \beta$. Accordingly, $\partial\tilde{\gamma}/\partial\tau_1 = 0$, given τ_2 and $(1-\tau_1-\tau_2)$, when $\tau_1 = \tau_1^* = \alpha$ and $\tau_2 = \tau_2^* = \beta$, as then the term in the square brackets in (22) equals zero. That is, when $\tau_1 = \tau_1^* = \alpha$, then the growth rate is maximized, and the public capital sector is set to equal the share of output it would receive if it was a private input in competitive output and factor markets. Similar results are obtained from (23) for $\partial\tilde{\gamma}/\partial\tau_2 = 0$, given τ_1 and $(1-\tau_1-\tau_2)$. Further, when $\tau_1 \lesseqgtr \alpha$ for given τ_2, or $\tau_2 \lesseqgtr \beta$ for given τ_1, then $\partial\tilde{\gamma}/\partial\tau_i \gtrless 0$, $i=1,2$.

From (22) also comes the implication that when τ_1 (the initial, optimally-set tax to fund the public capital sector) is set such that $\tau_1 = \alpha$, then if $\tau_2 \lesseqgtr \beta$, where β is the transfer sector of government's optimal size, then $\partial\tilde{\gamma}/\partial\tau_1 \gtrless 0$. So, to move the rate of growth closer toward its maximum rate it will be necessary to set $\hat{\tau}_1 \gtrless \tau_1$, where $\hat{\tau}_1$ is the revised tax on output used to fund the sector producing public capital goods. A related finding exists from (23) above: when τ_2 (the initial, optimally-set tax to fund the transfer payments) is set such that $\tau_2 = \beta$, then if $\tau_1 \lesseqgtr \alpha$, where α is the public-capital sector of government's optimal size, then $\partial\tilde{\gamma}/\partial\tau_2 \gtrless 0$. So, to move the rate of growth closer toward its maximum rate it will be necessary to set $\hat{\tau}_2 \gtrless \tau_2$, where $\hat{\tau}_2$ is the revised tax on output used to fund the sector producing transfers.

The above results are similar to those obtained by Barro (1990): for Cobb-Douglas technology the size of G(t) and T(t) that maximizes the rate of growth is that which sets each equal to the respective shares of aggregate income they would attain if they were private inputs in competitive markets. As with all endogenous growth models, sustained growth is possible here as the marginal product of private capital does not approach zero in the limit (it approaches $[(1-\tau_1-\tau_2)A(G(t)/K(t))^{\alpha}(T(t)/K(t))^{\beta}]$), so that the Inada conditions do not hold. Here, where the elasticity of substitution between K(t), G(t) and T(t) is unity in the aggregate production function, as in the case for Cobb-Douglas technology, then the relative size of government in each sector (τ_i for i=1,2) that maximizes utility for the representative household also maximizes the rate of growth. 1/

There are several reasons why we should expect that most governments are operating in the region where $\partial\tilde{\gamma}/\partial\tau_i > 0$, (i=1,2). First, if in the real world (3) is not approximated by Cobb-Douglas technology, then as noted by Barro (1990), the utility-maximizing government will set a rate of growth which is less than the maximum. If that is the case, then $\partial\tilde{\gamma}/\partial\tau_i > 0$, for i=1,2, and we should observe a positive effect on growth of public investment ($\dot{G}$/Y) and transfer payments (T/Y).

Second, if there are also some publicly provided goods which are not directly productive, then we should expect the size of government to be less than the growth-maximizing share of aggregate income for each sector of government, so then $\partial\tilde{\gamma}/\partial\tau_i > 0$, i=1,2. It is clear that there are other activities of government beyond the taxing, transfers, and public investment activities modeled here. Such public activities as defense expenditure, education, government consumption spending, interest on national debt and international aid contributions will presumably also enter (1), along with

1/ If the production function is not Cobb-Douglas, then the utility-maximizing size of government exceeds (is smaller than) the growth-maximizing size of government if the elasticity of substitution between the inputs is greater (less) than one.

per capita consumption. If that is the case, then the growth-maximizing share of G(t) and T(t) in aggregate income is smaller if the government is also using the income tax base to finance these other activities.

Of key importance is the model's predictions for the effect on $\tilde{\gamma}$ of changes in τ_1 and τ_2. It was shown above that $\tilde{\gamma}$ is: (i) increasing in $(1-\tau_1-\tau_2)$, which is the contribution of tax distortions; (ii) increasing in $\tau_1 = \dot{G}/Y$, the ratio of public investment to GDP; and (iii) increasing in $\tau_2 = T/Y$, the ratio of transfer payments to GDP. Accordingly, there is a nonmonotonic relationship between $\tilde{\gamma}$ and taxes (τ_1 and τ_2), with $\tilde{\gamma}$ increasing initially with $\tau_1 = \dot{G}/Y$ and $\tau_2 = T/Y$, but later decreasing with increases in τ_1 and τ_2 beyond the point where $\tau_1 = \tau_1^* = \alpha$ and $\tau_2 = \tau_2^* = \beta$. This result emphasizes the trade-off between the growth-enhancing provision of transfers and public capital goods, and the growth-diminishing influence of the distortionary taxes which need to be raised to fund the provision of these same transfers and public capital goods. For small government (that is, low τ_1 and low τ_2) then the former two effects are likely to dominate; for large government (high τ_1 and τ_2) the latter, detrimental effect is likely to dominate. Of course when $\tau_1 = \tau_1^*$ and $\tau_2 = \tau_2^*$ and government is at its optimal size, (as given by the results from (22) and (23)), then the beneficial and the detrimental effects of the size of government exactly offset one another.

IV. Description of the Data

The data are described in the Appendix. The main sources have been the International Monetary Fund's International Financial Statistics (IFS) and Government Finance Statistics (GFS) data files. Empirical estimation was carried out using TSCS data for the period 1971-88, for the 23 developed countries in the sample. 1/

The dependent variable is GRWKR, the average annual rate of growth of per capita real GDP (taken over three five-year time intervals from 1971-85, then one three-year time interval from 1986-88). All explanatory variables (except INIT, the logarithm of the initial income at the first year of each sub-period) are also five-year averages of annual variables, again taken over the interval 1971-85, with again a three-year average from 1986-88. Such a procedure is necessary as with 18 observations per country, it would otherwise be difficult to obtain good estimates of those variables affecting long-run growth without having the results unduly influenced by short-run fluctuations induced by movements in the business cycle.

1/ The 23 countries involved, all members of the Organization for Economic Cooperation and Development (OECD), are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States of America.

The explanatory variables, which all (except EDUC) enter in logarithmic form, comprise: the mean ratio of public investment to GDP (IGOV); the mean ratio of current taxation revenue to GDP (CURREV); and the mean ratio of expenditure on transfers to GDP (SOCSEC). Some of the regressions are carried out after controlling for differences in countries' steady states by including a measure of the mean sub-period stock of per capita human capital (EDUC). Also included is INIT, to allow for the possibility that the initial level of income may not be the steady-state value, which would then affect the rate of growth (a country initially below its steady-state level of income will appear to grow faster than one initially at its steady-state level, holding everything else constant). It is useful to think of EDUC as controlling for the steady state, with INIT proxying for the gap of initial income from its steady-state level. 1/ The data on gross domestic investment (at constant prices) has been disaggregated into investment in public (IGOV) and private (IPRIV) capital using the share of government capital expenditure in gross domestic investment as a weight. Further details on the definition, derivation, and sources of all the variables used in the model can be found in the Appendix.

V. Empirical Estimation

Even prior to the theoretical link between endogenous growth and government first explored by Easterly (1989, 1990), Barro (1990) and Barro and Sala-i-Martin (1992), there existed a voluminous empirical literature examining the relationship between fiscal policy and the growth performance of both developed and less developed countries. Some of the more notable recent contributions to this literature were those of: Kormendi and Meguire (1985), Landau (1986), Skinner (1987), Ram (1986, 1987), Grier and Tullock (1989), Koester and Kormendi (1989), Barro (1989, 1991), Levine and Renelt (1991, 1992), Barro and Sala-i-Martin (1992), Engen and Skinner (1992), Easterly and Rebelo (1993), Villanueva (1994), and Lin (1994). Previous studies of the influence of fiscal policies on growth have predominantly concentrated on the effects of government consumption spending and have

---

1/ The initial level of income has a strong influence on the growth experience of countries in the neoclassical (Solow-Swan) model of economic growth. Similarly, here by including INIT in the regressions we are holding constant the influence of initial income, and concentrate on explanations involving the endogenous growth explanators of growth. In effect in this empirical estimation we are testing the transition to steady state, rather than steady-state growth itself, as it is unlikely the OECD countries were in steady state over the entire sample period. INIT is accordingly included to take into account that income may not initially be at its steady-state level, which if so will affect the observed growth rate. By not including INIT in the regressions, the results obtained would be subject to omitted variables bias, due to a failure to account for initial incomes in analyzing the conditional convergence of countries to their respective steady states.

largely ignored the effects of distortionary taxes, public capital, and transfer payments. In this study, the model given in Section III.1 (equation 17') of the paper will be used to guide the empirical estimation.

1. Model specification

The estimated equation for empirical testing is based on (17'):

$$(24) \qquad GRWKR_{it} = \beta_1 \ln(IGOV_{it}) + \beta_2 \ln(SOCSEC_{it}) + \beta_3 \ln(CURREV_{it}) + \beta_4 \ln(INIT_{it}) + \epsilon_{it},$$

where: the variables are as described in Sections III and IV, and in the Appendix; $\epsilon_{it} = \alpha_i + \nu_{it}$ (i=1,.. .,N countries; t=1,... ,T time); ln is the natural logarithm; and β is a vector of coefficients associated with time-varying observable variables. 1/ One key reason for combining time-series and cross-sectional data is to attempt to control for any unobservable country-specific effects which may be correlated with other explanatory variables (that is, the potential for $E(\epsilon_{it}|X_{it}) = E(\alpha_i|X_{it}) \neq 0$). 2/

There are three alternative econometric specifications of the model, each differing in their treatment of α_i. The "fixed effects" (FE) estimator treats α_i as a fixed (time invariant) but unknown constant differing across individual countries. In FE it is assumed that differences across countries can be captured in differences in the constant term, and so each α_i is an unknown parameter to be estimated. In effect, differences between countries are here viewed as parametric shifts of the regression function.

Alternatively, the "random effects" (RE) or variance components specification assumes that country-specific constant terms are randomly distributed across cross-sectional units (that is, countries). In RE, each $\alpha_i \sim N(0,\sigma_\alpha^2)$, given that here $\alpha_i = \alpha + \eta_i$, where α is the group mean intercept and η_i are the errors associated with the ith country and which is constant over time, and are random (white noise) deviations (positive or

---

1/ The classical disturbance term ν_{it} is assumed to be iid over i and t, uncorrelated with the explanatory variables. The latent country-specific effect α_i is assumed to be iid over i, distributed independently across countries.

2/ To the extent that many of the previous analyses of the interrelationship between government spending, taxation, and growth used time-series analysis alone or cross-sectional analysis alone, then in the presence of such correlation these studies would have yielded biased and inconsistent estimates of the parameters.

negative) from this common mean. Then ϵ_{it}, the error term in (24), becomes $\epsilon_{it} = \nu_{it} + \eta_i$. In the RE specification it is assumed that α_i is uncorrelated with ν_{it} and the X_{it}. 1/

The third approach, known as "between effects" (BE), undertakes the estimation without considering country-specific intercepts (a single, group mean intercept α is postulated). That is, it is assumed that the error term in (24) is $\bar{\epsilon}_{it} = \eta_i + \nu_{i.}$, where $\nu_{i.}$ is the mean of the usual errors which vary over time and countries. BE is the OLS estimator based on the set of country (or group) means, which is an analogue to undertaking cross-sectional estimation, as BE simply asks whether poorer countries tend to grow faster than rich ones (that is, it looks at the growth experience between countries only). Hsiao (1986) demonstrates that RE is an optimal weighted average of both the FE (which uses variation within countries) and BE (which uses variation between countries) estimators.

In estimating these models a number of specification tests were carried out, to establish the efficacy of introducing unobserved, country-specific effects as opposed to OLS estimation (Breusch and Pagan 1980), and to determine which of the FE, BE, or RE specifications is superior (Hausman 1978). On economic grounds neither OLS nor FE appear to be reasonable set ups, given that they both assume the same constant term for all years and for all countries (OLS), or different (yet fixed) constant terms for each country (FE). Neither assumption is particularly palatable in the context of an analysis of the causes of secular economic growth. 2/

1/ In the absence of measurement errors if the assumed $E(\alpha_i|X_{it}) = E(\eta_i|X_{it}) = 0$ is violated, due for example to omitted variables, the RE estimator is biased and inconsistent, while the FE estimator is unbiased and consistent. However, the FE estimator is particularly sensitive to the presence of measurement errors, and if $E(\nu_{it}|X_{it}) \neq 0$ due to such errors then it may well be a worse estimator than either the RE or ordinary least squares (OLS) specifications (Hausman 1978).

2/ As noted above, the specification bias which arises from ignoring parameter heterogeneity among cross-sectional or time-series units can result in the erroneous application of pooled least-squares regression techniques to all NT observations, yielding inconsistent estimates of parameters. Hsiao (1986) suggests that given we assume the parameters are constant over time, but differ between individual countries, then the two possible cases are: (i) either heterogeneous intercept and homogeneous slope parameters, or (ii) heterogeneous intercept and slope parameters. The first case is examined here. An F-test for homogeneous intercepts (given homogeneous slope parameters) yields an F-statistic of 2.05, while the critical value for $F_{0.95}$ (22,63)=1.68, and so the null is not accepted.

2. Estimation results

This section reports the results of estimating the TSCS regressions of (24), where the elements of the vector X_{it} are those discussed in Sections III and IV. The results from using ln(INIT) as the lone explanatory variable are reported first, then results for the full set of X_{it} variables, then results including EDUC to control for differences in countries' steady states.

The results of all regressions are presented in Table 1, where in all cases the dependent variable is GRWKR, the rate of growth of GDP per worker. In column one a constant and ln(INIT) are the sole explanatory variables, where INIT is included to hold constant initial per-worker GDP. The estimated convergence coefficient is $\hat{\beta}_4$=-0.0062 [-3.36], a result which confirms the findings of Dowrick and Nguyen (1989), Barro (1991), Mankiw, Romer, and Weil (1992), and Barro and Sala-i-Martin (1992a) of a statistically significant tendency toward convergence in OECD countries. It also has implications for the speed of convergence of OECD economies: the relatively low estimated convergence coefficient means that the OECD economies move halfway to steady state in about 113 years.

The most likely reason absolute convergence is observed in column 1 of Table 1 is that the correlation between INIT and both the steady-state real GDP per worker and the steady-state growth rate is relatively weak. Differences in ln(INIT) among OECD countries (due to the residual effects of World War II, agricultural shocks, and oil shocks) approaching similar steady states would show up as unconditional or absolute convergence. That is, for the relatively homogeneous group of OECD countries with similar technologies and preferences, absolute convergence is very close to conditional convergence.

Column two follows Barro (1991) and Mankiw, Romer, and Weil (1992), and adds EDUC (a proxy for the stock of human capital) as an explanatory variable. Human capital has played an important part in the endogenous growth literature, either as a direct input into research (Romer 1990), or because of positive externalities flowing from the average stock of human capital per person (Lucas 1988, Becker, Murphy, and Tamura 1990). For these reasons it is expected that for given INIT, GRWKR will be positively related to EDUC. Further, once additional variables (such as EDUC) are included that attempt to hold constant the cross-country variations in steady-state real GDP per worker and the steady-state growth rate, then the partial relation between GRWKR and INIT should become more negative. The results of column 2 ($\hat{\beta}_4$=-0.0081 [-3.24]) show that the addition of EDUC does indeed result in INIT being even more strongly negatively-related to subsequent GRWKR, and accordingly conditional convergence is observed in the data. The speed of convergence here is such that the OECD economies now move halfway to steady state in about 86 years.

Table 1. GDP Growth Regressions, 23 Developed Countries, 1971-88 1/

Dependent Variable: GRWKR
Value of t-statistics in brackets

	BE 2/ (1)	BE 3/ (2)	BEIV 4/5/ (3)	BEIV 6/ (4)
Constant	0.0745 [4.06]	0.882 [4.01]	0.1297 [5.30]	0.1362 [5.36]
ln(IGOV)			0.0084 [1.76]	0.0115 [2.03]
ln(INIT)	-0.0062 [-3.36]	-0.0081 [-3.24]	-0.0093 [-3.65]	-0.0097 [-3.77]
ln(SOCSEC)			0.0083 [5.78]	0.0083 [5.87]
ln(CURREV)			-0.0190 [-4.53]	-0.0209 [-4.63]
EDUC		0.0001 [1.13]		0.0001 [0.80]
Sample size	92	92	92	92
LOGL	-602.54	-603.19	-137.54	-138.19

1/ All regressions use one-factor error structure for panel estimation, that is using group dummy variables. BE denotes between effects estimation; RE denotes random effects estimation; BEIV denotes between effects estimation and REIV denotes random effects estimation, both using the GIV technique. LOGL denotes the value of the log-likelihood function, where $LOGL = -(N/2)[1+\ln 2\pi-\ln((e'e)/N)]$. GRWKR is the rate of growth of real GDP per worker; IGOV is the mean ratio of public investment to GDP; INIT is the initial level of real GDP per worker; SOCSEC is the mean ratio of expenditure on social security and welfare to GDP; CURREV is the mean ratio of current revenue to GDP; EDUC is the mean ratio of secondary school enrollment to the population of children in that school age group. The sub-periods for analysis are: 1971-75, 1976-80, 1981-85, and 1986-88. For further details see the Appendix.

2/ The Breusch-Pagan (BP) test statistic had a value of 134.39 [1df, pval=1.54E-09], and the Hausman (H) test statistic comparing BE and RE a value of 8.12 [1df, pval=.004].

3/ The BP test statistic had a value of 134.43 [1df, pval=1.54E-09], and the H test statistic comparing BE and RE a value of 7.25 [1df, pval=.026].

4/ The BP test statistic had a value of 133.99 [1df, pval=1.54E-09], and the H test statistic comparing BEIV and REIV a value of 12.28 [4df, pval=.015].

5/ The H test for exogeneity of IGOV and SOCSEC had a value of 9.96 [2df, pval=0.041]; the independent variables used in the OLS reduced form estimation (to calculate predicted values for IGOV and SOCSEC) were R, CPI, AGE65, and YBAR.

6/ The BP test statistic had a value of 134.09 [1df, pval=1.54E-09], and the H test statistic comparing BEIV and REIV a value of 13.17 [5df, pval=.022]. The independent variables used in the OLS reduced form estimation (to calculate predicted values for IGOV and SOCSEC) were R, CPI, AGE65, and YBAR.

The explanatory variables in (24) are assumed to be exogenous, and to cause the consequent changes in economic growth. However, there is a strong likelihood of endogeneity with regard to some (or all) of these variables, and in order to correct for this potential simultaneity bias, generalized instrumental variable (GIV) estimation will be introduced. 1/ Hausman (1978) tests verified this suspicion of $E(\alpha_i|X_{it}) \neq 0$ by finding that both IGOV and SOCSEC were likely to be luxury goods (and hence endogenous), as given an initial income, a higher GRWKR which raises the mean level of income over the sub-sample will lead to higher sub-sample mean values for both IGOV and SOCSEC. 2/ Accordingly, GIV estimation was carried out using fitted values from reduced form estimation of IGOV and SOCSEC as instruments for actual IGOV and SOCSEC in the structural equation for growth (24). 3/

The results of GIV estimation are presented in columns 3 and 4 of Table 1, for the assumed one-factor error structure, excluding and including EDUC, respectively. The preferred BEIV specification in column 3 yielded parameter estimates which are all statistically significant (IGOV at the 10 percent level), with a coefficient on INIT of β_4=-0.0093 [-3.65]. 4/ As predicted from the theoretical relation of equation (17'), GRWKR is positively related to SOCSEC and IGOV respectively, holding constant INIT and all other variables. The estimated coefficients on SOCSEC and IGOV are both individually statistically different from zero, with the coefficient on CURREV also significantly different from zero, and as predicted by (17'), is negatively related to GRWKR. Given that the explanatory variables enter in

1/ Lagged endogenous variables cannot be used as instruments in the presence of endogeneity, due to potential biases in the presence of either fixed effects or serially correlated error terms. See Bowden and Turkington (1984) for details of GIV estimation.

2/ Engen and Skinner (1992) and Easterly and Rebelo (1993) also found that endogeneity in fiscal behavior is a potentially important problem in cross-country regressions.

3/ GIV estimation has advantages over the more traditional two-stage least squares (2SLS) estimator in that: (i) the 2SLS estimator will be inconsistent (even as the sample size grows) if not all the exogenous variables in the structural and reduced form equations are included in the reduced form regression - the GIV estimator will still be consistent should such an omission be made; and (ii) the standard errors obtained from least squares estimation of the structural equation need to be corrected - this is not the case for GIV (see White 1982).

4/ In traditional cross-sectional tests for the presence of convergence, when the initial level of GDP per capita is mis-measured, then the subsequent rate of growth will be biased toward acceptance of the convergence hypothesis (Romer 1989). However, when TSCS data are used then such measurement errors are less important, as the initial levels of GDP per worker are here used in each of the four sub-periods to calculate each sub-period's GRWKR, rather than one measure of the rate of growth as is typically done in cross-sectional studies.

ln form, their coefficients indicate the percentage increase in GRWKR from a 1 percent increase in the explanatory variable (for example, a 1 percent increase in IGOV will raise GRWKR by 0.84 of a percentage point).

Similarly, evaluating the coefficients of the BEIV specification of column 4 (which controls for inter-country variation in the stock of human capital by including EDUC) reveals that all of the coefficients have the expected signs, with all except EDUC being statistically significant. The coefficient of convergence in column 4 is significant and slightly larger at β_4=-0.0097 [-3.77]. Again, as predicted by (17'), there are the strongly significant and positive effects of SOCSEC and IGOV on GRWKR, and also the strong, growth-inhibiting effect of CURREV on GRWKR. The rejection of FEIV and REIV in favor of BEIV indicates that most of the variation in the growth experience is occurring between countries, rather than within particular countries over time, and is consistent with recent work by Easterly, Kremer, Pritchett and Summers (1993). Such a result is perhaps not so surprising when the data reveal the relatively wide disparity in GRWKR among the OECD countries.

3. Comparison with earlier results

The above specification is innovative in that it allows for the simultaneous analysis of the differential partial contributions to growth of public investment, public transfers, and the levying of distortionary taxes, and allows for a nonmonotonic relationship between government and growth. Earlier work often examined the influence of public spending variables on growth in isolation from the effects of public taxation, and vice versa.

The finding of a strongly positive partial effect of public investment on growth echoes recent TSCS work by Skinner (1987) and Knight, Loayza, and Villanueva (1993), and the time-series results of Aschauer (1989). However, it contradicts the cross-sectional findings of Diamond (1989), Ford and Poret (1991) and Barro (1991) of a weak relation between public investment and growth, especially if the ratio of private investment to GDP is held constant. 1/ Barro (1991) argues that his findings indicate either that public investment is not an important determinant of growth, or that governments are optimizing and going to the point where the marginal effect of such investment on the growth rate is close to zero. When private investment (IPRIV) was included in the regressions here (results not reported), all the coefficients were significant and had the expected signs, including IGOV (which becomes negative and insignificant in Barro's (1991) analysis). It is likely that the failure of the above three cross-sectional studies to account for the endogeneity of IGOV, and for the potential for cross-country heterogeneity, generated their different findings. Moreover, in contradiction of Barro's (1990) conclusions, my results for IGOV indicate that the typical OECD government was operating where the marginal effect of

---

1/ Easterly and Rebelo's (1993) cross-sectional study of 100 countries between 1970-88 found that the ratio of public investment in transport and communication to GDP was positively correlated with growth.

public investment on growth was positive. This is inconsistent with the optimizing behavior of government examined in Section III.2, where IGOV was chosen so as to maximize growth. However, in that section a number of caveats were given as to why utility-maximizing governments may choose to operate where $\partial\gamma/\partial(\mathrm{IGOV})>0$.

The equally strong positive partial effect of public transfers on growth has not been previously analyzed using a TSCS framework, and contradicts the findings from earlier work, which has traditionally modeled governments as levying distortionary taxes and using these resources for government consumption spending or unproductive transfer payments (see Alesina and Rodrick 1991). Barro (1989) found evidence in his cross-sectional study that transfer payments were a luxury good, which he argued accounted for the positive correlation of mean transfer payments as a share of GDP with the growth rate. While such endogeneity was also found here, once GIV estimation was carried out a strong, positive relation between transfers and growth was brought out in the data. As for IGOV, this result indicates that the typical OECD government was operating where the marginal effect of transfers on growth was positive, that is where $\partial\gamma/\partial(\mathrm{SOCSEC})>0$.

The detrimental partial effect of distortionary taxes on growth ($\partial\gamma/\partial(\mathrm{CURREV})<0$) has been observed and discussed previously by Marsden (1983), Skinner (1987), Barro (1989), Koester and Kormendi (1989), Martin and Fardmanesh (1990), Rebelo (1991), Dowrick (1992), and Engen and Skinner (1992), among others. The strong negative relation between taxes and growth found here concurs with the theoretical specification of Section III.1, where non-lump-sum taxes were shown to be growth-inhibiting. However, if the revenue from such taxes is used for productive government spending then growth can be promoted, if governments are operating (as shown above) in the range where the partial effects of such productive spending on growth are positive.

Unlike Barro (1991) and Mankiw, Romer, and Weil (1992), it is not clear that once endogeneity is taken into account, and given INIT, that GRWKR is significantly positively-related to the mean amount of human capital. 1/ This result could reflect the often mediocre quality and usefulness of the human capital measures available to researchers; in particular, enrollment data do not control for the quality of schooling (see Behrman and Rosenzweig 1992). It could also reflect the possibility that EDUC, as a measure of school enrollment rates, may be proxying for the mean flow of investment in human capital rather than its mean stock. 2/ However, the results of columns 1 and 3 are independent of doubts over the efficacy of EDUC.

1/ Indeed BE estimation (without accounting for the endogeneity of IGOV and SOCSEC) yields a positive and significant coefficient on EDUC, as in Barro (1991).

2/ Note that to the extent that current school enrollment is highly correlated with past school enrollment, then it will also be a good measure of the stock of human capital (see Mulligan and Sala-i-Martin 1993).

VI. Conclusion

There are several innovations arising from this paper. First, the use of the stock of public capital in an endogenous growth setting to examine the influence of public finance variables, rather than the flow of government services which had been assumed previously in the literature. Second, the model allows for congestion in the consumption of publicly provided capital and transfers (that is for rivalry in the consumption of these nonexcludable public goods), rather than the nonrivalrous, nonexcludable nature of the publicly provided private goods which had been assumed previously in the literature. Third, the model is able to separate and highlight the growth-diminishing effects of the levying of distortionary taxes, and the growth-enhancing effects of the provision of public capital and transfers. Previous empirical work examining the relationship between government and growth did not separately account for the divergent influences on the rate of economic growth of taxation, transfer payments, and investment in public capital. Fourth, empirical tests of the hypotheses predicted by the theoretical model confirmed the growth-enhancing effects of increases in the provision of public capital and the payment of transfers, and of the growth-inhibiting effects of the levying of distortionary taxes. In particular, the finding of a positive and significant effect of transfer payments on growth has not been obtained before using panel estimation techniques.

The policy implications arising from this paper are straightforward. Increased government spending on those items which enter private production functions as productive public inputs enhances economic growth. Examples of such productive public spending include public investment and (intragenerational and intergenerational) transfer payments, both of which generate positive externalities which raise private investment and thus economic growth. However, the size of government is limited by the need to fund such public spending by the levying of distortionary taxes, which reduce the marginal return to private capital, and so dampen economic growth. A clear implication of the theoretical and empirical work presented here is that there are significant trade-offs involved in considering the various contributions of government to the economic growth of nations.

Data Sources and Description of Variables

1. Abbreviations for data sources

IFS	International Monetary Fund, International Financial Statistics (1991) and earlier issues.
WT	World Bank, World Tables (1991) and earlier issues.
GFS	International Monetary Fund, Government Finance Statistics (1991) and earlier issues.
SH	Summers and Heston (1991), the Penn World Table (Mark V).
OECD	Organization for Economic Cooperation and Development (1991), Labor Force Statistics 1969-1989.

All series comprise 92 country-year observations, on 23 countries of four time-periods each, over the period 1971-88. As annual data include substantial random effects which tend to be diminished in influence by averaging, the length of time covered by any single country observation is five years for the first three sub-periods (1971-75, 1976-80, 1981-85) and three years for the last sub-period (1986-88). That is, five-year and three-year averages of each of the variables are used in this study.

2. Description of the variables

Variable Name	Mean	Standard Deviation
GRWKR	0.013	0.012

The rate of growth of gross domestic product (GDP) per worker, in constant prices (1985 international prices, PPP adjusted), with GDP per worker taken from SH, being their RGDPW (real GDP per worker in 1985 international prices). The annualized GRWKR is: $[\ln(RGDPW_t/RGDPW_{t-T})]/T$, where t is the last year of the subperiod, t-T is the first year of the sub-period, T is the time interval in years between t and t-T, and ln is the natural logarithm.

INIT	9.930	0.353

The natural logarithm of RGDPW at the start of each sub-period (that is, 1971, 1976, 1981 and 1986), with RGDPW taken from SH (see definition below).

IPRIV	0.164	0.038

This is a measure of the mean value of each sub-period's change in the stock of private capital, and is formed by accumulating the ratio of annual private investment in capital (taken to be the private share of gross fixed capital formation (IFS line 93e) plus increases in stocks (IFS line 93i), measured in current period, local currency terms) to GDP (taken from IFS line 99b, measured in current period, local currency terms) over the length of each sub-period, given a depreciation rate on capital of 8 percent per annum. The share of aggregate domestic investment (defined by IFS as gross domestic fixed investment plus the change in stocks) allocated to private investment is calculated by first estimating the average ratio of total government expenditure (taken from Table C, line II, GFS) less current government expenditure (taken from Table C, line III, GFS) to total aggregate gross domestic investment (IFS lines 93e plus 93i) over each sub-period (this is the share of public investment in total investment). Private investment is then one minus this ratio, multiplied by aggregate domestic investment. IPRIV is then formed by dividing private investment by GDP.

IGOV 0.056 0.015

This measure of the mean value of each sub-period's change in the stock of public capital as a share of GDP is formed by taking the difference between total accumulated capital (gross domestic fixed capital formation (line 93e of IFS) plus the change in stocks (line 93i of IFS)) and accumulated private capital (IPRIV, as calculated above), and dividing this value by the level of GDP (taken from line 99b of IFS).

YBAR 3.69E+11 7.07E+11

The mean level of GDP of each sub-period, in constant 1985 international prices, taken from SH, and formed by multiplying their RGDPCH (real GDP per capita, 1985 international prices) by their POP (national population, current year).

SOCSEC 0.117 0.053

Mean value of each sub-period's expenditure on social security and welfare (Table B, line 6, GFS in current, local currency terms) as a share of GDP (line 99b, IFS in current, local currency terms).

CURREV 0.371 0.110

Mean value of each sub-periods's current revenue (Table A, line III, GFS in current, local currency terms) as a share of GDP (line 99b, IFS in current, local currency terms).

EDUC 82.563 16.539

Mean value of each sub-period's gross enrollment of children aged 12 to 17 years at secondary school, taken from WT. Figures are expressed as the ratio of pupils to the population of children in the country's school age group. For some countries with near-universal secondary education, the gross enrollment ratios may exceed 100 percent because some pupils are younger or older than the country's standard secondary school age. The data include pupils enrolled in vocational or teacher-training secondary schools. Figures for years prior to 1975 have been interpolated from the 1970 and 1975 figures.

AGE65	0.120	0.027

Mean share (for each sub-period) of the total population of a given country which is aged 65 years or older as at June of each year, taken from OECD, Table 1, Population.

CPI	72.264	35.838

Mean value of each sub-period's consumer price index, with base 1985=100, taken from line 64, IFS.

R	10.859	6.415

Mean value of each sub-period's interest rate on treasury bills, taken from line 60c, IFS. Where such a rate is unavailable, the rate on short-term government bonds was used instead, and taken from line 61a, IFS.

RGDPW	17404.29	7381.09

Annual value of real GDP per worker, in 1985 international prices, PPP adjusted, taken from SH.

References

Alesina, A. and Rodrick, D. (1991), "Distributive Politics and Economic Growth", NBER Working Paper #3668.

Arrow, K.J. and Kurz, M. (1970), Public Investment, the Rate of Return, and Optimal Fiscal Policy, Resources for the Future Inc. and Johns Hopkins Press, Baltimore.

Aschauer, D.A. (1989), "Is Public Expenditure Productive?", Journal of Monetary Economics 23, 177-200.

Barro, R.J. (1989), "A Cross-Country Study of Growth, Saving and Government", NBER Working Paper #2855.

__________ (1990), "Government Spending in a Simple Model of Endogenous Growth", Journal of Political Economy 98, s103-s125.

__________ (1991), "Economic Growth in a Cross-Section of Countries", Quarterly Journal of Economics 106, 407-443.

Barro, R.J. and Sala-i-Martin, X. (1992), "Public Finance in Models of Economic Growth", Review of Economic Studies 59, 645-661.

__________ (1992a), "Convergence", Journal of Political Economy 100, 223-251.

Becker, G.S., Murphy, K.M. and Tamura, R. (1990), "Human Capital, Fertility and Economic Growth", Journal of Political Economy 98, s12-s37.

Behrman, J.R. and Rosenzweig, M.R. (1992), "The Quality of Aggregate Inter-Country, Time-Series Data on Educational Investments and Stocks", mimeo, Conference on Data Base of Development Analysis, Yale University, May.

Bowden, R.J. and Turkington, D.A. (1984), Instrumental Variables, Cambridge University Press.

Breusch, T.W. and Pagan, A.R. (1980), "The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics", Review of Economic Studies 47, 239-253.

Cass, D. (1965), "Optimal Growth in an Aggregative Model of Capital Accumulation", Review of Economic Studies 32, 233-240.

Diamond, J. (1989), "Government Expenditure and Economic Growth: An Empirical Investigation", IMF Working Paper, WP/89/45, Washington, D.C.

Dowrick, S. (1992), "Estimating the Impact of Government Consumption on Growth: Growth Accounting and Optimizing Models", mimeo, Australian National University, Canberra.

_________ and Nguyen, D.T. (1989), "OECD Comparative Economic Growth 1950-85: Catch-Up and Convergence", American Economic Review 79, 1010-1030.

Easterly, W. (1989), "Policy Distortions, Size of Government and Growth", NBER Working Paper #3214.

_________ (1990), "Endogenous Growth in Developing Countries with Government-Induced Distortions", mimeo, Macroeconomic Adjustment and Growth Division, World Bank.

_________ and Rebelo, S. (1993), "Fiscal Policy and Economic Growth", Journal of Monetary Economics 32, 417-458.

_________, Kremer, M., Pritchett, L. and Summers, L. (1993), "Good Policy or Good Luck? Country Growth Performance and Temporary Shocks", Journal of Monetary Economics 32, 459-483.

Engen, E. and Skinner, J. (1992), "Fiscal Policy and Economic Growth", NBER Working Paper #4223.

Feldstein, M.S. (1974), "Incidence of a Capital Income Tax in a Growing Economy with Variable Savings Rates", Review of Economic Studies 41, 505-513.

Ford, R. and Poret, P. (1991), "Infrastructure and Private Sector Productivity", OECD Economic Studies 17, 63-89.

Grier, K. and Tullock, G. (1989), "An Empirical Analysis of Cross-National Economic Growth, 1950-1980", Journal of Monetary Economics 20, 259-276.

Grossman, G. and Helpman, E. (1989), "Comparative Advantage and Long-Run Growth", NBER Working Paper #2809.

Hausman, J.A. (1978), "Specification Tests in Econometrics", Econometrica 46, 1251-1271.

Hsiao, C. (1986), Analysis of Panel Data, Cambridge University Press, Cambridge.

International Monetary Fund (1991), Government Finance Statistics Yearbook, Washington D.C., and earlier issues.

_________________ (1991), International Financial Statistics Yearbook, Washington D.C., and earlier issues.

Jones, L.E. and Manuelli, R. (1990), "A Convex Model of Equilibrium Growth", Journal of Political Economy 98, 1008-1038.

Judd, K.L. (1985), "Redistributive Taxation in a Simple Perfect Foresight Model", Journal of Public Economics 28, 59-83.

King, R.G., Plosser, C. and Rebelo, S.T. (1988), "Production, Growth and Business Cycles II: New Directions", Journal of Monetary Economics 21, 309-341.

Knight, M., Loayza, N. and Villanueva, D. (1993), "Testing the Neoclassical Theory of Economic Growth - A Panel Data Approach", IMF Staff Papers 40, 512-541.

Koester, R.D. and Kormendi, R.C. (1989), "Taxation, Aggregate Activity and Economic Growth: Cross-Country Evidence on Some Supply-Side Hypotheses", Economic Inquiry 27, 367-386.

Koopmans, T.C. (1965), "On the Concept of Optimal Growth", in The Econometric Approach to Development Planning, North Holland, Amsterdam.

Kormendi, R. and Meguire, P. (1985), "Macroeconomic Determinants of Growth: Cross-Country Evidence", Journal of Monetary Economics 18, 141-163.

Kurz, M. (1968), "The General Instability of a Class of Competitive Growth Processes", Review of Economic Studies 35, 155-174.

Landau, D. (1986), "Government and Economic Growth in the Less Developed Countries: An Empirical Study for 1960-1980", Economic Development and Cultural Change 35, 35-75.

Lee, J. (1992), "Optimal Size and Composition of Government Spending", Journal of the Japanese and International Economies 6, 423-439.

Levine, R. and Renelt, D. (1991), "Cross-Country Studies of Growth and Policy: Methodological, Conceptual and Statistical Problems", Policy Research and External Affairs Working Paper # 608, The World Bank.

________________ (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", American Economic Review 82, 942-963.

Levine, R. and Zervos, S.J. (1993),"What Have We Learned About Policy and Growth from Cross-Country Regressions?", American Economic Review 83, 426-430.

Lin, S.A.Y. (1994), "Government Spending and Economic Growth", Applied Economics 26, 83-94.

Lucas, R.E. (1988),"On the Mechanics of Economic Development", Journal of Monetary Economics 22, 3-42.

Mankiw, N.G., Romer, D. and Weil, D.N. (1992), "A Contribution to the Empirics of Economic Growth", Quarterly Journal of Economics 107, 407-438.

Marsden, K. (1983), "Links Between Taxes and Economic Growth: Some Empirical Evidence", World Bank Working Paper #605, Washington, D.C.

Martin, R. and Fardmanesh, M. (1990), "Fiscal Variables and Growth: A Cross Section Analysis", Public Choice 64, 239-251.

Mulligan, C.B. and Sala-i-Martin, X. (1993), "Transitional Dynamics in Models of Endogenous Growth", Quarterly Journal of Economics 108, 739-773.

Organization for Co-Operation and Development (1991), Labour Force Statistics 1969-1989, OECD Economics Statistics Division, Paris.

Ram, R. (1986), "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data", American Economic Review 76, 191-203.

________ (1987), "Wagner"s Hypothesis in Time Series and Cross-Sectional Perspectives: Evidence from "Real" Data for 115 Countries", Review of Economics and Statistics 69, 194-204.

Ramsey, F.P. (1928), "A Mathematical Theory of Saving", Economic Journal 38, 543-559.

Rebelo, S. (1991), "Long-Run Policy Analysis and Long-Run Growth", Journal of Political Economy 99, 500-521.

Romer, P.M. (1986), "Increasing Returns and Long-Run Growth", Journal of Political Economy 94, 1002-1037.

________ (1989), "Capital Accumulation in the Theory of Long Run Growth", in Barro, R. (ed.), Modern Business Cycle Theory, Harvard University Press, Cambridge MA, 51-127.

________ (1990), "Endogenous Technical Change", Journal of Political Economy 98, s71-s102.

Sala-i-Martin, X. (1992), "Pensions", Discussion Paper #657, Economic Growth Center, Yale University.

________ (1992a), "Public Welfare and Growth", Discussion Paper #666, Economic Growth Center, Yale University.

Skinner, J. (1987), "Taxation and Output Growth: Evidence from African Countries", NBER Working Paper #2335.

Solow, R.M. (1956), "A Contribution to the Theory of Economic Growth", Quarterly Journal of Economics 70, 65-94.

Srinivasan, T.N. (1964), "Optimal Savings in a Two-Sector Model of Growth", Econometrica 32, 358-373.

Summers, R. and Heston, A. (1991), "Penn World Table (Mark V): An Expanded Set of International Comparisons, 1950-1988", Quarterly Journal of Economics 106, 327-368.

Swan, T.W. (1956), "Economic Growth and Capital Accumulation", Economic Record 32, 334-361.

Thompson, E.A. (1974), "Taxation and National Defense", Journal of Political Economy 82, 755-782.

Villanueva, D. (1994), "Openness, Human Development, and Fiscal Policies", IMF Staff Papers 41, 1-29.

White, H. (1982), "Instrumental Variables Regression with Independent Variables", Econometrica 50, 483-499.

World Bank (1991), World Tables 1991, Washington D.C., and earlier issues.