NBER WORKING PAPER SERIES

POLICY DISTORTIONS, SIZE OF GOVERNMENT, AND GROWTH

William Easterly

Working Paper No. 3214

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 1989

An earlier version of this paper was written as background to the Report on Adjustment Lending II. I am grateful for comments by Ricardo Martin and other participants in the RALII workshop, by Stanley Fischer and other participants in the DECVP workshop, by Deborah Wetzel, Michael Gavin, Bela Balassa, and members of CECMG. This paper is part of NBER's research program in Growth. Any opinions expressed are those of the author not those of the National Bureau of Economic Research.

NBER Working Paper #3214
December 1989

POLICY DISTORTIONS, SIZE OF GOVERNMENT, AND GROWTH

ABSTRACT

This paper analyzes the structural relationship between policies that distort resource allocation and long-term growth. It first reviews briefly the Solow model in which steady-state growth depends only on exogenous technological change. Policy distortions do affect the rate of growth in the transition to the steady state in the Solow model. However, growth falls off so rapidly in the Solow transition as to make it unsatisfactory as a model of long-term growth, even over periods as short as a decade.

The paper proposes an increasing returns model in the spirit of the new literature on economic growth. With increasing returns, endogenous economic variables -- and thus policy -- will affect the steady-state rate of growth. The model gives output as a linear function of total capital, but a decreasing function of each of two types of capital. The distortion is defined as a policy intervention that increases the cost of using one of the types of capital. The relationship between this distortion and steady-state growth is negative but highly nonlinear. At very low levels and very high levels of distortion, the effect on growth of changing the distortion is close to zero. Changes in structural parameters of the economy -- the elasticity of substitution between the two types of capital and the share of nondistorted capital in production -- will affect significantly the impact of the policy distortion on growth.

The model is extended to an analysis of the relationship between the size of government and growth by treating the distortion strictly as a tax on one form of capital. The tax revenue is used to finance the acquisition of productive government capital. There is then a tradeoff between two forms of distortion--one resulting from distortionary taxation and the other from insufficient public capital. Increasing the tax from zero has a positive effect on growth, but with further tax increases the relationship will eventually turn negative. Tax revenue ("size of government") as a function of the tax rate will be given by a Laffer curve. Growth still remains above a certain minimum as the tax rate gets arbitrarily large, but the range between relationship maximum and minimum growth will be larger than in the original model. The relationship between tax revenue and growth for alternative tax rates can be positive, negative, or zero. The same is true of the relationship between public and private investment. Changes in the share of tax revenue devoted to capital accumulation ("government saving") will affect the results.

The results suggest that simple linear relationships between distortions and growth or between size of government and growth are untenable. The dialogue between advocates of liberalization and policymakers could be enriched by a recognition of the structural factors that influence the effect of lowering distortions on growth.

William Easterly
World Bank
1818 H Street, NW
Washington, DC 20433

TABLE OF CONTENTS

I. Introduction

Recent experience in developing countries has generated new interest in the theory of long-run economic growth. The decade of the 1980's has been a "lost decade" for many developing countries as a combination of policy mistakes and external shocks have led to a slowdown of economic growth. As Table 1 shows, this slowdown has been widespread across regions and income levels, with the sole exception of Asian countries. It has been particularly pronounced in the highly indebted countries and in sub-Saharan Africa. In view of the critical need to restart growth in those countries, the theory of the determinants of economic growth has recently attracted considerable attention.

1. The Solow model and long-run growth

This renewed attention comes after a long hiatus. The theory of economic growth has been guided for many years by the seminal model of Solow (1956). Solow's work was done partially in response to the Harrod-Domar model of the 1930's, which exhibited unstable dynamics because of a linear capital-output ratio and the response of investment to output changes. Solow pointed out that output growth could be a stable process when the production function allows the smooth substitution of labor for capital. He also pointed out something that was a nagging embarrassment to the field. If we assume constant returns to scale and exogenous labor (population) growth, then capital accumulation cannot be a source of long-run growth. If capital grows faster than labor, then diminishing returns will set in and growth will not be sustainable. Since capital accumulation is the variable in the Solow model that reflects all changes in the economic environment, this suggests that nothing endogenous can determine long-run growth. For example, both the level

Table 1: Average annual growth rate of GDP in developing countries (percent)

Country Group	1965-80	1980-87
Low income economies	5.4	6.1
China and India	5.3	8.5
Other	5.5	1.7
Middle-income economies	6.2	2.8
Lower middle-income	5.7	2.1
Upper middle-income	6.7	3.4
High-income economies	3.7	2.6
OECD countries	3.6	2.7
Others 1/	8.1	-2.6
Regional Aggregates (low and middle income)		
East Asia	7.2	8.0
Europe, M. East & N. Africa	6.2	NA
Latin America & Caribbean	6.0	1.4
South Asia	3.8	4.8
Sub-Saharan Africa	5.1	0.4
Memorandum items:		
Seventeen highly indebted	6.1	1.1
Highest growth rate 2/	15.2	13.0
Lowest growth rate 2/	0.1	-6.1

Source: World Bank (1989).
Note: Averages are weighted.

1/ Countries classified by UN or otherwise regarded by their authorities as developing.
2/ For an individual country.

of saving and distortions of resource allocation will affect only the level of output, not the long-run rate of growth. Thus, Solow identified exogenous technological change as the engine of per capita income growth.

The Solow model had clear implications for growth of developing countries. It predicted that productivity of capital would be higher and per capita income would grow faster in capital-poor countries in the transition to the long run (assuming labor quality is the same in rich and poor countries). Lending to developing countries would thus have a high rate of return, and income levels of all countries would tend to converge over time. While empirical results on convergence are mixed, it is clear that at best it has been disappointingly slow in coming.[1] Table 2 shows per capita income growth by region and income level for the past two decades. The countries growing the slowest are low-income countries (excluding China and India), which is due in part to the abysmal growth performance of sub-Saharan Africa. The fastest growth is in middle income East Asia, and in high-income developing countries (largely oil exporters). OECD countries grew at roughly the same rate as lower middle-income developing countries, while upper middle-income countries grew slightly faster.

These differences no doubt partly reflect different levels of investment, saving, and policy distortions across countries, since these do have an effect in the transition to the steady state in the Solow model. Table 2 shows, for example, the low level of investment and saving in sub-Saharan Africa as compared to the high levels in East Asia. Corden (1971) showed how trade policy can affect growth in the transition to the steady state in the Solow model. Much empirical work has indeed shown growth to be negatively affected by trade policy distortions, financial sector distortions,

1. See Romer (1986), Baumol (1986), Barro (1989b) and Barro and Sala-i-Martin (1989)

Table 2: Growth, Investment and Saving

	Average Per Capita Income Growth 1965-87	% Share of GDP 1987	
		Gross Domestic Investment	Gross Domestic Saving
Low income	3.1	28	26
China and India	3.9	31	31
Other	1.5	19	15
Middle income	2.5	23	25
Lower	2.2	21	21
Upper	2.9	25	27
High income	2.3	21	21
OECD	2.3	21	21
Other 1/	3.5	25	24
Low and middle income by region			
Sub-Saharan Africa	0.6	16	13
East Asia	5.1	30	35
South Asia	1.8	22	19
Europe, Middle East, North Africa	2.5	n.a.	n.a.
Latin America & Caribbean	2.1	18	20
Low and middle income			
Maximum	8.9		
Minimum	-2.7		

Source: World Bank (1989)

1/ Countries classified by UN or otherwise regarded by their authorities as developing.

macroeconomic instability, and current government spending, among other policy variables.[2]

However, much of the empirical work on growth and endogenous economic variables does not directly use the Solow model or any other theoretical framework. Much of it is open to question as to direction of causality -- perhaps growth leads to good policies rather than the other way around. In the absence of good measures of many policy distortions and without knowledge of the underlying functional relationship between these distortions and growth, the impact of any particular policy change on growth is still in doubt.

2. From the Solow transition to the new growth literature

While the Solow model can provide a framework to relate policy variables to growth in the transition to the steady state, this is not very satisfactory. For any plausible value of the share of capital in output, the per capita growth rate declines rapidly with capital accumulation because of diminishing returns. However, as we already saw, long-run per capita growth in the Solow model depends only on exogenous technological change.

Table 3 shows a simulation of a Solow-type CES model with constant returns to scale, with alternative parameters for the share of capital and the elasticity of substitution (e.s.).[3] Beginning from arbitrary initial stocks

---

2. A survey of the empirical literature and some further empirical testing is provided in Easterly and Wetzel (1989). Another general empirical discussion is contained in Chenery et al. (1986).

3. Strictly speaking, the "capital share" parameter referred to is the coefficient on capital in the CES function, which is only equivalent to the share of capital in output in the Cobb-Douglas case where e.s.=1.

TABLE 3: Per capita growth rate during transition to steady state from Solow model

	Capital share=0.6 at e.s.=1				Capital share=0.4 at e.s.=1			
	Elasticity of substitution:				Elasticity of substitution:			
Year	0.5	1.0	2.5	5.0	0.5	1.0	2.5	5.0
1	7.5%	7.3%	7.2%	7.2%	4.8%	4.7%	4.8%	4.8%
2	6.7%	6.8%	6.9%	6.9%	4.0%	4.3%	4.4%	4.5%
3	5.9%	6.3%	6.6%	6.7%	3.4%	3.8%	4.2%	4.3%
4	5.2%	5.9%	6.3%	6.5%	2.8%	3.5%	3.9%	4.1%
5	4.6%	5.5%	6.1%	6.3%	2.4%	3.2%	3.7%	3.9%
6	4.1%	5.2%	5.9%	6.1%	2.1%	2.9%	3.5%	3.7%
7	3.6%	4.9%	5.7%	6.0%	1.8%	2.7%	3.3%	3.6%
8	3.2%	4.6%	5.5%	5.8%	1.6%	2.5%	3.2%	3.4%
9	2.9%	4.4%	5.3%	5.7%	1.4%	2.3%	3.0%	3.3%
10	2.6%	4.1%	5.2%	5.5%	1.2%	2.1%	2.9%	3.2%
20	0.9%	2.5%	4.1%	4.6%	0.4%	1.1%	1.9%	2.3%
30	0.4%	1.6%	3.4%	4.1%	0.2%	0.6%	1.4%	1.7%
40	0.2%	1.1%	3.0%	3.8%	0.1%	0.4%	1.0%	1.4%
50	0.1%	0.8%	2.6%	3.6%	0.0%	0.2%	0.8%	1.1%
100	0.0%	0.2%	1.8%	3.1%	0.0%	0.0%	0.2%	0.5%
infinite	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Note: Investment ratio=.20 for all simulations of capital and labor, per capita growth will initially take place as the capital/labor ratio is increased towards its steady state value (which is zero in this simulation since there is no technological change). We begin with the year in which the growth rate is roughly the same for any elasticity of substitution. Growth will be higher with a higher share of capital for fixed initial stocks of capital and labor because the marginal product of capital will be higher.

For all the various parameter combinations, there is a significant fall-off in per capita growth over periods as short as a decade. The relative decline in growth is more severe the lower is the share of capital and the lower is the elasticity of substitution. In the worst case in the table (capital share=.4 and e.s.=0.5), per capita growth after a decade is only a quarter of growth in the first year. But even in the best possible case of extremely high e.s.(=5) and capital share (=.6), per capita growth still falls from 7.2 percent to 5.5 percent over a decade. There is little evidence of such rapid deceleration in growth in practice, which makes the Solow transition unappealing as a model of supply-side growth.[4]

Recent works in the theoretical literature have addressed this problem by dropping one of the key assumptions to the Solow model -- constant returns to scale. Such authors as Lucas (1987), Romer (1986, 1987, 1988, 1989a, 1989b), Obstfeld (1989) and Barro (1989a, 1989b) postulate increasing returns that arise either from technological externalities from investment in physical capital or spillovers from accumulation of human capital. With increasing returns, per capita growth is possible in the long run based on capital accumulation alone. The door is opened again for endogenous economic variables, and thus policy, to affect the rate of long-run growth.

4.In principle, this deceleration could be countered by technical progress and increased labor quality, but there is no reason to assume these will offset

II. An increasing returns model of distortions and growth

The model in this paper is intended as an illustration of the kind of effects policy distortions can have on growth in an increasing returns economy. It postulates a simple form of increasing returns that results in a linear relationship between output and capital. It then considers the effect of a distortion that causes the marginal products of different types of capital to diverge. The relationship between the distortion and the rate of growth is highly nonlinear, which suggests a certain caution about simplistic assumptions about the effect of distortions on growth.

1. The model

Equation (1) shows the production function that will provide the basis for our analysis.

$$(1) \qquad Q = A \left[(1 - \gamma_p) K_1^{\rho_1} + \gamma_p K_2^{\rho_1} \right]^{\frac{1-\beta}{\rho_1}} L^{\beta}$$

Output is a function of the stock of technological knowledge A, two types of capital K_1 and K_2, and labor L. The functional form chosen is a CES function of the two types of capital nested within a Cobb-Douglas function for total capital and labor. The function exhibits constant returns to scale in the three inputs. The main focus of the analysis will be on substitution between the two types of capital and so the more general CES form is chosen with elasticity of substitution $1/(\rho_1 - 1)$.

The distortion that will be considered is one that causes the marginal products of the two forms of capital to diverge:

$$(2) \qquad \frac{\frac{\partial Q}{\partial K_1}}{\frac{\partial Q}{\partial K_2}} = e^t$$

This specification covers any type of distortion that induces extra costs to the users of type 1 capital.[5] The most obvious is a tax by the government on the use of type 1 capital, with type 2 capital exempt. The distinction between the two capital types could reflect ownership, location, or other characteristics: rural versus urban capital, human versus physical capital, formal versus informal sector, corporate versus household capital, imported versus domestically produced capital goods, or foreign-owned versus domestically-owned capital. Besides taxes, other forms of distortion could include credit subsidies or quantitative credit allocation to particular capital types, or tariffs or QR's on imported capital goods. It could even include macroeconomic instability that induces noise in relative prices of capital goods.

Defining K_p as the sum of the two forms of capital, we can solve for their relationship to K_p from (2). The distortion t induces more of type 2 capital to be held relative to type 1 capital than is socially optimal:

$$(3) \qquad K_2 = \frac{\left(\frac{\gamma_p}{1-\gamma_p}\right)^{\frac{1}{1-p_1}} e^{\frac{t}{1-p_1}} K_p}{1 + \left(\frac{\gamma_\rho}{1-\gamma_\rho}\right)^{\frac{1}{1-\rho_1}} \cdot e^{\frac{t}{1-\rho_1}}}$$

---

5. We assume the same user cost for the two types of capital excluding the distortion.

$$K_1 = \frac{K_p}{1 + \left(\frac{\gamma_p}{1-\gamma_p}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}} \tag{4}$$

The specification of the technological knowledge parameter A as endogenous is what will make the economy exhibit increasing returns. Following Romer (1986), we simply specify technological knowledge as a function of the stocks of capital and labor:

$$A = \alpha K_p^{\lambda} L^{\xi} \tag{5}$$

In the long run, the stock of knowledge will be positively related to the stock of capital. This is because of learning that takes place in the process of creating physical or human capital, including the unintended spillovers to knowledge in other areas outside the one receiving the investment. More generally, innovation and investment respond to fundamentally the same incentives, so that in the long run an increase in capital will be associated with an increase in the stock of knowledge.

Of course, in the short run changes in capital are not necessarily matched by changes in knowledge -- a war that wipes out half a nation's physical capital leaves its stock of knowledge untouched. Also, the stock of knowledge will be influenced by investment in other countries, so there will be externalities across national borders. This last fact is not addressed by our model, but it is probably not as serious as it first appears, since much of the relevant knowledge is at the very specific level needed to implement technical advances in local circumstances.

The relationship between labor and the stock of knowledge is less clear. On one hand, there is the argument that the larger the population the more likely it is to produce an Einstein who will make a huge contribution to knowledge. On the other side, some have argued that abundant labor (relative to land or capital) acts as a disincentive to innovation -- "necessity is the mother of invention." The relative scarcity of labor in the 19th century U.S., for example, has been cited by some economic historians as the key factor explaining the huge amount of labor-substituting innovation that took place.[6] So ξ in equation (3) could be positive or negative.

Substituting from (3), (4) and (5) into (1), we get the following expression for output as a function of aggregate capital and labor:

$$(6) \qquad Q = \alpha\Phi K_p^{1+\lambda-\beta} L^{\beta+\xi}$$

where Φ is given by:

$$(7) \qquad \Phi = \left[(1-\gamma_p) \left(\frac{1}{1 + \left(\frac{\gamma_p}{1-\gamma_p}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}} \right)^{\rho_1} + \gamma_p \left(\frac{\left(\frac{\gamma_p}{1-\gamma_p}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}}{1 + \left(\frac{\gamma_p}{1-\gamma_p}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}} \right)^{\rho_1} \right]^{\frac{1-\beta}{\rho_1}}$$

To analyze the steady state, it is convenient to study cases where output is linearly related to capital, as in traditional development models and the models of Romer (1986) and Barro (1989a). For that we would assume

6. Habakkuk (1962).

$\lambda = \beta$. For the role of labor in the steady state, we consider three special cases that lead to similar analytical forms, although they have different interpretations. The most obvious is one where population is stationary in the steady state, so that we can normalize L=1 and it will drop out of (6). Secondly, we could assume ξ is equal to $1-\beta$, implying that output is a linear function of labor, or that per capita income is a function of the capital stock.

Finally, ξ could be equal to $-\beta$, implying that that technical knowledge is negatively related to labor and that total output is not a function of labor in the steady state. Capital is defined to include human capital, so labor skills continue to have an effect on production. Such a relation would only hold in the long run -- a relative decrease in labor creates an incentive to accumulation of technical knowledge that exactly offsets the decline in physical labor. In the short run, increases in labor still increase output.

Assuming that $\lambda = \beta$ and that labor is constant in steady state (or $\xi = -\beta$), we get the following expression for gross output:

(8) $$Q = \alpha\Phi K$$

It follows that growth in output will be given by the following:

(9) $$g = \alpha\Phi i - \delta$$

where i is the ratio of gross investment to output and δ is the rate of depreciation on capital. Growth is a function of the rate of gross investment, and the productivity of capital $\alpha\Phi$. Capital productivity reflects the effects of the distortion t, as shown in (7).

In the steady state in the open economy, investment will be equal to the saving rate plus some sustainable amount of foreign borrowing. We define sustainability as the requirement that the ratio of foreign debt to the capital stock be constant in the long run. Then investment will be given by the following in steady state:

$$(10) \qquad i_p = s_p - \frac{(r-g)\ \kappa_p}{\alpha\Phi}$$

where r is the real interest rate paid on foreign debt and κ_p is the ratio of debt to the capital stock. Substituting from (10) into (9), we can get a reduced form for the growth rate as follows:

$$(11) \qquad g = \frac{1}{1-\kappa_p}\left(\alpha\Phi s_p - r\kappa_p - \delta\right)$$

Growth will be given by the total productivity of saving, as measured by the saving rate times the productivity of capital, less interest on debt and depreciation, times the multiplier $1/(1-\kappa_p)$ that reflects the leveraging of saving into capital accumulation.

We can then substitute (11) back into (10) to get the steady state rate of investment:

$$(12) \qquad i_p = \frac{s_p - (r + \delta)\ \kappa_p/\delta\Phi}{1-\kappa_p}$$

2. Simulations of distortion and steady-state growth

We can simulate equation (11) to show the relationship between growth and distortion for plausible parameter values.[7] Figure 1 shows the steady state growth rate that corresponds to different values of t. It is clear that the relationship is highly nonlinear. As t increases from zero, the effect on growth is slight at first. Successive increases in t, however, cause larger and larger decreases in growth, as shown in the second panel of figure 1. However, at some point the effect on growth from successive distortion increases again diminishes. As t gets very large, the growth rate asymptotically approaches a minimum.

The nonlinear behavior of the model reflects two fundamental economic phenomena. The first is the phenomenon of diminishing returns. Although increases in total capital lead to proportional increases in output, increases in one form of capital alone will lead to successively smaller increases in output. As higher and higher distortions induce capital to shift from type 1 to type 2, more output and growth is sacrificed as diminishing returns set in on the use of type 2 capital. However, as the distortion increases the use of type 1 capital approaches zero. As it gets close to zero, the damage caused by additional increases in distortion become slight. Intuitively, there is not much difference between the effect of a 500% tax and a 600% tax -- both lead to the disappearance of the factor being taxed. Thus, growth reaches an absolute minimum (about 5% in figure 1) no matter how high the distortion.

A real world example of this phenomenon might be the informal sector as dramatized recently by de Soto (1987). A high level of state regulation of

7. For the base case, we specify $\alpha = .798$, $\beta = .4$, $\delta = .05$, $\rho_1 = .6$ (elasticity of substitution = -2.5), $\gamma_\rho = 0.5$, r = 0.1, and $s_p = .28$.

Figure 1a

GROWTH AND DISTORTION
(ELASTICITY OF SUBSTITUTION=-2.5)

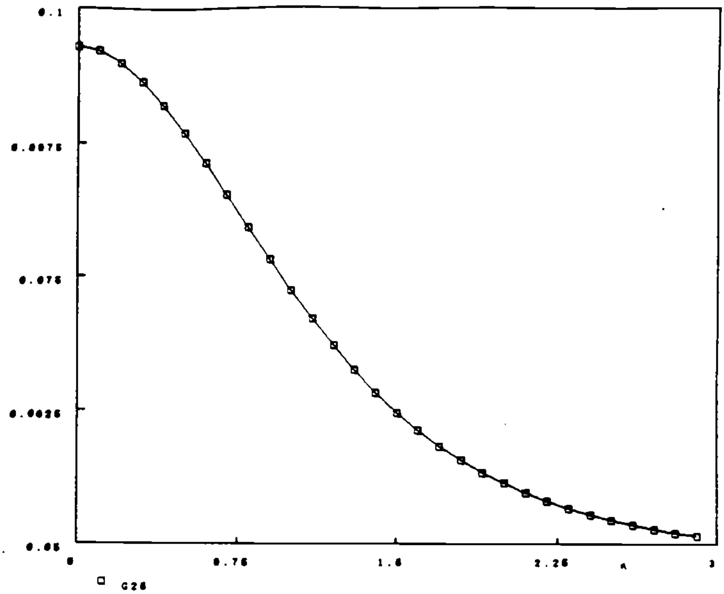
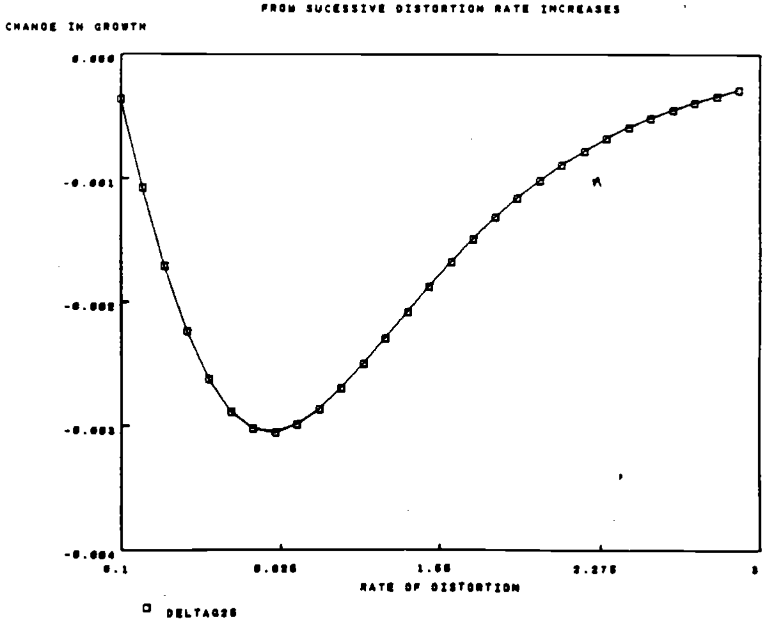


Figure 1b

CHANGE IN GROWTH
FROM SUCESSIVE DISTORTION RATE INCREASES



the formal sector simply causes capital to be transferrred to the informal sector. Growth continues at a certain level outside the control of the state, although it is lower than it would be if the formal sector were also unregulated, since the two types of capital are not perfect substitutes.

3. Sensitivity to structural parameters

It is clear from the expression for Φ in (7) that the critical parameter is the substitution parameter ρ_1. To see the effect of this parameter on behavior of the model, we consider alternative values of the elasticity of substitution (with absolute value equal to $1/(1-\rho_1)$). Figure 2 shows distortion-growth relationship for 2 extreme values of the elasticity of substitution -- 0.5 and 5.0 in absolute value. At low levels of distortion, the growth rate is higher with the lower elasticity. With inelastic substitution between types of capital, resource allocation is not changed as much by a given distortion and the loss of output is not as great.

However, as the distortion increases, growth reaches a minimum with the higher elasticity, but continues to decline with the inelastic production function. It can be shown from (7) that Φ goes to zero if the elasticity of substitution is less than or equal to one, while it has a nonzero limit if the elasticity is greater than one.[8] Intuitively, if the substitution of type 2 for type 1 capital is not strong enough to offset the effect of the distortion, then output goes to zero as t increases. To put it another way,

8. If the elasticity of substitution is less than one in absolute value, then ρ_1 is negative. Thus, the first term in (7) explodes as t goes to infinity. Since the exponent $(1-\beta)/p_1$ is also negative, Φ goes to zero. If $\rho_1 > 0$, then Φ converges to γ_ρ raised to the power of $(1-\beta)/\rho_1$.

Figure 2a

GROWTH AND DISTORTION
ALTERNATIVE ELASTICITIES OF SUBSTITUTION

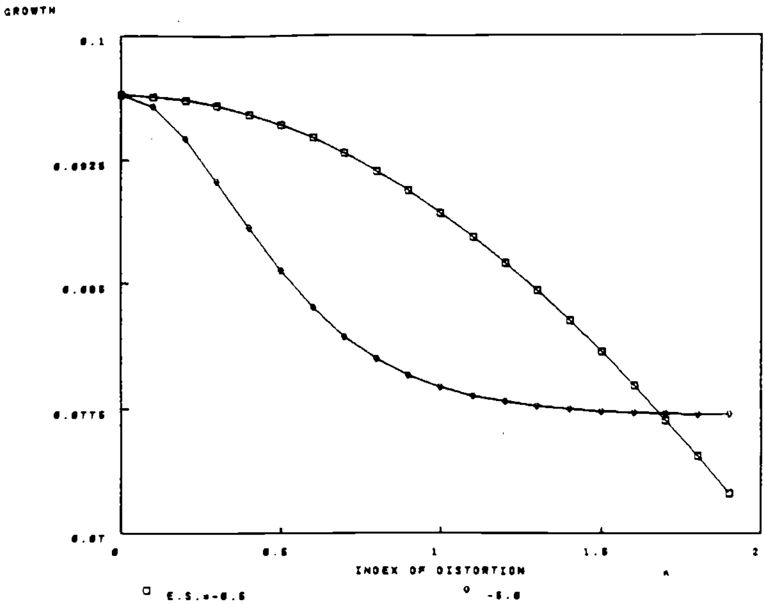
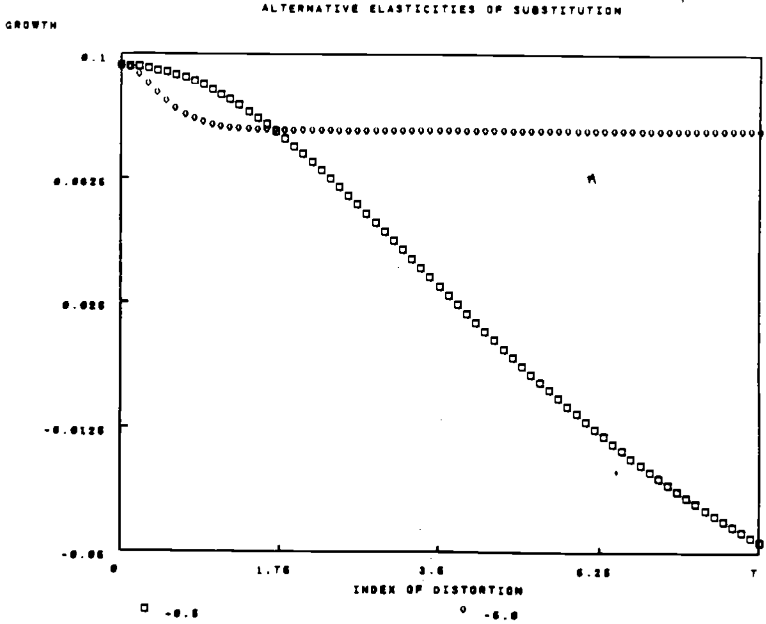


Figure 2b

GROWTH AND DISTORTION
ALTERNATIVE ELASTICITIES OF SUBSTITUTION



type 2 capital is not a good substitute for type 1 capital. As the use of type 1 capital is driven to zero by an arbitrarily large distortion, output will also go to zero.

The results of the model suggest that we must carefully evaluate the structure of the economy and the initial level of distortion in order to predict the long run effect of reducing distortions. In an economy with a low elasticity of substitution, reducing a small distortion may have little effect on growth. As figure 2 showed, the growth-distortion relationship is very flat for low distortion levels if the elasticity of substitution is small. Conversely, in an economy with a high elasticity of substitution, a small reduction in a high rate of distortion also may not have much effect. Such an economy may have already passed the rate of distortion at which the growth rate reaches a minimum. The true payoff to distortion reduction comes in the steep part of the curves in figure 2, which comes at lower rates of distortion in the high-substitution economy.

An example where the elasticity of substitution would be important in practice can be given by treating K_1 as imported capital goods and K_2 as domestically produced capital goods. The distortion t would be an import tariff or quota that raises the user cost of K_1. If the structure of the economy (resource endowments, size of the economy, etc.) is such as to foster an efficient domestic capital goods industry, then K_1 and K_2 would be close substitutes. In this case, even low levels of the tariff or quota premium t would distort resource allocation and lower growth significantly. However, as t is increased, the use of imported capital goods would approach zero and further changes in t would not make much difference to the rate of growth.

On the other hand, an economy in which structural characteristics restrict the scope of the domestic capital goods industry would have a low elasticity of substitution between K_1 and K_2. In this economy, small changes to low import tariffs or quota premia on capital goods would not make much difference. As import restrictions are tightened further and further, however, the damage to output and growth is practically unlimited. The use of imported capital goods does not go to zero very fast as t increases because they have no close substitute.

The implications of trade liberalization for capital goods would be very different in these two types of economies. In the high-substitution economy, small reductions in tariffs or quotas would be beneficial from low initial levels, but would not make much difference if initial tariffs or quota premia are high. In the low-substitution economy, trade liberalization from low distortion levels would make little difference, but would be very effective if initial trade distortions were high.

The finding that there is a maximum loss of growth associated with distortion also has important policy implications. If the substitution elasticity is high enough, the loss of growth from distortion may be small enough that it can be offset by other policy measures. Table 4 shows the maximum loss of growth associated with an infinite level of distortion for different elasticities of substitution. At elasticities of substitution higher than 2.5, the drop in the growth rate is under 5 percentage points.

The obvious variable to play the role of offsetting influence on growth in our model is saving. Since Φ reaches a nonzero limit as t goes to infinity with the elasticity of substitution greater than one, there is a finite amount of saving that can offset even an infinitely large distortion in such economies. Table 5 shows the saving increase that would be required. With e greater than 2.5, the increase in the saving rate is less than nine points of GDP. While this represents a massive loss in welfare, it does show

TABLE 4:

Maximum decline in growth rate from infinitely large distortion-- alternative elasticities of substitution

Elasticity of substitution	Maximum decline in growth rate
1.3	0.147
1.5	0.111
1.7	0.088
1.9	0.073
2.1	0.062
2.3	0.054
2.5	0.048
2.7	0.043
3.1	0.035
3.3	0.033
3.7	0.028
4.1	0.025
5.0	0.019

that even the most highly distorted economy can grow rapidly if saving is high enough. This may help to explain why an economy such as China known to be characterized by high state intervention and distortion could still grow respectably with a high saving rate.[9]

The other important structural parameter in the production function is the coefficient γ_p. This measures the technological importance of K_2 in the production function. If the elasticity of substitution is equal to unity (Cobb-Douglas), then γ_p is the value share of K_2 in total capital. With an elasticity of substitution different from unity, the share of K_2 will not be constant but will still be positively affected by γ_p.

Figure 3 shows the effect of changing γ_p on the growth-distortion relationship. A larger γ_p means that the type of capital favored by the distortion t is more important in total production, while the type of capital being penalized is less important. This will imply that a given distortion is much less damaging to growth, as shown in figure 3.

A real world example of the effect of γ_p can be given by once again treating K_1 as formal sector capital and K_2 as informal capital. If γ_p is high, then informal sector capital has a large weight in the production function, while the modern sector has a small weight. The effect of distortions imposed on the modern sector would be modest in such a case.

How γ_p differs across countries is not very clear. Even in countries that appear to have a large share of production accounted for by informal capital, it is difficult to distinguish whether this is due to the relative

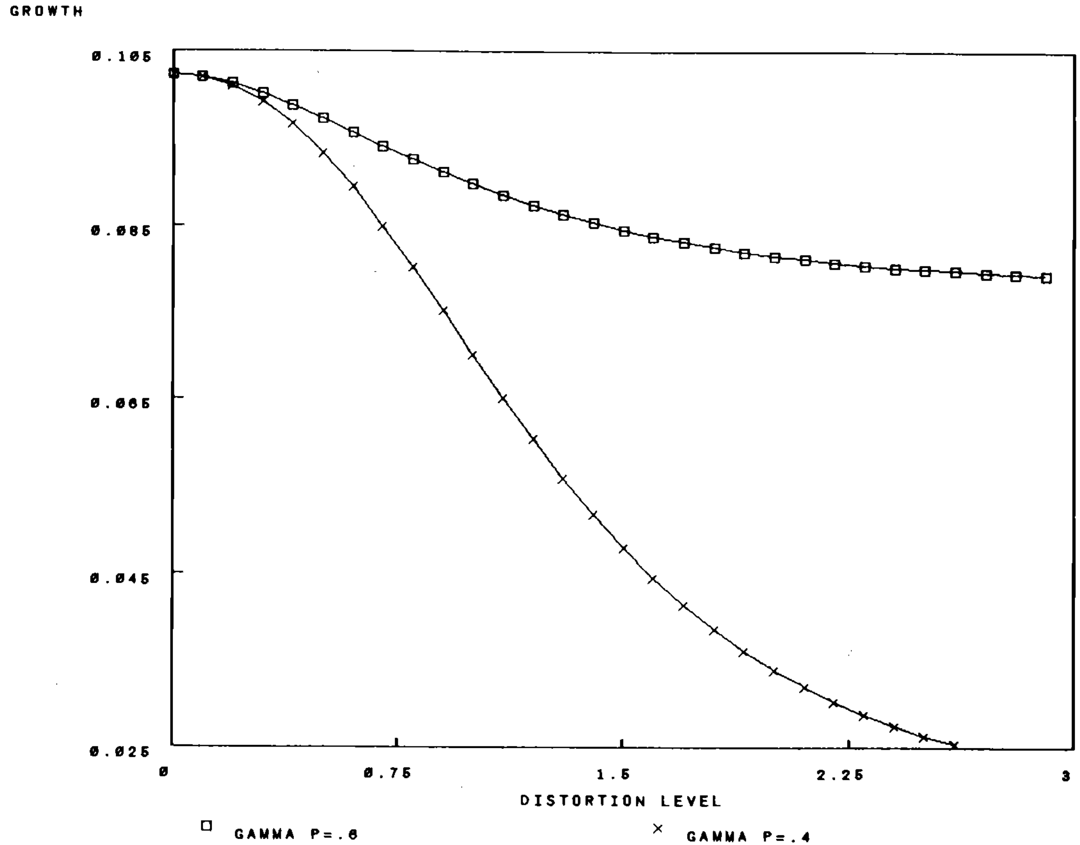
9. This contrasts to the explanation of Lucas (1988) who argued that the fact that centrally planned economies have respectable growth rates confirms that distortions only have level effects rather than growth effects.

TABLE 5: Required increase in saving to offset decrease in growth due to infinite distortion

Elasticity of substitution	Required increase in saving (ratio to GDP)
less than/equal to 1	infinite
1.300	0.840
1.500	0.363
1.700	0.227
1.900	0.164
2.100	0.129
2.300	0.106
2.500	0.089
2.700	0.078
2.900	0.069
3.100	0.061
3.300	0.055
3.700	0.047
4.100	0.040
5.000	0.031

Figure 3

EFFECT ON GROWTH OF SHARE OF FAVORED CAPITAL
ALTERNATIVE DISTORTION LEVELS (elasticity of substitution=2.5)



size of K_1 and K_2 or to the technological parameter γ_p. The former is an endogenous response to distortion, while the latter is exogenous. However, a larger share of informal capital in one country with the same distortion level as another would imply a larger γ_p in the first country, which may be due to cultural and historical factors or the overall level of development.

III. Distortionary taxes, size of government, and growth

The variable t has been treated so far as a generic distortion that simply causes marginal products of capital to diverge. We can extend the model to the analysis of fiscal behavior by treating t strictly as a tax on one form of capital. We will also treat this tax as the only form of tax revenue for the government. While an exaggeration, this is not unlike the situation in many developing countries where taxes are highly distortionary and large segments of the economy escape taxation altogether. A common situation is that the capital in the rural/subsistence/traditional sector largely escapes taxation, while the modern sector or export sector is heavily taxed.

Although the state lowers growth by imposing distortionary taxes, it can also contribute to growth by providing essential public goods such as roads, sanitation services, etc. Lack of such public goods in the absence of the state is itself a distortion. Since these are financed by taxes, we have a tradeoff between two types of distortions -- one caused by insufficient public goods and one caused by distortionary taxes.

1. The Model

We modify the production function from (1) to include a public capital stock:

$$(13) \qquad Q = A \left[\left(\gamma_1 K_1^{\rho_1} + \gamma_2 K_2^{\rho_1} \right)^{\frac{\rho_2}{\rho_1}} + \gamma_G K_G^{\rho_2} \right]^{\frac{1-\beta}{\rho_2}} L^{\beta}$$

Total capital K will be the aggregate of the two types of private capital (K_1 and K_2) and public capital K_G. The form of the production function is a CES function of the two types of private capital nested within a CES function of public and private capital, which is in turn nested within a Cobb-Douglas function for capital and labor. Thus, ρ_1 is the substitution parameter between the 2 types of private capital, while ρ_2 is the substitution parameter between public and private capital. We make the same assumptions about A as before except relating to total capital K. Equations (3) and (4) continue to hold for the determination of the two types of private capital as a share of total private capital, with $\gamma_1 = 1-\gamma_\rho$ and $\gamma_2 = \gamma_\rho$. Denoting k_p as the share of private capital in the total, we can substitute from (3), (4), and (5) into (13) to derive a new expression for Φ:

$$(14) \qquad \Phi = \left[\left(\gamma_1 \left(\frac{k_p}{1+\left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}} \right)^{\rho_1} + \gamma_2 \left(\frac{\left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}} k_p}{1+\left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}} \right)^{\rho_1} \right)^{\frac{\rho_2}{\rho_1}} + \gamma_G \, (1-k_p)^{\rho_2} \right]^{\frac{1-\beta}{\rho_2}}$$

Output continues to be given as a linear function of K with $\alpha\Phi$ as the output-capital ratio. Thus growth can be given as a function of public and private investment analogously to (6) above. We will define public and private investment equations based on their saving behavior and sustainable borrowing, analogous to (10) above.

Tax revenue as a ratio to output will be given as the linear tax rate e^t-1 times the ratio of K_1 to output. Substituting from (4) for K_1, we get the following expression:

$$(15) \qquad \frac{TREV}{Q} = \frac{(e^t-1)\, k_p/(\delta\Phi)}{1 + \left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}}$$

The accumulation of government capital will then be given as the saving ratio s_G times tax revenue, less depreciation and interest on debt, plus new sustainable borrowing. The latter is defined as keeping the ratio of government debt to output constant, which implies new borrowing will be the growth rate times the ratio of debt to output, which in turn is equal to the debt-capital ratio κ_G times the ratio of the government capital stock to output:

$$(16) \qquad \frac{\dot{K}_G}{Q} = s_g \frac{TREV}{Q} - \frac{(1-k_\rho)\delta}{\alpha\Phi} - (r-g)\, \kappa_G \frac{(1-k_\rho)}{\alpha\Phi}$$

An analogous expression will hold for the accumulation of private capital in steady state, except that private income is defined as total output less the tax revenue collected by the government:

$$(17) \qquad \frac{\dot{K}_P}{Q} = s_p \left[1 - \left(\frac{TREV}{Q}\right)\right] - \frac{\delta k_p}{\alpha\Phi} - (r-g)\,\frac{\kappa_p k_p}{\alpha\Phi}$$

Substituting from (15) into (16) and (17), and in turn from (16) and (17) into the expression for g, we get the following expression:

$$(18) \qquad g = \frac{1}{1-\ (\kappa_G(1-k_p) + \kappa_p k_p)}\left[\alpha\Phi\ s_p - r\ (\kappa_G(1-k_\rho) + \kappa_p k_p) + (s_g - s_p)\left[\frac{e^t - 1}{1+\left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}}\right] k_p - \delta\right]$$

The right-hand side of (18) still contains an endogenous variable, the share of private capital in total capital, k_p. To derive the steady state level of k_p, we need another equilibrium condition. (18) is derived from the condition that the percentage change in total capital be equal to the growth rate. However, in a steady state for k_p, we also have the condition that the percentage change in private capital be equal to the percentage change in public capital. Equivalently, the percentage change in public capital must also be equal to the growth rate. From (16), this gives us the following expression for k_p:

$$(19) \qquad k_p = \frac{g + \delta + (r-g)\,\kappa_G}{g + \delta + s_G \left[\dfrac{e^t - 1}{\left(1 + \left(\dfrac{\gamma_2}{\gamma_1}\right)^{\frac{1}{1-\rho_1}} e^{\frac{t}{1-\rho_1}}\right)} \right] + (r-g)\,\kappa_G}$$

(18) and (19) together determine the steady state values of k_p and g.

2. Simulation of growth and tax revenue

We again use the method of simulating the model for plausible values of the parameters to illustrate the properties of the model.[10] The first relationship of interest is that between the tax rate and tax revenue, shown in figure 4. We get a standard Laffer curve relationship. As the tax rate increases from zero, tax revenue initially rises rapidly, then flattens out as the decline in the tax base offsets the increase in the rate. If the elasticity of substitution between K_1 and K_2 is greater than one, then the effect of the decline in the tax base will eventually outweigh that of the rate increase, so that revenue declines with rate increases.

The relationship between the growth rate and the tax rate is more complex than in the model without government. As shown in figure 5, the growth rate initially increases with a rise in the tax rate. This is because tax revenues finance the accumulation of public capital, whose optimal level is greater than zero. However, as more public capital is accumulated diminishing returns set in, while at the same time the effect of the

---

10. The parameters for the base case are $\alpha = 1.05$, $\beta = 0.4$, $\delta = .05$, $\kappa_G = 0.25$, $\kappa_p = 0.25$, $\gamma_1 = \gamma_2 = \gamma_G = 1/3$, $\rho_1 = \rho_2 = 0.5$ (elasticity of substitution $= -2$), $r = 0.1$, $s_g = s_p = .25$.

Figure 4

TAX REVENUE AS FUNCTION OF TAX RATE
(GOVERNMENT SAVING=.25)

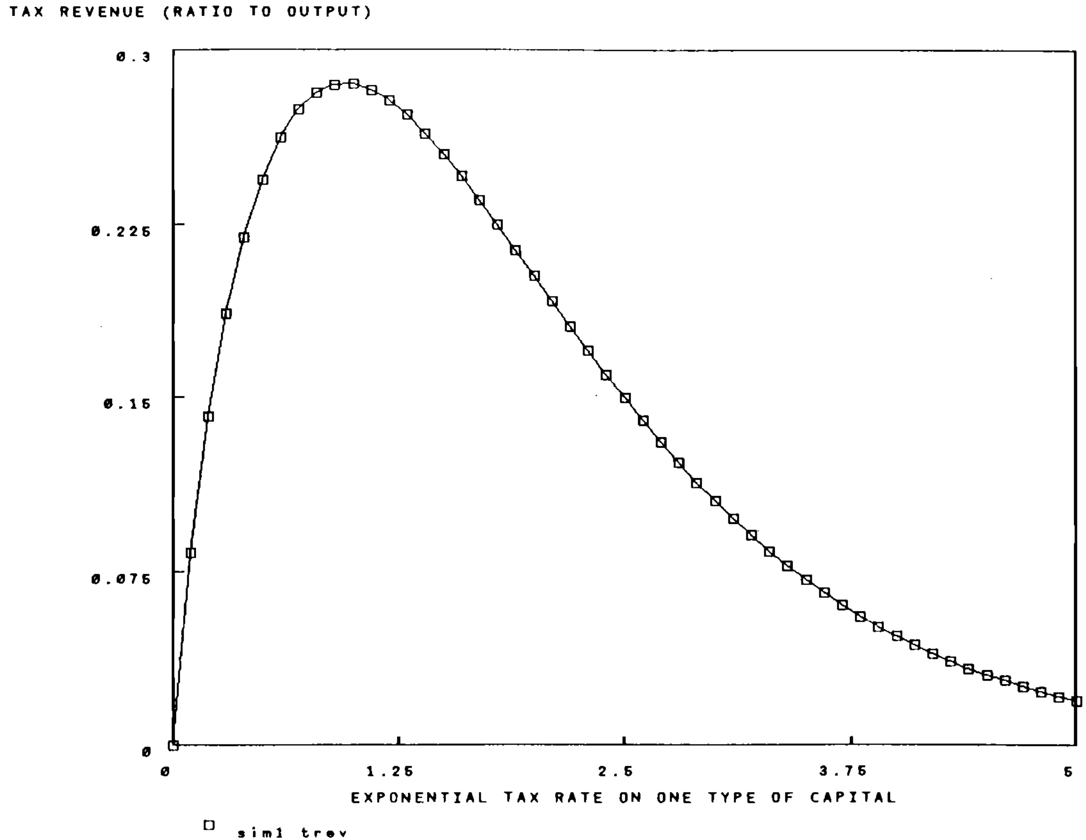
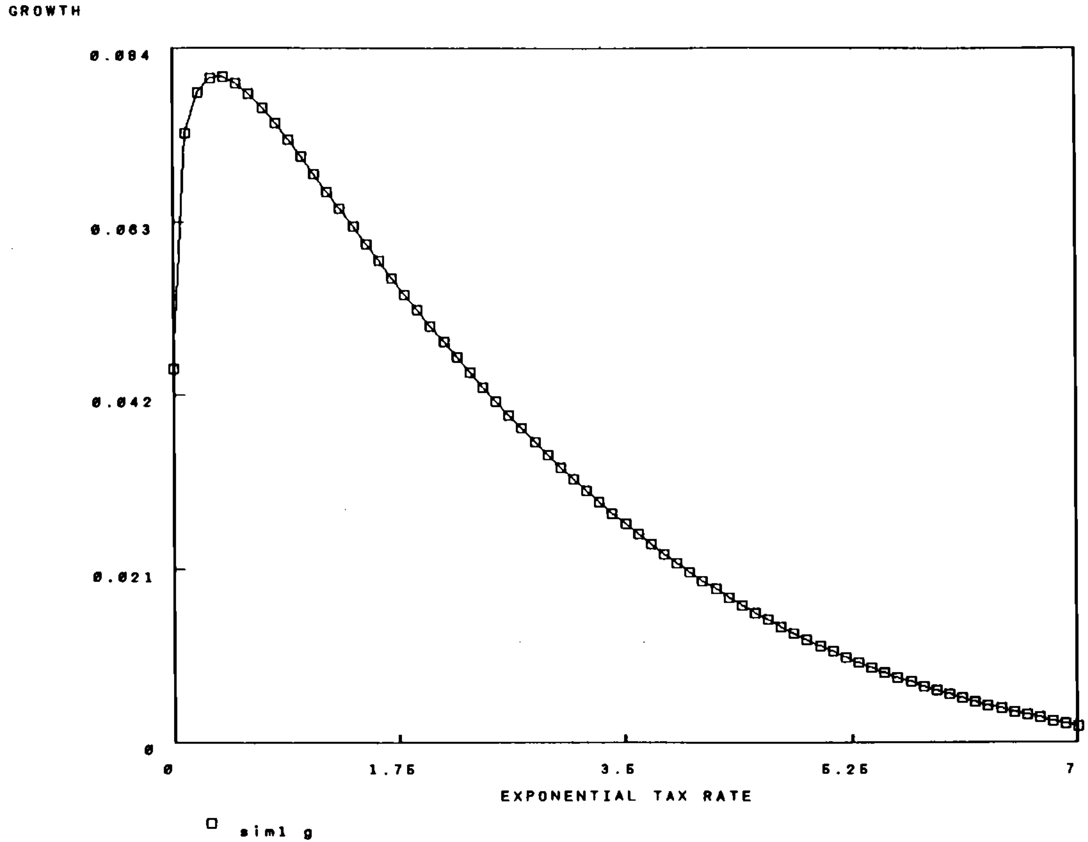


Figure 5

GROWTH AND TAX RATE
(GOVERNMENT SAVING=.25)



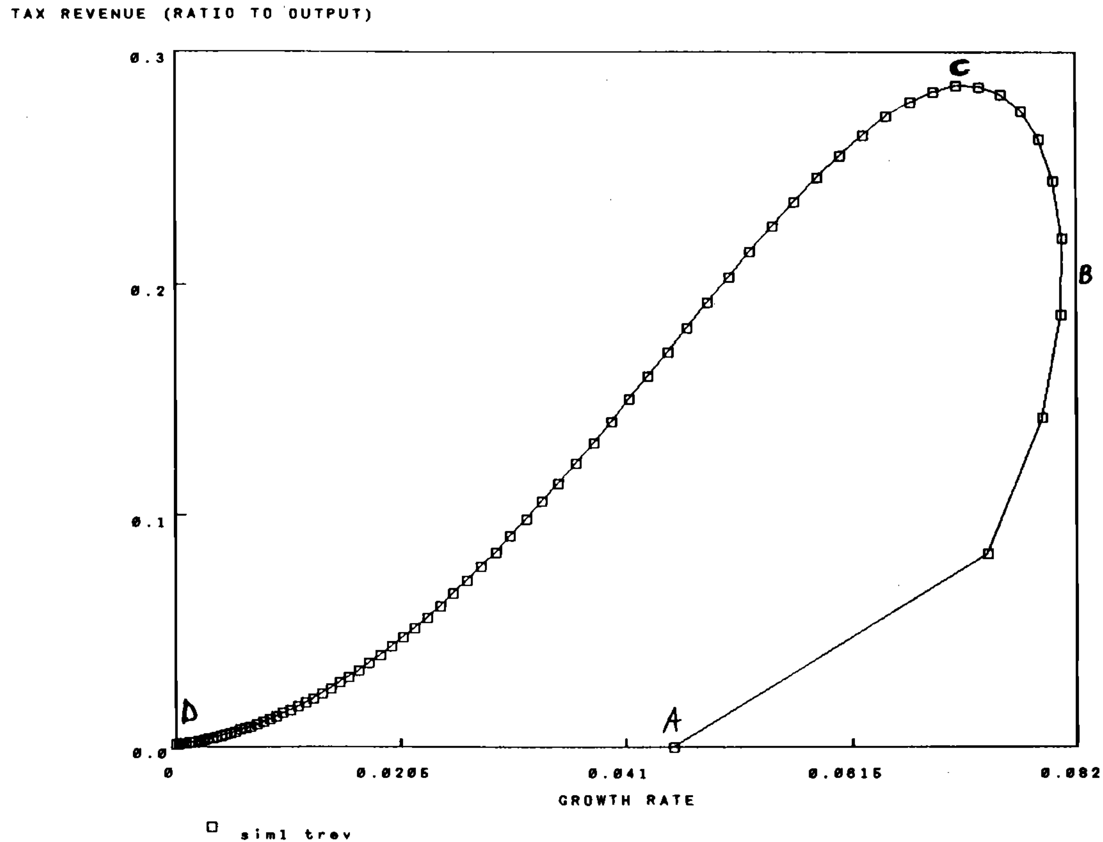
distortion to private capital allocation worsens with successive tax rate increases. Thus, at some point further tax rate increases will lower the rate of growth. From that point, the behavior of the growth-distortion relation is similar to the first model. Further increases in the tax rate are increasingly costly up to the point in which K_1 becomes close enough to zero that further rate increases do not make much difference. After that growth reaches a minimum if the elasticity of substitution is sufficiently large, just as in the model without government. However, the cost of an arbitrarily large tax rate will be larger in the model with government, because in addition to the arbitrarily large distortion the stock of public capital will approach zero as tax revenue goes to zero.

Putting figures 4 and 5 together, we can see the relationship between tax revenue and growth that will be traced out by varying the tax rate from zero to infinity. At point A in figure 6, the tax rate is at zero. Both growth and tax revenue increase strongly as the tax rate rises, since the additional tax revenue is used to finance the acquisition of productive public capital. Growth reaches a maximum at B, at which point the positive contribution of public capital to growth just offsets the negative effect of the tax distortion. From B to C, further increases in tax rates lead to a tradeoff between tax revenue and growth -- they continue to increase revenue (and public capital) but at the expense of a distortion severe enough to reduce growth. At C, tax revenue as a ratio to output reaches its maximum as in the Laffer curve of figure 4. From that point on, tax rate increases are counterproductive in terms of both revenue and growth -- revenue declines because we are on the "wrong" side of the Laffer curve, and growth declines because of the effect of the distortion. At point D, we converge to the

Figure 6

TAX REVENUE AND GROWTH

(GOVERNMENT SAVING RATE=.28)



minimum growth rate where tax revenue and the use of both K_1 and K_G are arbitrarily close to zero.

Figure 6 suggests caution on attempting to estimate the empirical correlation between growth and the size of government (as measured either by revenue or spending). If we think of countries with similar structure but different tax rates being distributed randomly along the curve, estimates of the relationship could be positive or negative. The absolute value of the coefficient on size of government in a growth regression could range from zero (at point B) to infinity (at point C). Even the interpretation of the coefficient is ambiguous. A positive relationship is implied by both of the segments AB and CD, but for much different reasons -- the former because tax rate hikes increase both growth and revenue and the latter because rate hikes decrease both. Causation is also problematic since both tax revenue and growth are endogenous.

To try to pin down where governments might wind up on figure 6 is a task for political economy theory. The benevolent growth-maximizing governments would tend to cluster around B. (As Barro (1989a) points out in a similar context, if we estimated a regression between growth and size of government from such a sample, we would erroneously conclude there was no relationship between the two.) The Buchanan-type patronage-maximizing state would move more towards point C (but not all the way if it also values future patronage which will increase with higher growth). In general, a rational state valuing some mixture of patronage and growth would be in the segment BC, which might explain the negative relationship traditionally found in empirical work. However, there are examples from the political economy literature of irrational outcomes from game-theoretic interactions between factions or coalitions, which could result in governments being along AB or CD.[11]

---

11. See the survey in Haggard (1989). See also Findlay (1989) and Srinivasan (1989) for provocative analyses of how the state behaves.

This model can also yield insight on the relationship between public and private investment. Figure 7 shows the combinations of public and private investment rates associated with different levels of the tax rate. This diagram should give us pause about the possibility of empirically estimating simple cross-section relationships between public and private investment, at least across steady states with different tax rates.

Initial increases in the tax rate (from zero at point A) increase growth sharply, which raises the financeable level of private investment (because the private sector can borrow more). However, the increase in tax revenue decreases private saving, lowering the financeable level of private investment. The two effects roughly offset each other for the initial increases in the tax rate (the positive effect even dominates at first). After that, however, "crowding out" of private investment by public investment takes place due to the redistribution of income from the private to the public sector with higher taxes. Growth could still be increasing over part of this range, however, if public investment is below the optimal level. At point B, tax revenue is maximized. Further tax rate increases lower revenue, so income is redistributed back towards the private sector, raising private and lowering public investment. At some point the effect of the distortion on growth becomes so severe, however, as to lower the financeable level of private investment again.

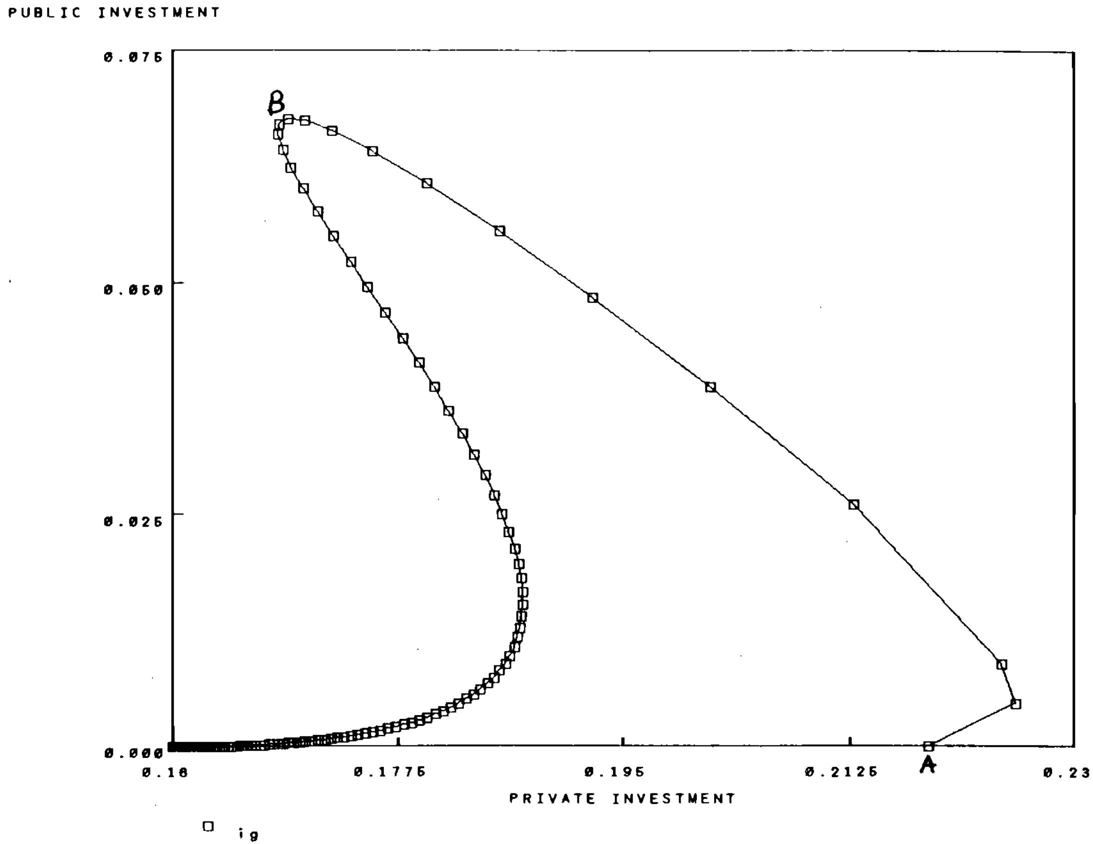
3. Tax reform and growth

So far we have taken as given that taxes are distortionary, since only one type of capital can be taxed. What if in fact a tax reform can be initiated that taxes both forms of capital equally? This makes it possible to finance the accumulation of public capital without distorting the allocation

Figure 7

PUBLIC AND PRIVATE INVESTMENT

ALTERNATIVE TAX RATES (GOVERNMENT SAVING=.25)



private capital between the two types. Tax revenue will be given as a function of private capital instead of type 1 capital alone. More tax revenue will be generated at each tax rate, while the tax rate itself does not directly affect growth.

A tax on all private capital makes it possible to generate a higher growth rate, since the tax will not distort private capital allocation and lead to efficiency losses. However, the difference is not dramatic--in the base case simulation described above, the maximum growth rate with a tax on one form of capital is 8.06%, while with a tax on all private capital maximum growth is 8.53%. Thus, reform of the tax system to tax all capital would lead to an improvement of roughly half a percentage point in the long run growth rate.

The effect of tax reform on growth is not large because we are comparing optimal policies in the two cases. With optimal policies, the tax rates will not be large--the optimal exponential rate is 36% with differential taxation and 25% in the case of uniform taxation of private capital. As was seen in the first section, the distortionary effect of low tax rates is limited, since diminishing returns have not come into play very strongly at low rates of distortion.

Tax reform makes much more of a difference if policies were not optimal to begin with. Figure 8 compares the relationship between tax revenue (as a ratio to output) and growth under uniform and differential taxation. It is evident that tax reform makes little difference if the initial level of revenue (and thus tax rate) is low. Roughly similar rates of growth are associated with low levels of tax revenue under the differential tax as under the uniform tax. Thus, a "revenue-neutral" tax reform at low levels of revenue would not increase growth very much.

Figure 8a

TAX REVENUE AND GROWTH
UNIFORM TAXES ON CAPITAL

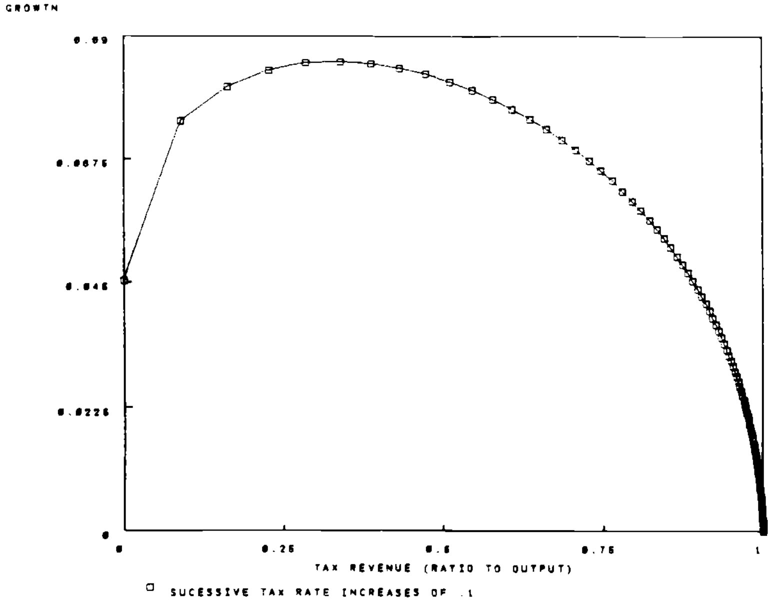
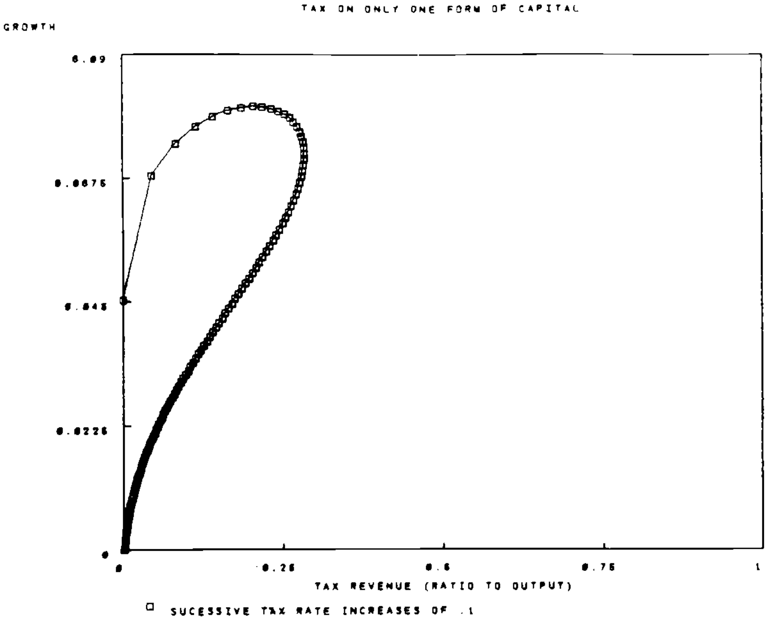


Figure 8b

TAX REVENUE AND GROWTH
TAX ON ONLY ONE FORM OF CAPITAL



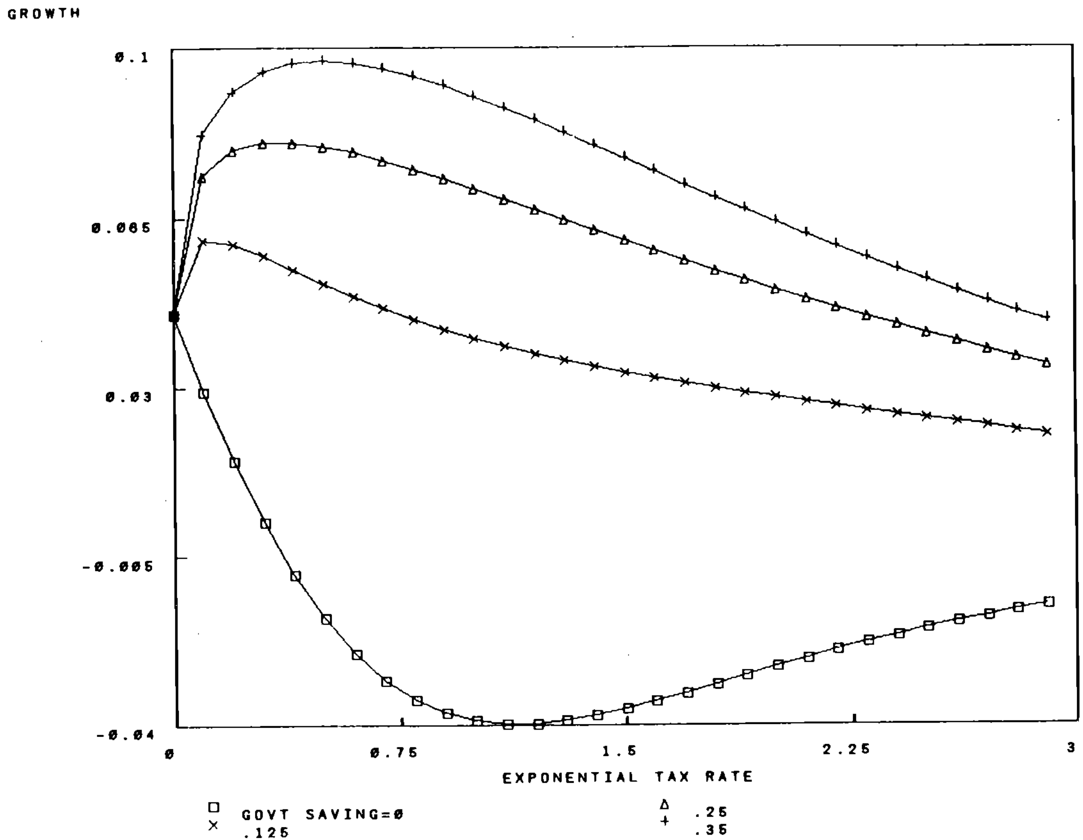
The picture changes, however, as further increases in tax rates and revenue are initiated under the two regimes. At the point of maximum revenue under the differential tax regime, growth is 1.3 percentage points lower than it is at comparable revenue levels under the uniform tax regime. After that, further increases in tax rates on one form of capital would cause both revenue and growth to fall. In such a situation, a "revenue-neutral" tax reform that involved both a reduction of the rate and an extension of the base would have two major benefits. It would move the economy back to the "right" side of the Laffer curve (a movement along the curve in figure 8(b)), and it would make possible a higher growth rate through less distortion of allocation of private capital (a movement from the curve in 8(b) to the curve in 8(a)). As can be seen from the graph, the first effect is likely to be more larger than the second. The value of a uniform tax rate regime is that it not only makes possible the attainment of a higher maximum growth rate, it also limits the damage from moving to the "wrong" side of the Laffer curve.

4. <u>The effect of government saving</u>

Beside the tax rate, the critical fiscal policy variable in this model is the saving rate s_G. This does not necessarily correspond to the traditional measure of government saving, i.e. current revenue less current expenditure. Rather it signifies the share of government tax revenue that is devoted to productive expenditure. This could include such staples of current expenditure as primary schoolteachers' salaries. Conversely, it would not include nonproductive items that might be included as part of traditional measures of government investment.

Figure 9 shows the implications of different government saving rates for the growth-tax rate relationship. In general, the higher the government saving rate, the higher the growth rate at each level of distortion, since a

Figure 9
TAX RATES AND GROWTH
ALTERNATIVE GOVERNMENT SAVING RATES



higher rate of government saving for a given tax rate and private saving rate raises total saving and total capital accumulation. It is also apparent from the graph that the growth rate will reach a maximum at a higher tax rate the higher is the government saving rate. Higher government saving means that tax rate increases pay off more in higher public investment, which will offset more the distortionary effects of the tax rate increases.

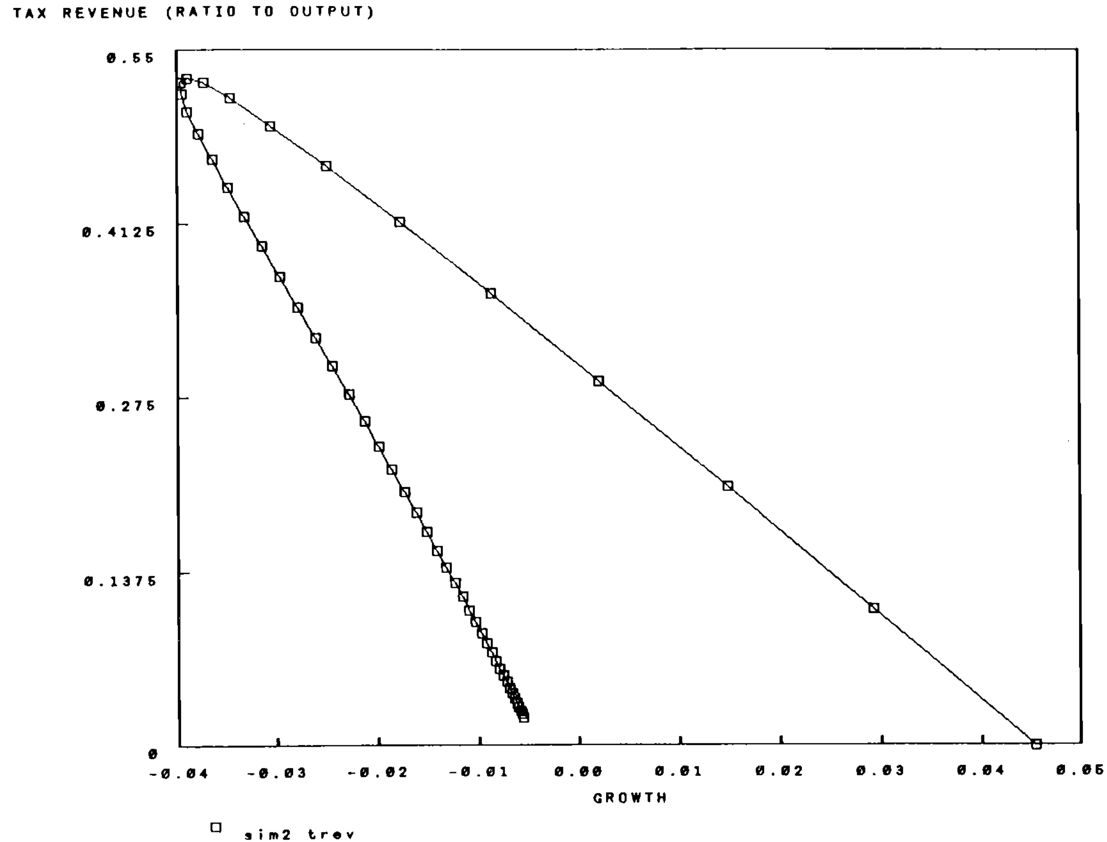
More unusual is the result shown in the graph for the extreme case in which the government has zero saving. Here tax rate increases always initially lead to a decrease in growth, since there is no offsetting benefit from productive government expenditure. Eventually, however, the growth rate hits bottom and then rises again with further tax increases. How can tax increases be good for growth if there is no productive government spending? The answer is that we are on the "wrong" side of the Laffer curve where tax rate increases decrease revenue, which in this case is a blessing in disguise. Since tax revenue is redistributing income from the high saving private sector to the zero saving government, a decrease in tax revenue has a positive effect on saving. This more than offsets the distortionary effect of tax rate increases in this case.

The implications of this peculiar case for the tax revenue-growth relationship are displayed in figure 10. Tax revenue is negatively related to growth, but with two possible slopes depending on which side of the Laffer curve we are on. Also it is apparent that maximum tax revenue is higher as a share of output than in the case of the high-saving government in figure 6. This is because tax revenue is a function of the share of type 1 private capital to output. Both the ratio of total capital to output and the ratio of private capital to total capital will be higher with a zero saving government.

Figure 10

TAX REVENUE AND GROWTH

(GOVERNMENT SAVING=0)



IV. Conclusions

The model in this paper has concentrated only on steady states and thus ignores much of the complexity of policy-making in which transitions play a large role. Although a model of transitions between steady-states would sacrifice the long-run simplicity of this model and give many ambiguous results, it is a fruitful area for further investigation. However, this paper has shown how a steady-state model can yield many insights.

The structural model of distortions and growth in this paper suggests that the relationship is more complicated than is acknowledged in most of the empirical work on growth. In particular, simplistic assumptions about linear inverse relationships between distortion and growth or between size of government and growth appear untenable. However, some of the complexities of the growth-distortion relationship can be captured by a simple increasing returns model that could in principle be estimated for a particular country.

Such a model could enrich the dialogue between advocates of liberalization and policymakers by recognizing that decreasing distortions does not have an equal effect on growth in all circumstances. The effect depends on how flexible the economy is (the elasticity of substitution), how large is the share of the factor being penalized in production, and how high distortions are initially. The policymaker should attempt to identify and to move along the steeply-sloped portion of the growth-distortion relationship where the payoff from reducing distortions is high. Small changes to either very low levels or very high levels of initial distortions have a minimal effect on growth. It would be unfortunate if policymakers expended political capital on such changes when the long run effects on growth are likely to be disappointing.

REFERENCES

Barro, Robert J. 1989a. "A Cross-Country Study of Growth, Saving and Government NBER Working Paper No. 2855. Cambridge, MA: NBER.

__________. 1989b. "Economic Growth in a Cross Section of Countries." Prepared for Conference on Human Capital and Growth, S.U.N.Y., Buffalo, May 1989.

__________ and Xavier Sala-i-Martin. 1989. "Economic Growth and Convergence Across the United States." Cambridge, MA: NBER.

Baumol, William J. 1986. "Productivity Growth, Convergence, and Welfare," American Economic Review, vol.76, no. 5, December: 1042-1085

Chenery, H., S. Robinson and M. Syrquin. 1986. Industrialization and Growth: A Comparative Study, Oxford University Press.

Corden, M. 1971. "The Effects of Trade on the Rate of Growth." In J. Bhagwati, et.al. eds., Trade, Balance of Payments, and Growth: Papers in Honour of Charles P. Kindleberger. Amsterdam: North-Holland.

de Soto, Hernando. 1987. El Otro Sendero, Bogota: Editorial Oveja Negra.

Easterly, William and Deborah Wetzel. 1989. "Policy Determinants of Growth: Survey of Theory and Evidence." PPR Working Paper.

Findlay, Ronald. 1989. "Is the New Political Economy Relevant to Developing Countries?" PPR Working Paper Series WPS 292.

Habakkuk, H. J. 1962. American and British Technology in the Nineteenth Century, Cambridge University Press.

Haggard, Stephan. 1989. "The Politics of Inflation and Stabilization in Middle-Income Countries," PPR Working Paper.

Lucas, R.E. 1988. "On the Mechanics of Economic Development." Journal of Monetary Economics 22, no. 1 (Jul.): 3-42.

Obstfeld, Maurice. 1989. "Saving, Investment, and Long-Run Growth," processed.

Romer, P.M. 1986. "Increasing Returns and Long-Run Growth." Journal of Political Economy 94, no. 5: 1002-1037.

_________. 1987a. "Growth Based on Increasing Returns Due to Specialization." American Economic Review 77, no. 2 (May): 56-62.

_________. 1987b. "Crazy Explanations for the Productivity Slowdown." In S. Fischer, ed., NBER Macroeconomics Annual. Cambridge: MIT Press.

_________. 1988. "Endogenous Technological Change." University of Chicago. May.

__________. 1989a. "Human Capital and Growth: Theory and Evidence." Processed, April.

__________. 1989b. "What Determines the Rate of Growth and Technological Change?" PPR Working Paper Series, WPS 279.

Solow, Robert. 1956. "A Contribution to the Theory of Economic Growth," Quarterly Journal of Economics, 70, February 1956, 65-94.

Srinivasan, T.N. 1989. "Political Economy of Foreign Trade Regimes," Yale University, processed.

World Bank. 1989. World Development Report 1989. Oxford University Press.