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Macroeconomic Adjustment and Growth

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Growth in Open Economies

Sergio Rebelo

A simple modification of recent growth models eliminates the implausible implication that growth rates should be equalized in the presence of free international capital mobility and is consistent with evidence that points to low rates of savings in low income countries.

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Rebelo surveys recent growth models that try to explain the diversity among countries in rates of economic growth.

He finds that these models can generate differences in growth rates only in the absence of international capital markets. Under these models, if there were free international capital mobility, the growth rate of consumption and GNP would quickly be equalized all over the world.

Rebelo describes a simple modification of standard preferences that eliminates this implausible equalization of growth and is consistent with the fact that the savings rate is lower in poor countries than in rich countries.

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I. INTRODUCTION

During the past five years growth theory has become one of the most active areas of research in economics. This paper evaluates the progress made by this recent literature in explaining differences in rates of growth across countries and across historical epochs. This evaluation points to an important shortcoming of new growth theories: they can only explain cross-country differences in rates of growth by assuming the absence of international capital markets.

Most recent models imply that low rates of growth are the result of low real rates of return to investment by private agents. If this is the case the development problem has a simple solution: allow stagnant countries to invest in the developed world where the real rate of return is high. This simple, costless policy would lead real per capita consumption and real per capita GNP to grow at the same rate in the developed and underdeveloped worlds.

Growth models point to this implausible solution to the development problem because of their specification of intertemporal preferences. The standard intertemporal utility function implies that the optimal savings rate is identical for two countries which have the same real rate of interest but different income levels. This property leads to the prediction that an underdeveloped country which can invest in the US will choose the same rate of savings, and hence will expand its GNP (but not its GDP) at the same rate as the US.

This paper studies a simple extension of standard preferences in which momentary utility has a Stone-Geary form: utility is derived from the amount of consumption that is above the level of subsistence consumption. With this modification it is possible to generate different rates of growth even in the presence of perfect international capital markets. These preferences also imply that the rate of savings should be lower in poorer countries as seems to be the case in the data.

The paper is organized as follows. Section II summarizes different theories that attempt to explain the observed diversity in growth rates. Section III discusses empirical evidence related to these theories. This section also examines the relation between the implications of various models for the real rate of return and an indicator often used to evaluate the growth performance of LDC's: the Incremental Output Capital Ratio (ICOR). Section IV discusses the role of international capital markets. Section V studies the properties of the rate of growth when preferences have a Stone-Geary form and presents evidence that accords with those properties. Section VI provides some conclusions.

II. WHY DO GROWTH RATES DIFFER?

This section summarizes some of the theories that have been advanced to explain cross-country differences in rates of growth. All the theories described can be seen as extensions of the neoclassical growth model of Solow (1956), Cass (1965) and Koopmans (1965).[1] We first review the channels by which government policy can affect rates of growth. We then describe three models that predict the presence of trends in rates of growth: the neoclassical growth model, and the models proposed by Romer (1986) and Jones and Manuelli (1990). The interactions between trade and growth are examined next. Finally, we discuss economies with poverty traps.

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[1]This emphasis on models that extend the neoclassical framework to explain differences in rates of growth means that a large number of interesting papers associated with the new literature will not be reviewed in this section. Examples include Greenwood and Jovanovic (1990), Bencivenga and Smith (1988), Marcet and Marimon (1991), and Levine (1991) on financial intermediation and growth; Stokey (1988,1991) on the process of introduction of new goods; Aghion and Howitt (1990) and Jovanovic and MacDonald (1990) on innovation; Krugman (1991) on economic geography; and Schmitz (1989) on the interaction between industrial organization issues and growth.

In describing these theories we always impose some symmetry between the economy under study and the rest of the world to rule out explanations of differences in growth rates that are based solely on the existence of cross-country differences in preferences or in technology. This type of symmetry is conventional in modern macroeconomic theory but is foreign to the development economics tradition. Most of the models used in development economics emphasize the unique features of underdeveloped countries.

II.1 GOVERNMENT POLICY

Before discussing how government policy can affect economic growth it is useful to lay out a simple linear growth model with no government. This model can be obtained by aggregating physical and human capital into a composite good in a Lucas (1988)-Uzawa (1965) economy that follows a steady state path, has no externalities, and has identical technologies in the output and human capital accumulation sectors.[2]

While the linear model is very useful as an expositional device and as a guide to back-of-the-envelope calculations, it has some drawbacks. As Romer (1990a) has emphasized, this model (as all others of the Lucas-Uzawa variety) cannot explain why private firms invest in R&D. The linear model also tends to exaggerate the effects of certain public policies by ignoring the role of population size and assuming that the ratio of physical to human capital is fixed. But the qualitative effects of government policy described below can be built into virtually any endogenous growth model.

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[2] Jones and Manuelli (1990) and Rebelo (1991) discuss the properties of the linear model and of related models. King and Rebelo (1990) compare the effects of taxation on growth and on welfare in the linear model and in a version of the Lucas-Uzawa model in which there are no externalities and physical capital is used in the production of human capital.

The Linear Growth Model

In this economy population grows at the exogenous gross rate γ_N and is composed by identical agents. To simplify the exposition all variables are expressed in per capita terms. We will represent the gross growth rate of variable X by γ_X.

There is a single type of capital good (Z_t) which is a composite of physical and human capital. Production is a linear function of the stock of capital and can be used in consumption (C_t) or investment (I_t):

$$Y_t = AZ_t \tag{1}$$

$$Y_t = I_t + C_t. \tag{2}$$

The law of motion for the per capita stock of capital is the standard one:

$$\gamma_N Z_{t+1} = I_t + (1-\delta)Z_t, \tag{3}$$

where δ represents the rate of depreciation. Since Z_t is a composite good that includes human capital it is natural to assume that investment is irreversible, $I_t \geq 0$.

To describe the operation of this economy it is convenient to think of a decentralization scheme in which there are two types of markets: spot factor markets and one-period credit markets.

Households own the capital stock which they rent to firms for R_t. Profit (or value) maximization by firms and equilibrium in the factor market implies that the rental price of capital must be equal to the marginal product of capital: $R_t = A$. Equilibrium in the credit market requires that the real rate of interest must be equal to $r_t = R_t - \delta = A - \delta$.

The growth rate of this economy is determined by the savings

decision of private agents. Defining the savings rate as the fraction of investment on net income, $s_t = (I_t - \delta Z_t)/(Y_t - \delta Z_t)$, we can express the rate of growth of output as:

$$\gamma_Y = (s\ r + 1)/\gamma_N \tag{4}$$

Equation (4) shows that changes in r have a direct effect on the growth rate and an indirect effect, associated with the response of the savings rate to changes in the real rate of return. To explore this indirect effect we need to make the savings rate endogenous. This will also clarify the effects of population growth on the rate of growth of per capita output. Thus we assume that each agent in the economy has perfect foresight and makes his savings decision so as to maximize his life-time utility:

$$U = \sum_{t=0}^{\infty} (\beta\ \gamma_N^{\eta})^t\ u(C_t) \tag{5}$$

The momentary utility function $u(C_t)$ is assumed to be isoelastic so as to be consistent with steady state growth:[3]

$$u(C_t) = \frac{C_t^{1-\sigma} - 1}{1-\sigma}, \qquad \sigma>0 \tag{6}$$

These preferences imply that households expand their consumption at a constant rate whenever the real interest rate is constant.

The parameter η represents the nature of the links between present and future generations. It is standard to assume that current generations care for the total utility of future generations, which corresponds to the case of $\eta=1$ (e.g. Lucas (1988)). However, Barro and Becker (1989) choose $0<\eta<1$ in their analysis of endogenous fertility decisions. As will be clear

[3]The choice of preferences and production technologies consistent with steady state growth is usually justified by appealing to the Kaldor (1961) stylized facts of economic growth. See Romer (1989) for a discussion of these facts.

below, in equation (6), the value of η is crucial to determine the influence of exogenous population growth on the rate of expansion of the economy.

In order to ensure that life-time utility is finite, so that (3) can be used to rank all feasible growth paths, we need to impose that:

$$(\beta\gamma_N^{\eta})^{1/\sigma} \{[A + (1-\delta)]/\gamma_N\}^{(1-\sigma)/\sigma} < 1. \tag{7}$$

Finite utility conditions analogous to this one will be assumed to hold in all other models that we describe but will not be stated explicitly.

The optimal rate of consumption growth from the standpoint of households is:

$$\gamma_C = [\beta\ \gamma_N^{\eta-1}\ (1+r)]^{(1/\sigma)} \tag{8}$$

This implies that the optimal savings rate is:

$$s = \{\gamma_N^{(\eta+\sigma-1)/\sigma}\ [\beta\ (1+r)]^{(1/\sigma)} - 1\}/r \tag{9}$$

It is well known that the response of savings to changes in the real interest rate depends on the relative strength of income and substitution effects. But the usual property that with $\sigma=1$ these two effects cancel each other and $ds/dr = 0$, while $ds/dr > 0$ with $\sigma<1$ and $ds/dr < 0$ with $\sigma>1$, does not apply here. In order for these relations to hold we would have to define the savings rate as: $s'_t = [I_t + (1-\delta)Z_t]/[Y_t + Z_t(1-\delta)]$. The savings rate s will generally respond to changes in r even in the case of $\sigma=1$.

The growth rate of output can be obtained by replacing s in equation (8). Alternatively, since output grows at the same rate as consumption, γ_Y can be obtained by replacing r in equation (8). One notable property of this economy is that it has no transitional dynamics, it always grows at the following rate:

$$\gamma_Y = \{\beta\, \gamma_N^{\eta-1}\, [A + (1-\delta)]\}^{(1/\sigma)} \tag{10}$$

This equation shows that an increase in the real rate of interest $r = A - \delta$ always leads to an increase in the rate of growth. Expression (10) ignores the possibility of the non-negativity constraint on investment being binding. When this is the case investment is zero and the gross rate of growth is $(1-\delta)/\gamma_N$.

Equation (10) also shows that population growth has a negative impact on the rate of growth of per capita output whenever $\eta<1$. When $\eta = 1$ the positive influence of population growth on savings (see equation (9)) is exactly offset by the fact that a higher rate of population growth requires a higher savings rate to maintain a given rate of growth of per capita output (see equation (4)).

This economy illustrates two features that are shared by virtually all endogenous growth models. The first is that the real rate of return does not decline toward zero as the capital stock increases. It is this property that makes sustained growth feasible. The second feature is the link between the real rate of return to investment and the rate of growth. If this rate of return is low the rate of capital accumulation declines and so does the rate of growth.

In a world composed of economies such as this one the rate of economic expansion is uniform across countries. Equation (8) shows that to generate different growth rates we need cross-country differences in the real rate of return. A natural candidate as a source for these differences is public policy. We explore this idea below but it is worthwhile noting that in this model the optimal public policy is generally independent of the country's income level.[4] Thus, if all governments maximized the

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[4]This is partly a result of the absence of transitional dynamics in the linear model. Chamley (1986) shows that in the neoclassical model the optimal capital tax rate is positive during the transition period but zero in the steady state. Thus the neoclassical model implies that countries at different levels

welfare of the representative agent all countries would grow at the same rate.[5]

The Effects of Taxation

Suppose that in the economy described above the government introduces a proportional income tax with rate τ. The revenue from this tax is used to finance public consumption, $G_t = \tau A Z_t$. For now we will assume that public consumption does not affect production and enters in utility in a separable manner:

$$U = \sum_{t=0}^{\infty} (\beta \gamma_N^{\eta})^t \{u(C_t) + \phi(G_t)\} \tag{11}$$

The function $\phi(.)$, which represents the utility associated with government expenditures, is assumed to be bounded.

With the introduction of income taxation the after-tax rental price of capital is $R = A(1-\tau)$ while the after-tax equilibrium real interest rate is $r_t = A(1-\tau) - \delta$. Since the growth rate of the economy continues to be given by (8), it is clear that income taxation reduces the rate of growth. Given that tax systems are different across countries this channel of influence of economic policy on the rate of growth can potentially be empirically important.

Not all forms of taxation have, however, growth effects. A consumption tax is, in this economy, equivalent to a lump sum tax and has no effects on growth. In contrast, an investment tax has

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of income should choose different tax systems. Lucas (1991), Yuen (1990) and Jones, Manuelli and Rossi (1990) discuss similar results for endogenous growth models.

[5] An interesting new line of work has begun to explore the connection between endogenous policy and economic growth. This involves modeling public policy as the outcome of a political process, instead of considering the two polar cases of exogenous policy and optimal policy from the standpoint of an infinitely-lived benevolent government. See Tabellini and Persson (1990) and Cohen and Michel (1991).

growth effects that are similar to those of an income tax: it reduces the real rate of interest and the rate of growth (see Rebelo (1991)).

There are other policies that have the same effects as income taxation on the rate of growth. Poor protection of property rights and transaction costs associated with the investment process have effects on growth that are similar to those of an income tax.[6] The same is true for the inflation tax associated with monetary expansion (see Easterly et al (1990) and Mino (1990)).

The Effects of Sectoral Distortions

In less developed countries comprehensive forms of taxation are rarely important. The tax collection mechanism is usually primitive and, for this reason, certain sectors (e.g. the export sector) are heavily taxed while others (e.g. the informal sector) escape taxation. Dual exchange rate systems, tariffs and import quotas are other forms of sectoral distortions commonly found in developing countries. Easterly (1990) analyses the effects of these distortions within an extension of the linear model.

In Easterly's model there are two types of capital Z_{1t} and Z_{2t}, both of which are composites of physical and human capital. Production combines two types of capital goods according to a constant returns to scale function. For convenience of exposition we will consider the special case in which this function is Cobb-Douglas:

$$Y_t = A\, Z_{1t}^{\alpha}\, Z_{2t}^{1-\alpha} \tag{12}$$

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[6]North (1987) provides an insightful historical discussion of the role of property rights in the growth process that accords with the implications of this model. Soto (1989) describes transaction costs that are commonly associated with the investment process in less developed countries.

Both types of capital are accumulated according to (3). The resource constraint that faces the private sector of this economy is:

$$Y_t = C_t + I_{1t}(1+\tau_1) + I_{2t} \tag{13}$$

where τ_1 represents an investment tax on sector 1 or some other type of sectoral distortion such as tariffs or investment licenses. The real interest rate for this economy, which can be obtained following the same reasoning used in the linear model, is given by:

$$r = \varphi A (1+\tau_1)^{-\alpha} - \delta \tag{14}$$

where φ is a positive function of α. It is clear that this type of sectoral distortion has a detrimental effect on growth. An increase in τ_1 lowers the real rate of return and the rate of growth.

To explore the impact that sectoral distortions can have on the growth process, it is useful to compare two governments that seek to finance public expenditures that represent a constant share of output (we describe below circumstances in which it is optimal to maintain a constant government share). The first government uses income taxes while the second employs the sectoral investment tax described above. Figure 1, which compares the growth rates under these two policies for various values of the government share in output, shows clearly that relying on the sectoral investment tax to raise revenue can have important negative effects on the rate of growth.[7] When the share of government in output is 20% the economy in which expenditures are financed through income taxes grows 1% faster

[7]The parameters that underlie this graph are α=1/2, δ=.10, η=1, γ_N = 1.014. The value of A was chosen so that the after tax real rate of return is 3.2% when the rate of income tax is 20%. The value of β was chosen so that the rate of growth is 2% per year in this scenario. See King and Rebelo (1990) for a more detailed discussion of these parameter values.

than the economy that relies on sectoral taxation.

The Role of Government Expenditures

In describing the effects of taxation we assumed that government expenditures enter separately in the utility function. Relaxing the separability assumption implicit in (11) can have important implications for the determination of optimal tax and expenditure policies but is not necessarily relevant for the relation between taxes and growth. To see this suppose that we replace the momentary utility $u(C_t) + \phi(G_t)$ by a non-separable function $v(C_t, G_t)$. To be consistent with steady state growth this function must have the form:

$$v(C_t, G_t) = [C_t^{1-\sigma} G_t^{\theta(1-\sigma)} - 1] \frac{1}{1-\sigma}, \qquad \theta>0,\ \sigma>0 \qquad (15)$$

where $\theta(1-\sigma) < 1$ and $\theta(1-\sigma) < \sigma$ to ensure strict concavity.

Suppose that the government follows a balanced budget policy by choosing a combination of income tax rate τ and government expenditures such that $G_t = \tau AZ_t$.[8] In this case the rate of growth of this economy is, ignoring the corner solution with zero investment:

$$\gamma_Y = \{\beta\gamma_N^{\eta-1} [A(1-\tau) + (1-\delta)]\}^{1/[\sigma-\theta(1-\sigma)]} \qquad (16)$$

If the government does not maintain a constant share of government expenditures in income this economy will not follow a steady state path. In this case the effects of taxation are harder to characterize but the property that higher taxes imply lower growth is generally preserved.

Evidence for developing countries suggests that certain

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[8]The optimal path for government expenditure, abstracting from the presence of distorting taxes, is such that $C_t/G_t = \theta$.

types of government expenditures may play an important role in the development process. The existence of infrastructures such as roads and an efficient legal system are often viewed as important preconditions for economic development. Barro (1990) has discussed these issues in another extension of the linear model that views public expenditures as having a productive role: the production function has the form $Y_t = F(Z_t, G_t)$. For simplicity we will consider the particular case of a Cobb-Douglas production function:

$$Y_t = A\, Z_t^{\alpha}\, G_t^{1-\alpha} \tag{17}$$

Government expenditures are financed by income taxation: $G_t = \tau\, Y_t$, so the tax rate τ coincides with the government share in output. It is easy to see that the marginal product of capital for a given value of τ is $\alpha\, A^{(1/\alpha)}\, \tau^{(1-\alpha)/\alpha}$. The rental price of capital will then be equal to $R_t = (1-\tau)\, \alpha\, A^{(1/\alpha)}\, \tau^{(1-\alpha)/\alpha}$, while the real interest rate is $r_t = (1-\tau)\, \alpha\, A^{(1/\alpha)}\, \tau^{(1-\alpha)/\alpha} - \delta$. The rate of growth of this economy can be obtained by substituting r_t in equation (8).

Unless all governments choose the optimal value of τ (which is $(1-\alpha)$) rates of growth will be different but the response of growth to taxation is now more complex: the growth effect of a marginal increase in τ is positive if $\tau < (1-\alpha)$ and negative if if $\tau > (1-\alpha)$.

II.2 TRENDS IN THE RATE OF GROWTH

There are three growth paradigms that predict that if preferences, technology <u>and</u> <u>public</u> <u>policy</u> were identical across countries we should detect time trends in the rate of growth of per capita output: the neoclassical model, the Jones-Manuelli (1990) model and the Romer (1986) model.

The neoclassical growth model predicts that poor countries should grow faster than rich countries as a result of

transitional dynamics: poor countries have a lower stock of capital and hence a higher real rate of return which induces a faster rate of growth. Using a battery of versions of the neoclassical growth model, King and Rebelo (1989) show that in order for these transitional dynamics to be important the real rate of interest has to take implausibly high values in low income countries. For instance, in order for transitional dynamics to explain the Japanese post-war growth the real interest rate in Japan in the end of World War II should have been close to 500%! These implausible predictions about the real rate of return can be traced to the presence of decreasing returns to scale to physical capital. When the production function is Cobb-Douglas there is a simple expression that relates the value of the real interest rates in two countries which are identical except for their level of output:

$$r_B = (r_A + \delta)\ (Y_A/Y_B)^{\alpha/(1-\alpha)} - \delta \qquad (18)$$

In this expression α represents the labor share and Y_A/Y_B the ratio of outputs in the two countries, A and B. If we assume that $\alpha = 2/3$, $\delta = .10$ (which are standard values used in growth accounting studies, see Maddison (1987)), $r_A = 6.5\%$ and that country B has half of the output of country A, we obtain a value for $r_B = 56\%$. This is an extremely implausible value in light of historical evidence on rates of return (see Homer (1963), Siegel (1991), and Neal (1989)). Lucas (1990) discusses how differences in the levels of human capital and capital market imperfections can moderate these rate of return implications. The effects of differences in human capital can be explained using the production function proposed by Mankiw, Romer and Weil (1990): $Y_t = AK_t^{\alpha 1}H_t^{\alpha 2}L_t^{1-\alpha 1-\alpha 2}$, where H is human capital and L raw labor. The relation between the real interest rate of two countries, A and B is, in this case:

$$r_B = (Y_A/Y_B)^{(1-\alpha 1)/\alpha 1}\ [(r_A + \delta)\ (H_B/H_A)^{\alpha 2}] - \delta \qquad (19)$$

This expression shows clearly how differences in the levels of per capital human capital (H_A and H_B) can offset the tendency for

the real rate of return to be low in poor countries.

The Mankiw, Romer and Weil (1990) model preserves the implications of the neoclassical model that, absent differences in technology, preferences and policy, poor countries should grow faster than rich countries. The same is true about the Jones-Manuelli (1990) model which relies on a production function of the type: $Y_t = AZ_t + BZ_t^{\alpha}T^{1-\alpha}$, where T represents non-reproducible factors such as land. The presence of T in the production function implies that the real rate of return is high for low levels of Z.

In contrast with these convergence implications, the theory proposed by Romer (1986) predicts that growth should accelerate over time. This prediction is based on an increasing returns to scale function such as the following:

$$Y_t = A\, Z_t^{\alpha 1}\, T^{\alpha 2}\, \underline{Z}_t^{\alpha 3} \qquad \alpha 1,\ \alpha 2,\ \alpha 3 > 0 \qquad (20)$$
$$\alpha 1 + \alpha 2 = 1.$$

The factors of production in this economy are Z_t, which is a composite of physical capital, human capital and disembodied knowledge, and T, which represents non-reproducible factors of production. The variable $\underline{Z}_t$ represents the per capita capital stock in the economy. The positive effect of $\underline{Z}_t$ on production is meant to capture an external effect: the accumulation of capital increases the stock of knowledge in the economy benefiting all production units.[9] This externality implies that the competitive equilibrium is not Pareto optimal and hence there is scope for government intervention.

In the borderline case in which $\alpha 1 + \alpha 3 = 1$ this economy displays a behavior that is identical to that of the linear model: there are no transitional dynamics and the rate of growth is constant. If $\alpha 1 + \alpha 3 > 1$ it is not feasible for this economy to

[9] See Benhabib and Jovanovic (1989) and Caballero and Lyons (1989) for attempts to isolate empirically this type of externality.

grow at a constant rate and the competitive equilibrium displays in general growth rates that accelerate.[10]

II.3 INTERNATIONAL TRADE

The belief that international trade can be one of the driving forces of economic growth is shared by many economists and policy makers. The model developed by Romer (1990a) has been used by Grossman and Helpman (1989a, 1989b) and by Rivera-Batiz and Romer (1991) to explore the links between trade and growth. This model has the advantage of being consistent with the observation that profit maximizing firms invest in R&D activities.

To describe the essential features of Romer's model it is useful to abstract from population growth and to view all variables as representing aggregate quantities. The production function for the output sector is:

$$Y_t = B\, L_Y^{\alpha} \int_0^{A_t} x(i)^{1-\alpha} di \tag{21}$$

The variable L_Y denotes the number of quality-adjusted units of labor employed in the production of output. A continuum of capital goods indexed by $i \in [0\ A_t]$ and represented by $x(i)$ is also employed in production.[11] Each capital good $x(i)$ costs υ units of output to produce and does not depreciate over time. For this reason the aggregate stock of capital in this economy is $K_t = \nu \int_0^{A_t} x(i)\, di$. To produce capital good i it is necessary to

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[10] Romer's (1986) model does not have the same implausible implications for the time series behavior of the real rate of return as the neoclassical model. Suppose for instance that $\alpha_1+\alpha_2 = 1.10$. In the benchmark case of King and Rebelo (1989) (which involves a real rate of return of 6.5% in the beginning of the century and a 6 fold increase output from 1900 to 1980) the model predicts that the real interest rate should have increased from 6.5% in 1900 to 9.7% in 1980.

[11] The assumption that there is a continuum of capital goods is convenient because it avoids dealing with integer constraints.

have its design, that is, it is necessary that $i \in [0\ A_t]$. New designs are produced with labor according to the following technology:

$$A_{t+1} = \delta(L-L_Y)\ A_t + A_t \tag{22}$$

where L is the total number of available efficiency units of time.

The market for intermediate products is competitive so the rental price associated with x(i) is equal to the its marginal product:

$$R(i) = (1-\alpha)\ B\ L_Y^{\alpha}\ x(i)^{-\alpha} \tag{23}$$

The inventor of a new type of capital has perpetual monopoly power in the market for that good as a result of a perfect patent system. Assuming that the economy is at the steady state, the quantity of each capital good produced is constant and the value of an additional patent is:

$$P_A = -\ \nu\ x(i) + (1+r)R(i)x(i)/r \tag{24}$$

where r is the real interest rate, $\nu x(i)$ the cost of production of the capital good (since there is no depreciation production takes place only once along the steady state path) and $(1+r)R(i)x(i)/r$ the present value of revenue from renting the capital good to firms in the output sector. Using equations (23) and (24) it is easy to see that the rental price that maximizes patent value is $R(i) = \nu\ r/[(1+r)(1-\alpha)]$ and that the optimal quantity of x(i) that should be produced is: $x(i) = L_Y[(1-\alpha)^2\ B\ (1+r)/(r\nu)]^{1/\alpha}$. The value of a patent is equal to:

$$P_A = \alpha\nu x(i)/(1-\alpha) \tag{25}$$

The symmetric role of the capital goods in production implies that in the steady state $x(i) = \underline{x}$ for all $i \leq A_t$.

Profit maximizing in the output sector and equilibrium in the labor market ensure that:

$$w = \alpha B L_Y^{\alpha-1} \underline{x}^{1-\alpha} A \tag{26}$$

Since there is free entry in the research sector the value of a patent has to be in equilibrium identical to its cost:

$$P_A \delta A/(1+r) = w \tag{27}$$

Using equations (25)-(27) it is possible to determine the quantity of labor employed in the output sector as being equal to: $L_Y = r/[(1-\alpha)\delta]$. This, in turn, determines the "innovation rate":

$$\gamma_A = 1 + \delta L - r/(1-\alpha) \tag{28}$$

Along the steady state path output is given by $Y_t = B L_Y^{\alpha} \underline{x}^{1-\alpha} A_t$, so Y_t grows at rate γ_A. Output is used in consumption and in the production of new capital goods: $Y_t = C_t + \nu \underline{x} (A_{t+1} - A_t)$. Both consumption and production costs grow at rate γ_A. Equating γ_C in equation (24) to γ_A in (28) yields the equilibrium value of the real interest rate and the equilibrium growth rate. This growth rate is suboptimal as a result of the presence of monopoly pricing in the intermediate goods market. Since equation (8) holds for this economy the property that higher real interest rates lead to higher growth is preserved. Equation (28) shows that there is a strong scale factor at work in this model, which may be troublesome in the presence of population growth. Integrating two economies identical to this one will increase the rate of growth, since L would double in the integrated area. Rivera-Batiz and Romer (1991) show that liberalizing the trade of goods and of ideas (represented by A_t) has the same effects as economic integration.

The effects of tariffs and other trade barriers are theoretically ambiguous. In models similar to the one described Helpman and Grossman (1989a) show that tariffs increase the rate

of growth while Rivera-Batiz (1989) discusses a case in which they slow down economic growth. This variety of theoretical possibilities is not surprising given the presence of increasing returns and monopolistic competition. It is well known that second best results are more complex and less intuitive than their first best counterparts.

II.4 POVERTY TRAPS

A striking feature of the growth phenomenon in this century is that a large number of countries have failed to improve their standard of living. Easterly (1991) shows that the rate of growth of per capita GDP is not significantly different from zero in 46 out of 87 developing countries included in the Summers and Heston (1988) data set. This evidence suggests that some countries may have been caught in a "poverty trap": a stable steady state which involves stagnation at low levels of income. Models which display poverty traps have been proposed in the endogenous growth literature by Azariadis and Drazen (1990), Tamura (1989), and Becker, Murphy and Tamura (1990).[12]

The mechanism at work in these models can be explained within a stylized example inspired by Azariadis and Drazen (1990). Consider a Lucas-Uzawa type model in which the equations that pertain to output production and to the accumulation of the capital stock are:

$$Y_t = AK_t^{\alpha} (N_t H_t)^{1-\alpha} \qquad 0 < \alpha < 1 \qquad (29)$$

$$Y_t = C_t + I_t \qquad (30)$$

$$\gamma_N K_{t+1} = I_t + (1-\delta)K_t \qquad 0 < \delta < 1 \qquad (31)$$

The production function for human capital takes the following special form:

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[12] The first poverty trap model was proposed by Nelson (1956). See Neves (1990) for a through discussion and critical evaluation of poverty trap models.

$$H_{t+1} = B(1-N_t)H_t + H_t \qquad \text{if} \quad H_t > \underline{H}$$
$$H_{t+1} = H_t \qquad \text{if} \quad H_t < \underline{H} \tag{32}$$

This technology implies that human capital can only be accumulated once the threshold level $\underline{H}$ of human capital is reached. It is clear that the evolution of the economy depends critically on whether its level of human capital is above or below $\underline{H}$. When $H < \underline{H}$ this economy is equivalent to the neoclassical growth model without technical progress. There can be no sustained growth and a steady state is reached whenever $\alpha AK_t^{\alpha-1} H^{1-\alpha} + (1-\delta) = \gamma_N^{1-\eta}/\beta$, that is, when the real interest rate is such that agents choose a constant level of per capita consumption.

If $H_t > \underline{H}$ the economy is identical to the one described in Lucas (1988) (abstracting from the production externality considered by Lucas). It will converge to a steady state where it will grow at rate $\gamma_Y = [\beta\gamma_N^{\eta}(1+B)]^{(1/\sigma)}$.

The human capital technology described in (32) is an extreme example since it implies that economies with human capital below $\underline{H}$ cannot accumulate human capital. But it captures the essential idea explored by Azariadis and Drazen (1990) that economies in which human capital is low are less efficient at accumulating human capital. This generates a poverty trap in which the steady state real interest rate is low and so is the growth rate.

Tamura (1989) and Becker, Murphy and Tamura (1990) explore a similar mechanism that works through the endogeneity of the fertility rate: since it is relatively more costly for poor families to educate their children they tend to have a larger number of children with less education than those raised by rich families.[13] This mechanism means that countries with low levels

[13] Erlich and Lui (1989a, 1989b) explore the role of implicit familial contracts in economies that have this type of poverty trap.

of human capital can converge to a low-level steady state in which there is high population growth, no human capital accumulation and no growth in per capita output.

III. EMPIRICAL EVIDENCE

The data that is currently available to test the theories described in section II are extremely scarce. There are some estimates of GDP, population, exports, imports and government expenditures for developed countries and for some developing countries (mostly in Asia and Latin America) that go back to the 19th century (see Maddison (1982,1983)). But, for most countries, the data that is available covers the period from 1950 to the present. For this reason most growth studies have focused on cross-country regressions. These cross-country regressions are hard to interpret because most of the variables considered can be viewed as endogenous. These regressions results are also affected by measurement error problems and lack of robustness.

The robustness problem has been examined in detail by Levine and Renelt (1990). These two authors show that virtually all policy variables (government share in GDP, proxies for property rights protection, measures of trade intervention, etc.) are related to growth but that the signs and statistical significance of these relations depend on the other variables included in the right hand side of the regression. This is partly a result of the fact that policy variables are highly correlated: countries that pursue highly distorting trade policies, also tend to employ highly distorting tax systems, fail to guarantee the protection of property rights, etc.

In an exhaustive study that uses one of Barro's (1991) basic regression equations as point of departure, Levine and Renelt (1990) identify two robust statistical relations: average rates of growth are positively related to the share of investment in GDP and the latter variable is positively related to the share of trade in GDP. Their basic regression equation, which employs

observations for 101 countries for the period 1960-1989 is (standard errors are reported in parenthesis):

$$GYP = -0.83 - 0.35xRGDP60 - 0.38xGPO + 3.17xSEC + 17.5xINV \quad (33)$$
$$\quad (0.85)\ (0.14) \qquad (0.22) \qquad (1.29) \qquad (2.68)$$
$$R^2 = 0.46$$

where GYP is the rate of growth of per capita GDP in the period from 1960 to 1989, RGDP60 is the level of GDP in 1960, GPO is the growth rate of population, SEC is the enrollment in secondary education in 1960, and INV the investment share in GDP. This regression accords with Barro's (1991) finding that growth is negatively related to the initial level of per capita income.[14]

The investment share is clearly the most important variable in the regression described above. A regression of the rate of growth on the investment share yields the following results:

$$GYP = -0.005 + 0.137xINV \quad (34)$$
$$\quad (0.004)\ (0.022)$$
$$R^2 = 30.6\%$$

Below we explore one way of assessing the extent to which we can explain growth as a function of the investment share that is, perhaps, more revealing than looking at the R^2 from this regression. This involves computing some model-implied real rates of return as a function of the investment share and the growth rate of output.

The Shadow Real Rate of Return

The linear model described in section II implies that there should be a simple relation between growth, the real rate of

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[14] This result, which continues to hold if we exclude the variable INV from regression (33), might be taken as indicating the presence of cross-country convergence. Barro and Sala-i-Martin (1989) and Quah (1990) discuss a different notion of convergence that involves a decline over time in the cross-country variability of per capita income.

return and the investment share in GDP. Defining the investment share as $i_t = I_t/(AZ_t)$, the equation of evolution for the per capita stock can be written as:

$$\gamma_{Nt}Z_{t+1} = i_t AZ_t + (1-\delta)Z_t \tag{35}$$

It is easy to see that the real interest rate $r_t = A - \delta$ can be written as a function of the investment share and of the rate of growth of aggregate output, γ_{Yt}, which, in this model always coincides with the growth rate of capital.

$$r_t = [\gamma_{Nt}\gamma_{Yt} - (1-\delta)]/i_t - \delta. \tag{36}$$

This formula is almost identical to the expression for one of the key indicators used in practice to evaluate the performance of programs designed to help developing countries: the Incremental Capital-Output Ratio (ICOR):

$$\text{ICOR} = I_t/(\tilde{Y}_{t+1} - \tilde{Y}_t) = i_t/(\gamma_{Nt}\gamma_{Yt}) \tag{37}$$

where $\tilde{Y}_t$ represents aggregate output.

Equation (36) holds for the Easterly (1990) model when the economy is at the steady state (in Easterly's model when investment is reversible the transitional dynamics last only for one period). It also holds for Barro's (1990) model with a slight modification (α represents the share of capital in production):[15]

$$r_t = \alpha[\gamma_{Nt}\gamma_{Yt} - (1-\delta)]/i_t - \delta. \tag{38}$$

When $\delta=0$, the ICOR is the inverse of the rate of return described in (36). Thus the linear model provides a theoretical foundation for an indicator that has a long tradition in

[15] Formulas similar to this one can also be obtained for the neoclassical growth model, and for the models proposed by Romer (1986), Lucas (1988) and King and Rebelo (1990).

development economics.[16]

Figure 2 depicts the real rates of return associated with the linear model. These were computed assuming that $\delta = .10$ and using growth rates for non-overlapping 10-year periods and average investment rates for the countries in the World Bank data set.[17] The range of values obtained is too wide to be believable, demonstrating the incomplete nature of our understanding of the growth phenomenon on the basis of rates of accumulation.

IV. THE ROLE OF INTERNATIONAL CAPITAL MARKETS

All the models reviewed in section II explain differences in rates of growth as the result of differences in real rates of return. But in order for these differences in rates of return to survive international capital markets must have a primitive form. With perfect capital markets rates of return would tend to be equalized across countries leading to uniform growth all over the world.[18] The only exception to this equalization result involves

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[16]The Bruno and Chenery (1962) model can also be seen as rationalizing the use of the ICOR. In their model the production function is Leontieff and there is a significant fraction of the active population that is unemployed. For this reason, the production function can be seen as being linear up to the point where all active population becomes employed. After that point the economy can no longer grow and hence no longer resembles the linear model.

[17]The levels of these rates of return are generally very high when compared with the 6.5% average real rate of return associated with common stock in the US in the 1928-1988 period (see Ibbotson and Sinquefield (1988)), or even to the 30% return on equipment investment estimated by De Long and Summers (1991). This is partly a result of the narrow concept of investment used which excluded, among other things, investment in education.

[18]This is the reason why Grossman and Helpman (1989a), who assume

the case of taxation under a worldwide system considered by King and Rebelo (1990) and Rebelo (1991) and further examined below.[19]

To describe the impact that international capital markets can have let us return to the linear model of section II and consider a country in which the real rate of return is $r = A(1-\varepsilon) - \delta$ as a result of transactions costs represented by ε. In developed countries these transaction costs do not exist and the real rate of return is $r^* = A - \delta$. What would happen if the private sector were allowed to invest in the international capital market at rate r^*? In the extreme case in which there are no irreversibilities or adjustment costs associated with the capital installed, production in the LDC would be driven to zero and all capital would be moved abroad. GDP would be zero but GNP and consumption would grow at the same rate as in the developed world.

This represents a solution to the development problem that in our view is markedly utopian. It suggests that the World Bank should be setting up mutual funds in developing countries that allow their population to invest their savings in the developed world. This simple, costless policy would lead to an equalization of the growth rate of GNP and of consumption. Below we discuss some modifications of this scenario that might mitigate the growth equalization implication.

More complex forms of production and accumulation

The first modification has to do with the reversibility of investment. If investment were irreversible all new investment

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the presence of international capital markets, focus on explaining the world growth rate, instead of cross-country differences in rates of expansion.

[19]The effects of liberalization of international capital markets are particularly dramatic in models with increasing returns, see Correia (1990).

would take place abroad and per capita GDP would tend to decline. In this case liberalizing capital markets leads to high growth rates in per capita GNP which quickly decline toward the growth rate of developed countries.[20]

Introducing sectors that use factors of production that cannot be moved abroad (e.g. land and labor) eliminates the prediction that GDP would embark on a declining path after the opening of international capital markets. Consider for instance the poverty trap model of section II.4. If an economy that has $H_t < \underline{H}$ and is at the low level steady state could obtain a rate of return r^* on its investments it would produce domestically until the point where the domestic real interest rate coincides with r^*: $r_t = \alpha A K_t^{\alpha-1} H^{1-\alpha} - \delta = r^*$. In this case GDP would be constant and domestic investment would only compensate depreciated capital.

Models with immobile factors can be used to show that liberalizing capital flows may have important redistribution effects. The owners of the immobile factors may become worst off as a consequence of financial liberalization due to decline in the level of domestic capital.

In a model in which the accumulation of physical and human capital are treated separately, such as the one in Lucas (1988) and in King and Rebelo (1990) the effects of a liberalization of capital flows are more complex than in the linear model. But they also involve a decline in the rate of domestic investment in favor of investment in the international capital markets.

Non-Tradable Goods

Introducing non-tradable goods does not generally eliminate the growth-equalization result. This can be illustrated by

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[20] The higher the rate of depreciation of the domestic capital stock the higher the growth rate in the initial period and the faster the convergence to the world growth rate.

modifying the linear model of section II.1 to assume that consumption is a non-tradable which is produced with land and capital:[21]

$$C_t = B\, Z_{ct}^{\alpha}\, T^{1-\alpha} \tag{39}$$

Capital is tradable and, before opening capital markets, it is produced according to a linear production function with productivity $A(1-\varepsilon)$ and accumulated according to (3). Before liberalizing capital flows this economy's real GNP, measured in units of the tradable good, grows at the rate:

$$\gamma_{GNP} = [\beta\, \gamma_N^{\eta-1}\, (1+r)]^{1/[1-\alpha(1-\sigma)]} \tag{40}$$

where $r = A(1-\varepsilon) - \delta$. Once liberalization is accomplished the new growth rate of GNP is given by expression (40) with r replaced by r^*, that is, the growth equalization result obtains despite consumption being a non-tradable. This result, suggested by this example, holds generally as long as the non-tradable goods are produced with tradables. When this is not the case it is possible to have two countries with different GNP growth rates despite the presence of integrated capital markets. One example of this type is discussed in Buiter and Ketzler (1991). In their model human capital is produced with a non-traded input (inherited human capital) which cannot be used in production.

The role of uncertainty

The consideration of uncertainty can also potentially influence the growth equalization result. Households in LDC's might not be willing to bear the risks associated with investment in the developed world. But the evidence points to the conclusion that investment in LDC's is much riskier than in developed countries even when we disregard the possibility of

[21] This model is described in more detail in Rebelo (1991).

confiscation of private assets by the government.

The data available for the "emerging stock markets" in LDC's indicates that the variance of returns to their stock market indexes is much higher than the variance of returns to the Standard & Poors 500 index. But since average returns in LCD's have also been generally higher than average returns to the S&P 500, nothing can be concluded from this observation unless we have a model that allows us to price risk.[22]

If we use the variance of real GDP to measure the risk associated with investment, we conclude that this risk is higher in LDC's: in the Summers and Heston (1988) data set the variance of real GDP for the 1/3 poorest countries is twice the variance of the 1/3 richest countries (.0033 versus .0016) (see Renelt (1991)).

It is worthwhile noting that the presence of political risk cannot eliminate the growth equalization result because the flows of capital that are being discussed go from LDC's to developed countries, not the other way around.

Theoretically the influence of uncertainty on growth is ambiguous. As is clear from Levhari and Srinivasan's (1969) classical paper on savings under uncertainty, whether a mean preserving spread increases or decreases the rate of growth depends on whether σ is greater or smaller than one. Assuming that $\log(1+r_t)$ is i.i.d. and follows a normal distribution with mean μ and variance v^2, the growth rate of the linear economy discussed in section II.1 is:

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[22]The data collected by the International Finance Corporation (1990) shows that during the period 1984-89 the standard deviation of returns to the S&P 500 was 5.12%, while the standard deviation associated with the returns to a composite index of stock in developing countries was 7.06% The variance of returns for every single country included in the index was higher than that of the S&P 500.

$$\gamma_t = (\beta\ \gamma_N^{\eta-1})^{(1/\sigma)}\ (1+r_t)\ \exp\{\ [\mu(1-\sigma) + (1-\sigma)^2(v^2/2)]/\sigma\ \} \quad (41)$$

The mean growth rate is given by a simpler expression which shows clearly that a mean preserving spread (an increase in the variance term v^2 together with an adjustment in μ that keeps $E(1+r_t)$ constant) decreases the mean growth rate if $\sigma < 1$ and increases it when $\sigma > 1$.

$$E(\gamma_t) = [\beta\ \gamma_N^{\eta-1}\ E(1+r_t)]^{(1/\sigma)}\ \exp\ [(v^2/2)\ (\sigma-1)] \quad (42)$$

As one would expect, the variance of the rate of growth, which is given by:

$$\mathrm{var}(\gamma_t) = [E(1+r_t)\ \beta\ \gamma_N^{\eta-1}]^{(2/\sigma)}\ \exp\ (\sigma v^2)\ [1 - \exp(-v^2)] \quad (43)$$

always increases with a mean preserving spread.

The taxation of foreign investment

Whether tax-driven differences in rates of growth can survive in the presence of international capital markets depends on how income from foreign investment is taxed.

There are essentially two systems regarding the tax treatment of foreign investment: the worldwide system and the territorial system. Under the worldwide tax system an investor pays domestic taxes on income from foreign investment but receives credit for any taxes paid abroad on the same income. Since this credit cannot exceed the amount of domestic taxes associated with foreign income, the relevant tax rate is in this case $\max(\tau,\tau^*)$, where τ^* is the foreign tax rate. Under the territorial system foreign income is exempted from taxation.[23]

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[23] This discussion ignores other relevant features of the tax system such as the role of transfer prices, the possibility of tax deferral, and the existence of a tax credit by country versus an overall tax credit. See Slemrod (1988) and Swenson (1989) for more detailed discussions of the tax treatment of foreign

The worldwide system is used by the US, the UK, Japan and Canada, while the territorial system is followed by France and by the Netherlands.

It is easy to see that under the worldwide system taxation can still generate different rates of growth in the presence of international capital markets. If $\tau^* > \tau$ no foreign investment will be undertaken. If $\tau^* \leq \tau$ there is still no reason to move investment abroad since the relevant tax rate continues to be τ. For this reason the effects of taxation are the same as in a closed economy.[24]

Under the territorial system an increase in domestic taxes rate above τ^* has the dramatic implications already discussed: all new investment is undertaken abroad.

In summary, with the exception of taxation under the worldwide system, the mechanisms described in section II do not survive as sources of growth differentials in the presence of international capital markets. These mechanisms can nevertheless be important to explain differences in rates of growth across historical periods. Goodfriend and McDermott (1990) is an example of a model that can be viewed as explaining how the world as a whole moves from primitive forms of production to modern, specialization-based, forms of organization.

V. SAVINGS AND GROWTH

In the absence of international capital markets differences in real rates of return that reflect aspects of the technology or of government policy translate into differences in rates of

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investment.

[24] One problem with the worldwide system is that it is only optimal under very restrictive assumptions; see Feldstein and Hartman (1979).

growth. In the opposite polar case of perfect international capital markets the real rate of return is the same all over the world and, as a consequence, technology and government policy cannot influence the rate of growth of consumption and have generally a small impact on the rate of expansion of GNP.

This section considers a simple extension of the standard preference specification that is consistent with differences in rates of growth with perfect international capital markets. These preferences have the time-separable form described in (5) but have a different momentary utility function:

$$u(C_t) = \frac{(C_t - \underline{C})^{1-\sigma} - 1}{1 - \sigma} \tag{44}$$

The only difference between this Stone-Geary function and the one described (6) involves the consumption subsistence term $\underline{C}$. With this utility function the elasticity of intertemporal substitution, which is $(1-\underline{C}/C_t)(1/\sigma)$, is no longer constant: it is equal to zero when $C_t = \underline{C}$ and converges to $(1/\sigma)$ when consumption grows at a sustained rate.[25]

Before we discuss the role of international capital markets it is useful to describe the competitive equilibrium for a closed economy when the technology is linear and the government levies a proportional tax on income as in section II.1. In this case, it is possible to solve the model in closed form. Given the level of per capita capital stock, Z_t, the optimal level of consumption associated with these preferences is given by:

$$C_t = a\,[Z_t - \underline{Z}] + \underline{C}, \tag{45}$$

[25] King and Rebelo (1989) discuss the transitional dynamics of a version of the neoclassical model that has these preferences. Christiano (1989) uses a neoclassical model with Stone-Geary preferences in which a trend is introduced in subsistence consumption to interpret the growth of Japan in the post-war period.

In this expression $\underline{Z} = \underline{C}/(1+r-\gamma_N)$ is the minimum level of capital that can support the subsistence level of consumption. The real interest rate is given by $r_t = A(1-\tau) - \delta$. The constant a is equal to $a = (1+r) - [\beta\ \gamma_N^{\eta-1}\ (1+r)]^{(1/\sigma)}\ \gamma_N$. The optimal rate of savings is given by the following hyperbola:

$$s_t = (r - a)/r + (a\underline{Z} - \underline{C})/(rZ_t) \tag{46}$$

The rate of savings converges to $(\gamma_N-1)/r$ when the level of capital approaches $\underline{Z}$. When $1+r > \gamma_N^{1-\eta}/\beta$, the country pursues unbounded growth. When $1+r < \gamma_N^{1-\eta}/\beta$ it converges toward the subsistence level $\underline{Z}$.

To have a better feel for the implications of this model it is useful to look at two examples. The first, depicted in Figure 3, pertains to country A where the private rate of return is low, for one of the reasons suggested in section II, so that $1+r < \gamma_N^{1-\eta}/\beta$. The level of income in this economy converges toward the subsistence level.

Suppose that agents in this country are allowed to invest in the developed world and that currently the level of income in the economy is twice the subsistence income level. As we have seen in section III, if $\underline{C}$ were zero the growth rate would suddenly increase to the same level as that of the developed world. But since $\underline{C} > 0$ and the economy is close to subsistence consumption, there is a very long period of slow growth. The reason for this is that locally around the subsistence steady state the elasticity of intertemporal substitution is close to zero. As consumption increases so does the elasticity of intertemporal substitution, eventually converging to $1/\sigma$, and leading households to choose steeper paths for their consumption profiles.

Figure 4 shows that the pattern of evolution that would follow a liberalization of financial flows. This transition process can be extremely slow, it can take a long time for the economy to grow at a "healthy rate" and the brush with poverty

will leave permanent scars: there is no tendency for this country to catch up with the level of income of the rest of the world.

After the liberalization of capital flows all new investment is undertaken abroad but initially these flows are very small and the effects on growth almost negligible. One way to see that the short term effects of financial liberalization are likely to be disappointing is to look at the relation between the savings rate and the rate of growth associated with equation (4): $\gamma_Y = (s\ r + 1)/\gamma_N$. When the level of consumption is close to $\underline{C}$ the response of savings to changes in r is very small and s is close to zero. As a consequence, eliminating internal distortions or allowing investment abroad to raise r will have almost no short term impact on the rate of growth.

The idea that poor countries have lower savings rates is not new. It was one of the empirical regularities discovered by Kuznets (1966, pp. 426-7) and it is a prominent feature of the famous Kaldor (1956) model. This idea is, however, often associated with the time-honored question concerning the relation between the income distribution and growth. In the Kaldor (1956) model there are two groups of agents that have different marginal savings rates. Thus, redistributing income raises the aggregate savings rate and the rate of growth. The Stone-Geary preferences described in (44) do not imply any relation between income distribution and the rate of growth.[26] The reason for this is that the consumption decision rule (45) is linear implying that although different agents have different <u>average</u> savings rates, they all have the same <u>marginal</u> rate of savings.

There are several sources of evidence consistent with the idea that poor countries have lower savings rates. Giovannini (1985) has estimated the elasticity of intertemporal substitution in LDC's is extremely low and often insignificantly

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[26]See Williamson (1989, Lecture 3) for an historical discussion that supports the idea that inequality and growth are unrelated.

different from zero. This is exactly what one would expect from our Stone-Geary formulation. Recall that the elasticity of intertemporal substitution is equal to $(1-\underline{C}/C_t)(1/\sigma)$, so countries with consumption levels close to $\underline{C}$ should be expected to have low values for the rate of intertemporal substitution.[27]

Atkeson and Ogaki (1991) show that two types of utility functions rationalize simultaneously the fact that rich people have higher savings rates and lower food expenditure shares than poor people: a two-good extension of (44) and a 2-good addilog utility function They discuss a large body of evidence that supports both of these empirical regularities and describe simulations in which their models reproduce the S-shaped pattern of savings as a function of income suggested by Kuznets. They also prove aggregation results for these utility functions that guarantee that the relevant elasticity parameters can be estimated using aggregate data. In a separate paper (Ogaki and Atkeson (1991)) they report estimation results focusing only the addilog utility function. This narrower focus is justified by the fact that their 2-good extension of (44) has the counterfactual implication that the elasticity of the demand for food is highest for poor people.

Figure 5 shows the relation between the share of gross domestic savings in GNP and the level of real per capita GNP.

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[27]One possible problem with Giovannini's estimates is that they rely on data for the real return to time deposits. It is unclear whether these real rates of return, which are often negative, are a good measure of the real rate of return to capital in LDC's. In developing countries the financial intermediary system is often primitive and retained earning are used to finance investment projects whose rates of return are much higher than the time deposit rate. The fact that the change in time-deposits as a fraction of savings is small can be seen as suggesting that direct financing of investment is, in fact, an important phenomenon in LDC's. Gelb (1989) reports that the change in M3 (which includes currency plus deposits) on savings during the period 1965-73 was 18.7% for countries with a positive real interest rate, 12.7% for countries that had small negative real interest rates and 6.4% for countries that had large negative real interest rates.

Each point corresponds to the average savings rate and income level for a given country during a 10-year period (only non-overlapping periods were used; the Figure has the same features if we take averages over a different time horizon). The solid line in this Figure corresponds an estimate of the hyperbola described in (46). Figure 6 presents the same evidence but concentrating on countries with incomes less than 15000 1987 US dollars. The dotted line in Figure 7 depicts an estimate of (46) while the solid line was constructed by ordering the countries by income, dividing them into 10 classes and computing the simple average of the savings rate for these various classes. This set of Figures shows a relation between the rate of savings and the level of income that accords remarkably with the predictions of equation (46).

Table 1 shows that the relation between the inverse of the level of income and the rate of savings holds up when we move from a bivariate comparison to a multivariate analysis. The data used in these regression is that of the Barro-Wolf data set extended to include World Bank measures of the savings rate and of the share of exports in GDP. Standard errors, reported in parenthesis, are based on White's (1980) heteroskedasticity-consistent covariance matrix. The first regression describes the relation between the savings rate and the inverse of the level of income 1960 (INVGDP60), depicted in Figures 5 through 7. The second regression includes the variables in the Barro-Wolf data set that are not highly correlated with the initial income level. These variables are the share of government consumption expenditures in GDP (GOV), number of revolutions per year (REVOL), number of assassinations per million population per year (ASSASS) and the magnitude of the deviation of the investment deflator from the sample average (PPI60DEV). In this regression the coefficient on INVGDP60 continues to be negative and significant. The same result holds when we include, in the third regression, the share of exports in GDP (XGDP). The motivation to include this variable is Levine and Renelt's (1990) finding that this is the only variable that

is robustly correlated with investment.[28] Regressions (6) and (7) on Table 2 include the variables of the Barro-Wolf data set that are highly correlated with the initial level of income (Table 2): the enrollment ratios for primary and secondary education in 1960 (PRIM60 and SEC60, respectively) and the dummy variables for Africa and Latin America. Not surprisingly all the variables in the regression become insignificant, with the exception of the export share, as a result of multicolinearity. In contrast with what one might expect on the basis of life-cycle theories of savings, population-related variables (the growth rate of population, measures of the age structure, mortality rates) are insignificant when included in regression (3).

Table 3 reports similar results for a set of regressions in which the share of investment is used as a proxy for the savings rate. These regressions are presented to show that the results that we reported are not likely to be an artifact of measurement error in the savings rate series.

VI. CONCLUSION

The new growth literature has identified several mechanisms which can potentially explain differences in rates of growth across countries. Unfortunately most of these mechanisms fail to generate different rates of expansion in the presence of international capital markets. Existing models predict that a liberalization of capital flows would be followed by "capital flight" from stagnated countries, where the rate of return is low, to fast growing countries. As a result, the growth rates of consumption and of GNP would be equalized around the world.

A significant part of the new growth literature has been

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[28] Romer (1990b) reports results similar to those of this equation for the investment share. He found that per capita real income in 1960 is the only variable that has explanatory power for the investment share after one controls for the influence of the share of exports in GDP.

devoted to studying alternative specifications of the technology that makes sustained growth feasible without exogenous technical progress. The thought experiment of liberalizing capital flows suggests that properties of the technology alone cannot rationalize the diversity of growth experiences that we observe. When we combine those properties with the standard time-separable, isoelastic preferences we obtain the implication that allowing stagnant countries to invest their savings in growing economies would solve the development problem. This suggests that the standard preference specification is inadequate to think about growth in open economies.

This paper explored perhaps the simplest modification of standard preferences that has two properties: it is consistent with evidence that poor countries save less than rich countries and implies that a liberalization of capital flows would have negligible short term effects on the rate of growth. Empirical and theoretical work that improves on this preference specification can potentially enhance significantly our understanding of the development problem.[29] An important by-product of this research might be the solution to another classical problem in development economics: the relation between the dynamics of income distribution and the growth process.

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[29] Allen (1989) and Zervos (1991) are examples of studies of the consequences of departures from standard preferences for the implications of growth models.

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Table 1

Savings Rate Regressions

	(1)	(2)	(3)	(4)	(5)
CONSTANT	0.240	0.310	0.278	0.128	0.132
	(0.017)	(0.050)	(0.061)	(0.072)	(0.078)
INVGDP60	-0.050	-0.419	-0.039	-0.019	-0.018
	(0.009)	(0.010)	(0.010)	(0.015)	(0.020)
GOV		-0.377	-0.397	-0.230	-0.224
		(0.311)	(0.300)	(0.302)	(0.296)
ASSASS		-0.011	-0.006	-0.008	-0.009
		(0.022)	(0.024)	(0.018)	(0.019)
REVOL		-0.075	-0.046	-0.011	-0.012
		(0.097)	(0.096)	(0.093)	(0.093)
PPI60DEV		0.006	0.007	0.004	0.006
		(0.035)	(0.034)	(0.030)	(0.033)
XGDP			0.098	0.072	0.074
			(0.068)	(0.073)	(0.079)
SEC60				-0.042	-0.046
				(0.092)	(0.130)
PRIM60				0.141	0.138
				(0.053)	(0.060)
AFRICA					-0.010
					(0.037)
LAAMER					-0.001
					(0.060)
R^2	0.14	0.17	0.19	0.24	0.24

Table 2

Variable	Correlations with INVGDP60
GOV	0.35
ASSASS	-0.17
REVOL	0.18
PPI60DEV	0.22
XGDP	-0.16
SEC60	-0.65
PRIM60	-0.69
AFRICA	0.67
LAAMER	-0.25

Table 3

Investment Rate Regressions

	(1)	(2)	(3)	(4)	(5)
CONSTANT	0.234	0.229	0.206	0.070	0.074
	(0.010)	(0.019)	(0.024)	(0.031)	(0.036)
INVGDP60	-0.041	-0.034	-0.034	-0.004	-0.009
	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)
GOV		0.107	0.073	0.137	0.122
		(0.099)	(0.102)	(0.093)	(0.092)
ASSASS		-0.007	-0.005	-0.007	-0.003
		(0.014)	(0.015)	(0.010)	(0.010)
REVOL		-0.125	-0.090	-0.027	-0.024
		(0.021)	(0.029)	(0.027)	(0.027)
PPI60DEV		-0.049	-0.048	-0.059	-0.062
		(0.018)	(0.088)	(0.015)	(0.015)
XGDP			0.088	0.092	0.085
			(0.023)	(0.020)	(0.018)
SEC60				0.125	0.115
				(0.044)	(0.047)
PRIM60				0.068	0.077
				(0.025)	(0.025)
AFRICA					0.012
					(0.016)
LAAMER					-0.016
					(0.013)
R^2	0.29	0.47	0.49	0.63	0.64

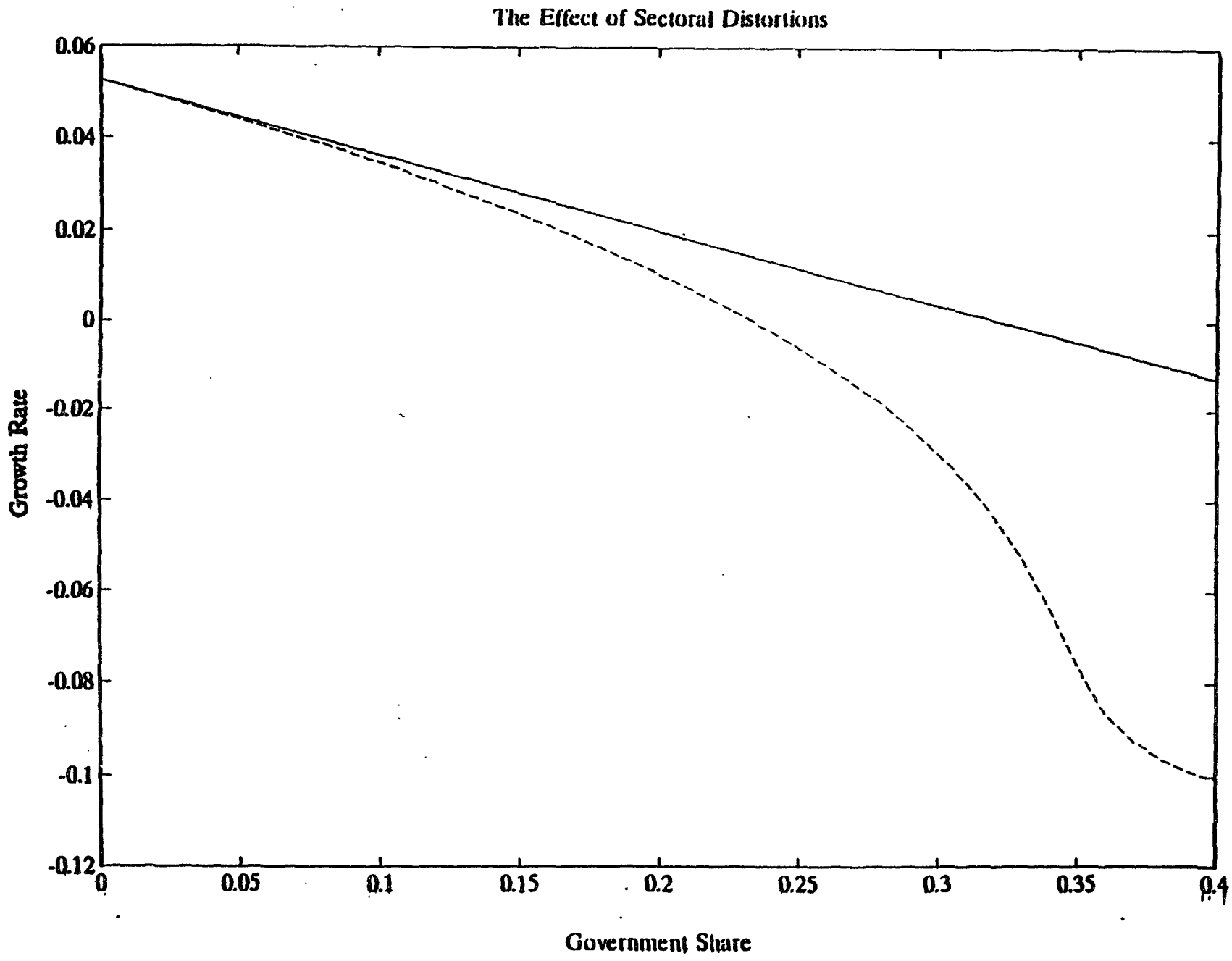

The Effect of Sectoral Distortions
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
Growth Rate
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Government Share

FIGURE 2

Linear Model

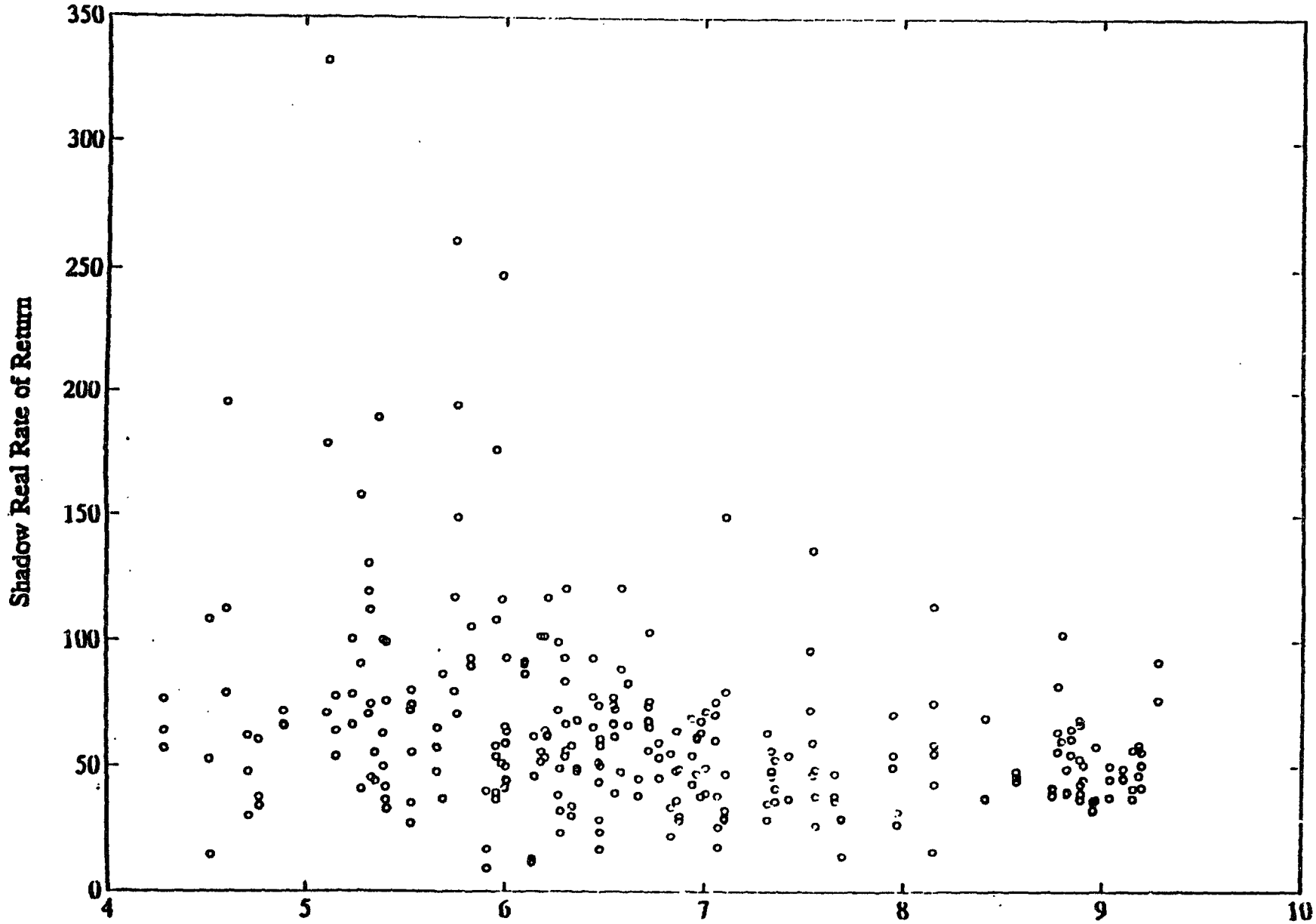


FIGURE 3

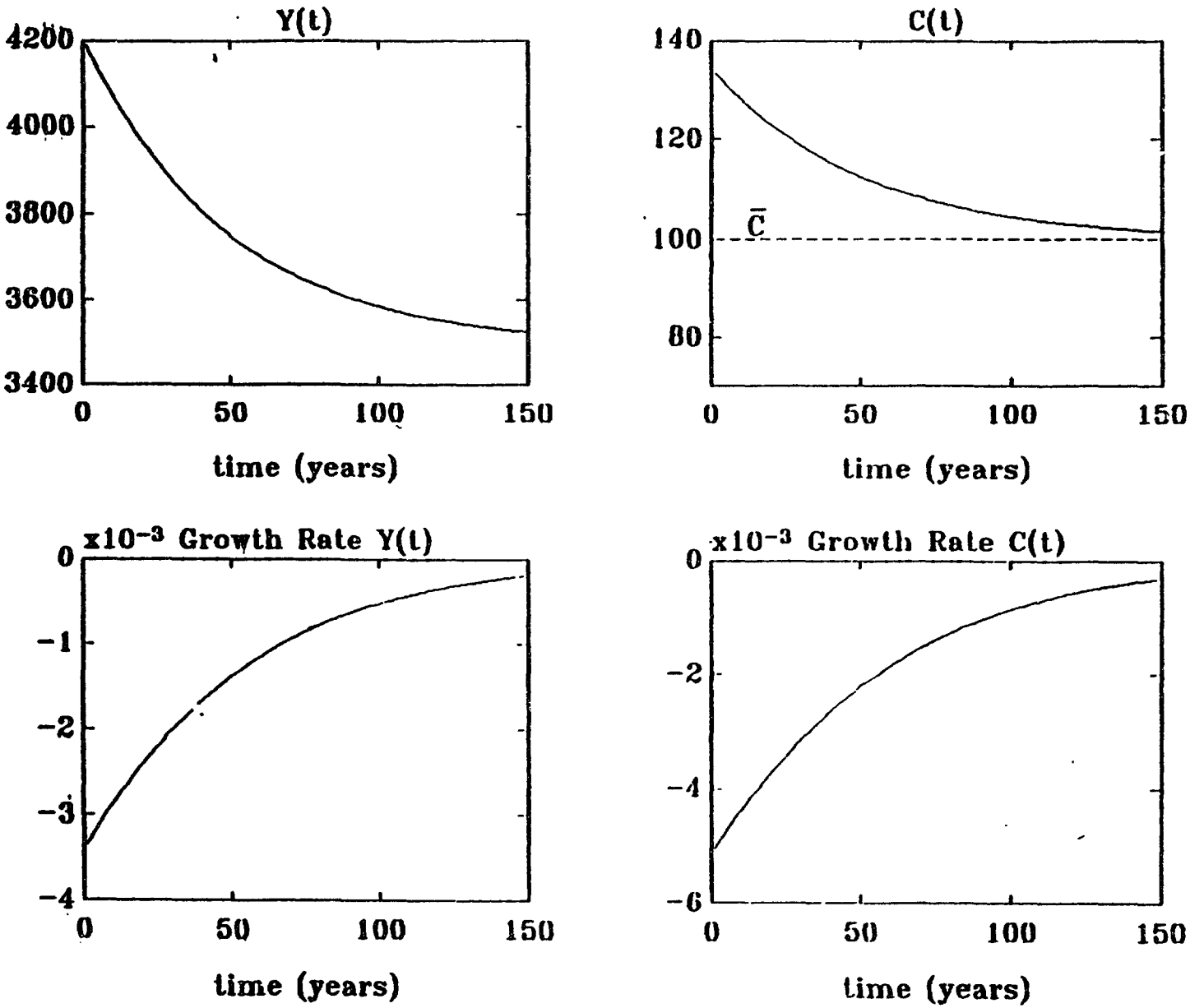

Y(t)
4200
4000
3800
3600
3400
0
50
100
150
time (years)
C(t)
140
120
100
80
$\bar{C}$
0
50
100
150
time (years)
x10⁻³ Growth Rate Y(t)
0
-1
-2
-3
-4
0
50
100
150
time (years)
x10⁻³ Growth Rate C(t)
0
-2
-4
-6
0
50
100
150
time (years)

FIGURE 4

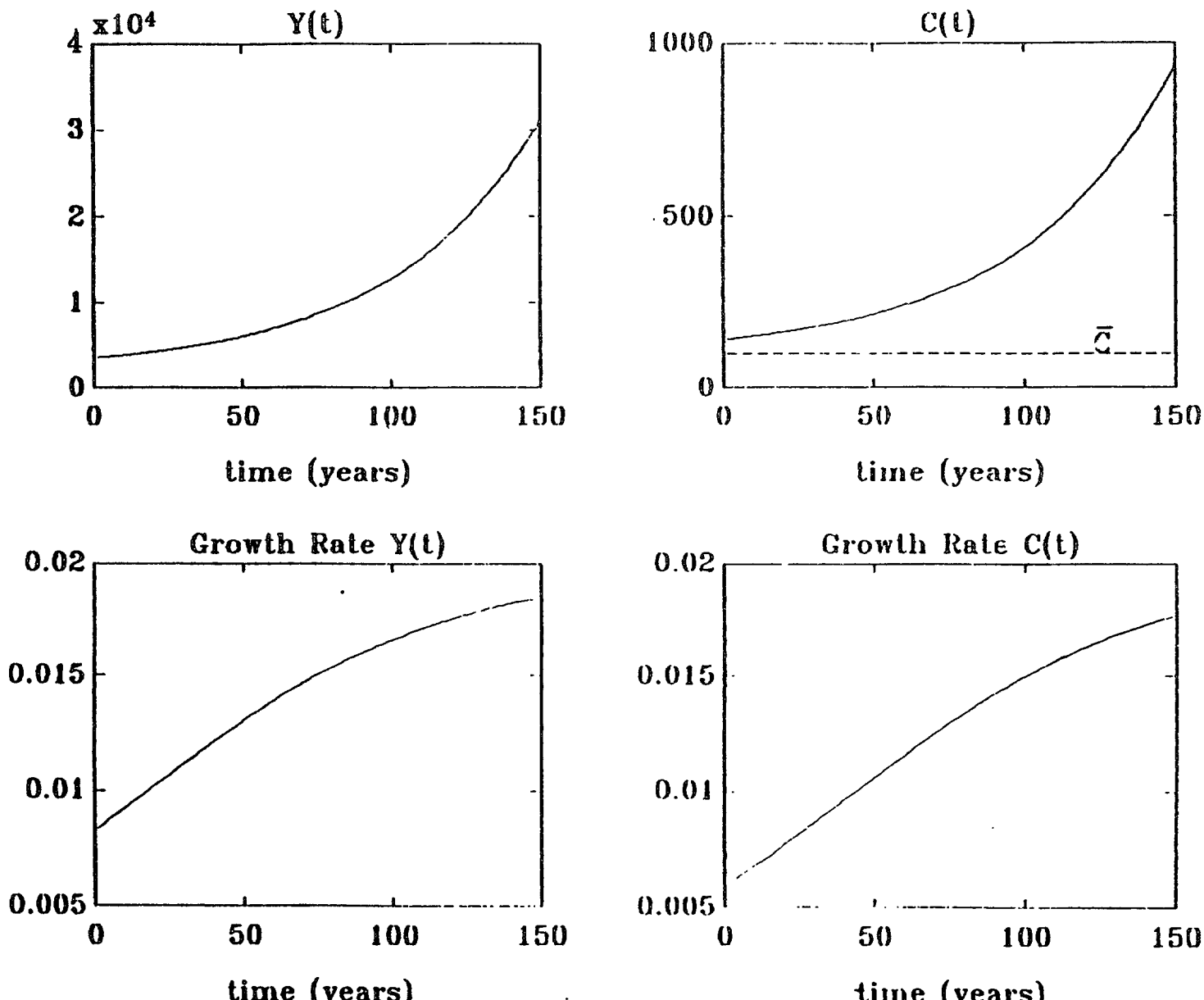

x10⁴
Y(t)
4
3
2
1
0
0
50
100
150
time (years)
C(t)
1000
500
0
$\bar{C}$
0
50
100
150
time (years)
Growth Rate Y(t)
0.02
0.015
0.01
0.005
0
50
100
150
time (years)
Growth Rate C(t)
0.02
0.015
0.01
0.005
0
50
100
150
time (years)

FIGURE 5

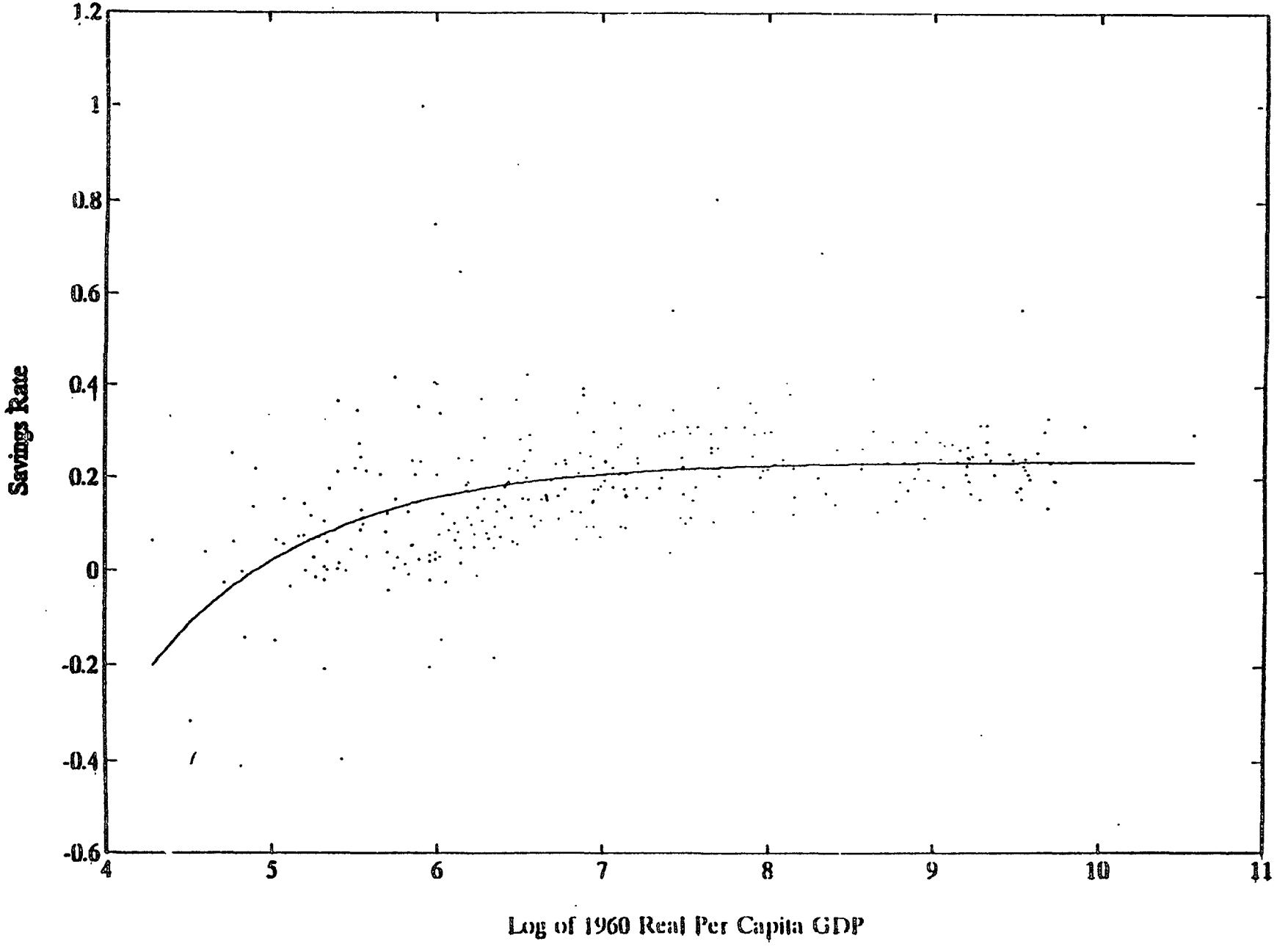
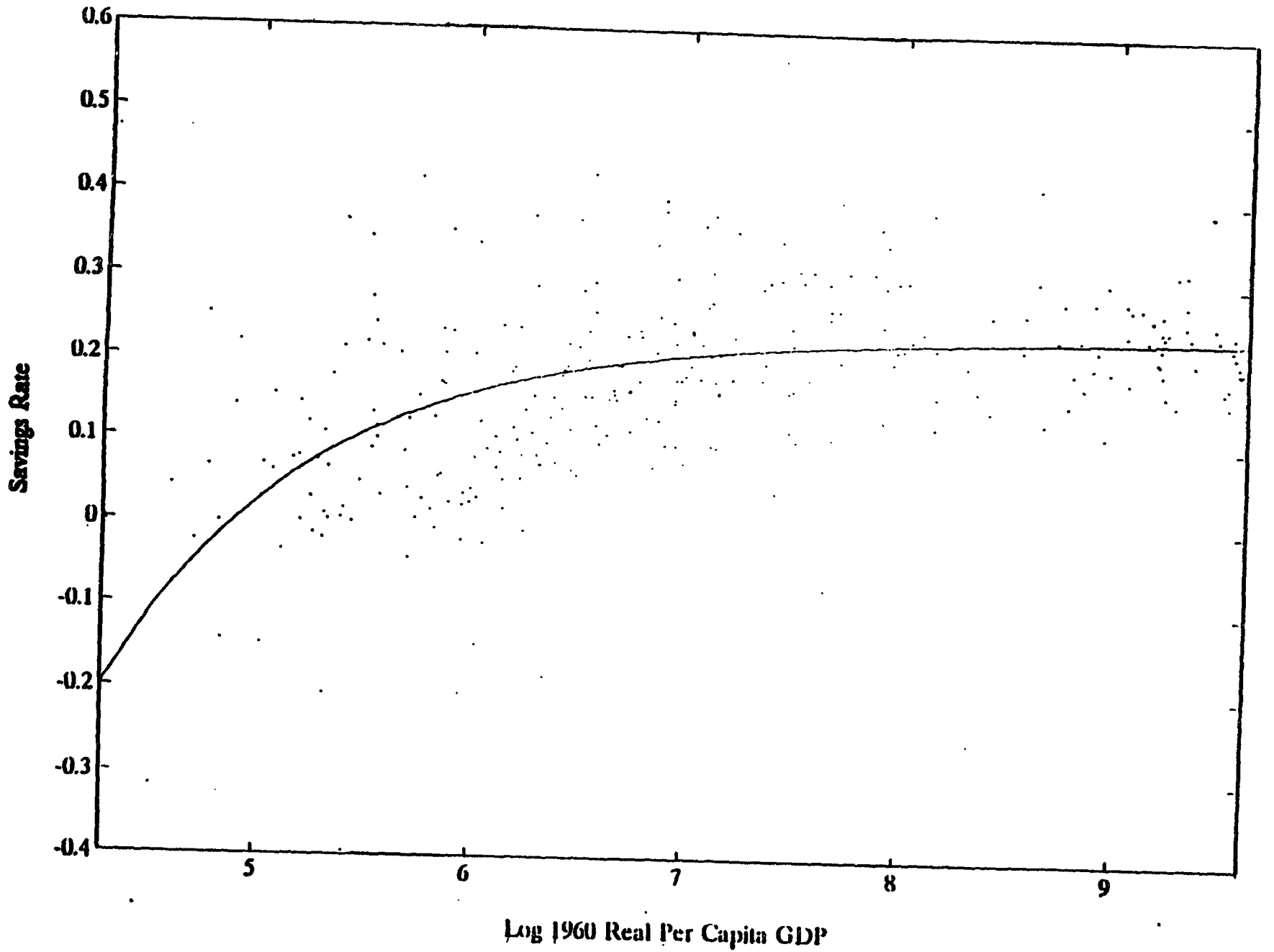
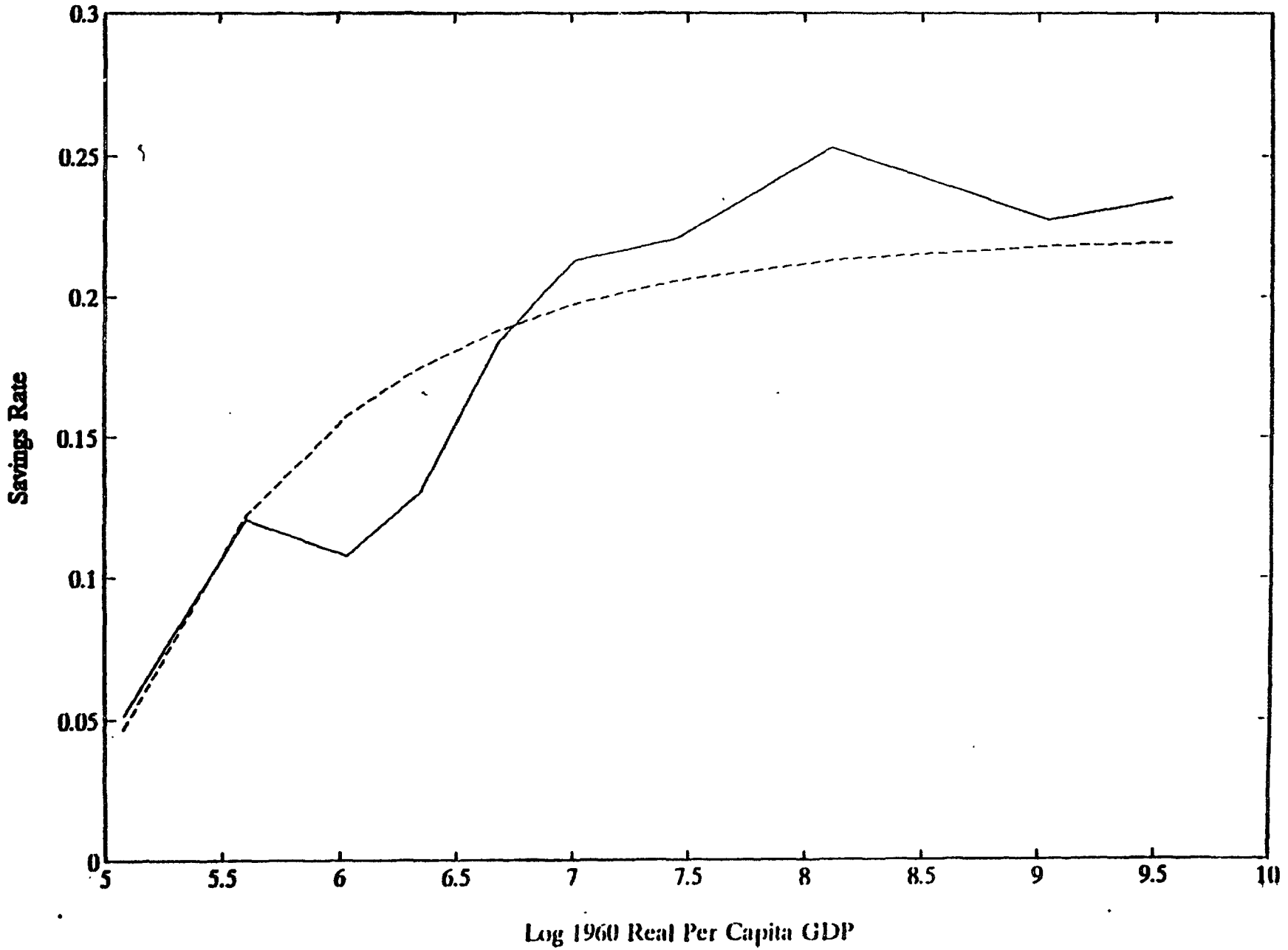

1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Savings Rate
4
5
6
7
8
9
10
11
Log of 1960 Real Per Capita GDP

FIGURE 6


0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Savings Rate
5
6
7
8
9
Log 1960 Real Per Capita GDP


0.3
0.25
0.2
0.15
0.1
0.05
0
Savings Rate
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Log 1960 Real Per Capita GDP

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