Policy, Research, and External Affairs

WORKING PAPERS

Macroeconomic Adjustment and Growth

Country Economics Department
The World Bank
October 1991
WPS 795

Economic Stagnation, Fixed Factors, and Policy Thresholds

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Economic policies, not initial conditions, determine whether countries stagnate. The black market premium on foreign exchange is an important factor in stagnation.

WPS 795

This paper — a product of the Macroeconomic Adjustment and Growth Division, Country Economics Department — is part of a larger effort in PRE to assess the effect of national policies on long-run growth. This research was funded by the World Bank's Research Support Budget under research project "Do National Policies Affect Long-Run Growth?" (RPO 676-66). Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Rebecca Martin, room N11-053, extension 39065 (39 pages). October1991.

Many developing countries have experienced economic stagnation. Africa had negative per capita growth in the 1970s and 1980s, and Latin America in the 1980s. Per capita growth was significantly greater than zero only in 41 of 87 developing countries in 1950-85, but it was significantly positive in all OECD countries.

Analysis of decade-long growth rates in all countries shows a striking regularity: Episodes of rapid growth are limited largely to a middle range of initial income; neither very poor nor very rich countries experience rapid growth. Episodes of negative growth are limited to low and middle-income countries.

Easterly develops a simple model that sheds light on this historical experience. The model has two familiar elements from the growth literature: (1) a Stone-Geary utility function (saving is low at low incomes), and (2) fixed factors with the marginal product of capital bounded away from zero. The second property is derived by assuming an elasticity of substitution greater than one between an exogenous labor input and a broad concept of capital. Easterly extends the model to consider multiple capital goods and public capital.

He finds that stagnation because of fixed factors is consistent with an array of statistical evidence. Economic policies — not initial conditions — determine whether countries stagnate. The black market premium on foreign exchange is particularly helpful in explaining stagnation.

Empiric' results show that growth first accelerates and then falls as income rises. Results confirm that initial income and policy variables have a different effect on whether a country stagnates than they do on the rate of growth once it starts growing, as expected from the distinction between steady-state and transitional effects.

These results suggest that cross-section growth regressions may be misspecified because of the nonlinearity inherent in the possibility of steady-state stagnation.

TABLE OF CONTENTS

I have benefitted from comments of Robert Barro, Jose de Gregorio, Stanley Fischer, Robert King, Michael Kremer, Ross Levine, Lant Pritchett, Sergio Rebelo, Dani Rodrik, Alwyn Young and Heng-Fu Zou, as well as of participants in a seminar at University of Maryland and in the Northwestern University Summer Workshop. I am grateful for research assistance from Piyabha Kongsamut and Maria Cristina Siochi.

I. Introduction

Stagnation due to fixed factors bulks large in both the old and the new literature on growth. The diminishing returns to endogenous factors with other factors fixed exogenously is at the heart of classical and neoclassical theories of growth from Malthus to Solow. Malthus postulated a model with population growth constrained at zero because of the dimininishing marginal product of labor with land held constant. Ricardo put forward his model of rising rents and landlord enrichment based on a fixed supply of land. Mill recognized that other economic forces could offset diminishing returns to fixed factors, but the outcome was far from certain:

> Whether, at the present or any other time, the produce of industry proportionally to the labor employed, is increasing or diminishing ... depends upon whether population is advancing faster than improvement, or improvement than population.[1]

Mill seems to be a precursor to the broad notion of capital in the current growth literature in that his "improvement" includes inventions, institutional change, and education and training.

Solow could afford to ignore land as a factor of production; in his model it is diminishing returns to capital with exogenous labor growth that prevents sustained per capita growth. Thus, his famous conclusion that exogenous technological change, the "residual", was the force behind per capita growth. However, in retrospect, the predictions of the model seem to have had decidedly mixed success in describing postwar economic development. The prediction of the model that poor countries would grow faster than rich countries seems to have been confirmed among the subset of advanced countries (or among regions of one rich country) but not among all countries (Baumol and Wolff (1988), Barro and Sala-I-Martin (1989)). Some empirical studies have found that growth is inversely related to per capita income when policy variables are included (Barro (1991), Romer (1989), Levine and Renelt (1990)).

The new literature on growth makes growth endogenous by postulating externalities to human or physical capital that overwhelm diminishing returns to fixed factors (Romer (1986,

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[1]quoted in Abramowitz (1989), p.6

1990), Lucas (1988)). Another strand of the literature simply omits fixed factors (Rebelo (1991), King and Rebelo (1990), Barro (1990)), arguing that even labor can be increased endogenously through investment in human capital, so that "everything is capital." This literature bears a resemblance to the development literature of the 1940's and 50's, which also argued that production depended only on capital, albeit for much different reasons -- in the famous Lewis surplus labor model, for example, an infinitely elastic supply of labor makes (physical) capital the only constraint on output.[2]

The new literature on growth has also begun to address the apparent predicament of the poorest countries. Models with multiple equilibria are of particular interest here. Azariadis and Drazen (1990) show how a threshold requirement in the externality generated by human capital accumulation can yield multiple steady states in per capita growth, some characterized by low growth and no human capital investment, others by high growth and high investment in human capital. Similarly, using a model of endogenous fertility, Becker, Murphy, and Tamura (1990) postulate an increasing marginal product of human capital over low income ranges to generate alternative steady states of high fertility and zero per capita growth and low fertility and high per capita growth. Murphy, Shleifer, and Vishny (1988) present a model with coordination externalities in which a "big push" may be needed to start development in a low income economy. In all of these models, initial conditions can play a critical role in whether a country develops. Again, these models echo earlier strands of the development literature -- e.g. the "low-level development trap" of Nelson (1956), and the "big push" theory of Rosenstein-Rodan (1947).

Other endogenous growth models supply other elements useful to understand the apparent stagnation of the poor countries without reference to increasing returns or initial conditions. Rebelo (1991b) and Easterly (1990a) postulate models in which the rate of saving

[2]The models continue to be influential up to the present. For a recent example, see Taylor (1989).

rises with income, in the tradition of the Stone-Geary consumption function. Rebelo (1991b) presents strong evidence for this hypothesis with analysis of cross-country saving rates. A country can then be stuck in a zero growth equilibrium with "subsistence" income and zero saving. Jones and Manuelli (1990) present an endogenous growth model in which the production function exhibits constant returns and diminishing marginal products of all factors, but the marginal product of capital is bounded away from zero.[3] This model has two attractive features: (1) endogenous growth can be explained without any reference to market failure or externalities; (2) the model can generate either stagnant per capita income or sustained growth depending on the parameters. In this paper, we will combine the elements of Stone-Geary consumption behavior with a Jones-Manuelli production function to analyze possible causes of growth and stagnation.

The paper is organized as follows. In section II, we present some descriptive statistics on the phenomenon of income stagnation. In section III, we present a model that explains stagnation and growth by policies such as income taxes. Some variations of the model to consider distortionary policies and government investment are also presented. Section IV presents some empirical results which relate the probability of stagnation to policy variables. Section V concludes.

II. Evidence on output stagnation and growth

Although the euphemism "developing countries" is universally used to describe poor countries, it is far from clear that sustained per capita growth is underway in all countries. Determining long-run growth tendencies is problematic because of the short time-series available for most countries. Reynolds (1985) concluded that 7 of 40 developing countries whose long-run

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[3]The earlier growth literature had also considered this type of model (Gale and Sutherland (1968), Kurz (1968)).

experience he analyzed had not begun sustained per capita growth. The 1991 World Development Report of the World Bank shows negative or zero per capita growth for 19 developing countries from 1965-89.[4] All developed countries had per capita growth rates well above zero over this period. Income levels at or near subsistence in some low-income countries could also be taken as prima facie evidence that those countries have never grown.[5]

Even for those countries that display positive per capita growth, it is unclear whether this represents an underlying trend or merely random variation around a stationary income level. To test this for individual countries, the log change in real per capita GDP was regressed on a constant and then the significance of this constant was assessed. The results are shown in table 1.[6] Only 41 out of 87 developing countries had significant positive per capita growth in the postwar period. In other words, growth is so low and/or the variation in output in 46 of the 87 countries is so great relative to the trend that it is impossible to discern whether the countries are growing or not.[7] By contrast, all OECD countries had significant growth rates (not shown in the table).

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[4]The countries are Ethiopia, Chad, Tanzania, Zaire, Madagascar, Uganda, Zambia, Niger, Togo, Benin, Central African Republic, Ghana, Mauritania, Bolivia, Senegal, Peru, El Salvador, Jamaica, and Argentina. Venezuela, Libya, and Kuwait also had negative growth but are excluded because their economies are dominated by oil. Many other countries that probably had negative growth are excluded because of unavailablity of data: Afghanistan, Bhutan, Kampuchea, Liberia, Myanmar, Sudan, Vietnam, Lebanon, Mongolia, Nicaraugua, Iraq, and Romania.

[5]The 1990 World Development Report defines US$375 per capita consumption as the poverty line in 1985 PPP prices. 10 countries were below this level in 1988 according to Summers and Heston (1988). This argument was suggested by Lant Pritchett.

[6]Countries dominated by oil are excluded. An earlier version of these results is contained in Easterly (1990a).

[7] To discriminate between insignificance due to low growth and that due to high variation, we calculate the power of the test, as suggested by Andrews (1989). If the absolute value of true growth is less than the coefficient value under "region of low power", the probability of failing to reject is greater than 50 percent. A high value of this coefficient implies a weak test. For example, 13 of 28 countries with insignificant positive growth have a region of low power spanning more than [-1,1], which means that even if the true growth rate were above 1 percent (or less than -1 percent), there would still be a 50 percent chance the test would fail to reject zero growth. For these countries, there is little chance of detecting whether growth is occurring -- the test is indeed very weak. For the other countries, the region of low power is within [-1,1]. This implies for those countries that there is a high probability of failing to reject zero growth only if growth is in fact close to zero. This technique was suggested by Lant Pritchett. Detailed results are available upon request.

Table 1
Per capita growth performance of developing countries, 1950-85

Negative growth	Positive but insignificant growth	Positive and significant growth
Afghanistan	Argentina	Algeria
Angola	Bangladesh	Barbados
Benin	Chile	Botswana
Bolivia	Congo	Brazil
Burundi	Cote d'Ivoire	Burkina Faso
Central African Rep.	El Salvador	Cameroon
Chad	Ethiopia	China
Ghana	Fiji	Colombia
Guinea	Guatemala	Costa Rica
Guyana	Haiti	Cyprus
Madagascar	Honduras	Dominican Republic
Mali	Jamaica	Ecuador
Mozambique	Kenya	Egypt
Senegal	Liberia	Gabon
Somalia	Mauritania	Hong Kong
Sudan	Mauritius	India
Zaire	Nepal	Indonesia
Zambia	Nicaragua	Jordan
	Nigeria	Korea
	Papua New Guinea	Lesotho
	Peru	Malawi
	Philippines	Malaysia
	Rwanda	Malta
	Sierra Leone	Mexico
	The Gambia	Morocco
	Togo	Myanmar
	Uganda	Pakistan
	Uruguay	Panama
		Paraguay
		Singapore
		South Africa
		Sri Lanka
		Suriname
		Swaziland
		Syria
		Taiwan
		Tanzania
		Thailand
		Tunisia
		Turkey
		Zimbabwe
18	28	41

Source: Summers and Heston data set.

Although there is doubt about the long-term trend of many countries, there is no doubt about recent stagnation in most developing countries. Table 2 shows growth rates by decade for regional groups of developing countries. The African countries (almost all low-income economies) stagnated in both the 1970's and 1980's. Latin America stagnated in the 1980's in the aftermath of the external debt crisis. South Asia has done better than Africa and Latin America, but only East Asian countries (almost all middle-income economies) compare favorably to OECD countries.

Figure 1 shows decade-long per capita growth rates graphed against initial per capita income level. Two striking facts are evident. One is that the phenomenon of negative growth is limited to developing countries. The second is that the upper boundary to the distribution displays a bell shape -- the most rapidly growing countries are at middle income levels. (This is more evident in figure 1b which displays a logarithmic scale). Contrary to the predictions of the Solow model, even the "best" poor countries grow less rapidly than the "best" middle-income countries. However, beginning with middle-income levels, the "best" growth rates decline with income level. The rapid growth of middle-income countries mirrors the earlier experience of "catch-up" of late industrializers such as Japan and Russia, as famously noted by Gerschenkron (1962).[8] To see whether this pattern is due to the scarcity of observations in the tails of a bivariate normal distribution, Figure 1c graphs the observations from the sample stratified into equal groups. We still see a strong tendency for the upper boundary of the graph to show a bell shape.

[8]The "catch-up" phenomenon was attributed by Gerschenkron to, among other things, the advantage that latecomers have in borrowing technology which they do not need to develop themselves. For recent discussions of the dynamics of technological diffusion and adoption, see Jovanovic, Lach (1990), Wan (1990), and Parento and rescott (1991).

Table 2
Growth rates of output per capita, 1960 to 1989

Country group	GDP per capita growth Annual averages 1960-70	1970-80	1980-89
Low and middle-income economies	2.2	1.7	0.1
Low-income economies	1.2	0.6	-0.2
Middle-income economies	3.0	2.7	0.3
Sub-Saharan Africa	1.4	-0.2	-0.5
East Asia	3.6	4.6	3.6
South Asia	1.4	1.4	2.3
Latin America and the Caribbean	2.4	2.0	-1.2
OECD	4.1	2.3	2.0

All averages are unweighted. Cil-dominated countries have been excluded.
Regional aggregates include only developing countries.

Sources: WDR 1981, 1982, and 1990.

Figure 1(a)

Per capita income and growth

(Linear scaling)

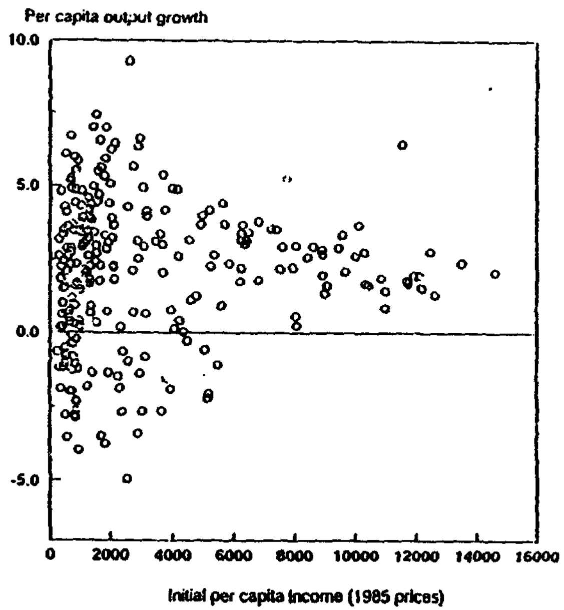


Figure 1(b)

Per capita income and growth

(Logarithmic scaling)

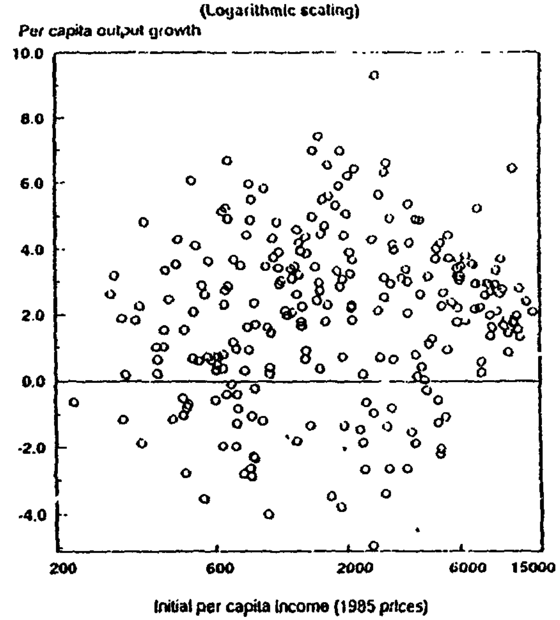
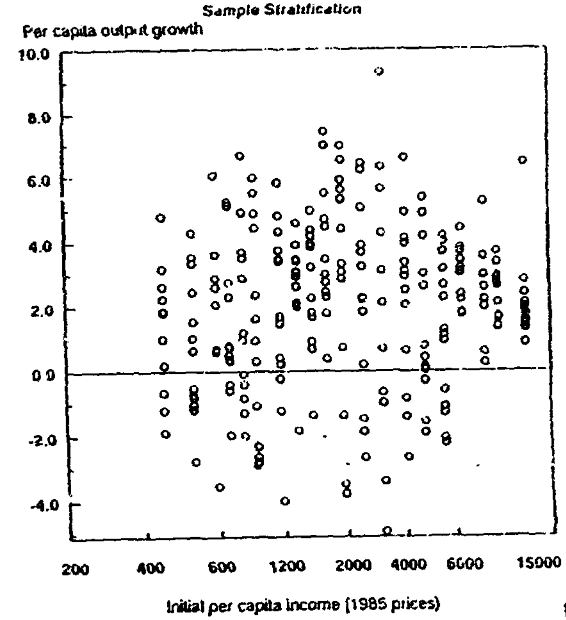


Figure 1(c)

Per capita income and growth

(Logarithmic scaling)

Sample Stratification



To assess whether the patterns presented are statistically significant, Table 3 shows a contingency table and tests for the independence of income and growth under various classifications. With a 3-way classification (low, middle, and high income, and high positive, medium positive, and negative growth) the independence of growth and income is decisively rejected. This is an interesting contrast to the well-known lack of significance of the simple linear correlation between growth and income (in this sample, the correlation coefficient is .06).[9] The pattern that high growth rates are disproportionately represented among middle income countries is confirmed statistically at the 5 percent level, as is the relative absence of negative growth at high incomes.[10]

III. A model of policy-induced stagnation

In this section we present a model where policy and model parameters determines whether a country is in one of 3 possible long-run equilibria: (1) zero per capita growth with income at subsistence; (2) zero per capita growth with income above subsistence; or (3) positive per capita growth. Only one equilibrium at a time exhibits saddle point stability, so the outcome is well-defined. We show how the model displays the alternative equilibria depending on the overall rate of income tax. We then consider some extensions of the model to the case of

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[9] This lack of simple correlation between per capita income and growth was noted by, among others, Summers and Heston (1988) and Barro (1991).

[10] Alternative breakdowns of growth and income were tested to assess the robustness of these results. With high growth defined alternatively as greater than 4 percent and greater than 3 percent, disproportionate representation of high growth at middle incomes is confirmed even more strongly. With the income breakpoints at 700 and 7000, a tendency toward high growth at middle incomes is confirmed if high growth is defined as greater than 3 or 4 percent, but not 5 percent. With income breakpoints at 800 and 6200 (chosen as the 1980 per capita incomes corresponding to the borderline low and high income countries in the WDR), high middle income growth is again confirmed with the 3 and 4 percent definitions, but not the 5 percent. We conclude the result of greater frequency of high growth at middle incomes is reasonably robust. The general independence of growth and initial income (i.e. also including the lack of negative growth at high income) is rejected at the 1 percent level with all of these breakdowns.

Table 3:
Contingency table of per capita income and per capita growth, decade averages

initial per capita income	Y<600	6000>Y>600	Y>6000	totals
per capita growth	#observations:			
g>5	1	23	2	26
5>g>0	24	109	51	184
g<0	10	43	1	54
totals	35	175	54	264
proportions of income				
g>5	2.9%	13.1%	3.7%	9.8%
5>g>0	68.6%	62.3%	94.4%	69.7%
g<0	28.6%	24.6%	1.9%	20.5%
sum	100.0%	100.0%	100.0%	100.0%
proportions of growth				
g>5	3.8%	88.5%	7.7%	100.0%
5>g>0	13.0%	59.2%	27.7%	100.0%
g<0	18.5%	79.6%	1.9%	100.0%
sum	13.3%	66.3%	20.5%	100.0%
Chi-squared statistics for rejecting independence of growth and income:				
for entire table (4 d.f.)				23.58 ***
for growth > < 5% (2 d.f.)				6.36 **
for growth > < 0% (2 d.f.)				14.73 ***
correlation coefficient of growth rates and per capita income:				0.06
(t-statistic)				(.98)

Sources: growth, World Bank data;per capita income (85 prices), Summers and Heston (1988)
*** significant at 1% ** significant at 5%

multiple types of capital goods, which is relevant for the analysis of policies that affect resource allocation. Two such policies that are considered are differential taxes on investment goods, and government investment in infrastructure.

1. The model

The production function for the single good is a conventional CES function for capital K and labor L:

$$(1) \qquad Y = A\,(\gamma K^{\epsilon} + (1-\gamma)L^{\epsilon})^{\frac{1}{\epsilon}}$$

The elasticity of substitution between capital and labor is $1/(\epsilon-1)$. The only difference from a conventional neoclassical specification is that capital is defined more broadly than just fixed physical assets. As in Rebelo (1991b) and Barro (1990), we have in mind a broad concept of capital that includes human capital, "knowledge" capital, "organizational" capital, etc.[11] However, unlike Rebelo and Barro, but like Jones and Manuelli (1990), a fixed factor like "raw" labor still has a role in production.[12]

With such a broad concept of capital in mind, it is assumed $\epsilon>0$, i.e. the elasticity of substitution between capital and labor is greater than one. It is true that a great deal of econometric evidence suggests that this elasticity is less than or equal to one. However, if (1) is the true relation where K is defined to be "broad" capital, the estimation of (1) with only physical capital and labor included would result in biased coefficient estimates, because of the omission of

[11] Since some or all of these nontraditional types of capital are embodied in people, K should be thought of as including an element hL where h is embodied capital per person. We ignore this complication to simplify the presentation.

[12] Another production function that satisfies the Jones-Manuelli property is $Y = AK + BK^{\gamma}L^{1-\gamma}$ (dubbed the "Sobelow function" by Sala-i-Martin (1990) because it is a linear combination of the Rebelo and Solow models).

other non-physical types of capital. A large substitution elasticity is plausible if we think of labor-saving innovation (traditionally considered exogenous) as a way of substituting physical capital, human capital, and "knowledge" for labor.[13]

With an elasticity greater than one, this production function obeys the Jones-Manuelli property that the marginal product of capital approaches a nonzero limit as the capital-labor ratio goes to infinity. Specifically, if $\epsilon>0$, then:

$$(2) \qquad \lim_{k\to\infty} \frac{\partial y}{\partial k} = A\gamma^{\frac{1}{\epsilon}}$$

where k is the capital-labor ratio, and y is per capita income.

It is assumed that infinitely-lived producer-consumer dynasties maximize the per capita welfare of themselves and their descendants:

$$(3) \qquad \max \int_0^\infty e^{-\rho t} \frac{(c - c_s)^{1-\sigma} - 1}{1-\sigma} L^\beta dt$$

Utility is an isoelastic function of per capita consumption in excess of a "subsistence" level of c_s.

The labor term in the intertemporal utility function reflects the weight placed on numbers of descendants vis-a-vis the per capita utility of those descendants, as in Rebelo (1991b) and Becker and Barro (1988). If β is equal to zero, then only the per capita welfare of future descendants is considered. If $\beta=1$, then the aggregate welfare of descendants is considered -- one

[13]This function also has the apparently counter-intuitive property that neither input is strictly essential, i.e. there could still be positive production with zero labor. However, keeping the broad definition of capital in mind, this does not imply some 21st century fantasy of machines doing all the work. Capital includes human capital embodied in persons.

is indifferent between an increase in aggregate dynasty "income" because of more descendants and an increase due to higher per capita "income" of an unchanged number of descendants.

We assume that income is taxed by the government at rate τ. Per capita consumption is constrained by:

$$(4)\qquad c = (1-\tau)A\,(\gamma k^{\epsilon} + 1-\gamma)^{\frac{1}{\epsilon}} - i$$

where i is investment per capita. The evolution of the capital-labor ratio is given by:

$$(5)\qquad \dot{k} = i - (\delta+\eta)k$$

where η is the rate of exogenous labor growth.

The first-order conditions yield the following equation for the growth of consumption:

$$6)\qquad \frac{\dot{c}}{c} = \left[\frac{(1-\tau)A\gamma(\gamma + (1-\gamma)k^{-\epsilon})^{\frac{1-\epsilon}{\epsilon}} - ((1-\beta)\eta+\delta+\rho)}{\sigma}\right]\left[\frac{c-c_s}{c}\right]$$

The first expression in brackets is the familiar condition that growth of per capita consumption is given by the net marginal product of capital less the discount rate and labor growth rate (adjusted by β), times the intertemporal elasticity of substitution. The second expression in brackets is the ratio of "excess" (i.e. above subsistence) consumption to total consumption. This term will be close to zero with low consumption and close to one with high consumption.

Equation (6) displays two possible zero-growth equilibria. One is the "modified golden rule" equilibrium where the net marginal product of capital (the marginal product less depreciation) is equal to labor growth (adjusted by β) plus the discount rate. The other is the subsistence equilibrium where consumption is equal to subsistence consumption c_s. We will see that at most one of these can be stable, and that the tax rate will determine which one is stable, if either. Unlike nonconvex models, initial conditions do not affect the outcome.[14]

The value of the capital-labor ratio at subsistence will be given by the k_s that satisfies the condition that subsistence consumption is just equal to after-tax income less the investment required to replace depreciated capital and keep up with labor growth.

$$(7) \qquad c_s = (1-\tau)A\,[\gamma k_s^{\epsilon} + 1-\gamma]^{\frac{1}{\epsilon}} - (\delta+\eta)k_s$$

This equation could have two solutions for k_s: one less than the "golden rule" consumption-maximizing k, and one greater. The lesser one, where the derivative of consumption with respect to k is positive, is the relevant one (the higher one will be dynamically inefficient and unstable). It is also conceivable that (7) would have no solution -- i.e. subsistence is not feasible. There will always be some τ that implies infeasibility of subsistence -- this range of τ is ignored here.

From (7), we can show that the subsistence capital stock will be positively related to c_s, τ, n, and δ. A higher subsistence requirement, higher taxes, higher labor growth, and higher depreciation all force the consumer to accumulate more capital to satisfy her subsistence requirements.

[14]Models with multiplicity of equilibria and dependence on initial conditions include Murphy, Shleifer and Vishny (1989), Becker, Murphy, and Tamura (1990) and Azariadis and Drazen (1990). See also the discussion in Sala-i-Martin (1990). With nonconvexities in the present model, whether the economy grows or stagnates would depend on initial conditions, since the marginal product curve would intersect the time preference line in more than one place. However, note that policies could be such as to avoid the dependence on history. A policy change could shift the after-tax marginal product curve entirely above the sum of labor growth, depreciation, and discount rates, leading to sustained growth regardless of initial conditions.

The subsistence equilibrium will be stable if the first term in brackets in (6) is negative, i.e. if the net marginal product of capital is less than the discount rate plus the adjusted labor growth rate, evaluated at the subsistence capital stock k_s:

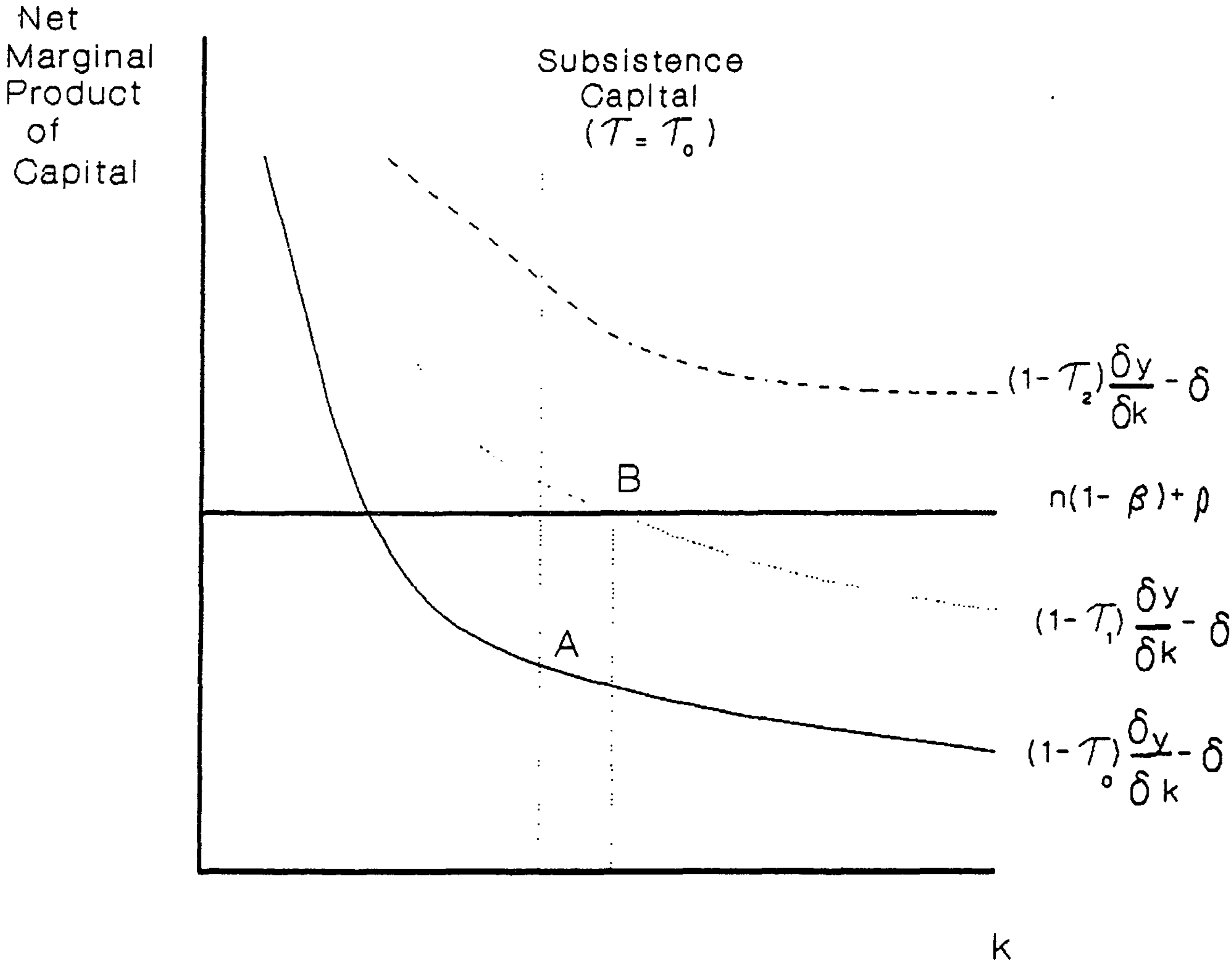
$$(8) \qquad (1-\tau)A\gamma(\gamma + (1-\gamma)k_s^{-\epsilon})^{\frac{1-\epsilon}{\epsilon}} - ((1-\beta)\eta+\delta+\rho) < 0$$

If (8) holds, then at subsistence the consumer will not find it worthwhile to accumulate more capital (point A in figure 2).[15] A higher tax rate will make it more likely that (8) holds, both because it lowers the first term directly, and because it increases the subsistence capital stock k_s. Similarly, higher labor growth, higher depreciation of capital, and a higher discount rate will all make it more likely that (8) holds, i.e. that the economy will be stuck at subsistence.

If (8) is violated at the subsistence level k_s, then the consumer will want to accumulate more capital until the net marginal product falls to equality with the discount rate plus the rate of labor growth (i.e. till (8) holds with equality such as point B for a capital level above k_s in figure 2). This will be the modified golden rule equilibrium of the Solow-Cass model. Note that this equilibrium will only be feasible if it yields a value of consumption above subsistence. Thus, another interpretation of (8) is that it gives the condition for the subsistence capital stock to lie above the modified golden rule capital stock. Whichever capital stock is greater will be the stable equilibrium.

[15]This result mirrors that of Rebelo (1991b).

Figure 2
Net marginal product of capital and alternative steady states



However, it is not assured that there is any capital stock sufficiently large to equate the net marginal product to the discount rate plus labor growth. Recall from (2) that the marginal product of capital approaches a positive minimum as the capital labor ratio goes to infinity. If this minimum, net of depreciation, lies above the discount rate plus labor growth, then no stable fixed income equilibria will exist:

$$(9) \qquad \frac{(1-\tau)A\gamma^{\frac{1}{\epsilon}} - ((1-\beta)\eta+\delta+\rho)}{\sigma} > 0$$

If (9) holds, then the consumer will find it worthwhile to increase capital indefinitely (see τ_2 curve in figure 2). In the limit, per capita growth will approach the expression given in (9).

From (9), we see that stagnation is more likely with higher taxes, higher labor growth, higher depreciation, and a higher discount rate.[16] If there is growth, the same factors make growth lower. (However, note that if $\beta = 1$, labor growth will have no effect on whether per capita growth takes place.) Combining this result with the previous one, we see policy continuity -- as the tax rate rises, it lowers the rate of growth, until finally growth stops all together. Further increases in the tax rate lower the fixed level of income until income falls to subsistence. A range of tax rates will be consistent with subsistence.[17]

Figure 3 shows the conventional Cass-Koopmans phase diagrams for the subsistence and modified golden rule equilibrium. Multiple steady states exist, but only one steady state at a time exhibits saddle-point stability.

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[16]A similar result is noted in Jones and Manuelli (1990).

[17]From (8) and (9) it is apparent that changes in A are equivalent to changes in τ of opposite sign. This implies that a permanent one-time exogenous technological shift can be sufficient to escape a subsistence income trap, or to move from zero per capita growth to positive growth. This gives an interesting contrast to the traditional neoclassical model in which continuous technological progress is required for per capita growth. Similarly, a negative shock (like a civil war) could induce stagnation in a previously growing economy.

The transitional properties of this model are also interesting. From (6), we can see that two offsetting factors will be at work in determining the speed of growth during a transition from stagnation to growth. A country with an initially low per capita capital stock will have a high before-tax marginal product of capital and would grow rapidly, just as in the Solow model. However, this is offset by the low saving propensity at low income levels, as reflected in the second term in (6). Simulations of the saddle path of the model reveal a "hump-shaped" pattern of accelerating then decelerating growth as shown in figure 4.[18] This property of the model offers a possible explanation of the rapid growth of middle-income countries compared to very poor and very rich countries.

2. Extensions of the Model

A model with multiple inputs is relevant to analyze policies which distort the allocation of resources among different activities, policies that are common in developing countries. This extension will also be useful to examine the role played by public sector capital.

[18] Accelerating growth (but not decelerating) during the transition is noted in the Rebelo (1991) application of a Stone-Geary utility function. A "hump-shaped" relationship between transitional growth and per capita income is observed in the analysis of King and Rebelo (1990) of the transitional dynamics of the Solow model with Stone-Geary utility, for exactly the same reason as in this paper. "Hump-shaped" transition paths also follow from technology adoption models because of the well-known logistic curve for new product output (Jovanovic and Lach (1991), Wan (1990)).

Figure 3

Subsistence and modified golden rule equilibria

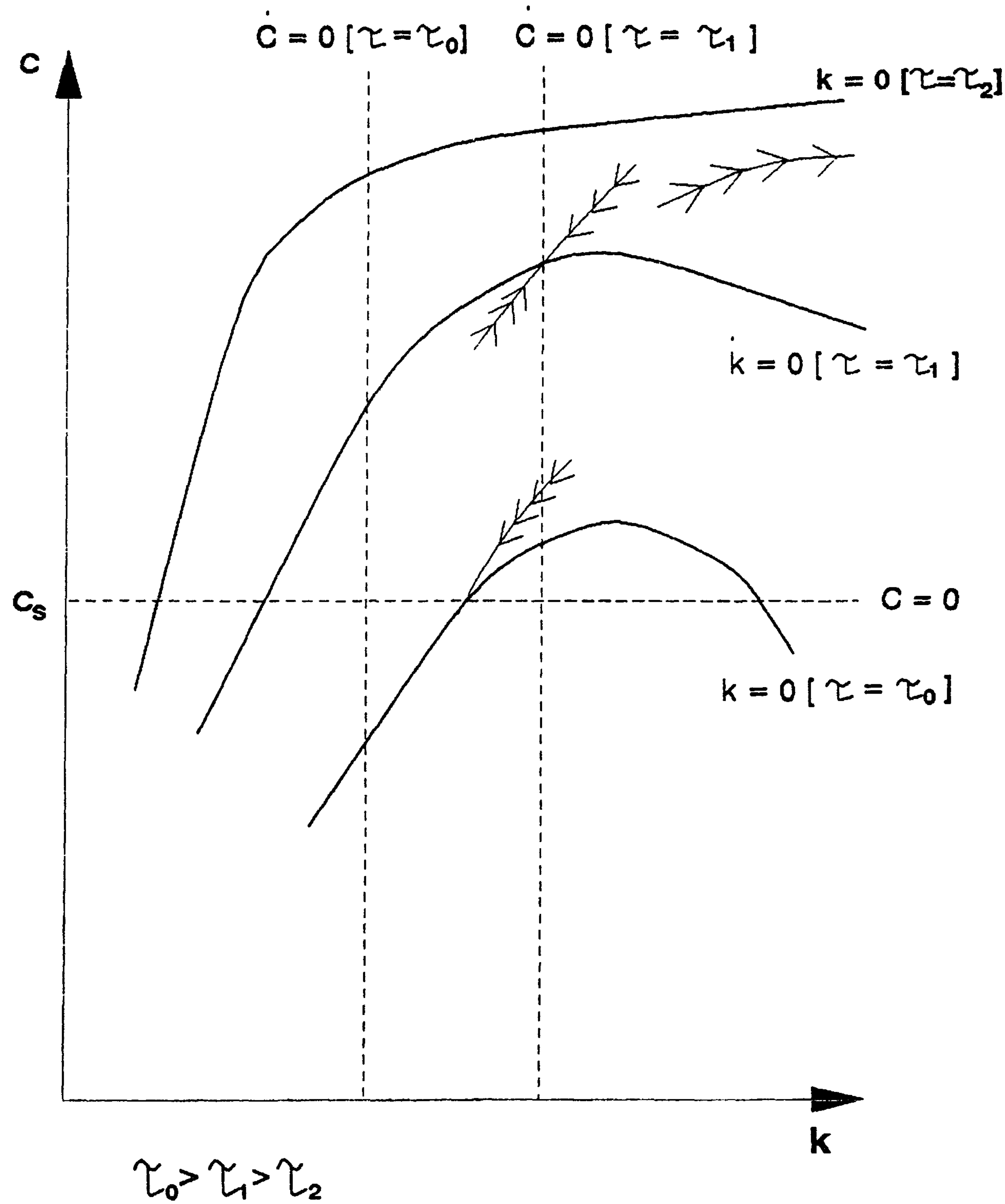
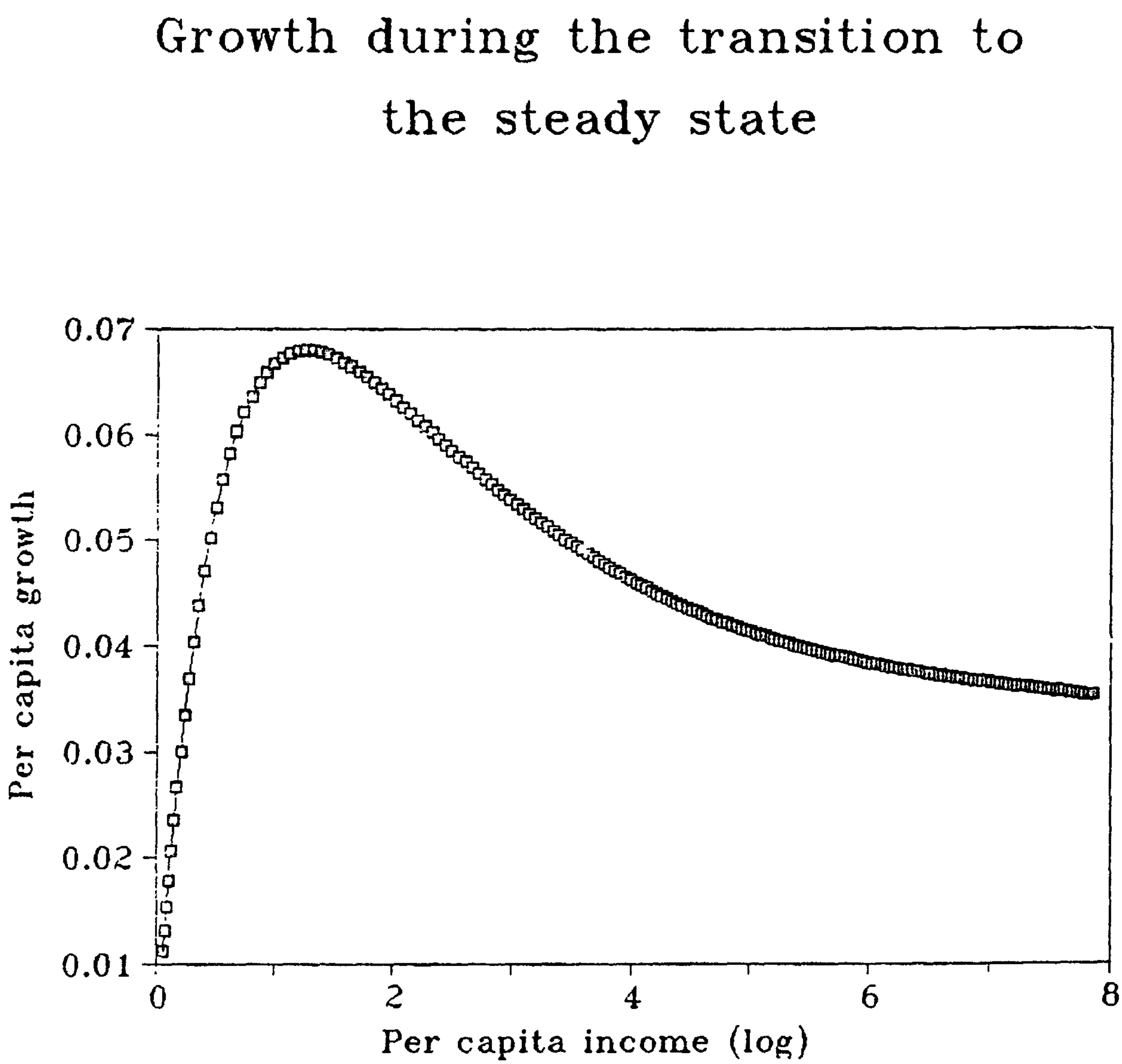


FIGURE 4


Growth during the transition to the steady state
0.07
0.06
0.05
0.04
0.03
0.02
0.01
Per capita growth
0
2
4
6
8
Per capita income (log)

a. Multiple inputs with distortionary policies

We extend the production function to include two generic types of capital, K_1 and K_2, with elasticity of substitution $1/(\Theta-1)$. Capital and labor continue to have elasticity of substitution $1/(\epsilon-1)$ (which is still assumed to be greater than one in absolute value):

$$(10) \qquad Y = A \left[\gamma \left[\alpha K_1^{\theta} + (1-\alpha) K_2^{\theta} \right]^{\frac{\epsilon}{\theta}} + (1-\gamma) L^{\epsilon} \right]^{\frac{1}{\epsilon}}$$

We assume the consumer-producer still maximizes (3). The equations of accumulation of the two types of capital in per capita terms are:

$$(11) \qquad \dot{k}_1 = i_1 - (\delta+\eta) k_1$$

$$(12) \qquad \dot{k}_2 = i_2 - (\delta+\eta) k_2$$

The type of distortionary policy that we consider will be a sales tax that falls on investment purchases of type 1, with type 2 investment exempted or able to evade the tax. Easterly, King, Levine, and Rebelo (1990) show how this type of structure can be applied to many types of distortionary policies in developing countries, including sales taxes that are evaded by the underground economy, import tariffs and quotas, administrative credit allocation, black market premia in dual foreign exchange markets, and inflation taxes that fall on the monetized sector but are avoided by the non-monetized sector.[19]

[19] A sales tax on investment type 1 is also equivalent to a tax on the income from capital type 1. The income tax equivalent to a sales tax t is t/(1+t). The proceeds of the tax are assumed to be nonproductively dissipated.

Per capita consumption must obey the household's per capita budget constraint:

$$(13) \qquad c = A\left[\gamma\left[\alpha k_1^{\theta} + (1-\alpha)k_2^{\theta}\right]^{\frac{\epsilon}{\theta}} + 1-\gamma\right]^{\frac{1}{\epsilon}} - (1+\tau)\ i_1 - i_2$$

where τ is the rate of sales tax on type 1 investment. The first order conditions for maximizing (3) imply that the ratio of marginal products of type 1 to type 2 capital is equal to $1+\tau$, which implies the following ratio of the type 2 to type 1 of capital, denoted Φ:

$$(14) \qquad \Phi = \frac{k_2}{k_1} = \left[\frac{(1-\alpha)\ (1+\tau)}{\alpha}\right]^{\frac{1}{1-\theta}}$$

The growth in per capita consumption along the optimal path will be given by:

$$(15) \qquad g = \left[\frac{r_2 - ((1-\beta)\eta+\delta+\rho)}{\sigma}\right]\left[\frac{c - c_s}{c}\right]$$

where r_2 is the derivative of per capita output with respect to the per capita stock of type 2 capital. This in turn will be given by:

$$(16) \qquad r_2 = A\gamma(1-\alpha)\left[\gamma(\alpha\Phi^{-\theta} + 1-\alpha)^{\frac{\epsilon}{\theta}} + (1-\gamma)k_2^{-\epsilon}\right]^{\frac{1}{\epsilon}-1}(\alpha\Phi^{-\theta} + 1-\alpha)^{\frac{\epsilon}{\theta}-1}$$

As before, if $\epsilon>0$ (elasticity of substitution between capital and labor greater than one in absolute value), the marginal product of capital will go to a nonzero limit as both capital-labor ratios go to infinity (recall the ratio Φ is given by (14)). Specifically, we have:

$$(17) \qquad \lim_{k_2\to\infty} r_2 = A\gamma^{\frac{1}{\epsilon}}(1-\alpha)\ (\alpha\Phi^{-\theta} + 1-\alpha)^{\frac{1-\theta}{\theta}}$$

If this limit is greater than the sum of the discount rate, depreciation rate, and labor growth, then positive per capita growth will ensue at the asymptotic rate:

$$(18) \qquad g = \frac{A\gamma^{\frac{1}{\epsilon}}(1-\alpha)\left(\alpha\Phi^{-\theta}+1-\alpha\right)^{\frac{1-\theta}{\theta}} - (\delta+(1-\beta)\eta+\rho)}{\sigma}$$

In other words, per capita growth will take place if the right-hand side of (18) is positive. If (18) is negative, per capita output will stagnate and the capital-labor ratio will be such as to satisfy the modified golden rule. From (14) and (18), it can be seen that distortionary policies tend to make stagnation more likely.[20] An increase in the distortionary tax τ will increase the ratio of type 2 to type 1 capital (14) above the socially optimal level. This could lower the asymptotic marginal product of type 2 capital (17) sufficiently that (18) becomes negative and growth stops. Further tax increases can cause a regression toward subsistence income, just as in the previous section.

b. Public capital and growth

The model of the previous section can also be used to discuss the effect of public capital on growth. It is plausible that there are capital inputs that can only be provided by the public sector. We consider public capital inputs that will not be forthcoming in a competitive market system (say because of technological difficulties in charging per unit of use), but otherwise satisfy the usual properties of private goods (rivalry in consumption, perfect divisibility, diminishing marginal product, etc.).

Equation (10) can then be used to cover the case of public and private capital. Government "capital investment" includes all activities that contribute to human or physical

[20]This is in contrast to the argument that distortionary policies only have level effects, as argued by Lucas (1988) and Young (1991). A micro-based model with effects of distortionary policies on growth is Murphy, Shleifer and Vishny (1991.

capital, such as education, highways, basic health measures, or electrical distribution. K_1 is interpreted as a government capital input, and K_2 is interpreted as private capital. We assume that the government finances the construction of public capital with lump-sum taxes (taxes which do not affect growth). The government is assumed to follow a policy rule where the ratio of public to private capital is maintained constant over time. τ in equation (14) can be interpreted as a measure of the ex-post distortion induced by supplying too little (positive τ) or too much (negative τ) public capital.

Equation (18) now gives the asymptotic growth rate determined by private sector investment in type 2 capital. If (18) is negative, output will stagnate. We see that output is more likely to stagnate the lower is the ratio of public to private capital (i.e. the higher is the ratio of type 2 to type 1 capital Φ). The reason is simple: lower public capital lowers the asymptotic rate of return to private capital, possibly below the critical value given by the sum of the depreciation, population growth, and discount rates. Since growth is determined by the private return to capital, higher public capital always increases the likelihood of growth, even if it is suboptimal from the standpoint of total welfare.[21]

IV. Empirical evidence

The model makes several predictions: (1) countries that penalize capital or distort its allocation are more likely to stagnate (and such policies will cause lower growth if a country is growing); (2) initial income does not affect whether countries stagnate; (3) countries that do grow will follow a hump-shaped transition path where growth rises and then falls with rising income.

[21] An obvious extension is to consider public capital spending financed by a tax that affects growth. This was considered for more general growth models in Barro (1990) Barro and Sala-i-Martin (1990), and Easterly (1990b), and is not directly considered here.

These predictions differ from those of other endogenous growth models underlying recent work on growth (e.g. Barro (1991)), in that right-hand side variables do not affect growth continuously. The model suggests that countries can be in one of two regimes -- either sustained growth, where right-hand side variables have growth effects, or stagnation, when a function of right-hand side variables passes a threshold level. The determination of stagnation involves steady-state factors -- forward-looking consumer-producers decide on the basis of preference, production, and policy parameters whether steady-state growth is worthwhile.[22] The growth of growing countries, on the other hand, includes transitional dynamics such as the aforementioned hump-shaped relationship between growth and initial income. Policy variables also could have transitional effects on growth that differ from their effects on the stagnation/growth outcome.

This formulation suggests the use of limited dependent variable methods to take into account the truncation of growth rates induced by stagnation. A probit equation will be specified to predict whether countries stagnate. A truncated regression will predict the growth rate of growing countries. Under a null hypothesis of the conventional continuous model, both methods would still yield consistent estimators of the effect of right-hand side variables on growth. The continuous model in effect imposes the restriction that the coefficients are the same in the two equations.[23] This implication can be tested by nesting the probit and truncated regressions within a tobit equation (which also yields consistent estimators of the continuous model under the null hypothesis) and constructing a likelihood ratio statistic for equality of coefficients between the probit and truncated equations.[24] If equality of coefficients were rejected, the continuous model

[22]Positive (or negative) growth could still result from transitional dynamics from one stagnant equilibrium to another, such as that due to a favorable (or unfavorable) policy change. There is no a priori reason to expect such effects to be large for stagnating countries.

[23]Adjusted for the standard error, since the probit is based on the standard normal distribution.

[24]Greene (1990) has a lucid description of this procedure. Note the "equality of coefficients" must be evaluated with probit coefficients (based on the standard normal) adjusted for the size of the standard error.

would be shown to be inappropriate and the prediction of different regimes for growth and stagnation would be confirmed.

The empirical problem is to define stagnation. The approach taken here is to define a country as stagnating when its growth rate is below 0.1 percent. All countries with negative growth are presumed to be in a transition towards a lower fixed-income equilibrium. In the tobit equation, for example, the dependent variable will be defined as zero for all observations that satisfy this definition of stagnation, while the actual per capita growth will form the dependent variable in the non-stagnating cases.[25]

The set of right-hand side variables indicated by the model include (1) implicit or explicit taxes on capital (section II.1), (2) variables reflecting policy distortions of resource allocation (section II.2.a), and (3) variables that reflect government physical and human capital spending (section II.2.b). Labor growth and per capita income will also enter as explained earlier. The equations are estimated alternatively with all variables defined as 10-year averages (table 4) and 30-year averages (table 5), except for per capita income, which is given as income in the first year of the period. We also show in the table the probit coefficients adjusted by the standard error to be comparable to the tobit and truncated coefficients.

One set of variables common to other empirical growth work that is not used here are investment ratios and measures of human capital like primary and secondary enrollment ratios. Since the model relies on a definition of capital that includes unobservable components like training and knowledge, it seems best to estimate reduced forms that do not rely on measuring

[25] This procedure is equivalent to discarding the information contained in differences among negative growth observations. As argued before, this does not bias the estimates even if the true model is continuous. The sample is endogenously truncated, and the limited dependent variable methods then correct for the truncation. This roundabout prodecure allows us to test the implication of regime change with separate probit and truncated regressions.

capital accumulation. Only exogenous variables (policy and other) will be included in these regressions.[26] The results obtained are as follows:[27]

Likelihood ratio tests. The restriction that coefficients are the same across probit and truncated regressions is rejected in five out of the six regressions using decade averages (Table 4). It is notable that the coefficients on per capita income (and income squared) are insignificant in the probit equation but significant in the truncated equation. These results support the prediction that initial income does not affect whether a country stagnates or not but does affect the growth rate if it grows.[28]

In the regressions with 30-year averages (Table 5), the restriction is not rejected. It makes sense that the restriction is more likely to be rejected with 10-year averages but not with 30-year averages, since one would expect transitional effects to be stronger with the former. However, one would have expected transitional effects to still be important with 30-year growth rates.

Initial per capita income. The hump-shaped relation between income and growth is confirmed by 5 out of the 6 regressions using decade averages (Table 4), as both income and income squared are significant with the predicted signs in the truncated regressions.[29] The maximum of the hump varies between $900 and $1800 in 1985 prices. This contrasts to the negative linear effect of per capita income on growth found by, among others, Balassa (1985),

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[26]Some regressions were run with the total investment ratio on the right-hand side to examine whether it crucially affects the results. The interpretation of such equations would be that stagnation would occur either because investment was too low or because other variables lowered the efficiency of investment. Investment was generally significant and the results were otherwise similar to those reported here. However, these regressions are problematic because investment is presumably endogenous, which is difficult to address in the limited dependent variable context.

[27]For the citations of previous results, I was assisted greatly by the survey of Renelt (1991).

[28]When the sample is restricted to developing countries, equality of coefficients is rejected in 3 out of the 6 regressions. The weaker result is not surprising in view of the narrower range of the per capita income variable in this case.

[29]Again, the results are weaker if the sample is limited to developing countries, with only 1 out of the 6 truncated regressions showing significant coefficients on income and income squared.

Barro (1991), Fischer (1991), Grier and Tullock (1989), Landau (1986), and Murphy, Shleifer, and Vishny (1991).[30] A quadratic term was found to be marginally significant by Barro (1991), but with the opposite sign from that found here.

No effect of per capita income on growth is detected in the regressions with 30-year averages for all variables (except initial income) in Table 5. Again, it is not surprising that transitional effects are weaker with 30-year averages.[31]

The black market exchange rate premium. This is a widely available measure of price distortion, reflecting an implicit tax on producers of traded goods that are priced according to the official exchange rate. For example, it is a tax on exporters that are forced to deliver foreign exchange at the official rate, rather than the black market rate. We assume the proceeds of the "tax" are dissipated. An increase in the black market premium should than make stagnation more likely. Levine and Renelt (1990) and Easterly (1990b) found this variable to be insignificant in cross-section regressions.[32]

By contrast, the black market premium is found to be consistently significant here, no matter what other right-hand side variables are included. The significance of the probit and truncated coefficients varies -- with 30-year averages, it is the probit that is consistently significant, while with 10-year averages, both are generally significant. We conclude that the black market

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[30]However, Michael Kremer reports finding the "hump-shaped" pattern predicted here in unpublished results.

[31]Although again the lack of significance with 30-year averages is disconcerting, since simulations seem to indicate that transitional dynamics in the Jones-Manuelli model can be quite prolonged.

[32]However, other measures of price distortions have been found to be significant in the literature. Barro (1991) reports that the absolute value of deviations of the relative price of investment goods is significantly negative in a cross-country growth regression. De Long and Summers (1991) found that a high relative price of equipment investment goods has a negative effect on growth. De Long and Summers (1991) and Easterly (1990a) found a dummy variable measuring outward trade orientation from the 1987 World Development Report to have a positive and significant effect on growth. Dollar (1990) found a measure of general overvaluation of real exchange rates, based on Summers-Heston relative price data, to lower growth.

premium is a good predictor both of whether countries stagnate, and how fast they grow if they do not stagnate.

Public investment as a share of GDP. The theory predicts that higher public investment (measured conventionally as physical investment only) makes stagnation less likely. This variable is only available for the 1970's and 80's, and only for a reduced sample of countries. (For this reason, this variable was omitted from the regressions with 30-year averages). Other studies, such as Barro (1991) and Khan and Reinhart (1990), have generally found this variable to be insignificant in growth regressions.

The regressions with decennial averages show some evidence that higher public investment makes stagnation less likely.[33] Public investment is positive and significant at 5 percent in one probit regression and at 10 percent in another. However, we also find the puzzling and significant result that higher public investment causes growth to be lower in the truncated regressions. This surprising finding is inconsistent with theoretical predictions and merits further investigation.

Government consumption. The share of government consumption in GDP is found to have a significant effect on growth in studies such as Barro (1990, 1991), Romer (1989a), and Easterly (1990b). In terms of this model, government consumption can be seen a proxy for the part of the tax burden not offset by productive spending. Thus, an increase in government consumption should make stagnation more likely. We find no evidence for such an effect, however, as government consumption is only significant at the 10 percent level in one regression, and of the wrong sign.

[33]No regressions were run including public investment for the 30-year averages, because the sample size was too small for the use of nonlinear econometric techniques.

Government expenditure on education. This measures one form of productive government investment. Higher education spending should make stagnation less likely. This variable was found to have an insignificant effect on growth in Diamond (1990). In contrast, we find some evidence here that government spending on education influences stagnation and growth, as it is significant in the tobit and truncated regressions for 30-year averages, and in one of the tobit and probit equations for decennial averages. The significance is not robust, as it vanishes when variables like government consumption are added.

Labor force growth. The model predicts that population or labor growth has a zero or negative effect on growth, depending on whether the parameter β is equal to or less than one, respectively. If it is one, then consumers place a value on the number of their descendants that exactly offsets the negative effect of having to spread future capital around more people. Thus, higher labor growth will either make stagnation more likely or will have no effect. Mixed results for the effects of labor growth on per capita growth have been reported in the literature: Barro found it to be significantly negative, Grier and Tullock (1989) positive, and Balassa (1985), De Long and Summers (1990), Landau (1986) and Mankiw, Romer and Weil (1990) insignificant. The results here include some weak evidence for high labor growth making stagnation more likely. The coefficient on labor in probit equations is significant at 5 percent in one instance, but the coefficient reverses sign in other specifications.

Inflation. Inflation represents a tax on investment to the extent that cash must be held in advance of investment transactions. Higher inflation will make stagnation more likely if these cash-in-advance requirements are significant. Inflation was found to be significantly negative in growth regressions in Grier and Tullock (1989) and Fischer (1991). The results here show some evidence that inflation makes stagnation more likely, as the coefficient is significant and negative in one of the truncated regressions (regression v in table 4). The coefficient on inflation in the probit equation with the same set of variables is not significant. Even the significance of the inflation coefficient in the probit regression vanishes in other specifications.

Financial repression dummy. Controls on interest rates such that real interest rates in the financial system are highly negative will lead to allocation of credit by administrative fiat. This imposes a tax on investment by those who do not have access to subsidized credits; we presume the subsidized credits themselves to flow to nonproductive uses. This variable is defined as 1 if the average real deposit interest rate over the period is less than -5 percent and 0 if it is greater. A value of 1 makes stagnation more likely. This variable was found to be significant in Gelb (1990), Easterly (1990b), and Roubini and Sala-i-Martin (1991). However, we fail to find any evidence for financial repression affecting growth or stagnation in these results. The main effect of including this variable is to render insignificant per capita income and the likelihood ratio test statistic.

Time and continent dummies. The model considers only national policies as affecting growth, but it is plausible that there are also global influences (the well-known slowdown in world growth in the 80's for example). The regressions control for these influences by putting one dummy variable each for the decades of the 60's and 70's. We also consider continent dummies that other studies have found to be significant.

The dummies for Latin America and Africa are generally significant in these results, as they have been in most other studies (e.g. Barro (1991)). This suggests there are other factors influencing growth and stagnation that have not been captured here. The time dummies are also generally significant in both probit and truncated regressions, which could be indicating some exogenous worldwide productivity trends.[34]

[34]The model of section II could be modified to incorporate exogenous productivity growth. Stagnation would then be defined as growth equal to the exogenous productivity trend. The result here indicates that stagnation (defined as zero growth and below) became more likely in the 1980s, which could be interpreted as a decrease in exogenous productivity growth.

V. Conclusion

Stagnation due to the presence of fixed factors is consistent with an array of statistical evidence. Economic policies, and not initial conditions, determine whether countries stagnate. The black market premium on foreign exchange is particularly helpful in explaining stagnation. Empirical results show that growth first accelerates and then falls as income rises. Results confirm that initial income and policy variables have a different effect on whether a country stagnates than they do on the rate of growth once it starts growing, as expected from the distinction between steady state and transitional effects. These results suggest that cross-section growth regressions may be misspecified because of the nonlinearity inherent in the possibility of steady-state stagnation.

Table 4
Tobit, Probit, and Truncated regression results, regression by decades
(T-Statistics in parentheses)
Dependent variable: per capita growth

		Constant	Exchange Rate Premium	Inflation	Public Investmt share of GDP	Gov't expend. on educ share GDP	Initial level of inc per cap	Square of Initial lev of inc per cap	Gov't consump. share of GDP	Labor force growth	Financial Dummy	Time dummy 1960s	Time dummy 1970s	Asia dummy	Africa dummy	Latin America dummy	Sample Size	Likelihood [1] ratio test	Maximum point w.r.t. per capita income
i.	Tobit	-0.17 *	-0.03 ***	-0.005			0.054 **	-0.004 **	-0.01	-0 0013		0.019 ***	0.017 ***	0.006	-0.016 ***	-0.017 ***	210	24.24 **	1429
		(-1.66)	(-4.22)	(-0.297)			(2.004)	(-2.08)	(-0.27)	(-0.74)		(5.109)	(5.34)	(1.18)	(-3.21)	(-3.64)			
	Probit	0.87	-1.79 ***	0.015			0.420	-0 031	-0.56	-0.34 *		1.37 ***	1.19 ***	0.211	-1.29 **	-1.42 ***	210		933
		(0.095)	(-3.44)	(0.02)			(0.17)	(-0.18)	(-0.15)	(-1.88)		(3 64)	(3.85)	(0 297)	(-2.36)	(-2.79)			
	Adj. Prob.	0.01	-0.03 ***	0.0002			0.006	-0.0005	-0.01	-0.005 *		0.02 ***	0.02 ***	0.003	-0.02 **	-0.02 ***			
	Truncated	-0.36 ***	-0.024 **	-0.022			0.106 ***	-0.007 ***	0.005	0.0002		0 012 ***	0 012 ***	0.005	-0.01 *	-0.01 **	162		1830
		(-2.95)	(-2.099)	(-1.12)			(3.21)	(-3.25)	(0.13)	(0.12)		(2.78)	(2.99)	(0.99)	(-1.94)	(-2.16)			
ii.	Tobit	0.076	-0.033 ***				-0.0102	0.0005	-0.06		-0.003	0.023 ***	0 019 ***	0 007	-0.021 ***	-0.011 *	116	15.57	21765 [2]
		(0.58)	(-2.87)				(-0.31)	(0.24)	(-1.08)		(-0.55)	(5.26)	(4.21)	(1.14)	(-3.08)	(-1.94)			
	Probit	19.73	-2 60 **				-3.287	0.203	-4.33		-0 47	2.51 ***	2.38 ***	-4 52	-6.93	-6.03	116		3250 [2]
		(0.07)	(-2.38)				(-0.61)	(0.55)	(-0.54)		(-0.65)	(3.27)	(2.99)	(-0.016)	(-0.025)	(-0.022)			
	Adj. Prob.	0.30	-0.04 **				-0.049	0.003	-0.06		-0.01	0.04 ***	0 04 ***	-0.07	-0.10	-0.09			
	Truncated	-0.02	-0.03 *				0.014	-0.001	-0.044		-0.001	0.019 ***	0.016 ***	0 01	-0.014 *	-0.005	95		759
		(-0.099)	(-1.67)				(0.304)	(-0.36)	(-0.66)		(-0.15)	(3.298)	(2.69)	(1.62)	(-1.68)	(-0.73)			
iii.	Tobit	-0.12	-0.04 ***			0.24 **	0.0401	-0.003 *				0.026 ***	0.019 ***	0.008	-0.015 ***	-0.014 ***	177	20.45 **	860
		(-1.23)	(-4.898)			(2.24)	(1.57)	(-1.77)				(6.26)	(5.87)	(1.56)	(-2.75)	(-2.696)			
	Probit	12.76	-2.16 ***			20.62 **	-2.844	0.172				2.21 ***	1.66 ***	-0.15	-2.28 ***	-1.96 **	177		3847 [2]
		(1.09)	(-3.77)			(2.08)	(-0.89)	(0.80)				(4.44)	(4.49)	(-0.15)	(-2.58)	(-2.48)			
	Adj. Prob.	0.20	-0.03 ***			0.33 **	-0.045	0.003				0.04 ***	0.03 ***	-0.002	-0.04 ***	-0.03 **			
	Truncated	-0.28 **	-0.03 ***			0.205 *	0.084 ***	-0.006 ***				0.02 ***	0 015 ***	0.01	-0.01	-0.01 *	137		1385
		(-2.46)	(-2.82)			(1.74)	(2.81)	(-2.97)				(3 87)	(3.38)	(1.56)	(-1.37)	(-1.77)			
iv.	Tobit	0.013	-0.05 ***		-0.024		0.008	-0.001					0.013 ***				96	42 31 ***	157
		(0.08)	(-7.85)		(-0.20)		(0.196)	(-0.303)					(2.71)						
	Probit	61.82 **	-5.88 ***		17.98		-16.195 **	1.052 **					6 45 ***				96		2200 [2]
		(2.53)	(-3.35)		(1.59)		(-2.52)	(2.51)					(2.81)						
	Adj. Prob.	0.91 **	-0.09 ***		0.26		-0.238 **	0.015 **					0 095 ***						
	Truncated	-0.23 *	-0.05 ***		-0.16 *		0.081 **	-0.006 ***					0.001				77		1103
		(-1.81)	(-4.07)		(-1.67)		(2.57)	(-2.89)					(0.28)						

[1] The test statistic, which is distributed chi-squared, measures equality of coefficients between probit and truncated regressions.

[2] [illegible]

Table 4 (continued)
Tobit, Probit, and Truncated regression results, regression by decades
(T-Statistics in parentheses)
Dependent variable: per capita growth

		Constant	Exchange Rate Premium	Infla-tion	Public Investmt share of GDP	Gov't expend. on educ share GDP	Initial level of inc per cap	Square of Initial lev of inc per cap	Gov't consump. share of GDP	Labor force growth	Finan-cial Dummy	Time dummy 1960s	Time dummy 1970s	Asia dummy	Africa dummy	Latin America dummy	Sample Size	Likelihood[1] ratio test	Maximum point w.r.t. per capita income
v.	Tobit	-0.26	-0.034 ***	-0.056 ***	0.007		0.074	-0 005					0.014 ***				95	55.92 ***	2452
		(-1.37)	(-3.69)	(-3.70)	(0.067)		(1.58)	(-1.61)					(3.16)						
	Probit	33.86	-2.84	-12.46 **	45.28 **		-10.778	0.809					9.15 **				95		777[2]
		(0.82)	(-1.30)	(-2.37)	(2.26)		(-1.01)	(1.17)					(2.39)						
	Adj. Prob.	0.46	-0.04	-0.17 **	0.62 **		-0.148	0.011					0.12 **						
	Truncated	-0.50 ***	-0.04 ***	-0.03	-0.18 **		0.149 ***	-0.009 ***					0.002				76		1805
		(-3.20)	(-3.09)	(-1.22)	(-2.03)		(3.78)	(-4.03)					(0.52)						
vi.	Tobit	-0.084	-0.05 ***		-0.03	-0.08	0.033	-0.002	0.11				0 014 **				82	39.84 ***	647
		(-0.36)	(-6.67)		(-0.199)	(-0.47)	(0.58)	(-0.70)	(1.07)				(2.53)						
	Probit	31.51	-6.78 ***		26.79 *	-17.73	-8.934	0.574	25.05 *				7.70 ***				82		2407[2]
		(1.31)	(-3.17)		(1.83)	(-0.94)	(-1.45)	(1.44)	(1.94)				(2.80)						
	Adj. Prob.	0.48	-0.10 ***		0.41 *	-0.27	-0.137	0.009	0.38 *				0.12 ***						
	Truncated	-0.27	-0.05 ***		-0.23 **	0.28	0.095 **	-0.007 **	-0.04				-0.002				65		940
		(-1.47)	(-3.64)		(-2.17)	(1.16)	(2.14)	(-2.40)	(-0.28)				(-0.35)						

* -- Significant at 10 % level   ** -- Significant at 5% level   *** -- Significant at 1% level

[1] The test statistic, which is distributed chi-squared, measures equality of coefficients between probit and truncated regressions.

[2] Minimum not maximum.

Table 5
Tobit, Probit, and Truncated regression results for 30-year-average period
(T-statistics in parentheses)

Dependent variable: Per capita growth

	Constant	Exchange Rate Premium	Inflation	Initial level of income per capita	Square of initial level of income per capita	Government consumption share of GDP	Labor force growth	Govt exp on education share of GDP	Asia dummy	Africa dummy	Latin America dummy	Sample Size	Likelihood ratio test
1. Tobit	0.042	-0.02**		-0.003		-0.05	0.003		-0.003	-0.03***	-0.02**	60	7.56
	(1.36)	(-2.31)		(-0.9)		(-0.9)	(1.16)		(-0.25)	(-2.8)	(-2.5)		
Probit	3.91	-1.78**		0.23		-10.81	0.43		-0.38	-5.62	-5.84	60	
	(0.01)	(-2.2)		(0.55)		(-1.57)	(1.28)		(0)	(-0.01)	(-0.01)		
Adjusted Probit	0.04	-0.02**		0.002		-0.106	0.004		-0.004	-0.06	-0.06		
Truncated	0.08	-0.02		-0.009		-0.006	0.002		-0.004	-0.03**	-0.02**	48	
	(1.52)	(-1.55)		(-1.29)		(-0.13)	(0.66)		(-0.36)	(-2.37)	(-1.98)		
2. Tobit	-0.01	-0.02*		0.00005		-0.01	0.006					60	4.17
	(-0.41)	(-1.86)		(0.02)		(-0.28)	(1.49)						
Probit	-2.17	-1.47**		0.24		-5.44	0.47					60	
	(-1.07)	(-2.04)		(0.92)		(-1.21)	(1.47)						
Adjusted Probit	-0.03	-0.022**		0.004		-0.08	0.007						
Truncated	0.02	-0.007		-0.005		0.05	0.006					48	
	(0.55)	(-0.49)		(-0.76)		(0.5)	(1.16)						
3. Tobit	0.04	-0.02**		-0.004				0.28**	0.001	-0.02**	-0.02*	54	9.95
	(1.39)	(-2.43)		(-1.33)				(2.4)	(0.15)	(-2.45)	(-1.93)		
Probit	4.03	-1.59*		0.02				7.53	0.43	-5.11	-4.72	54	
	(0.01)	(-1.91)		(0.06)				(0.48)	(0.001)	(-0.01)	(-0.01)		
Adjusted Probit	0.03	-0.01*		0.002				0.065	0.0037	-0.04	-0.04		
Truncated	0.06	-0.02		-0.008				0.298**	0.0005	-0.02**	-0.02**	43	
	(1.46)	(-1.5)		(-1.24)				(2.32)	(0.07)	(-2.31)	(-2.3)		
4. Tobit	-0.005	-0.02**		-0.001				0.39*				54	4.99
	(-0.19)	(-2.3)		(-0.3)				(1.76)					
Probit	-1.84	-1.41**		0.196				10.46				54	
	(-0.93)	(-1.97)		(0.72)				(0.68)					
Adjusted Probit	-0.02	-0.02**		0.002				0.13					
Truncated	0.03	-0.01		-0.004				0.42*				43	
	(0.87)	(-1.01)		(-0.97)				(1.93)					

Table 5 (continued)
Tobit, Probit, and Truncated regression results for 30-year-average period
(T-statistics in parentheses)

Dependent variable: Per capita growth

		Constant	Exchange Rate Premium	Inflation	Initial level of income per capita	Square of initial level of income per capita	Government consumption share of GDP	Labor force growth	Govt exp on education share of GDP	Asia dummy	Africa dummy	Latin America dummy	Sample Size	Likelihood ratio test
5.	Tobit	0.04	-0.02***	0.007	-0.005				0.29**	0.002	-0.02**	-0.02**	52	11.86
		(1.34)	(-2.68)	(0.81)	(-1.46)				(2.38)	(0.21)	(-2.47)	(-2.09)		
	Probit	3.72	-2.24**	1.67	-0.04				12.13	0.8	-5.29	-5.05	52	
		(0.01)	(-2.03)	(1.1)	(-0.1)				(0.73)	(0.001)	(-0.01)	(-0.01)		
	Adjusted Probit	0.03	-0.02**	0.014	-0.0003				0.10	0.0068	-0.05	-0.04		
	Truncated	0.06	-0.02**	0.003	-0.008				0.25*	-0.00004	-0.02**	-0.02**	41	
		(1.52)	(-2.1)	(0.53)	(-1.34)				(1.95)	(-0.005)	(-2.23)	(-2.28)		
6.	Tobit	-0.04	-0.02**		0.02	-0.002			0.28**	0.001	-0.02**	-0.02*	54	10.05
		(-0.32)	(-2.26)		(0.47)	(-0.56)			(2.34)	(0.11)	(-2.29)	(-1.87)		
	Probit	-5.36	-1.46*		2.7	-0.19			6.75	0.3	-5.00	-4.7	54	
		(-0.01)	(-1.76)		(0.61)	(-0.6)			(0.43)	(0)	[illegible]	(-0.01)		
	Adjusted Probit	-0.05	-0.01*		0.023	-0.0016			0.06	0.0026	-0.04	-0.04		
	Truncated	0.02	-0.02		0.006	-0.0009			0.30**	0.0004	-0.02*	-0.02**	43	
		(0.04)	(-1.16)		(0.06)	(-0.14)			(2.17)	(0.06)	(-1.93)	(-2.23)		

* -- Significant at 10% level   ** -- Significant at 5% level   *** -- Significant at 1% level

Variable Definition

Dependent variable:

Per capita income growth	= log (1 + growth); SOURCE: World Bank Database.
Per cap income growth, PROBIT	= dummy of per capita income growth; Equal to 0 if growth < 0.1; 1 otherwise. SOURCE: World Bank Database.
Per cap income growth, TOBIT and TRUNCATED	= Equal to 0 if growth < 0.1; 'g' otherwise, where 'g' is the growth rate. In the truncated regressions, the g<0.1% observations are excluded. SOURCE: World Bank Database.

Independent variables:

Exchange rate premium	= log (1 + black market exchange rate premium); SOURCES: 1960-83: World Currency Yearbook; 1984: Pick's Currency Yearbook (various years), 1984-89: Financial Times International Reports' Statistical Market Letter, 1989: Africa Analysis for certain countries.
Inflation	= log (1 + inflation rate); SOURCE: World Bank Database.
Public Investment, share of GDP	= log (1 + real public investment as a share of GDP); SOURCE: Pfefferman, G. and A. Madarassy. "Trends in Private Investment in Developing Countries". IFC Discussion Paper No. 11, World Bank (1989).
Initial level of income per capita	= log (GDP per capita income) initial year for each decade, i.e., 1960 for the 60's, 1970 for the 70's, 1980 for the 80's. SOURCE: Summers and Heston.
Government consumption as a share of GDP	= log (1 + real government consumption as a share of GDP); SOURCE: World Bank Database.
Labor force growth	= Average annual growth rate of population of working age (15-64). Based on data in World Development Indicators, World Bank (1987).
Government expenditure on education, share of GDP	= log (1 + nominal government expenditure on education as a share of GDP). SOURCE: World Bank Database.

Dummy Variables:

Financial Dummy	= Dummy variable for financial policy distortions. 1 if real interest rates are less than -5%, 0 otherwise. Based on World Development Report 1989. Data from 1965-85 from Financial Policy Division, World Bank.

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