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An African Growth Trap: Production Technology and the Time-Consistency of Agricultural Taxation, R&D and Investment*

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RRH: AN AFRICAN GROWTH TRAP
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Why do so many African governments consistently impose high tax rates and make little investment in productive public goods, when alternative policies could yield greater tax revenues and higher national income? We posit and test an intertemporal political economy model in which the government sets tax and R&D levels while investors respond with production. Equilibrium policy and growth rates depend on initial cost structure. We find that in many (but not all) African countries, low tax/high investment regimes would be time-inconsistent, primarily because production technology requires relatively large sunk costs. For pro-growth policies to become sustainable, new political commitment mechanisms or new production techniques would be needed.

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1. Introduction

This paper presents and tests a model of interaction between government policymakers and private investors, aimed at helping to explain why some countries are able to sustain policies that foster high levels of investment and rapid economic growth, while others remain at near-subsistence for long periods of time. This question is of particular urgency in Africa, where numerous countries have experienced a succession of harsh policy regimes that invite little investment and foster little productivity growth.

Persistent stagnation in Africa seems to be widespread but not inevitable: since independence at least a dozen African countries have adopted more favorable economic policies and experienced real income growth (Rodrik 1998), and variation in growth rates is greater in Africa than in any other region.[1] In this paper we use the variation in growth rates within Africa to ask, can African countries' economic performance be explained in terms of their governments' policy choices? And if so, can those choices be explained as rational policymakers' responses to observable conditions?

Many analyses of African policy-making explain the persistence of low-growth policies in terms of conflict among interest groups (Bates 1981) or across ethnic divisions (Easterly and Levine 1997). But such explanations beg the question of why such conflicts are more readily resolved in some locations than in others. An alternative approach is to ask how material conditions might influence policy outcomes. Engerman and Sokoloff

(1997) and Acemoglu, Johnson and Robinson (2001) study how cross-country differences in biophysical conditions during the 18th and 19th century influenced national institutions, whose persistence helps explain subsequent economic growth.[2] Bloom and Sachs (1998) present several mechanisms through which material differences might have an effect on economic outcomes in the present. In our model, biophysical conditions matter by influencing policy through the payoff matrix and hence equilibrium conditions of a repeated game between policy-makers (who impose taxes and make public investments) and the private sector (who produce for the market). This approach leads to specific policy implications concerning the technologies or institutions that sustain pro-growth equilibria.

Our approach builds on analyses of time-consistency in pricing policies by McMillan (2000), Besley (1997), McLaren (1996) and Gilbert and Newbery (1994), extending that earlier work to include public R&D, productivity change and economywide growth. We focus on African agriculture because it is a key sector in these economies, because its production technology is sensitive to local biophysical conditions and public R&D investment,[3] and because it offers substantial variation in performance that we can capture in a consistent dataset to test the model.

2. Theory

Our model focuses on two specific policy instruments – output taxation and investment in public goods – and treats economic growth as the equilibrium outcome of an infinitelyrepeated game between government officials and the private sector. In specifying the model, we begin with farmers' investment and production choices, then address the government's options, and derive the conditions under which repeated interactions between optimizing farmers and optimizing policymakers result in persistent stagnation, and those which sustain high levels of investment and productivity growth.

Farmers

In the model, farmers choose between remaining at subsistence and producing for market, where they can earn positive profits but are exposed to taxation. The total cost of producing for market, c, varies across farmers continuously over [0, c_{max}], representing variation in distance to market and/or agro-climatic conditions. These costs can be divided into sunk costs, s, and harvesting costs, h, which also vary continuously across farmers.

Each farmer chooses q_t to maximize the present value of profits or,

$$\pi_t = \sum_{t=0}^{\infty} \delta^t (P_t^f - c) q_t (P_t^f)(1+\gamma(rd_{t-1})) \tag{1}$$

where δ^t is the farmer's discount rate, P_t^f is the farmer's price received at the market, q_t is the farmer's investment level (normalized, for example, to one unit of land), $\gamma(rd_{t-1})$ is the productivity gain generated by investment in public R&D in the previous five-year period, determined by its productivity (γ) and the government's spending level (rd_{t-1}), and c are total costs, where $c=s+h$. Thus, in a competitive market where subsistence yields zero profits, farmers plant as long as the farmgate price covers total costs.

The Government

The government cannot itself undertake production, perhaps because supervision costs would be prohibitive. But it does control the marketplace, and is the only provider of R&D. The government sets the tax wedge between the price paid to farmers, P^f, and the price received from consumers which for simplicity (and realism, in a small-country setting) we assume to be an exogenous world price, P^w. We assume that policymakers have an infinite time horizon, and seek to maximize the present discounted value of some social welfare function which is a weighted sum of tax revenue and producer surplus given by,

$$W_t = \sum_{t=0}^{\infty} \beta^t \left\{ (P_t^w - P_t^f) \int_0^{P^f} q_t(c)(1+\gamma(rd_{t-1}))dc + \alpha \int_0^{P^f} (P_t^f - c_t) q_t(c)(1+\gamma(rd_{t-1}))dc - rd_t \right\} \quad (2)$$

where β^t is the government's discount rate, and α is the relative weight placed by policymakers on producer's surplus relative to tax revenue.

Equilibrium policy

Maximizing (2) with respect to *rd* and the farmgate price (subject to the constraint that spending on *rd* not exceed tax revenue) yields the revenue-maximizing tax rate or cooperative equilibrium. In the context of sunk costs and a delay in farmers' price response, the sustainability of this tax rate depends on the governments' incentives to act strategically. For example, a government whose value of α is less than unity may be tempted to announce low taxes to induce investment, then raise taxes after sunk costs are incurred to expropriate the resulting economic rent. Farmers may, with experience, learn to doubt the government's announcements, fearing to lose their sunk costs. Thus observed investment and tax levels will be the outcome of a repeated game between policymakers and farmers, whose equilibrium depends on the strategies available to the government and farmers.

The gains to the government of deviating from the cooperative policy are equal to farmers' sunk costs plus public R&D for *T* periods. We assume that farmers have no recourse against expropriation other than to retreat from the market to subsistence farming for *k* periods. Thus, the loss to the government of deviating from the cooperative policy is the loss in earnings associated with the reduction in output, until farmers begin to plant again in period *T*+*k*+1. As long as the gain associated with excess taxation is less than the loss imposed as farmers retaliate, the cooperative outcome is sustainable.

Comparing the cooperative and non-cooperative scenarios yields the following condition under which the cooperative outcome is a sustainable equilibrium, where $\tilde{Q}$ represents aggregate output adjusted for R&D:

$$\left[(1-\alpha)\frac{s^*}{P^{f*}}\right] \le \frac{\beta^{T+1}-\beta^{T+k+1}}{\beta-\beta^{T+1}}\left[\left(\frac{P^W}{P^{f*}}-1\right)-\frac{rd}{P^{f*}\tilde{Q}}\right]+\frac{rd}{P^{f*}\tilde{Q}} \qquad (3)$$

The left-hand side of inequality (3) is the ratio of sunk costs to total costs, weighted by government's relative valuation of farm income as opposed to tax revenue. It thus represents the government's short-run gains available in defection away from the low-tax, high-growth path. The right hand side of inequality (3) is the present discounted value of the long-run costs of deviating from the high-growth path: once farmers' profits are expropriated by high taxation, they revert to subsistence farming for *k* periods and the government loses the present discounted value of the foregone tax revenue adjusted for productivity increases owing to continued spending on R&D.

Equation (3) provides the testable hypotheses of the model. The higher is this sunk/total cost (STC) ratio, the greater is the government's incentive to undertake predatory taxation after investment occurs. Two other variables, α and β, formalize the role of political conditions that are often discussed in previous studies (e.g. Bates 1981): α reflects the degree to which the government is representative of farmers as opposed to those who benefit from tax revenue, and β reflects the degree to which the government is impatient and discounts future tax revenues. For example, Hall and Jones (1999) argue that poor policies could be due to the limited political accountability associated with nondemocratic traditions, as would be captured by the parameter α. Similarly, Easterly and Levine (1997) argue that African countries' poor policy choices may be due to their internal ethnolinguistic divisions and frequent political conflict, one consequence of which would be high discount rates as captured by parameter β.

The remaining two variables, expected future world prices and the productivity of R&D, may be thought to differ systematically between Africa and the rest of the world. But recent projections of Africa's terms of trade (Hertel et al. 1998) suggest relatively high demand for African farm products, and studies of the productivity of African agricultural research suggest that it is at least as productive as research elsewhere (Masters et al., 1998; Alston et al., 2000).

Consequences of agricultural policy for economywide growth

The political-economy model described above provides testable predictions about which countries will adopt what policies. To generate predictions as to the consequences of those policies for the economy as a whole we need to control for other major determinants of growth. Following the conditional-convergence approach to empirical growth of Barro (1991) and Barro and Sala-i-Martin (1995), we assume that our agricultural sector is embedded in a Cobb-Douglas aggregate economy for which growth is a transitional process from its randomly determined initial income to its steady-state potential income.

In the cross-country empirical implementation, we first ask whether policy choices are in fact correlated with material conditions as predicted by equation (3) – looking particularly for an effect of cross-country differences in the *STC* ratio when controlling for differences in other factors that influence policy. Then, we ask whether our measures of agricultural taxation and R&D investment are significant correlates of growth, raising the steady state income level controlling for its other possible determinants.

3. Empirical Application

Equation (3) is a condition for sustaining optimal policy. The model predicts that, if condition (3) is met, we will observe low taxes, high investment, and high rates of economic growth. If the condition is not met we expect to observe high taxes and low investment associated with the Nash equilibrium growth trap. Specifically, the model suggests that the low-tax, high-growth equilibrium will be harder to sustain: (a) the larger the share of sunk costs in total costs, (b) the smaller are expected future profits from a particular investment, (c) the greater the government's discount factor and, (d) the lower is expected future productivity of R&D spending. In deriving our estimating equations we will avoid needing to measure α, the weight on producer surplus, which we will treat as an unobservable variable taking on country-specific values.

To simplify notation, we rename each of the variables we are interested in testing. The sunk to total cost ratio is called *STC*. The government's discount factor is $\delta(T,k)$, where $\delta(T,k) = (\beta^{T+1}-\beta^{T+k+1})/(1-\beta^{T+1})$. It is expressed as a function of *T* and *k* to remind us that its value will depend on the length of punishment, *k* and on the type of crop, *T*, as well as on the pure time-preference factor β. The expected future profit margin is $PROF^e$. The expected productivity of R&D spending is $R\&D^e$. Rewriting equation (3) with the new variable names gives the following condition for sustaining the "high-growth" equilibrium,

$$STC(1-\alpha) \leq \delta(T,k)(PROF^e - R\&D^e). \qquad (4)$$

Our empirical strategy is to construct a direct test of the model followed by a variety of alternative formulations and robustness tests. Taken literally, the model implies that countries make discrete jumps from one regime to the other. Thus the direct test requires us to classify countries in terms of whether the observed tax rate is higher than the optimal tax implied by equation (4). In the absence of information on α, we classify as high-tax only those governments whose tax rates exceed the revenue-maximizing tax, computed using long-run elasticities following McMillan (2001). This model-based classification of tax regime differs substantially from the prespecified cutoffs used in other studies to differentiate between favorable and unfavorable policy environments, such as the 30% tax rate used by Jaeger (1992). We also classify countries into low- and high-growth regimes, based on whether per-capita growth rates were negative or positive.

Using the regime classifications we conduct a direct test of the model, asking whether the variables in inequality (4) are statistically relevant predictors of regime type in non-deterministic setting. The advantage of taking the model literally in this way is that, if it were the true model, these parameter estimates would be precise. To obtain an estimating equation we rewrite equation (4) isolating the unobservable variable 1-α_i and make the assumption that this variable is log normal with mean μ and variance σ^2. This yields the following estimating equation:

$$prob(y_i = 1) = \Phi[\gamma_0 + \gamma_1 \ln(\delta(T,k)_i) + \gamma_2 \ln(PROF_i^e - R\&D_i^e) + \gamma_3 \ln(STC_i)]. \quad (5)$$

where Φ is the cumulative distribution function of the normal distribution.

We also wish to test the robustness of our observed correlations to alternative model specifications. In particular, we would like to use the tax and growth variables in a continuous OLS specification, to retain any information implicit in the magnitude of these variables, and to ensure that our results are directly comparable to others' work in the empirical-growth literature. The relevant estimating equations are described below, first for the limited-dependent-variable probit specification and then for the linear OLS regression. For OLS estimation we use inequality (4) informally, as a guide to the variables that might be important in determining policy levels rather than regime type. Here our dependent variables are the original continuous measures of taxation and spending on research and development in agriculture (policy in the estimating equation). Specifically, we estimate the following equation:

$$policy_{it} = \beta_0 constant + \beta_1 STC_{it} + \beta_2 PROF_{it}^{e} + \beta_3 \delta(T,k) + \varepsilon_{it} \qquad (6)$$

Then, to evaluate consequences of these policies for growth, we use the following estimating equation:

$$growth_{it} = \beta_0 constant + \beta_1 initial\ income + \beta_2\ determinants\ of\ steady\ state\ income + \varepsilon_{it} \qquad (7)$$

Data

Details of the data used are provided in the data appendix. The unpublished data on research and development expenditures for 19 African countries over the period 1961-1991 are available upon request.

Our measure of initial income is GDP per capita in purchasing power parity dollars in 1965, from the Penn World Tables version 5.6. Growth is measured as the average annual change in the natural logarithm of GDP per capita between 1965 and 1990. Agricultural R&D is measured in real per-capita terms, and is derived from the work of Pardey et al. (1998). R&D expenditures are available on an annual basis for a total of 19 countries over a period of 30 years, 1961-1991. Agricultural taxation is measured in the product markets as one minus the nominal protection coefficient (NPC), the farmgate to border price ratio. These data are derived from the work of Jaeger (1992), extended by McMillan (2000), and are available for a total of 56 crops and 32 countries for various years. For the cross-country regressions, the crop specific variables (eg tax rates and ratios of sunk to total costs) are aggregated up to national levels using production weights. All of these variables are computed annually, then averaged up to four sub-periods, 1970-74, 1975-79, 1980-84 and 1985-89 to take account of variation in world commodity prices and economic conditions.[4] Statistical tests are performed both for the individual sub-periods and then for the pooled data.

4. Results

Table 1 reports estimates of equations (5), (6) and (7). Each row reports estimates of a different model and each column reports the coefficients for one of the explanatory variables. There are five types of models with different dependent variables or estimation methods, each of which is estimated using four different proxy measures for the government's discount factor δ, starting with the measure developed by McMillan (2000) and then substituting alternative measures of political conditions reported in the Barro-Lee data set.

For Models 1 and 2, the signs of the estimated coefficients on all explanatory variables are as predicted by our model in all regressions, although the political variables are statistically significant in only three of the eight regressions. In the tax-regime regressions of Model 1, the STC ratio is by far the most strongly significant regressor; in the growth-regime regressions of Model 2, it is the net profitability variable. From Model 1, countries whose production systems require higher levels of sunk costs are more likely to have confiscatory agricultural tax regimes, and also to not grow – this is consistent with the model, as it is the taxation of these sunk costs which might tempt the government into deviation from the optimal policy. From Model 2, countries whose agricultural production is very profitable are particularly likely to experience growth, and also to have low tax regimes. Again this is consistent with the model, as it is the pursuit of these expected profits that induces the government to sustain the optimal policy.

Models 3 and 4 report regression results for equation (6). The signs of the estimated coefficients are again as expected, and here the political variables are significant in five of the eight regressions. Although there is a much smaller sample size for regressions explaining R&D, significance levels are similar for the two dependent variables. In this context the magnitudes of the coefficients can be interpreted directly, and the importance of the STC ratio is clearly visible in the results. Model 5 reports results for growth rates in a comparable way, revealing that a ten percent higher STC ratio is associated with a one percent lower growth rate.

Table 2 reports regression estimates of equation (7), using a cross section of the long-run data (Model 1) and then a panel of the five-year averages (Model 2). The first column of both tables establishes the correlation between growth rates and our two agricultural policy instruments (taxation and R&D) plus their interaction. In both cases the predicted correlations are strong and significant. The Model 1 formulation permits us to include controls for three economywide policy measures that have achieved prominence in the empirical-growth literature: aggregate government savings as a measure of fiscal prudence, the openness of policy to foreign trade as a measure of rent-seeking and distortions in the external sector, and the quality of institutions as a measure of rent-seeking and distortions in the domestic sector. None of these controls has much influence on the results. Adjusted R-square values are high and unchanged, and coefficients are uniformly large and significantly different from zero—except for the taxation variable when controlling for the external openness, which may be due to similarities in the types of policies these two variables pick up. In any case, R&D levels remain a highly significant correlate of growth and long-run productivity, confirming the association between R&D and economywide growth in this context.

Model 2 in Table 2 provides the same regressions using panel data, allowing controls for unobservable influences on growth rates in particular countries or time periods. Column (1) gives results without controls for any such fixed effects. Column (2) allows for period-specific fixed effects, column (3) checks for both period- and country fixed effects, and column (4) drops the initial-income variable which, as a lagged value of the dependent variable could bias the panel results. As before the correlations between R&D and taxation with growth are highly robust to these controls. Results for each variable are similar to those using the long-run growth data in Model 1, although model R-square values are lower due to the presence of business cycles, terms of trade shocks, weather disturbances and other noise.

Finally, to provide results that are fully comparable to many other studies and provide a different sort of robustness test, Table 3 presents regressions that use our agricultural-policy measures as controls in a standard growth-accounting context. The first column of Table 3 takes the growth-accounting specification identified as empirically important on a worldwide basis by Sachs and Warner (1997), and replicates it for our within-Africa sample. Columns 2 and 3 do the same, discarding the variables that lose their significance in this context, for both the restricted Sachs-Warner sample and the larger sample for which the data are available. Columns 3a, 3b and 3c then add three alternative measures of taxation, and columns 3a', 3b' and 3c' do so with the R&D variable as well. Results are consistent across all three taxation measures: Columns 3a and 3a' use the dummy variable constructed by Deaton and Miller (1995) to indicate whether a country paid producers a relatively high proportion of the world price during the period 1970-1975, constructed using a weighted average of the country's most important exports. Columns 3b and 3b' use a similar dummy constructed by McMillan (2000) covering the period 1970-1979. Columns 3c and 3c' use the same continuous measure as in the previous tables, namely the average nominal protection coefficient, or ratio of domestic producer price to world price. Once again the R&D variable overshadows tax policy as a correlate of growth. This may be because its effect is stronger, but it could also be due to other factors such as having less measurement error than the tax variable.

5. Conclusions

This paper presents and tests a model of policy choice aimed at explaining why so many (but not all) African governments adopt self-defeating predatory policies towards the private sector, when pro-growth reforms would yield greater incomes for both government and the private sector.

The theory is a political-economy model in which the government sets the level of taxation and R&D in a strategic game with domestic producers who produce output. One equilibrium has the government commit to low taxes with investment in R&D, so as to elicit high and growing levels of production. Another possible equilibrium involves high tax rates and no investment, to which the economy responds with low and stagnant levels of production and perhaps a retreat to subsistence.

Without an institutional mechanism for commitment to a particular strategy, the government can credibly be expected by farmers to sustain high-growth policies only if material conditions make it consistently in government’s favor to do so. This requires that the sector’s share of sunk costs in total costs be relatively small (yielding a low potential payoff to exploitation by a rent-seeking government), the government's discount rate be relatively low (leading to a high value on the future costs of exploitation in the present), high expected future profitability and high relative weight on farmers’ as opposed to government’s own income.

Empirical tests of these hypotheses find considerable support for the model, particularly for the relevance of the sunk-to-total-cost ratio in determining policy choice. Our conclusion is that one factor contributing to African economic performance could be that African policy-makers are trapped in a low-growth equilibrium of opportunistic policies and low investment, induced by high levels of sunk costs in the production system. Changes in technology or institutions that enable producers to escape taxation or retaliate against it, as well as changes enabling governments to make credible pro-growth commitments, are thus likely to have a high payoff in promoting a more favorable policy environment.

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ENDNOTES

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[1] . Long-run growth rates for the 1965-95 period across African countries ranged from -2.3 to +5.7%, with a coefficient of variation of 2.7%. The next-highest variability was in East Asia and Latin America.

[2] Engerman and Sokoloff (1997) address the geographic pattern of growth in the Americas. They argue that factor endowments favored greater use of slave labor in some regions than in others, and that slavery's persistent legacy of political inequality retards growth. Acemoglu, Johnson and Robinson (2001) address growth across ex-colonies, arguing that settler mortality favored the establishment of more extractive colonial institutions in some regions, where the persistent legacy of rent-seeking retards growth.

[3] Lusigi and Thirtle (1997) find that agricultural R&D spending with a six-year lag accounts for between 1.8 and 3.1% of agricultural output growth, and agriculture is by far the largest sector in most African economies.

[4] These sub-periods are similar to the sub-periods used by Bevan, Collier and Gunning (1993) in a comparative analysis of Tanzania and Kenya and the impact of the boom in coffee prices.

Table 1. Regression Results for Agricultural Taxation, Public Agricultural R&D, and Economic Growth

	Explanatory Variables: Sunk-to-Total-Cost ratio	Net Profitability	Imputed Discount Rate	Political Instability	Frequency Revolutions	Political Rights	*Number of Obs.*	*Test of Model*
Model 1:	-4.72 (1.56)***	0.53 (0.38)	0.19 (0.11)*				128	19.94
Tax	-9.01 (3.07)***	0.74 (0.33)**		-1.17 (1.19)			62	8.86
regime as	-8.81 (3.11)***	0.67 (0.31)			-0.59 (0.35)*		62	9.81
probit	-6.01 (1.81)***	0.27 (0.26)				-0.18 (0.16)	84	14.22
Model 2:	-7.06 (3.70)***	0.33 (0.08)***	0.04 (0.03)				96	20.97
Growth	-3.12 (2.65)	0.28 (0.09)***		-0.86 (0.86)			56	14.09
regime as	-3.01 (2.68)	0.29 (0.23)***			-0.46 (0.26)		56	13.47
probit	-3.18 (1.96)*	0.72 (0.19)***				-0.08 (0.14)	76	16.88
Model 3:	-2.01 (.362)***	-.032 (.010)***					128	.24/.265
Tax	-1.65 (.483)***	-.036 (.010)***	.005 (.004)				128	.25/.263
level as	-1.65 (.398)***	-.023 (.016)		-.186 (.132)*			62	.23/.216
linear-OLS	-1.59 (.407)***	-.020 (.016)			-.091 (.052)**		62	.22/.218
	-1.93 (.463)***	-.024 (.016)				-.049 (.037)	84	.27/.267
Model 4:	-.015 (.004)***	.0004 (.0002)**					44	.26/.002
Agricultural	-.016 (.007)**	.0004 (.0002)*	.0000 (.0001)				44	.24/.002
R&D	-.019 (.004)***	.0005 (.0001)***		-.006 (.001)***			32	.51/.002
level as	-.015 (.005)**	.0005 (.0002)**			-.003 (.001)***		32	.28/.002
linear-OLS	-.016 (.004)***	.0004 (.0002)**				-.0009 (.0002)***	44	.39/.002
Model 5:	-.113 (.004)***	.004 (.001)**					95	.26/.002
GDP growth	-.113 (.004)***	.004 (.001)**	-.001 (.011)				95	.24/.002
rates as	-.102 (.061)***	.003 (.001)***		-0.49 (.022)***			56	.51/.002
linear-OLS	-.101 (.044)***	.003 (.001)**			-0.26 (.011)***		56	.28/.002
	-.088 (.051)***	.003 (.001)**				.004 (.003)***	75	.39/.002

Notes: Regime indicators for Models 1 and 2 are 0 if the tax rate is above its revenue-maximizing level or the growth rate is negative, and 1 otherwise; definitions and sources of all other variables are in the data appendix. Figures in parentheses are robust (Huber-White) standard errors. Significance levels are 99% (***), 95% (**), and 90 (*). Likelihood ratio tests reported for Models 1 and 2 are for the null hypothesis that the coefficients excluding the constant term are jointly zero for each model. Under the null, the test statistic is distributed as Chi-2(3). The null is rejected for values greater than 7.8 at the 5% level. Tests of model for Models 3-5 are the adjusted R-squared and root MSE respectively.

Table 2. Regression Results for Economic Growth on Policy

Model 1. Cross-sectional regression using long-run averages, 1965-90

Explanatory Variables	(1)	(2)	(3)	(4)
Initial income	-3.96	-3.11	-3.92	-3.32
	(.954)***	(1.05)**	(1.17)***	(1.37**
R&D	3.03	2.35	2.72	3.05
	(.646)***	(.687)***	(.773)***	(.786)***
Taxation	6.28	6.31	2.84	12.9
	(1.62)***	(1.74)***	(3.64)	(6.85)*
R&D x taxation	1.18	1.11	.562	2.21
	(.350)***	(.352)***	(.641)	(1.16)*
Govt. savings		.096		
		(.056)		
Openness			1.71	
			(1.74)	
Institutional quality				.141
				(.317)
No. of obs.	19	19	18	15
Adj. R^2	0.67	0.71	0.62	0.60
Root MSE	1.098	1.039	1.15	1.18

Model 2. Panel regression using averages by five-year period, 1965-90

Explanatory Variables	(1)	(2)	(3)	(4)
Initial income	-.042	-.038	-.126	
	(.016)**	(.015)***	(.029)***	
R&D	.030	.031	.057	.039
	(.009)***	(.008)***	(.012)***	(.009)***
Taxation	.094	.118	.079	.151
	(.040)**	(.031)***	(.041)**	(.046)***
R&D x taxation	.015	.019	.012	.022
	(.007)**	(.005)***	(.007)**	(.007)***
Control Variables	none	time	time & country	time & country
No. of obs.	93	93	93	93
Adj. R^2	0.23	0.31	0.64	0.46
Root MSE	.038	.030	.035	.037

Notes: Dependent variable for all models is growth of real GDP per capita. Figures in parentheses are robust (Huber-White) standard errors. Significance levels are 99% (***), 95% (**), and 90 (*). Definitions and sources for all variables are in the data appendix.

Table 3. Regression Results for GDP Growth on Policy in a Growth-Accounting Model

Explanatory Variables		(1)	(2)	(3)	(3a)	(3b)	(3c)	(3a')	(3b')	(3c')
Initial Conditions	Income 1965	-1.76	-1.19	-1.08	-1.47	-1.48	-1.53	-2.24	-2.02	-2.12
		(.471)***	(.331)***	(.452)***	(.254)***	(.295)***	(.429)***	(.309)***	(.332)***	(.526)***
	Life 1965	.13	.11	.15	.16	.14	.13	.15	.14	.16
		(.051)***	(.052)***	(.038)***	(.037)***	(.038)***	(.056)***	(.046)***	(.034)***	(.069)***
	Primary 1970	0.59								
		(1.741)								
Policy Variables	Openness	26.21								
		(90.37)								
	Gov. Savings	.21	.21	.18	.17	.18	.18	.09	.14	.26
		(.046)***	(.027)***	(.029)***	(.019)***	(.024)***	(.059)***	(.037)***	(.046)***	(.094)***
	Institutions	.14								
		(.194)								
	Demography	4.21	2.73	2.03	1.28	1.82	2.21	1.39	1.48	4.14
		(1.536)***	(1.142)***	(.861)***	(.612)***	(.778)***	(1.503)	(1.139)	(1.243)	(2.168)
	Open*initial	-4.09								
		(6.932)								
	Taxation				-0.76	-0.73	2.34	-0.49	-0.02	1.15
					(.361)**	(.372)**	(1.059)**	(.557)	(.013)	(.982)
	R&D							1.22	1.18	1.69
								(.557)**	(.711)*	(.961)*
Immutable Character-istics	Tropics	.82								
		(.759)								
	Access	-0.84								
		(.464)*								
Adjusted R^2		0.76	0.76	0.66	0.69	0.67	0.44	0.78	0.76	0.39
No. of Countries		23	23	34	34	34	25	19	19	12

Notes: Dependent variable for all regressions is growth of real GDP per capita, 1965-90. Figures in parentheses are robust (Huber-White) standard errors. Significance levels are 99% (***), 95% (**), and 90 (*). Definitions and sources for all variables are in the data appendix. Columns denoted *a*, *b* and *c* use different measures of taxation, and the signs of the measure in *a* and *b* is opposite to that of *c*.

Data Appendix. Definition and Source of All Variables

Variable Name	*Definition*	*Source*
GDP Growth	Average annual change in real gdp p.c. 65-90	Penn World Tables 5.6 and World Bank World Tables (1995)
Initial Income	Log of real GDP per ec. Active person 1965	Penn World Tables 5.6 and World Bank World Tables (1995)
Agricultural R&D	Log of ave. annual real R&D expenditure p.c. in agriculture	Pardey, Alston and Roseboom (1998)
Agricultural Taxation	One over the nominal protection coefficient	Jaeger (1991), McMillan (2001)
Government Savings	Average central government surplus/deficit over GDP	World Bank World Tables (1995)
Openness (Sachs-Warner index)	Fraction of years in which country meets S/W criteria	Sachs and Warner (1997)
Institutional Quality (ICRG index)	Index over five measures of institutional quality	Center for Institutional Reform and the Informal Sector (IRIS)
Sunk-to-Total-Cost ratio	One minus ratio of harvest costs to total costs	McMillan (2001)
Imputed Discount Rate	One over the mean time in power since independence for each government in each year	McMillan (2001)
Revenue Maximizing Tax Rate	One over one plus the elasticity of supply	McMillan (2001)
Political Instability	Average over ‘60-90 of 5 yr. averages in Barro/Lee	Barro and Lee
Frequency of revolutions	Average over ‘60-90 of 5 yr. averages in Barro/Lee	Barro and Lee
Political rights	Average over ‘60-90 of 5 yr. averages in Barro/Lee	Barro and Lee
Life Expectancy	Life expectancy at birth	Sachs and Warner (1997)
Primary	Primary-school enrollment rates	Sachs and Warner (1997)
Demography	Growth of econ. active pop. minus total pop. growth, 65-90	Sachs and Warner (1997)
Tropics	Fraction land in tropics	Sachs and Warner (1997)
Access	Dummy equals 1 if landlocked	Sachs and Warner (1997)