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ABSTRACT

This research challenges previous findings regarding the robustness of the African growth dummy by expanding the list of variables to include those suggested by Easterly and Levine (1998) and Sachs and Warner (1997b). Using the Bayesian Averaging of Classical Estimates approach, this paper concludes that the African growth dummy does not appear to be robustly related to growth. This supports the interpretation that the presence of the African dummy in other studies results from misspecification. The paper also contributes to the debate on growth strategies for Africa by assessing the robustness of divergent perspectives offered in the recent literature.

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1. Introduction

In the past decade and a half several studies[1] have found that traditional determinants of growth systematically overpredicted growth rates in Africa. More recently, Sala-i-Martin, Doppelhofer and Miller (2004) have confirmed the significance of the African dummy using a Bayesian Averaging of Classical Estimates (BACE) approach to assess the robustness of the relationship. Though the method followed here is similar to the BACE method proposed by Sala-i-Martin et al.,[2] their conclusions are challenged here by supplementing their data set with a range of variables that have been offered as explanations for slow growth in African countries by Sachs and Warner (1997b) and Easterly and Levine (1998), among others. This paper uses the BACE method not only to challenge the Sala-i-Martin et al. finding, but also to test the robustness of competing explanations for the disappointing growth performance in African countries.

The next section introduces the literature on the slow growth in African countries and is followed by a description of the econometric method in the third section. The interpretation of the results is discussed in the fourth section and the fifth section concludes.

2. Competing Explanations for Slow Growth in African Countries

The poor economic performance of sub-Saharan African economies since the early seventies has not only been worse than the comparative performance in other regions, it has frustrated the expectations of policy makers and consultants and contradicted the explanations offered by the empirical growth literature. This last aspect manifests as the inability of several empirical studies to explain the slow growth of sub-Saharan African economies, without including a regional dummy in standard cross-country growth regressions. Due partly to the challenge posed by this finding, there is a burgeoning empirical and theoretical literature that attempts to explain why African growth is considerably and significantly lower than is predicted by the traditional models. To say, as Collier and Gunning (1999b:4) did, that "Africa has suffered a chronic failure of economic growth" is to admit at least the hope – or perhaps even the expectation – that another, more prosperous path of development was possible for this continent. The search for causes of failure has yielded many important insights into the reasons for poor economic growth in Africa. In this article the focus falls on the additional variables suggested by the work of Sachs and Warner (1997b), Easterly and Levine (1998) and Englebert (2000).[3]

Easterly and Levine (1998) eliminate the African dummy with their neighbourhood effect variable that is constructed using the growth rates of their neighbours with each growth rate weighted by the size of the economy. They also include the neighbour's growth determinants as instruments because of the complex implied causality patterns. A neighbourhood effect would mean that neighbours' growth affect a country's growth rates, but also that the country's growth will affect that of its neighbours. Other significant regressors in their model are educational attainment, political assassinations, financial depth, the black market premium and a government budget surplus. The experience of each country in the 1960s, 1970s and 1980s are treated as separate observations. They have 169 observations for this regression.

In the work of Sachs and Warner (1997b) the emphasis is on trade openness.[4] They consider a sample of 74 countries in a cross-country regression for per capita growth between 1965 and 1990. They find that access to the sea, life expectancy, government savings, institutional quality and a growing population share of working age persons have a significant and positive influence on growth. Their results also show that resource endowments and a tropical climate impede growth. They add the Easterly and Levine's neighbourhood effect variable to their model, but find that it is insignificant.

Englebert (2000) uses a very parsimonious empirical framework to consider per capita growth from 1960 to 1992 with a sample of 99 developing countries. His empirical model of growth includes only five significant variables: a lagged dependent variable, state legitimacy index,[5] a developmental capacity index (modified to be orthogonal to state legitimacy), an East Asian dummy (which positively affects growth) and a tropical climate index. He provides a strong motivation for the relevance of this state legitimacy variable for explaining slow growth in African countries, but his econometric results are not very convincing due to the suspected omitted variable bias. Englebert finds that the African dummy becomes an insignificant regressor when he includes a dummy for the historical legitimacy of the state. The state legitimacy variable is highly significant in his regressions, with a coefficient that is relatively stable around 0.02. Englebert shows that the significance of the African dummy is very sensitive to the inclusion of the state legitimacy variable: when this variable is included, the t-statistic on the coefficient of the African dummy turns insignificant. He also shows that legitimate states are more likely to have high scores on a range of indicators of institutional stability, good governance and prudent policymaking, including variables such as trade openness, the depth of the financial sectors, foreign indebtedness, enforceability of contracts, the risk of expropriation and civil liberties.

3. Assessing rival explanations for slow growth in African countries

Model selection is notoriously complex, especially in the field of growth where there are a remarkably large number of potential regressors and insufficient theoretical guidance to form a consensus on model specification. In the empirical literature on economic growth the traditional approach has been to formulate a regression such as equation (1) with *n* explanatory variables (Dixit and Pindyck) and a vector of growth rates as the dependent variable.

$$y_i = \alpha + \sum_{i=1}^{n} \beta_i x_i + \varepsilon_i \qquad (1)$$

Levine and Renelt (1992) note that due to disagreements in growth theory there is no comprehensive list of control variables that is commands generally agreement. This complicates model selection and as noted by, *inter alia*, Sachs and Warner (1997a), also increases the threat of omitted variable bias. Unsurprisingly, this has resulted in a range of contradictory empirical results in the empirical growth literature.

In reaction to the vast array of explanations for economic growth in the empirical growth literature,[6] Levine and Renelt (1992) suggested a version of 'extreme bounds analysis' (drawing on Leamer, 1983, 1985) as an solution to the problem of model uncertainty. Accordingly they calculated the lower and upper estimates for a given parameter β_i in (1) by considering all possible combinations given the data and potential growth models. If the estimated coefficient changed sign in one of these regressions then it was labelled fragile; else it was robust. Despite the sophisticated techniques employed to isolate the vital relationships from the effect of opportunistic factors in growth regressions, Levine and Renelt (1992) conclude that their research shows that "almost all results are fragile".

Levine and Renelt's (1992) binary classification of variables as either fragile or robust has been criticised as being unreasonably restrictive (Sala-i-Martin et al., 2004). Sala-i-Martin (1997) suggested considering the whole distribution of the parameter by calculating the weighted average of the parameter's estimates and of its variance, across all possible models in which it occurs (where the weights are proportional to the likelihoods of the separate models[7]). Using this methodology, Sala-i-Martin (1997) found a number of variables to be significantly correlated with cross-country growth, including African (and Latin American) dummies.

But the Sala-i-Martin (1997) and Levine and Renelt (1992) approaches still require some variables to be identified as "fixed regressors" (that will occur in all models) upfront, with the remaining possible entering in the various combinations allowed by a given model size. "Bayesian model averaging" offers an alternative solution to the problems of model uncertainty.[8] Fernandez et al. (2001) revisited the Sala-i-Martin (1997) data set but applied Bayesian model averaging to investigate the contribution of the various factors purportedly relevant to cross-country growth. The fully Bayesian approach of Fernandez et al. (2001) required the specification of a prior distribution for all potential parameters conditional on each possible model. This is an exacting challenge, given the 2^K possible linear models in a data set with K possible regressors.

Sala-i-Martin et al. (2004: 804) have criticised the "essentially arbitrary" priors which are used in the literature to solve this problem in Bayesian model averaging. Assuming diffuse priors for the parameters of each possible linear regression yields the OLS sampling distribution of the parameters as a posterior distribution, given the model (Sala-i-Martin et al., 2004). By adopting diffuse priors for the parameters, Sala-i-Martin et al. (2004) propose an intermediate technique – called Bayesian Averaging of Classical Estimates (BACE) – a hybrid of the fully Bayesian model averaging of Fernandez et al. (2001) and the classical approach of Sala-i-Martin (1997). The name is appropriate, since the classical estimation of each model's parameters will be combined with a Bayesian treatment of the distribution across all potential models. A major advantage of this method, as emphasised by Sala-i-Martin et al. (2004), is that it requires the prior specification of only one "hyper-parameter", the expected model size. This achieves a remarkable economy over the fully Bayesian approach that requires a prior for each parameter.

On Bayesian reasoning, the posterior density of a parameter β_j is the weighted average of the posterior densities of the parameter conditional on the possible models. Equation (2) shows the resulting posterior mean of parameter β_j and equation (3) the posterior variance of β_j.

$$E(\beta|y) = \sum_{j=1}^{2^K} P(M_j|y)\hat{\beta}_j \tag{2}$$

where $(\bullet)|y$ means conditional on the data

$\hat{\beta}_j$ represents the OLS estimate for parameter β_j conditional on model j (given the diffuse priors in BACE)

$P(M_j|y)$ represents the posterior model probability of model j[9].

$$Var(\beta|y) = \sum_{j=1}^{2^K} P(M_j|y)Var\left(\hat{\beta}_j, M_j\right) + \sum_{j=1}^{2^K} P(M_j|y)\left(\hat{\beta}_j - \sum_{j=1}^{2^K} P(M_j|y)\hat{\beta}_j\right) \tag{3}$$

In addition to the posterior means and variances, another useful summary statistic is what Sala-i-Martin et al. (2004) call the posterior inclusion probability, that is, the posterior probability that a particular variable x_j is in the "true" model. This posterior inclusion probability is the sum of the posterior model probabilities of those models that include variable x_j.

The posterior inclusion probability will become an important decision variable in the analysis below. Sala-i-Martin et al. (2004) sidestep the requirement of specifying a prior for the model probability by assuming a constant model size, *k*. With a model size *k*, each variable amongst the *K* in the data set has an equal prior probability $\frac{k}{K}$ of being included in the "true" model.

A relevant criterion of the importance of a variable is whether the posterior inclusion probability of the relevant parameter exceeds the parameter's prior inclusion probability. In other words, variables that are robustly related to growth should have a higher inclusion probability after the prior inclusion probability has been updated with the data. Additionally, the posterior distribution could be used to calculate the probability that a given parameter has the same sign as its conditional mean, called the sign certainty probability.

In our implementation of BACE the following decision criteria suggested by Sheedy (2002) were used to judge the robustness of a variable:

1. Whether the posterior inclusion probability exceeded the prior inclusion probability
2. A high sign certainty probability (above 0.975)
3. A high conditional *t* (above 2)

It is important to clarify that the proposed empirical method aims to investigate the robustness of competing explanations for growth and cannot confirm the validity or

appropriateness of a specific model. As Hendry and Krolzig (2004) note, the validity of a model is contingent on a range of factors including the completeness of the data set in terms of the variables as well as the observations, the weak exogeneity of the regressors, accurate measurement of the underlying phenomena and the homogeneity of the observations in the sample. They add that "every one of these assumptions is open to legitimate doubt in the 'growth regressions' context" (Hendry and Krolzig, 2004:800). Furthermore, it should also be emphasised that tests of robustness can seldom resolve model uncertainty. They are constrained by the same degrees of freedom problems as standard regressions. It is difficult to establish the congruency[10] of cross-country growth regressions owing to the very large number of potential regressors relative to the number of observations available – or as Sala-i-Martin et al. phrased it "the number of proposed regressors exceeds the number of countries in the world" (2004:814). This necessitates pragmatic decisions about the inclusion and exclusion of variables from the data set. Further, the uneven distribution of missing observations implies that the selection of explanatory variables often restricts the country sample.

The selection of variables and countries used in our empirical analysis is the result of merging the raw data from Easterly and Levine (1998), Sachs and Warner (1997b) and Englebert (2000). Due to the more complex model specification of Easterly and Levine (1998), the simple cross-section specification applied here cannot claim to test their model. The aim is a comparison of the Englebert (2000) and Sachs and Warner (19997b) results, with some cognisance of the findings reported in Easterly and Levine (1998).

To avoid multi-collinearity, highly correlated variables were never included simultaneously in the set of variables used for testing. To prevent endogeneity, variables represent the initial values – as in 1960 – at the start of the period under consideration. In cases where there was no value available for 1960, the earliest possible variable value after 1960 was selected for our data set. Table 1 shows descriptive statistics for the data set, while the countries are listed in Appendix Table 1 and variables in the data set are described in detail in Appendix Table 2.

Tables 2 and 3 below reports the output of the BACE procedure based on a hyper-parameter (the prior model size) of k=7. Support for this decision is offered in Tables 4A and 4B where the prior and posterior values are shown for the hyper-parameter as well as the associated prior inclusion probabilities for the 22 variables in the data set. These tables indicate that the posterior model converges on 7 for models with larger prior model sizes. Further, for models with prior model size up to 12 there is no impact on the ranking of those variables for which the posterior inclusion probability exceeds the prior inclusion probability.

The first seven variables in this table are classified as robust according to the three criteria outlined previously. As required, all seven of these variables have a posterior inclusion probability exceeding the prior inclusion probability, sign certainty probabilities exceeding 0.975, and conditional t-statistics above 2. In the table the variables are ordered according to their posterior inclusion probabilities.

The results are broadly in agreement with the Sala-i-Martin et al. (2004) findings. As expected, initial GDP is robustly significant. In fact, the convergence or catch-up effect has the highest posterior inclusion probability (1.00) and it has a sign certainty likelihood of 1.

Confirming the results of Sala-i-Martin et al. (2004), the tropical climate variable, primary school enrolment in 1960 and the Sachs and Warner trade openness variable are found to be robustly related to growth. The median value for the tropical variable is 0.5, which implies a penalty of 0.75% per annum on per capita growth after controlling for the impact of other variables. The economic significance of this variable is raised by the relatively large standard deviation of this variable which implies that for those countries with largely tropical climates the marginal growth penalty had been 1.5%. Primary school enrolment has a median value of 0.83 in the data set which implies a positive contribution of 2.06% per annum on per capita growth after controlling for the impact of other variables. But here too the relatively large standard deviation means that countries with primary school enrolment two standard deviations below the median (Benin and Senegal) would have suffered a growth penalty of 1.39% per annum compared with the median and 1.81% per annum compared with the counties with full enrolment at the primary school level.

The distribution of the Sachs and Warner trade openness variable is bi-polar with 24 countries scoring above 0.88 on a scale of zero to one and 31 countries scores less than 0.1. The coefficient of 0.77 reflects an economically meaningful difference in the experience of the top third and bottom thirds of the distribution on openness.

The black market premium variable is shown to be robustly significant and is comparable to the real exchange rate distortion variable in Sala-i-Martin et al. (2004). This variable is also economically significant, but in an asymmetric manner: half of the counties had black market premia of less than ten percent and for these countries the variable had negligible impact on growth. However, for 10 countries in the data set their black market premia implied a growth penalty of at least 0.3% per annum, which rose to 0.7% per annum for black market premia as high as those of Uganda and Nicaragua.

However, in sharp contrast with Sala-i-Martin et al. (2004), neither the sub-Saharan Africa nor Latin American dummies are robustly significant after our expansion of the variable list to include additional variables from the models of Easterly and Levine (1998), Sachs and Warner (1997b) and Englebert (2000). Not only do these variables fail the robustness test, but they are also economically insignificant with coefficients of -0.04 and -0.03% respectively in the model reported in table 3.

In line with Sachs and Warner's (1997b) argument, the significance of the regional dummies in the Sala-i-Martin et al. (2004) work could be attributed to an omitted variable problem. Two of the variables that are found to be robustly associated with growth here were not included in the Sala-i-Martin et al. (2004) study. Although they include a population growth rate and two variables respectively measuring the fraction of the population below 15 years and above 65 years in 1960, their work does not include a variable to measure the change in the dependency ratio. In our BACE results the growth in the labour force relative to the population contributed as much as 1.5% per annum to growth for a country such as Korea compared while the same factor subtracted as much as 0.42% per annum from the growth rate of a country such as Cameroon or Gabon at the other end of the scale. This variable has a high standard deviation of 0.31 compared with the median value of 0.17 and is therefore a powerful explanatory factor of the cross-country growth variation in this data set.

Finally, Sala-i-Martin et al. (2004) did not include a neighbourhood variable. Though the neighbourhood effect is robustly significant in the BACE exercise and though the variable shows a large variation around the median value of 1.67 the small coefficient of the neighbourhood effect diminishes the economic significance of this variable.

If the significance of the African dummy can indeed be attributed to the omission of this list of variables, then the low growth rates of African countries over this period could be adequately explained by a standard growth model. As Collier and Gunning conclude, "Africa's slow growth is thus partly explicable in terms of particular variables that are globally important for the growth process, but are low in Africa" (1999a:65).

As an assessment of rival explanations of slow growth in Africa, the results appear to favour the model proposed by Sachs and Warner (1997b). This is consistent with the findings of Bleaney and Nishiyama (2002). Sachs and Warner's results overlap more with the list of robust regressors reported below than the Englebert (2000) model. The Sachs and Warner (1997b) model contains four of the seven variables found to be robustly significant: the catch-up term, the tropics variable, the trade openness index and the working age population's share of the total population. It is, however, interesting to note that three variables – namely life expectancy (also included both as a squared term), resource abundance and access to the sea – are significant in the Sachs and Warner (1997b) model, but are not found to have robustly significant relationships to growth. Additionally, previous tests showed that the Sachs and Warner institutional quality index was not robustly significant. To allow for the inclusion of the state legitimacy and political constraints variables, Sachs and Warner's institutional quality index was omitted in the round of testing reported in Table 1 and 2 below.

The Sachs and Warner model omits only three variables that are robustly significant according to our findings here: primary enrolment, the black market premium and the neighbourhood effect[11]. All three of these variables are included in the Easterly and Levine (1998) model (although Easterly and Levine measure schooling using the average years of schooling attainment, not primary school enrolment). Easterly and Levine's financial depth variable does not appear to be robustly significant. As stated earlier, because of the more complex model specification of Easterly and Levine, this study cannot claim to test the model with the simple specification used here for the robustness analysis.

The Englebert model does not perform well. Only two of the variables in the Englebert (2000) model are robustly significant: initial income levels[12] and tropical climate. The results show that Englebert's (2000) pivotal variable, state legitimacy, is not robustly significant.

Table 1 Descriptive statistics

Variables	Mean	Median	Standard deviation
Financial depth	0.35	0.27	0.23
Fractionalisation	0.39	0.32	0.3
Government	17.75	16.2	6.41
Growth in real GDP p.c.	1.8	2.1	1.63
Initial GDP (logged)	3.4	3.38	0.41

Investment rate (logged)	-2.03	-1.87	0.74
Labour	0.2	0.17	0.31
Landlocked	0.15	0	0.36
Latin American dummy	0.24	0	0.43
Life expectancy	54.59	52.7	12.38
Malaria	0.5	0.55	0.5
Neighbourhood effect	1.5	1.67	1.67
Political constraints	0.21	0.2	0.21
Population	0.02	0.02	0.01
Premium	0.18	0.08	0.23
Primary enrolment	0.74	0.83	0.28
Primary exports	0.12	0.1	0.09
Sachs Warner openness	0.38	0.12	0.44
Secondary enrolment	0.23	0.14	0.23
Sub Saharan Africa dummy	0.28	0	0.45
State legitimacy	0.63	1	0.49
Terms of trade change	0.28	-0.89	5.73
Tropics	0.53	0.5	0.48

Table 2. BACE Results A

Variable	**Rank**	**Prior inclusion probability**	**Posterior inclusion probability**	**Proportion OLS significant**	**Sign certainty probability**
Initial GDP	1	0.318	1.00	0.99	1.00
Tropics	2	0.318	0.98	0.68	1.00
Primary enrolment	3	0.318	0.97	0.76	1.00
Labour	4	0.318	0.91	0.89	1.00
Sachs Warner openness	5	0.318	0.69	0.65	0.99
Premium	6	0.318	0.53	0.35	0.99
Neighbourhood effect	7	0.318	0.42	0.35	0.98
Terms of trade change	8	0.318	0.29	0.16	0.97
State legitimacy	9	0.318	0.28	0.57	0.96
Investment rate	10	0.318	0.13	0.40	0.91
Financial depth	11	0.318	0.11	0.08	0.84
Latin American dummy	12	0.318	0.09	0.32	0.80
Life expectancy	13	0.318	0.09	0.22	0.75
Sub-Saharan African dummy	14	0.318	0.09	0.29	0.75
Population	15	0.318	0.08	0.03	0.65
Malaria	16	0.318	0.07	0.14	0.75
Political constraints	17	0.318	0.07	0.00	0.74

Fractionalisation	18	0.318	0.06	0.05	0.55
Secondary enrolment	19	0.318	0.06	0.05	0.59
Landlocked	20	0.318	0.06	0.00	0.66
Primary exports	21	0.318	0.06	0.01	0.52
Government	22	0.318	0.05	0.00	0.52

Table 3. BACE Results B

Variable	**Coefficient**	**Standard error**	**Conditional coefficient**	**Conditional standard error**	**Conditional t-stat**
Initial GDP	-2.88	0.55	-2.88	0.55	-5.28
Tropics	-1.50	0.46	-1.53	0.41	-3.74
Primary enrolment	2.48	0.84	2.57	0.72	3.57
Labour	1.50	0.66	1.65	0.49	3.35
Sachs Warner openness	0.77	0.63	1.12	0.43	2.60
Premium	-0.74	0.82	-1.39	0.59	-2.35
Neighbourhood effect	0.07	0.10	0.18	0.08	2.16
Terms of trade change	0.01	0.02	0.04	0.02	1.86
State legitimacy	0.23	0.45	0.83	0.47	1.76
Investment rate	0.04	0.13	0.31	0.23	1.32
Financial depth	0.09	0.38	0.85	0.83	1.02
Latin American dummy	-0.03	0.18	-0.38	0.46	-0.84
Life expectancy	0.00	0.01	0.03	0.04	0.67
Sub-Saharan African dummy	-0.04	0.23	-0.47	0.66	-0.71
Population	-0.60	6.59	-7.92	22.75	-0.35
Malaria	0.02	0.17	0.35	0.52	0.68
Political constraints	0.03	0.22	0.46	0.72	0.63
Fractionalisation	0.00	0.14	-0.07	0.57	-0.12
Secondary enrolment	0.01	0.27	0.24	1.09	0.22
Landlocked	-0.01	0.09	-0.14	0.35	-0.41
Primary exports	-0.01	0.39	-0.10	1.62	-0.06
Government	0.00	0.01	0.00	0.02	0.04

Table 4A. Robustness check on BACE Results

	Ranking by posterior inclusion probability					
Variables	**7**	**8**	**9**	**10**	**11**	**12**
Initial GDP	1*	1*	1*	1*	1*	1*
Tropics	2*	2*	2*	2*	2*	2*
Primary enrolment	3*	3*	3*	3*	3*	3*
Labour	4*	4*	4*	4*	4*	4*
Sachs Warner openness	5*	5*	5*	5*	5*	5*
Premium	6*	6*	6*	6*	6*	6*
Neighbourhood effect	7*	7*	7*	7*	7*	7*
Terms of trade change	8	8	8*	8*	8*	8*
State legitimacy	9	9	9	9*	9*	9*

Investment rate	10	10	10	10	10	10
Financial depth	11	11	11	11	11	12
Latin American dummy	12	12	12	13	13	13
Life expectancy	13	14	14	14	14	14
Sub-Saharan African dummy	14	13	13	12	12	11
Population	15	15	15	15	15	15
Malaria	16	16	16	16	16	16
Political constraints	17	17	17	17	17	17
Fractionalisation	18	18	18	18	18	18
Secondary enrolment	19	19	19	19	20	20
Landlocked	20	20	20	20	21	21
Primary exports	21	21	21	21	19	19
Government	22	22	22	22	22	22
Prior model size	7	8	9	10	11	12
Posterior model size (rounded)	7	7	8	8	9	9
Prior inclusion probability	0.318	0.364	0.409	0.455	0.5	0.545

*indicates that the posterior inclusion probability exceeds the prior inclusion probability

Table 4B. Robustness check on BACE Results

	Ranking by posterior inclusion probability					
Variables	**13**	**14**	**15**	**16**	**17**	**18**
Initial GDP	1*	1*	1*	1*	1*	1*
Tropics	2*	2*	2*	2*	2*	2*
Primary enrolment	3*	3*	3*	3*	3*	3*
Labour	4*	4*	4*	5*	5*	7*
Sachs Warner openness	5*	5*	5*	4*	4*	4*
Premium	6*	6*	8*	8*	8*	8*
Neighbourhood effect	9*	9*	9*	9*	9	9
Terms of trade change	8*	8*	7*	7*	7*	6*
State legitimacy	7*	7*	6*	6*	6*	5*
Investment rate	10	10	10	10	10	10
Financial depth	12	13	16	17	18	18
Latin American dummy	13	14	14	15	15	17
Life expectancy	14	17	17	16	16	15
Sub-Saharan African dummy	11	11	11	11	12	12
Population	16	15	13	14	14	14
Malaria	17	16	15	13	13	13
Political constraints	15	12	12	12	11	11

Fractionalisation	18	18	18	18	19	19
Secondary enrolment	20	21	21	21	21	21
Landlocked	21	22	22	22	22	22
Primary exports	19	19	19	19	17	16
Government	22	20	20	20	20	20
Prior model size	13	14	15	16	17	18
Posterior model size (rounded)	10	10	11	12	12	13
Prior inclusion probability	0.59	0.64	0.68	0.73	0.77	0.82

*indicates that the posterior inclusion probability exceeds the prior inclusion probability

3.1 Confirming our results via automatic general to simple model selection

An alternative strategy for dealing with non-nested rivals is to employ encompassing tests. Hendry and Krolzig (2004) acknowledge that multi-regression methods of model selection do little harm, but prefer their automatic general to simple model on account of the considerable reduction in research time it entails. The general to simple modelling strategy starts with an overparameterised general model[13] that is conjectured to nest the underlying data generating process. Hendry has described this approach a method that "combines constructive aspects in a basically destructive methodology" (Hendry, 2000 [1985]: 275). That is to say, it eliminates the obviously hopeless models, to leave less bad models for further consideration. The destructive part of this method concerns the testing of the postulated model. Here we distinguish between diagnostic tests, leading up to the decision regarding the validity of the model, and the reduction process. Methodological rules are useful in this destructive part (the scientific part) of the modeling exercise[14] and these methodological rules could be implemented via an algorithm as Hoover and Perez (1999) showed. Hendry and Krolzig (1999) subsequently improved upon the Hoover and Perez (1999) algorithm and added the automated algorithm to the *PcGive* econometrics platform as *PcGets*.

The proposed method and the algorithm are explicitly data based, but the strong emphasis on encompassing eliminates the risk of data mining, when that term is meant to indicate statistical gymnastics to confirm the econometrician's prejudice. A constructive data-based approach can be salutary in that it lowers the search cost for the local data generating process, without risking data mining in the pejorative sense (Hendry, 2000).

Whereas this approach does not guarantee that the local data generating process will be found, it lowers the cost of searching for the local data generating process when starting from a more general model. The method reduces the search costs dramatically, though it leaves the cost of inference unaffected (Hendry, 2000, Hendry and Krolzig, 1999). This is precisely what one could hope for from an automated search algorithm.

The software provides two basic settings (called Liberal and Conservative) for the levels of significance, degree of pre-testing and so on, all of which affects the probability of either retaining opportunistic variables or deleting significant variables (Hendry and Krolzig, 2001). The liberal strategy is "liberal" in the British sense, i.e. tolerant, and reduces the risk of deleting significant variables. In contrast, the conservative strategy reduces the chance

of over-fitting the final specification with opportunistic variables. Table 5 reports the results of both strategies.

Table 5. Automated Selection Results

Liberal strategy			**Conservative strategy**		
Variable	**Coefficient**	**t-stat**	**Variable**	**Coefficient**	**t-stat**
Initial GDP	-3.12	-6.83	Initial GDP	-2.74	-75.82
Tropics	-1.40	-4.13	Primary enrolment	2.51	3.92
Primary enrolment	2.39	3.94	Labour	1.70	4.13
Labour	1.37	3.17	Tropics	-1.61	-4.73
Premium	1.28	-2.46	Sachs Warner openness	1.24	3.36
Terms of trade change	0.05	2.47			
State legitimacy	0.70	2.08			
Sachs Warner openness	1.14	3.15			

4. Interpreting the findings: Growth prospects in African countries

The primary objective of the previous section was to ascertain whether the negative effect of being an African country on growth, as identified by other empirical studies (Barro 1991; Barro and Lee, 1994; Sala-i-Martin, 1997; Easterly and Levine, 1998, amongst others) was robust to a myriad of potential specifications. We conclude that the African dummy is not robustly related to growth. Although the sign certainty is fairly high – implying that African countries can rarely be considered to be at an international advantage – the posterior inclusion probability is only 9% and the African dummy variable is significant in less than a third of the potential specifications. The same is true for the landlocked state variable. Although many studies have concluded that the high proportion of countries in Africa that lack domestic access to a coastline is partly to blame for the continent's poor growth performance, this study shows that this relationship is not robust.

The results reported above suggest that the poor economic performance is non-deterministic in an empirically important sense: the degree of openness for the economy, black market premia and primary enrolment are all empirically important to growth and closely related to policy decisions. Other than initial GDP, which suggests catch-up potential for sub-Saharan African countries to is only the geographical given of tropical climate which is both statistically and economically significant in this study and about which policy can do very little. According to Sachs and Warner (1997b), tropical climates have an adverse impact on growth owing to the poorer soil quality and prevalence of tropical diseases such as malaria.[14] The neighbourhood effect, which may also have worked against rapid growth in sub-Saharan African countries was not economically significant in this study, though it was statistically robust.

The crucial role of education – and specifically primary schooling – in stimulating growth is confirmed by these findings. The coefficient on primary school education suggests that if universal primary school enrolment had been achieved by 1960, African countries would have grown at an additional 1.4 percentage points annually[17] - a substantial increase considering that the average growth rate for our sample of African countries was 0.5% between 1960 to 2000.

Secondary schooling does not enter the growth model robustly. However, this result should not necessarily be interpreted as suggesting that African countries should divert funding away from secondary and tertiary education to primary education, since Banerjee and Duflo (2004) find that in developing countries the Mincerian returns to education are greater at higher levels of education. Easily accessible, good quality primary education is a prerequisite for the successful completion of higher levels of education, and the achievement of this goal therefore represents a good starting point for policy makers.

The findings of the previous section also confirm the importance of demographic trends for growth. The difference between the growth rates of the working aged population and the whole population is found to be robustly related to a country's growth performance. Africa has not made the transition from high fertility and high mortality to low fertility and low mortality. From the middle of the last century the region's infant and child mortality rates have declined sharply, although fertility rates have stayed comparatively high. This has resulted in Africa having the highest youth dependency ratios in the world. As the labour force participation – and consequently also the savings – of youth is expected to be lower than that of the working-age population, higher youth dependencies ratios can be expected to impede growth.

Trade openness is also found to be robustly related to growth. Sachs and Warner (1997b:351) claim that closed trade policies have been "cutting Africa off from the growth dynamism of world markets". It is argued that trade openness induces growth by promoting competition and hence enhancing allocative efficiency and technological progress.[18] The impact of trade openness on growth can also work through discouraging rash policy moves by raising the expected cost of policy flaws due to the economy's amplified vulnerability to changes in the exchange rate or foreign payments. In this way, trade openness may act as a proxy for general policy prudence. This line of interpretation is also supported by Rodriguez and Rodrik's (2000) critique of the Sachs and Warner variable. They show that the significance of the variable is largely attributable to two of the five measures included in the index, namely a black market exchange premium and extreme controls on exports. They argue that in the case of both of these measures it may be more appropriate to broadly interpret policy prudence being beneficial for growth than to take Sachs and Warner's conclusions at face value.[21] In his growth empirics survey, Temple (1999) makes a similar point. He finds that openness to trade appears to be favourable for growth given international historical experience, but added that we do not yet know enough about the conditions under which this holds true.

Foreign exchange black market premiums also negatively affect growth. There are many direct costs to having a parallel foreign exchange market, including foregone government revenue, weakened capital controls, increased domestic price volatility and the disincentive to export (Agénor and Montiel, 1996:70). It is more likely, however, that the black market premium variable represents a wide range of distortions which interventionist government policies introduce into domestic markets, thus capturing the harmful effects such policies can have on growth (Barro and Sala-i-Martin, 1999:434).

Our results also lend support to Easterly and Levine's (1998) suggestion that Africa's slow growth may be partly due to a negative neighbourhood effect.[20] According to our tests, the neighbourhood effect has a robustly significant relationship to growth. Easterly and Levine (1998) argue that the significance of this variable demonstrates that neighbours often face comparable conditions and learn from each other's policy experiments. Additionally, Easterly and Levine argue that having a poor and slow-growing neighbour is likely to affect a country's own position via constraining regional trade. Foreign direct investment in a particular country may be less attractive if there is little opportunity for expanding to neighbours at a later stage. The neighbourhood effect could also work through other channels, such as technological adaptation or migration.

It is vital to note that the lack of robust significance cannot be interpreted as evidence that the particular variable does not matter for growth. Two alternative, and more cautious interpretations are that (i) the variable does not appear to have a direct impact on growth or (ii) that the impact of the variable cannot be estimated accurately given the existing range of experience.

This observation is of particular importance for the institutional and governance variables. In the institutional literature, the role of institutions is to provide incentives to encourage or discourage specific choices – in the case of government, policy choices. It is thus expected that sound institutions affect growth indirectly by motivating prudent policy making. There are also empirical foundations for this view. Using a developing country sample, Temple (1998) finds that social arrangements matter for growth, and this effect operates through economic policy.

There is also scope for interpreting the tropical location variable as an indicator of institutional quality. Recently, Easterly and Levine (2002) and Acemoglu et al. (2001) proposed that the debilitating impact of a tropical climate may be due to its impact on the institutional development of a country. For instance, Acemoglu et al.'s (2001) thesis is that tropical climates may have encouraged formerly colonising societies to create "extractive institutions".[19] This contrasts with institutions supportive of private property rights and limited government in temperate colonies where colonisers were willing to settle and live.

5. Conclusion

The analysis shows that although growth is a complex process, there are a number of policy variables and country characteristics that are robustly related to growth. The paper shows that initial GDP, tropical location, primary school enrolments, the growth rate of the working age population, trade openness, the black market premium and a neighbourhood effect can robustly explain changes in growth between 1960 and 2000 for the sample of countries under investigation. The African dummy is not significant when the variable list is expanded to include those used in Sachs and Warner (1997b) and Easterly and Levine (1998). This result is contrary to findings reported by previous studies of robustness - including Levine and Renelt (1992), Sala-i-Martin (1997) and Sala-i-Martin (2004) - and consistent with an interpretation that the African dummy result can be attributed to omitted variables.

The analysis indicates that the Englebert (2000) model performs poorly and also appears to suffer from omitted variables. The core findings from the Sachs and Warner (1997b) and Easterly and Levine (1998) results survive the robustness analysis. The results suggest that slow growth in Africa is not attributable to structural differences between African countries and other regions, but rather to differences in the levels of variables that are vital for growth.

Optimistically, a number of the variables that are reported to have a robust relationship to growth are policy variables or variables that can be influenced by policy.

Appendix

Appendix Table 1 and 2 describes the data set in more detail. Due to data availability problems the 1960 to 2000 growth rates were calculated using the 1998 and 1967 values for Haiti, the 1961 values for Tunisia and Togo, the 1970 value for West Germany, the 1999 value for Botswana, the 1998 value for the Central African Republic and the 1997 value for Zaire/DRC. The external terms of trade is the ratio of an export price index to an import price index. More information regarding the construction of the other variables is available from the data descriptions relating to these sources.

Table Appendix 1: List of countries in sample

Algeria
Argentina
Australia
Austria
Belgium
Benin
Botswana
Brazil
Burundi
Cameroon
Canada
Central African Republic
Chile
Colombia
Congo
Costa Rica
Denmark
Dominican Republic
Ecuador
Egypt
El Salvador
Finland
France
Gabon
Gambia
Germany/West Germany
Ghana
Greece
Guatemala
Haiti
Honduras
India
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Pakistan
Paraguay
Peru
Philippines
Portugal
Senegal
Spain
Sri Lanka
Sweden
Switzerland
Syria
Tanzania
Thailand
Togo
Trinidad & Tobago
Tunisia
Turkey
Uganda
United Kingdom
United States
Uruguay
Zaire/DRC
Zambia
Zimbabwe

Kenya
Korea
Madagascar
Malawi
Malaysia
Mali
Mexico
Morocco

Table Appendix 2: List of variables

Variable tag	Variable description	Data source
Financial depth	Financial depth: ratio of liquid liabilities of the financial system to GDP. Liquid liabilities consist of currency held outside the banking system, demand and interest-bearing liabilities of banks, and non-bank financial intermediaries. Average of their decade averages	Englebert (2000)
Fractionalisation	Measure of Ethno-linguistic fractionalisation used previously in Easterly and Levine (1997). This variable measures the probability that two randomly selected people from a country will not belong to the same ethnic or linguistic group.	Sachs and Warner (1997a)
Government	Average real government share of GDP (percent), 1985 international prices, starting in the year of independence until 1992	Englebert (2000)
Growth in real GDP per capita	Growth in real GDP per capita (Constant price: chain series) between 1960 and 2000	Penn World Table Mark 6.1 (2000)
Initial GDP	Log of real GDP per capita in 1960	Penn World Table Mark 6.1 (2000)
Investment rate	Average investment share of real GDP 1960 to 1975	Penn World Table Mark 6.1 (2000)
Labour	Average annual growth of the economically active population minus average annual growth of population	Sachs and Warner (1997a)
Landlocked	Dummy variable that takes the value 1 if a country is completely landlocked; 0 otherwise.	Sachs and Warner (1997a)
Latin American dummy	Dummy variable equal to 1 for Latin American countries, 0 otherwise	Sachs and Warner (1997a)
Life expectancy	Life expectancy at birth in 1960	Barro & Lee (1994)
Malaria	Percentage of population living in areas	Gallup, Sachs

	with malaria in 1996	and Mellinger (1999)
Neighbourhood effect	Average annual growth of neighbouring economies between 1970 and 1989. For each country, we summed GDP and population of all neighbouring economies. Then standard growth rates for GDP per capita were calculated for this aggregation.	Sachs and Warner. (1997a)
Political constraints	An index measuring political constraints. According to Henisz (2002) the measure of political constraints estimates the 'the extent to which a change in the preferences of any one actor may lead to a change in government policy' by investigating the number of independent branches of government and the degree of alignment between them.	Henisz (2002)
Population	Average annual population growth rate between 1960 and 1965	Barro & Lee (1994)
Premium	Log of (1 + foreign exchange black market premium). Average of their decade averages	Englebert (2000)
Primary enrolment	Total gross enrolment ratio for primary education in 1960	Barro & Lee (1994)
Primary exports	Share of exports of primary products in GNP in 1970	Sachs and Warner (1997a)
Sachs Warner openness	Proportion of year during which a country has been open to international trade between 1960 and 1990s. According to Sachs and Warner (1997), an economy is deemed to be open to trade if it satisfies five criteria: • average tariff rates below 40 percent • average quota and licensing coverage of imports of less than 40 percent • a black market exchange rate premium of less than 20 percent • no extreme controls (taxes, quotas, state monopolies) on exports • not considered a socialist country by the standard in Kornai (1992)	Gallup, Sachs & Mellinger (1999)
Secondary enrolment	Total gross enrolment ratio for secondary education in 1960	Barro & Lee (1994)
SSA dummy	Dummy variable equal to 1 for countries in sub-Saharan Africa, 0 otherwise	Sachs and Warner (1997a)

State legitimacy	Dummy variable equal to 1 for legitimate states, 0 otherwise. As described in Englebert (2000) the dummy variable is constructed according to five criteria. If a country meets any of the five criteria, it is classified as legitimate. If it meets none of the five criteria, it is classified as illegitimate. The five criteria are: • The country was not colonised in modern times. • The country was colonised in modern times, but it recovered its previous sovereignty, identity or effective existence when it gained independence. • There was no human settlement predating colonialisation. • The colonisers (and/or their imported slaves) reduced the pre-existing societies to numerical insignificance (or assimilated them) and became new citizens of a new country. • The postcolonial state did not do severe violence to pre-existing political institutions.	Englebert (2000)
Terms of trade change	Average annual growth in the log of the external terms of trade between 1970 and 1980.	Sachs and Warner (1997b)
Tropics	Approximate fraction of a country's land area that is subject to a tropical climate	Sachs and Warner (1997a)

Notes

[1] See for instance Barro (1991), Levine and Renelt (1992), Barro and Lee (1994), Sala-i-Martin (1997) and Easterly and Levine (1998).

[2] The method is implemented here with the algorithm developed by Sheedy (2002).

[3] Although the work of Hoeffler (2002) is noteworthy, it was not included in this comparison. Hoeffler argues that the African dummy is an artifact of endogeneity present in the cross-country regression frameworks. It is clear that the African dummy can be successfully eliminated with a panel data approach. However, panel data methods may not be best suited to growth analysis because in growth regressions the "main evidence turns out to come from the cross-sectional or between-country variation" while the time series or within-country dimension provides only "some additional information" (Barro, 1997:15). Furthermore, there is also an argument that, due to panel data's magnification of measurement error, a panel data approach might be particularly inappropriate when the focus of the empirical work is the growth experiences of African countries. There are concerns about the reliability of the data in many of these countries due to, among other things, suspect consumer price indices (Sahn and Stifel, 2000). Lastly, it is important to note that Hoeffler (2002)'s panel data work faces the same model selection difficulties as cross-section models. It is consequently not surprising that other panel data studies such as Keller and Du Plessis (2002) and Burger (2002) has succeeded in eliminating the African dummy with alternative extensions to the Solow growth model.

[4] See Appendix Table 2 for the five criteria that Sachs and Warner (1997b) used to construct their trade openness variable.

[5] See Appendix Table 2 for more information on the content of the state legitimacy.

[6] Competing models of growth emphasise different factors, e.g. the accumulation of physical capital (a venerable tradition) or human capital (Lucas, 1988; Mankiw et al., 1992); the production of technology (e.g. Romer, 1990), the dissemination of that knowledge (e.g. Landes, 1998), or its application by workers (e.g. Lucas 2002 [1997]). Others emphasise institutions (e.g. Easterly and Levine, 2002; Knack and Keefer, 1995) or the rule of law and democracy (e.g. Barro, 1994). Another class of models is concerned with the role of destiny in determining growth performance, and so focuses on the abundance of natural resources (e.g. Sachs and Warner, 2001), the economic impact of geography (e.g. Sachs and Bloom, 1998), climate (e.g. Sachs, 2001) or disease (e.g. Sachs and Gallup, 2000).

[7] The rationale is to increase the relative weight of models that show better data adherence (Sala-i-Martin, 1997).

[8] See Hoeting et al. (1999) for a summary of the expanding literature on the Bayesian model averaging. There is also a Bayesian model averaging home page at http://www.research.att.com/~volinsky/bma.html

[9] Sala-i-Martin et al. (2004) show that the posterior model probability is proportional to the prior model probability multiplied by a function of the Schwartz model selection criterion.

[10] See Hendry (1995) for a formal exposition of congruency.

[11] They added a neighbourhood effect to their model, but it was not significant.

[12] However, the initial income term is added just as a control together with the square of the initial level and is not significant.

[13]An overly generous specification increases the chance of opportunistic variables will reach the final model; though the *PcGets* algorithm places a high hurdle in the path of such opportunism. Given the risk of omitting relevant variables if the initial model is too small, Hendry and Krolzig (1999) suggest a generous specification, in practice.

[14] An economist could conceivably dream of the correct reduced model in a flash, but experience suggests search cost is usually positive and often significantly so. The relative efficiency of *Gets* in terms of search cost is a strong selling point for this methodology.

[15] Sachs and Warner (1997b:1) noted that "The colonial legacy or ethnic divisions, for example, may help to explain Africa's poor choices of economic policy, which in turn are responsible for much of the growth shortfall according to our regression estimates. Similarly, Africa's distinctive geography – with a substantial population in landlocked countries, and a very high proportion of land in tropical climates –surely has contributed to the poor economic outcomes in Africa, but in ways that are consistent with the effects of geography evident in other parts of the world".

[16] If malaria has an important impact on growth, as claimed by Gallup, Sachs and Mellinger (1999), it may be that this impact is captured by the tropical variable, explaining why the malaria variable is not robust in our tests. Bloom and Sachs (1998) argue that adverse geography has imposed a considerable burden on African economies. The tropical climate has an adverse impact on agricultural productivity, and tropical regions are also home to diseases like malaria that can lower life expectancy and labour productivity and discourage foreign investment.

[17] This conclusion is almost identical to the result of Artadi and Sala-i-Martin (2003).

[18] Collier and Gunning (1999a) add an interaction variable to the trade openness variable to capture the specific way that openness affects growth in Africa. The interaction variable is positive; indicating that in Africa the impact of trade openness on growth is larger than it is for the sample average.

[19] In the case of the black market premium indicator (above or below 20%) Rodriguez and Rodrik (2000) argue that this variable is usually associated with general policy

failure. They claim that sample selection issues may distort the meaning of the export control measure.

[20] Hoeffler (2002) argues that the neighbourhood effect variable does not explain much and may merely be taking the place of the African dummy. However, the tests show that the African dummy does not become significant if we exclude the neighbourhood effect from the sample.

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