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Political Economy, Growth and Convergence in Less Developed Countries

It is well known that the growth process in LDCs is a complex one: there are obviously many factors which may facilitate or retard growth. One feature of the growth process which has received increasing attention in recent years is the issue of "Convergence" or "Catching-up". As the name suggests, this relates to the question of whether the growth process is an equalising one, thus tending to promote convergence in income levels per capita across countries. This debate is of particular importance in the LDC context. Convergence implies that uneven development is a transient phenomenon whereas divergence implies that uneven development can persist indefinitely.

The first authors to address these issues within a systematic hypothesis testing framework were Baumol(1986) and Baumol and Wolff(1988). In these studies, the essential method was to "explain" current real GDP per capita in terms of past real GDP per capita. Baumol and Wolff(1988) also expanded the analysis to investigate the role of education in explaining growth and convergence. Subsequent authors (Barro(1991), Mankiw et al (1992), and Zind(1991)) have broadened the analysis by adding further explanatory variables. These studies have offerred insights into the growth process and identified conditions for convergence - savings ratios, human capital and government spending programmes have been found to be of importance. However none of these studies has focussed attention on the potential effects of "political freedom" and "enterprise culture" in influencing growth. Indeed despite their importance such "non-economic" variables have rarely, if ever, been examined in formal econometric growth models. This paper addresses these issues in a limited way.

We also clarify the methodology used by previous analyses. In these, convergence was said to be occurring if regression analysis on a cross section of countries revealed that growth over a certain period was significantly negatively related to initial per capita income.[1] We argue that this is test is sensitive to the particular regression specification choosen and develop a more general method for testing for convergence.

In Section I, we discuss the methodological issues involved in testing for Convergence. In Section II, we presesnt our Base model, which is essentially a variant of the Baumol-Wolff(1988) specification. In Section III, we introduce our political variable, discuss its construction and examine its role in affecting growth. In Section IV, we examine the role of enterprise culture whilst Section V concludes the paper.

I Tests for Convergence

The first formal test of convergence was due to Baumol(1986) who estimated a regression of the form:

$$\ln (Y_T / Y_0) = a + b\, Y_0 \qquad (1)$$

where Y stands for per capita real GDP [2] and the subscripts 0 and T stand for initial and terminal period respectively. Convergence was then taken to be implied by a significantly negative value of b. Essentially the same methodology has been followed by others .[3]

Baumol-Wolff(1988) - herafter referred to as BW - generalised this by allowing for the possibility that b itself was a (linear) function of Y_0 , thus generating the quadratic estimating equation :

$$\ln (Y_T / Y_0) = a + b\, Y_0 \; - c\, Y_0^2 \qquad (2)$$

This specification has the advantage of testing for the presence of an exclusive Convergence Club whose membership is based on initial per capita income. [4] We shall refer to the interval [0,T] as a "generation". BW estimated (2) using the Heston-Summers(1985) data set for 72 countries with 1950 as the initial period and 1980 as the terminal period. The estimates they obtained were $\hat{a} = 0.586$, $\hat{b} = (38/10^5)$ and $\hat{c} = (1/10^7)$ [5].

For each country, the LHS of (2) is a measure of the growth rate of Y over the generation whilst the RHS is a quadratic in initial Y. The quadratic expression has a unique maximum at Y_0 = (b/2c) = \$ 1900. Clearly for countries with an initial real per capita income in excess of this critical value growth is inversely related to initial level. Thus for any two countries in this set the ratio of their per capita real incomes will be lower at the end of the generation than at the beginning. BW call this set of countries the Convergence Club. The reverse is true for those countries whose initial Y is below the critical level.

This is illustrated in Figure 1 below.

[INSERT FIGURE 1 HERE]

Clearly, long as the focus of attention is one generation only, there is some merit to defining the Convergence Club as the set of countries for whom growth and initial level are negatively correlated. However this condition of negetive correlation between growth over the period and initial level is neither necessary nor sufficient for the variance of real per capita income to be lower at the end of the period than at the beginning. [6] Quite simply the absolute gap between two BW Convergence Club members can be bigger at the end of the generation than it was at the beginning. More importantly the BW analysis offers no concrete answer to the question : *convergence to what ?* Suppose the same growth process implicit in (2) were to repeat itself generation after generation. The question that naturally arises then is : *does there exist a steady state towards which some countries converge and what are the characteristics of this steady state ?*

Abramovitz(1985) has suggested that one interprets convergence as implying a long run tendency towards the equalisation of levels of per capita income or levels of per worker product. We retain this interpretation and define convergence as requiring two conditions . First, the existence of a steady state in which per capita real income is equalised; and secondly the presence of dynamic forces which in the long run drives the world economy to this steady state. The existence of an exclusive Convergence Club is then taken to imply the existence of a non-exhaustive set of countries which in the long run are driven to this steady state with equalised real per capita incomes. We turn below to an analysis of such a possibility but staying within the BW paradigm.

For the purpose of analysing long run convergence, we recast (2) in a standard difference equation framework. Redefining Y_T as Y_t and Y_0 as Y_{t-1} we can rewrite (2) as :

$$\ln Y_t = a + \ln Y_{t-1} + b\, Y_{t-1} - c\, Y_{t-1}^2 \qquad (3)$$

The existence of a steady state equilibrium requires $Y_t = Y_{t-1} = Y$ (say)

Hence the steady state level of real per capita income is given by :

$$cY^2 - bY - a = 0 \qquad (4)$$

which implies a steady state equilibrium value for real per capita income given by :

$$Y^* = \frac{b+\sqrt{b^2+4ac}}{2c} \qquad (5)$$

Given BW's estimates this turns out be \$ 4977.

To examine the issue of whether the world economy converges to this equilibrium we rewrite (2) using the transformation

ln $Y_t = y_t$ or $Y_t = e^{y_t}$. Hence

$$y_t = a + y_{t-1} + b\, e^{y_{t-1}} - c\, e^{2y_{t-1}} = F(y_{t-1}) \qquad (6)$$

Convergence to the steady state value of $y^* = e^{Y^*}$ will occur if the absolute value of the slope of F at the equilibrium is less than unity. Since the slope of F is given by $F'(y) = 1 + b\, e^y - 2ce^{2y}$ and $e^y = Y$, we can calculate the slope of F at the equilibrium as:

$$\rho = 1 + bY^* - 2c\{Y^*\}^2 \qquad (7)$$

For BW's estimates , the calculated value of ρ is - 2.06 which is greater than 1 in absolute value. Hence there is no convergence to the steady state. *The Convergence Club is empty!*

The analysis of convergence would be simpler if one slightly alters the fundamental BW model (equation (2)) to have the logarithm of intial per capita income as the RHS variable. This yields :

$$\ln (Y_T / Y_0) = a + b \ln Y_0 - c \ln Y_0^2 \qquad (8)$$

which using our notation can be written as a simple difference equation in the logarithm of Y as :

$$y_t = a + (b + 1) y_{t-1} - c\, y_{t-1}^2 \qquad (9)$$

The steady state equilibrium value [7] is given by :

$$y^{*}=b+\frac{\sqrt{b+4ac}}{2c}$$

(10) The sufficient condition for convergence is that $-1 < \rho < 1$ where ρ is given by the slope of $F(y) = a + (b+1)y - cy^2$ at y^* . Thus

$$\rho = b + 1 - 2cy^2 \qquad (11)$$

Once again there is no reason to believe that an exclusive Convergence Club exists. Indeed given (8) and (9) the implication of $-1 < \rho < 1$ is that the variance of y is less at the end of a generation than at the beginning . [8] This implies a sort of convergence within a generation. Thus both within a generation for countries reasonably close to y^* and in the long run for all countries we get the same condition for convergence.

Some authors (eg Zind(1991), Mankiw *et al*(1992)) have used a special case of (8) with $c = 0$ imposed in order to test for convergence. The test has taken the form of testing for the negativity of b. From (11) it is clear that $\rho = 1 + b$, so that $b < 0$ is indeed a necessary condition for convergence. [9]

In general however, the appropriate methodology is to extend (8) and test for an appropriate functional form F() on the RHS of the regression and then examine the derivatives of F() in the neighbourhood of equilibrium. It should be pointed that this methodology is not without some shortcomings. Regressions like (8) or extensions thereof cannot easily be interpreted as behavioural. Rather they may be seen as reduced form equations which capture complex structural equations representing the growth process. Furthermore the test procedure requires the (reduced form) parameters to be time-invariant. Despite these limitations, the method does yield insights into the convergence debate.

II. The Base Model

We start by constucting an econometric model to explain the level of real GDP per capita in 1985 in terms of the level in 1960. The updated Heston-Summers(1988) data set provides the real GDP per capita in 1960 and 1985 for the less developed countries of Africa, Asia, and Latin America as well as the OECD countries. For the purpose of this paper, we restrict attention to 85 LDCs. Initially, trial and error methods (and some economic sensibility) are employed to find a model that would adequately *represent* the data. We estimate various linear and non-linear functional forms. Our model selection criteria were significance of coefficients and adequacy of the diagnostic test statistics. We did **not** use goodness of fit criterion. The model that seems to best represent the data is called the Base model. It is a regression of the form:

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 \qquad (12)$$

where Y_t stands for per capita real GDP in 1985 and Y_{t-1} is per capita real GDP in 1960. This model is a variation of the BW model which is itself a special case of :

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 + \alpha_4 \text{ Ln } Y_{t-1} \qquad (13)$$

The BW model was originally estimated with the first Heston-Summers(1985) data set[10]. A re-estimation of the BW model using the updated 1988 data set reveals that the coefficients of this model are not altogether significant for the sample of developing countries. Specifically the coefficient of Ln Y_{t-1} is entirely insignificant, which is why we opt for the Base model.

Another model which which seems to represent the data well is referred to as the Alternative model. It is a regression of the form:

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 \text{ Ln } Y_{t-1} + \alpha_3 \text{ Ln } Y_{t-1}^2 + \alpha_4 \text{ Ln } Y_{t-1}^3 \qquad (14)$$

In this model all the coefficients have explanatory power individually and jointly. Additionally the model is well specified. We did not choose this model because it is analytically more difficult to work with than our base model because of the cubic term.

The estimates of the BW model, the Base model and the Alternative model are reported in Table 1 below.

[INSERT TABLE 1 HERE]

The Base model represents a significant improvement over the BW model since all the coefficients are significantly different from zero and there is no evidence of misspecification suggested by the diagnostic test statistics FU, N and H. The alternative model is also a fairly robust specification, but for reasons of analytical tractability we use the Base model in further analysis below.

In long run steady-state $Y_t = Y_{t-1} = Y$, the equilibrium value. This means that the Base model in the long run takes the form:

$$\text{Ln } Y = \alpha_1 + \alpha_2 Y + \alpha_3 Y^2 \qquad (15)$$

Analytically solving the above is strenuous, if possible. Therefore we must plot ln Y and the fitted values of the RHS quadratic (using the MLE estimates of α_1, α_2, α_3) against Y. The intersection point of these two functions yields the steady state value. We find the equilibrium value to be approximately \$4633. To check this estimate and obtain its standard error, we analyse the function:

$$Y^* = e^{(\alpha_1 + \alpha_2 Y_c + \alpha_3 Y_c 2)} \qquad (16)$$

where the value of Y_c obtained from the graphical analysis is \$4633.[11] The steady-state equilibrium range of values for Y is $Y^* = \$4627 \pm 331$.[12] Convergence to this level requires that $G'(Y^*)$ is less than unity in absolute value, where $G(Y^*)$ is given by:

$$G(Y^*) = e^{(\alpha_1 + \alpha_2 Y^* + \alpha_3 Y^* 2)} \qquad (17)$$

and thus G'(Y) is

$$G'(Y^*) = e^{(\alpha_1 + \alpha_2 Y^* + \alpha_3 Y^* 2)} \cdot (\alpha_2 + 2\,\alpha_3\, Y^*) \qquad (18)$$

The range of $G'(Y^*)$ is -2.36 ± .127. Therefore, our Base model suggests that LDCs do not converge - uneven development will persist even in the long run.

III. Political Culture

Using the Base model as a starting point, we then proceed to see whether we can do better on the basis of a priori information about the degree of political freedom in various countries. This factor may possibly be expected to influence growth in two conflicting ways. First in liberal political climates, the freer exchange and dissemination of ideas may be a stimulus to innovation. On the downside, harsher political regimes may be able to impose greater discipline on the work force.

In order to study the effects of political regimes, we first start by creating a variable which captures the varying degrees of political freedom in each country of the Heston-Summers data set. This is achieved by simply ranking the country on a scale of 1 to 85 (since there are 85 countries in question), where 1 represents the highest degree of political freedom and 85, the lowest degree of political freedom. The rankings were formulated on the basis of Gastil's index of political rights (Gastil 1978) and the Human Freedom Index (HFI) as was reported in *Human Development Report 1991*.[13]

Once the ranks of the individual countries are obtained they are all assigned to a new variable which we call, X, the political freedom variable. This variable is simply added to our existing Base model, which may be rewritten as :

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 + \alpha_4 X \qquad (19)$$

The coefficient of the political freedom variable, α_4, represents the degree to which a country's growth will change as its political freedom varies (moves down the rank). The regression results of (19) are presented in Table 2 below.

[INSERT TABLE 2 HERE]

The negative coefficient on X in Table 2 implies that a greater degree of political freedom corresponds to a higher growth in real GDP per capita. This finding is fairly robust: the errors appear to be normally distributed and homoskedastic; there is no evidence to suggest that the functional form is inappropriate. Furthermore, the political freedom variable turns out to be significantly different from zero.

We employ a method similar to the one used for the base model to analyze the steady-state. To begin analysis of whether this model converges to any given steady-state, we rewrite (8) as:

$$\text{Ln } Y = \alpha_1 + \alpha_2 Y + \alpha_3 Y + \alpha_4 X \qquad (20)$$

We solve the following equation in terms of Y, which we call Y^*. Every nation has a different steady-state value which depends upon X. It is found that the ranges of steady-state levels of real per capita GDP are \$4938 ± 460, \$4581 ± 306, and \$4021 ± 211 for the country with the highest, mean, and lowest degree of political freedom respectively. This calculation reaffirms our earlier statement regarding the role of political freedoms in facilitating growth.

For investigating convergence we first apply the usual transformation to (20) to obtain:

$$Y = e^{(\alpha_1 + \alpha_2 Y + \alpha_3 Y2 + \alpha_4 X)} = G(Y) \qquad (21)$$

Again, for convergence to the steady state value, the absolute value of the slope of G at the equilibrium must be less than unity, except this time it depends on the level of X. The slope is given by:

$$G'(Y^*)= \rho = e^{(\alpha_1 + \alpha_2 Y^* + \alpha_3 Y^{*2} + \alpha_4 X)} \cdot (\alpha_2 + 2\,\alpha_3\, Y^*) \qquad (22)$$

For the three different estimates of the country with the highest, mean, and lowest political freedom the calculated values of ρ imply ranges of $\rho_1 = -2.6716 \pm .117$, $\rho_2 = -1.7155 \pm .158$, $\rho_3 = -.58347 \pm .154$ respectively. The results suggest that convergence occurs only for countries with low levels of political freedom. One can infer that as we move down the chart towards the least political freedom, there is a greater chance of convergence in the long run. Hence, introducing into the model prior knowledge of the political systems of these LDCs gives the model greater explanatory power. Nations with more political freedom have higher long-run equilibrium levels of real GDP per capita than those with less political freedom. Those with less political freedom will converge to a lower level of real GDP per capita in the long run. Once again, we note the existence of permanent uneven development (non-convergence) for countries with moderate to high political freedom. Given the positive relationship between growth and political freedom, this suggests that the benefits of political freedom may be very long lasting.

IV. Enterprise and Geography

In this section we examine the potential role of enterprise culture in the growth process. We do this in an admittedly crude way - essentially by assuming that these cultural forces vary systematically across the three continents included in our sample. Certain countries may have good international reputations as being productive and safe havens for international investment.

These may cluster by continent. For example investors may regard Asian countries in general as being better investment outlets than African countries. We capture these complex forces in a simple way - essentially by using dummy variables for the continents. In effect we are really examining the role of geographical factors. These may affect growth through a variety of other channels that are quite unconnected with enterprise culture - for instance the extent and quality of land, environmental and climatic factors etc. These caveats should be borne in mind when interpreting the results focussing on the geographic variable.

Specifically, we define two dummy variables, one for Africa(DAF), the other for Latin America(DLA), leaving Asia as the base group. Thus our model takes the form:

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 + \alpha_4 X \quad (23) \quad + \alpha_5 \text{DAF} + \alpha_6 \text{DAF } Y_{t-1} + \alpha_7 \text{DAF } Y_{t-1}^2 + \alpha_8 \text{DAF X} \quad + \alpha_9 \text{DLA} + \alpha_{10} \text{DLA } Y_{t-1} + \alpha_{11} \text{DLA } Y_{t-1}^2 + \alpha_{12} \text{DLA X}$$

Before estimating (23) by OLS, we must test whether the error variance is equal across the three groups; that is, we investigate whether the above model is equivalent to the model represented by (24) to (26) below:

$$\text{Ln } Y_t = \alpha_1 + \alpha_2 Y_{t-1} + \alpha_3 Y_{t-1}^2 + \alpha_4 X, \quad T_1 = 1 \text{ to } 42 \text{ [Africa]} \quad (24)$$

$$\text{Ln } Y_t = \delta_1 + \delta_2 Y_{t-1} + \delta_3 Y_{t-1}^2 + \delta_4 X, \quad T_2 = 43 \text{ to } 66 \text{ [Latin America]} \quad (25)$$

$$\text{Ln } Y_t = \gamma_1 + \gamma_2 Y_{t-1} + \gamma_3 Y_{t-1}^2 + \gamma_4 X, \quad T_3 = 67 \text{ to } 85 \text{ [Asia]} \quad (26)$$

We derive a likelihood ratio test for testing the null hypothesis that the error variances in (24) to (26) are the same so that (23) and (24) to (26) are equivalent.[14] The three separate regressions of (24) to (26) provide three residual sums of squares, one for each group, S_1, S_2, S_3. If the error variance is indeed equal across the groups then:

$$-2\mathrm{Ln}\lambda = T\ \mathrm{Ln}(S_1+S_2+S_3)/T - T_1\mathrm{Ln}(S_1/T_1) - T_2\mathrm{Ln}(S_2/T_2) - T_3\mathrm{Ln}(S_3/T_3) \tag{27}$$

where $T = T_1 + T_2 + T_3$.

Under the null hypothesis of equal error variances, $-2\mathrm{Ln}\lambda$ is distributed Chi-Square with 2 degrees of freedom. In this case, $-2\ln\lambda$ equals 9.329, which implies the rejection of the null hypothesis that the variances are equal. Therefore, we cannot estimate (23) as is. We must first deal with the heteroskedastisticies of the error term. To do so, we let:

$$\lambda_1^2 = \Theta_1/\Theta_3, \quad \lambda_2^2 = \Theta_2/\Theta_3, \quad \text{and } \lambda_3^2 = 1 \tag{28}$$

where Θ_i, $i = 1,2,3$ are the respective error variances.

Deflating (24), (25), (26) by λ_1, λ_2, and λ_3 respectively should yield a model with a equal error variance.15 Because the true values of the variances are not available, we proceeded as

follows. We use the Maximum Likelihood Estimators ($\hat{\theta}_1$, $\hat{\theta}_2$,and $\hat{\theta}_3$) obtained from the OLS regressions (24), (25), (26) to obtain initial estimates of λ_i from (28). We then use these to transform the variables in (23), obtain OLS estimates of the residual vector which generates further estimates of λ_i and iterate until convergence. Due to the concavity of the likelihood function, we can be confident that convergence will occur.

From the individual regressions (24) to (26) we obtain $\hat{\theta}_1$ = .238, $\hat{\theta}_2$ = .072, and $\hat{\theta}_3$ = .169. Thus $\hat{\lambda}_1$ = 1.187, $\hat{\lambda}_2$ = .654, and $\hat{\lambda}_3$ = 1. We deflate (23) by $\hat{\lambda}_1$, $\hat{\lambda}_2$, and $\hat{\lambda}_3$ over the respective samples and then estimate the regression. Saving the squared residuals, summing and dividing by appropriate sample sizes, allows us to find the variances of the three groups. The first iteration yields convergence : the variance is equal across the groups. This redefinition of the variables in (23) allowed us to proceed and test hypotheses about the coefficients.

Tests for significance of the dummy variable coefficients demonstrate that α_5, α_7, α_8, α_9, α_{10}, and α_{12} are insignificant individually but that α_6 and α_{11} are significant. A likelihood ratio test that drops all 6 coefficients gives us $-2\ln\lambda = 5.167$ which under the null, that all 6 are zero, is distributed Chi-Square (6). Failure to reject the null provides evidence that we should adopt the following model:

$$\text{Ln } \tilde{Y}_t = \alpha_1 + \alpha_2 \tilde{Y}_{t-1} + \alpha_3 \tilde{Y}_{t-1^2} + \alpha_4 \tilde{X} + \alpha_6 \text{ DAF } \tilde{Y}_{t-1} + \alpha_{11} \text{ DLA } \tilde{Y}_{t-1} \quad (29)$$

where the $\sim$ variables are transformed by deflating the original variables by λ_i.

The only effect geography has is on the level GDP of 1960. To test the hypothesis that geography has no effect at all on the model is to test whether α_6 and α_{11} together are significantly different from zero. Executing this test, we obtain a Chi-Square (2) statistic equal to 15.0, implying a rejection of the null that both are zero. Hence geography **does** have an effect on growth for LDCs.

The results of the OLS regression of the transformed model (29) are in table 3 below.

[INSERT TABLE 3 HERE]

The results in Table 3 suggest that Africa and Latin America have a lower growth rate than Asia. These findings are robust since all the coefficients are significant and more importantly the model is not misspecified.

We move now to the analysis of convergence to a steady state. Using the same procedure as in the previous sections, we find that for a country with average political freedom, the steady state equilibrium range for Africa is $Y^*=\$4140 \pm 374$; for Latin America, it is $Y^*= \$4503 \pm 184$, whilst for Asia, the range is $Y^*= 6890 \pm 1350$. Will these countries converge ? The range for the slope of $G(Y^*)$ for Africa is $G'(Y^*) = -.64122 \pm .130$; for Latin America $G'(Y^*) = -1.0265 \pm .142$; and for Asia $G'(Y^*) = -4.7810 \pm .4404$. These results suggest that African countries with average political freedom will converge, Latin America may converge and Asian countries will not converge.

Thus a refinement of our model using prior knowlege of the geographic location of the LDCs adds to its explanatory power. Asian countries have higher long-run equilibrium levels of real GDP per capita than those in Africa and Latin America; however this higher steady-state value is not a convergent equilibrium. Permanent uneven development does appear to be an Asian phenomenon. In interpreting these results it is important to recall that whilst the geographic variable was introduced to proxy enterprise culture, it could in fact be a proxy for other aspects which differ significantly across the continents.

V. Conclusion

This paper begins by formulating a model for economic growth of the LDCs over the generation from 1960 to 1985 using the updated Heston-Summers (1988) data set. The model we arrive at which adequately represents the data is a variation of the model used by Baumol-Wolff(1988). However the steady-state equilibrium value of real GDP per capita represents a non-convergent equilibrium. We then hypothesize that a country's political freedom may have influence over its growth. To allow for this possibility we add our political freedom variable (X) to the model and find that it does have significance. The sign of the variable implies that the more politically free countries have higher growth. The steady-state analysis reveals that the more politically free countries are less likely to converge to a common steady-state. The paper then adds the final element of our analysis - the impact of enterprise culture (and possibly other factors) as proxied by continental location. Our results indicate that Asian countries will have higher growth. Asian countries of equal political freedom appear not to converge to each other whilst those in Africa do; Latin American countries are on the boundary between these extremes. It would appear that permanent uneven development is a characteristic of relatively liberal regimes; it is also certainly a characteristic of Asian countries and posssibly Latin American countries too.

These results are suggestive but not definitive. The characterisation of political culture and enterprise culture that we employ is rudimentary. However our results do suggest that more work in this area may generate rich insights.

NOTES

[1] Baumol and Wolff(19880 used a broader methodology. Besides the negative correlation hypothesis test, they also used a number of informal tests such as examining the decline in the coefficient of variation and the reduction in the Gini coefficient as suggestive of convergence.

[2] It is perfectly possible to base the analysis on some other appropriate variable such as labour productivity.

[3] See for example, Barro(1991).

[4] Since (1) is a special case of (2) with c = 0 imposed, we shall focus on the analysis of (2). Any problems using (20 in the analysis of convergence apply a fortiori to (1).

[5] There is clearly a misprint in the paper where the value of $\hat{c}$ is reported as $(9.9 / 10^7)$or $(1/ 10^6)$. This does not square with later calculations done by the authors.

[6] This point is elaborated further when we discuss a slight variant of the BW approach.

[7] The negative root for y is discarded despite being a theoretical possibility since it implies a steady state equilibrium income which is a fraction.

[8] The result follows from the fact that $Var(y_t) = \rho^2 \, Var\,(y_{t-1})$. We alluded to this earlier in footnote 5.

[9] The necessary and sufficient condition is : $-2 < b < 0$.

[10] The BW model is a special case of (2) with $\alpha_4 = 1$ imposed.

[11] Because the errors in the Base model are normally distributed, our estimates of α_1, α_2, and α_3 are MLEs. Therefore, any transformation of these estimators will be an MLE. The approximation involved here is that we use the approximate value of Y_c in calculating the

standard error of Y^*.

[12] This range is a 95% confidence interval. The standard error of Y^* is calculated from (5) and the covariance-matrix of (4). All future ranges will be similarly constructed.

[13] For a list of the rankings and a more detailed description of how the ranks are assigned, see appendix B.

[14] See Appendix A for a derivation of this test.

[15] See appendix A for a proof of this proposition.

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Table 1 : Results of the various models

Model	LHS	const	Ln Y_{t-1}	Ln Y_{t-1}^2	Ln Y_{t-1}^3	Y_{t-1}	Y_{t-1}^2	R^2
BW	Ln Y_t	5.4149 [2.534]	.07746 [.4570]			1.515×10^{-3} [7.053×10^{-4}]	-2.153×10^{-7} [1.037×10^{-7}]	.6652
Alt.	Ln Y_t	72.1516 [39.799]	-29.8395 [17.4048]	4.3784 [2.5198]	-.20530 [.1208]			.6627
Base	Ln Y_t	5.8436 [.1609]				1.630×10^{-3} [1.985×10^{-4}]	-2.31×10^{-7} [4.711×10^{-8}]	.6692

Model	FU	N	H
BW	.1059	4.051	.5993
Alt.	.6862	3.464	.4597
Base	.0763	4.133	.5990

Notes

(1) LHS denotes the dependent variable

(2) Y_t = real GDP per capita in 1985, Y_{t-1} = real GDP capita in 1960

(3) Figures in square brackets are standard errors.

(4) Sample size = 85

(5) The diagnostic test statistics FU, N and H are the Reset test for Functional Form, the Jacques-Berra test for Normality of errors, and a test for Homoskedasticity against a simple heteroskedastic alternative. Under the null hypotheses of appropriate functional form, normality of errors and homoskedasticity, these are distributed as Chi-square wit 1, 2 and 1 degree of freedom respectively. Rejection of the null implies mispecification.

Table 2 : The role of political regimes

const	Y_{t-1}	Y_{t-1}^2	X	R^2	FU	N	H
6.3024 [.2363]	1.423×10^{-3} [2.08×10^{-4}]	1.96×10^{-7} [4.75×10^{-8}]	-6.572×10^{-3} [2.547×10^{-3}]	.6906	.3990	3.653	.3366

Notes

(1) Dependent variable is Y_t = Ln GDP per capita in 1985

(2) Y_{t-1} = GDP per capita in 1960

(3) Figures in square brackets are standard errors

(4) Sample size 85

(5) The test statistics FU, N and H are the Reset test for Functional Form, the Jacques-Berra test for Normality of errors, and a test for Homoskedasticity against a simple heteroskedastic alternative. Under the null hypotheses of appropriate functional form, normality of errors and homoskedasticity, these are distribted as Chi-square with 1, 2, and 1 degree of freedom respectively. Rejection of the null implies mispecification.

Table 3 : The Geographic Model

const	$\tilde{Y}_{t-1}$	$\tilde{Y}_{t-1}^2$	X	DAF $\tilde{Y}_{t-1}$	DLA $\tilde{Y}_{t-1}$	R^2
6.3492 [.2202]	$1.508\text{x}10^{-3}$ [$1.87\text{x}10^{-4}$]	$-1.640\text{x}10^{-7}$ [$3.79\text{x}10^{-8}$]	$-5.660\text{x}10^{-3}$ [$2.23\text{x}10^{-3}$]	$-2.90\text{x}10^{-4}$ [$1.07\text{x}10^{-4}$]	$-2.570\text{x}10^{-4}$ [$6.90\text{x}10^{-5}$]	.9181

FU=1.745; B=2.2067; and H=.1208.

Notes

(1) Tilde variables have been transformed

(2) Dependent variable is Ln Y_t = Ln GDP per capita in 1985

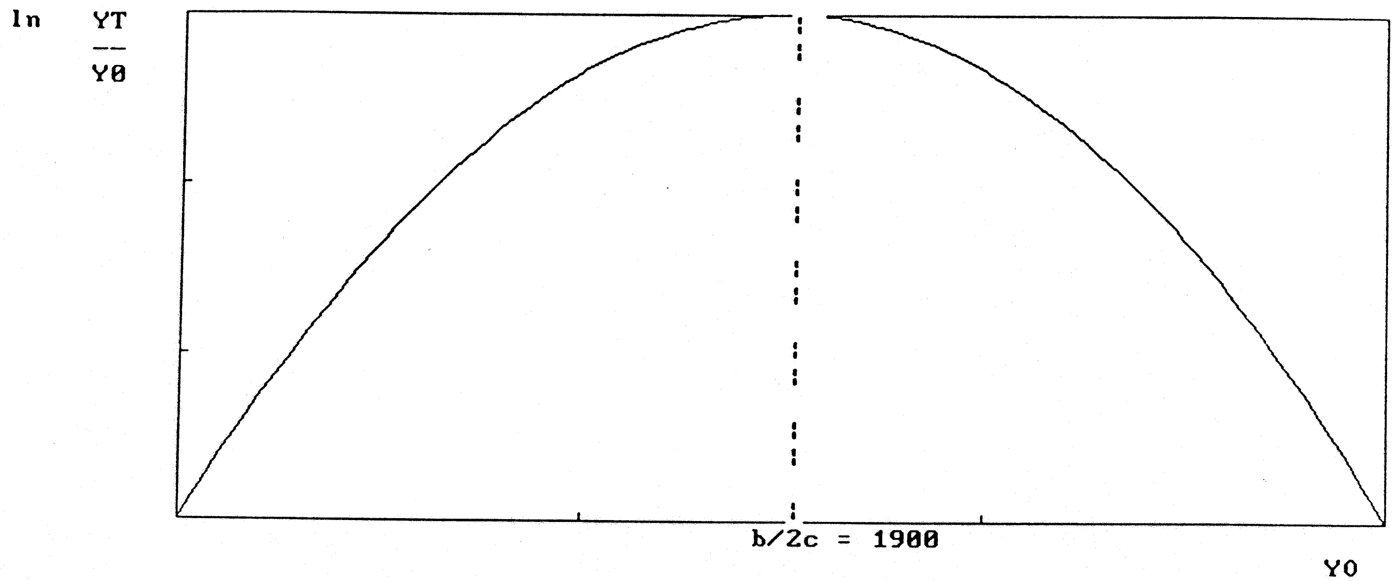
(3) Y_{t-1} = GDP per capita in 1960

(4) Figures in square brackets are standard errors.

(5) Sample size 85

(6) The test statistics FU, N and H are the Reset test for Functional Form, the Jacques-Berra test for Normality of errors, and a test for Homoskedasticity against a simple heterskedastic alternative. Under the null hypotheses of appropriate functional form, normality of errors and homoskedasticity, these are disbributed as Chi-square with 1, 2, and 1 degree of freedom respectively. Rejection of the null implies mispecification.

FIG 1 : The BW Convergence Club



APPENDIX A

I. Derivation of Likelihood Ratio Test

The maximized value of log likelihood when all three error variances are different is:

$$\text{Ln } L_u = -T/2.\text{Ln}(2\pi) - \sum_{i=1}^{3} T_i/2.\text{Ln}(S_i/T_i) - T/2 \qquad \text{(A)}$$

where $T = T_1 + T_2 + T_3$

This is the unrestricted case. Imposing the null hypothesis, that $\Theta_1 = \Theta_2 = \Theta_3 = \Theta$, yields the resticted case.

$$\text{Ln } L_r = -T/2.\text{Ln}(2\pi) - T/2.\text{Ln}(\Theta) - T/2 \qquad \text{(B)}$$

Thus $-2\text{Ln}\lambda$ is given by (28) in the text.

II. Error Variance in the Dummy Variable Model

$\Theta_1 = \lambda_1^2.\Theta$ $\qquad \Theta_2 = \lambda_2^2.\Theta$ $\qquad$ and $\Theta_3 = \lambda_3^2.\Theta$

Without loss of generality, let $\lambda_3 = 1$.

The error terms in (24), (25), and (26) are ε_1, ε_2, and ε_3 respectively. With the transformation, we have

$\tilde{\varepsilon}_1 = \varepsilon_1/\lambda_1$ $\tilde{\varepsilon}_2 = \varepsilon_2/\lambda_2$ and $\tilde{\varepsilon}_3 = \varepsilon_3/\lambda_3$

Hence, the variances become:

$$V(\tilde{\varepsilon}_1) = 1/\lambda_1^2 . V(\varepsilon_1) = (\Theta/\Theta_1) . \Theta_1 = \Theta = V(\tilde{\varepsilon}_2) = V(\tilde{\varepsilon}_3)$$

APPENDIX B

Rankings of Countries According to Political Rights and Human Freedom

Rank	Country	Gastil Index	Human Freedom Index
1	Costa Rica	1	31
2	Venezuela	1	29
3	Barbados	1	
4	India	2+	14
5	Mauritius	2+	26
6	Hong Kong		26
7	Trinidad and Tabago	2	25
8	Colombia	2	14
9	Sri Lanka	2	11
10	Gambia	2	
	Botswana	2	
	Surinam	2	
	Israel	2	
14	Jamaica	2-	25
15	Moroco	3+	7
16	Guatemala	3+	
17	Malaysia	3	9
18	Guyana	3	

19	Dominican Republic	4	21	
20	Brazil	4	18	**cont**
Rank	Country	Gastil Index	Human Freedom Index	
21	Mexico	4	15	
22	El Salvador	4		
23	Senegal	5+	23	
24	Sierra Leone	5+	14	
25	Nigeria	5+	13	
26	Syria	5+	5	
27	Madagascar	5+		
28	South Korea	5	14	
29	Egypt	5	11	
	Singapore	5	11	
31	Paraguay	5	10	
	Phillipines	5	10	
	Zambia	5	9	
34	Kenya	5	8	
35	Taiwan	5		
	Nicaragua	5		
	Lesotho	5		
38	South Africa	5-	3	
39	Panama	6+	21	
40	Ghana	6+	11	
41	Bangladesh	6+	7	
42	Zaire	6+	5	

43	Argentina	6	25	
44	Ecuador	6	24	
45	Bolivia	6	18	
46	Peru	6	16	**cont**

Rank	Country	Gastil Index	Human Freedom Index
47	Thailand	6	14
	Iran	6	14
49	Tunisia	6	11
50	Tanzania	6	10
51	Algeria	6	8
	Cameroon	6	8
	Zimbabwe	6	8
54	Liberia	6	7
55	Gabon	6	
	Mauritania	6	
	Sudan	6	
	Swaziland	6	
	Honduras	6	
	Afganistan	6	
	Jordan	6	
	Uruguay	6	
	Ivory Coast		
	Nepal	6	
65	Pakistan	6-	5
66	Benin	7	13

67	Haiti	7	9
68	Chile	7	8
69	Mozambique	7	6
70	Ethiopia	7	2
	Burundi	7	
	Central African Republic	7	**cont**
Rank	Country	Gastil Index	Human Freedom Index
	Chad	7	
	Guinea	7	
	Malawi	7	
	Niger	7	
	Rwanda	7	
	Somalia	7	
	Togo	7	
	Uganda	7	
	Mali	7	
	Iraq	7	0
85	Angolia	7-	
	Burma (Mynmar)	7-	
	Congo	7-	

The Gastil index runs from 1 - 7 where 1 means the greatest degree of political freedom and 7, the lowest degree of political freedom. The + and - signs indicate improving and deteriorating conditions of political freedom.

The Human Freedom Index (HFI), on the other hand, is a composite score based on the Human Rights Guide by Humana (1985). Based on 40 different criteria, countries are given a score of 1 for each political freedom retained and 0 for each right violated. Hence, the maximum possible score is 40 and the lowest , 0.
The rankings of the countries was achieved by assigning primary importance to the Gastil Index. The reason why this is so is because we are attempting to explain growth in 1985 in terms of 1960 hence the political situation of countries during 1978 would be preferred to the situation during 1985. Countries with 1 for this index would be ranked higher than countries with 2. Likewise, countries having a 3+ would have a higher rank than those with just 3. It is only when two countries have the same Gastil index that the HFI is used. Therefore, if two countries are given 3 for the Gastil index, the country with the higher HFI score will be given a better rank. If HFI scores are unavailable to differentiate between countries given the same Gastil index, they are given the same rank.

A word of caution should be mentioned. The only country which is not ranked by Gastil is Hong Kong. But since Hong Kong has a HFI score of 26, it seems appropriate to place it amongst other countries earning similar scores. Again, this rank is somewhat arbitrary.

The rankings could be improved further in a number of ways, for example, a weighted index of the Gastil index and the HFI. It is hoped that these rankings will be refined in any further work.