TABLE II

ESTIMATION OF THE AUGMENTED SOLOW MODEL

Dependent variable: log GDP per working-age person in 1985			
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	6.89	7.81	8.63
	(1.17)	(1.19)	(2.19)
ln(I/GDP)	0.69	0.70	0.28
	(0.13)	(0.15)	(0.39)
$\ln(n + g + \delta)$	−1.73	−1.50	−1.07
	(0.41)	(0.40)	(0.75)
ln(SCHOOL)	0.66	0.73	0.76
	(0.07)	(0.10)	(0.29)
$\overline{R}^2$	0.78	0.77	0.24
s.e.e.	0.51	0.45	0.33
Restricted regression:			
CONSTANT	7.86	7.97	8.71
	(0.14)	(0.15)	(0.47)
$\ln(I/GDP) - \ln(n + g + \delta)$	0.73	0.71	0.29
	(0.12)	(0.14)	(0.33)
$\ln(SCHOOL) - \ln(n + g + \delta)$	0.67	0.74	0.76
	(0.07)	(0.09)	(0.28)
$\overline{R}^2$	0.78	0.77	0.28
s.e.e.	0.51	0.45	0.32
Test of restriction:			
p-value	0.41	0.89	0.97
Implied α	0.31	0.29	0.14
	(0.04)	(0.05)	(0.15)
Implied β	0.28	0.30	0.37
	(0.03)	(0.04)	(0.12)

Note. Standard errors are in parentheses. The investment and population growth rates are averages for the period 1960–1985. $(g + \delta)$ is assumed to be 0.05. SCHOOL is the average percentage of the working-age population in secondary school for the period 1960–1985.

TABLE III

TESTS FOR UNCONDITIONAL CONVERGENCE

Dependent variable: log difference GDP per working-age person 1960–1985			
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	−0.266	0.587	3.69
	(0.380)	(0.433)	(0.68)
ln(Y60)	0.0943	−0.00423	−0.341
	(0.0496)	(0.05484)	(0.079)
$\overline{R}^2$	0.03	−0.01	0.46
s.e.e.	0.44	0.41	0.18
Implied λ	−0.00360	0.00017	0.0167
	(0.00219)	(0.00218)	(0.0023)

Note. Standard errors are in parentheses. Y60 is GDP per working-age person in 1960.

Mankiw, Romer and Weil (1992, QJE)

TABLE IV
TESTS FOR CONDITIONAL CONVERGENCE

Dependent variable: log difference GDP per working-age person 1960–1985			
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	1.93	2.23	2.19
	(0.83)	(0.86)	(1.17)
ln(Y60)	−0.141	−0.228	−0.351
	(0.052)	(0.057)	(0.066)
ln(I/GDP)	0.647	0.644	0.392
	(0.087)	(0.104)	(0.176)
$\ln(n + g + \delta)$	−0.299	−0.464	−0.753
	(0.304)	(0.307)	(0.341)
$\bar{R}^2$	0.38	0.35	0.62
s.e.e.	0.35	0.33	0.15
Implied λ	0.00606	0.0104	0.0173
	(0.00182)	(0.0019)	(0.0019)

Note. Standard errors are in parentheses. Y60 is GDP per working-age person in 1960. The investment and population growth rates are averages for the period 1960–1985. $(g + \delta)$ is assumed to be 0.05.

TABLE V
TESTS FOR CONDITIONAL CONVERGENCE

Dependent variable: log difference GDP per working-age person 1960–1985			
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	3.04	3.69	2.81
	(0.83)	(0.91)	(1.19)
ln(Y60)	−0.289	−0.366	−0.398
	(0.062)	(0.067)	(0.070)
ln(I/GDP)	0.524	0.538	0.335
	(0.087)	(0.102)	(0.174)
$\ln(n + g + \delta)$	−0.505	−0.551	−0.844
	(0.288)	(0.288)	(0.334)
ln(SCHOOL)	0.233	0.271	0.223
	(0.060)	(0.081)	(0.144)
$\bar{R}^2$	0.46	0.43	0.65
s.e.e.	0.33	0.30	0.15
Implied λ	0.0137	0.0182	0.0203
	(0.0019)	(0.0020)	(0.0020)

Note. Standard errors are in parentheses. Y60 is GDP per working-age person in 1960. The investment and population growth rates are averages for the period 1960–1985. $(g + \delta)$ is assumed to be 0.05. SCHOOL is the average percentage of the working-age population in secondary school for the period 1960–1985.

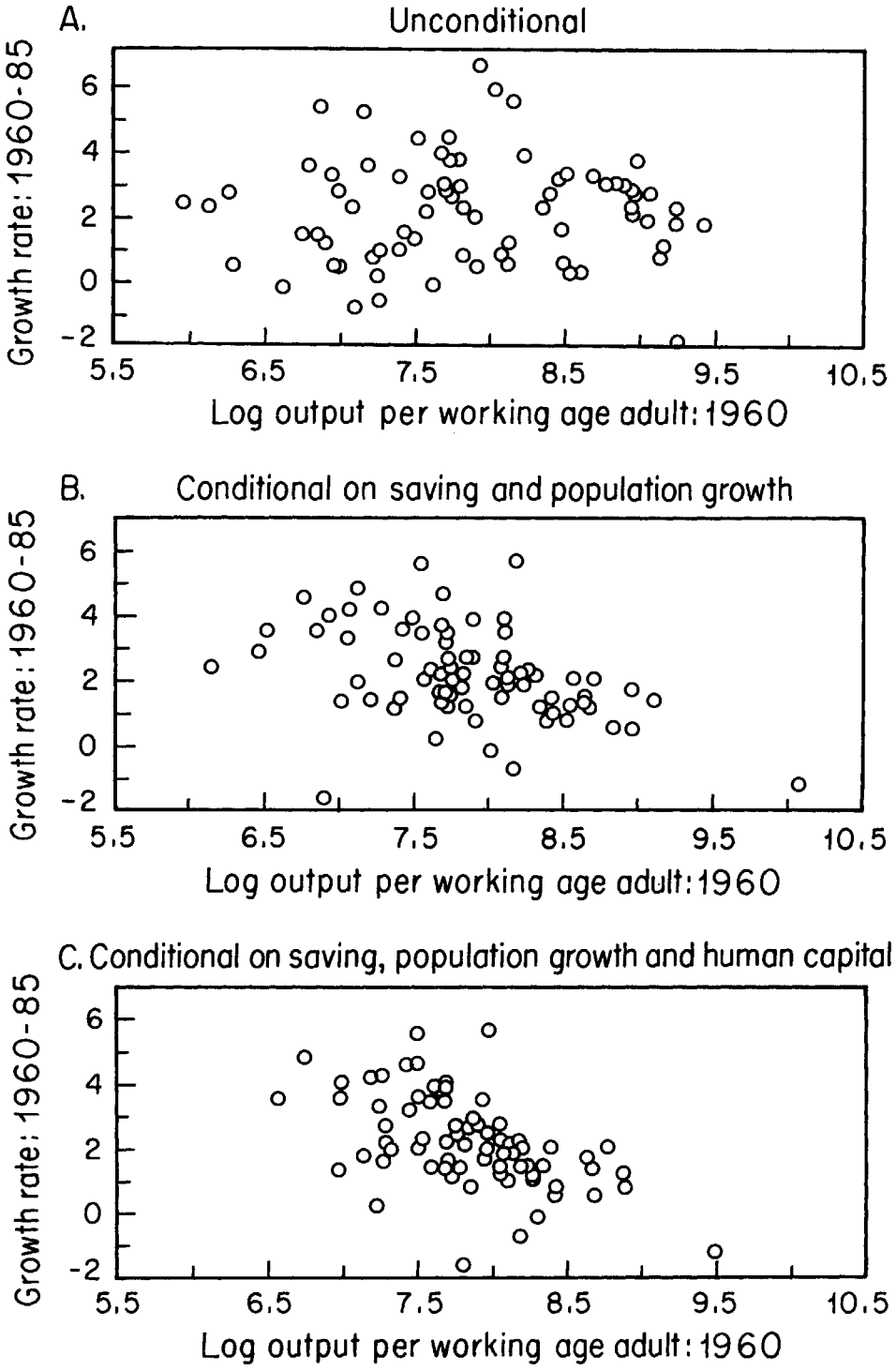


FIGURE I
Unconditional versus Conditional Convergence

TABLE IV
INTERACTIONS BETWEEN GROWTH AND INVESTMENT

	(24)	(25)	(26)	(27)	(28)	(29)
No. obs.	98	98	76	76	76	98
Const.	0.0229	0.0494	0.0391	0.0315	0.0401	0.0447
	(0.0073)	(0.0119)	(0.0079)	(0.0081)	(0.0094)	(0.0119)
GDP60	−0.0072	−0.0077	−0.0075	−0.0068	−0.0076	−0.0070
	(0.0009)	(0.0009)	(0.0010)	(0.0010)	(0.0010)	(0.0009)
SEC60	0.0225	0.0100	0.0312	0.0240	0.0330	0.0004
	(0.0090)	(0.0087)	(0.0074)	(0.0086)	(0.0073)	(0.0084)
PRIM60	0.0181	0.0118	0.0138	0.0074	0.0151	0.0150
	(0.0060)	(0.0057)	(0.0068)	(0.0082)	(0.0077)	(0.0063)
g^c/y	−0.119	−0.114	−0.132	−0.115	−0.131	−0.094
	(0.027)	(0.026)	(0.028)	(0.028)	(0.028)	(0.024)
REV	−0.0159	−0.0167	−0.0158	−0.0128	−0.0169	−0.0146
	(0.0062)	(0.0065)	(0.0067)	(0.0066)	(0.0066)	(0.0059)
ASSASS	−0.0315	−0.0254	−0.0345	−0.0298	−0.0341	−0.0179
	(0.0182)	(0.0172)	(0.0169)	(0.0152)	(0.0152)	(0.0149)
PPI60DEV	−0.0119	−0.0103	−0.0202	−0.0174	−0.0215	−0.0106
	(0.0058)	(0.0059)	(0.0052)	(0.0055)	(0.0047)	(0.0052)
i/y	0.068	0.064	—	—	—	0.061
	(0.032)	(0.032)				(0.031)
i/y	—	—	—	0.073	—	—
(70–85)				(0.039)		
FERTNET	—	−0.0043	—	—	—	−0.0028
		(0.0014)				(0.0013)
g^t/y	—	—	0.128	−0.015	—	—
			(0.103)	(0.119)		
g^t/i	—	—	—	—	0.014	—
					(0.022)	
AFRICA	—	—	—	—	—	−0.0104
						(0.0035)
LAT. AMER.	—	—	—	—	—	−0.0104
						(0.0028)
R^2	0.59	0.62	0.62	0.65	0.60	0.66
$\hat{\sigma}$	0.0123	0.0120	0.0115	0.0111	0.0117	0.0114

Notes. The dependent variable is the growth rate of real per capita GDP from 1960 to 1985. See Appendix 2 for definitions of variables. See the notes to Table I for additional information.

APPENDIX 2: DEFINITIONS OF VARIABLES IN TABLES I–IV AND APPENDIX 1 (see Barro and Wolf [1989] for details)

GR6085 (GR7085): Growth rate of real per capita GDP from 1960 to 1985 (1970 to 1985).

GDP60 (GDP70, GDP85): 1960 (1970, 1985) value of real per capita GDP (1980 base year).

GDP60SQ: Square of GDP60.

i/y (i/y, 70–85): Average from 1960 to 1985 (1970 to 1985) of the ratio of real domestic investment (private plus public) to real GDP.

i^{priv}/y: Average from 1970 to 1985 of the ratio of real private domestic investment to real GDP.

g^{i}/y: Average from 1970 to 1985 of the ratio of real public domestic investment to real GDP.

g^{i}/i: Average from 1970 to 1985 of the ratio of real public domestic investment to real domestic investment (private plus public).

g^{c}/y: Average from 1970 to 1985 of the ratio of real government consumption (exclusive of defense and education) to real GDP.

FERT: Total fertility rate (children per woman), average of 1965 and 1985.

MORT04: Mortality rate for age 0 through 4, average of 1965 and 1985.

FERTNET: FERT × (1 − MORT04).

GPOP6085: Growth rate of population from 1960 to 1985.

POP: Population in millions (geometric average of values from 1960 and 1985).

SEC50 (SEC60, SEC85): 1950 (1960, 1985) secondary-school enrollment rate.

PRIM50 (PRIM60, PRIM85): 1950 (1960, 1985) primary-school enrollment rate.

STTEAPRI (STTEASEC): Student-teacher ratio in primary (secondary) schools in 1960.

LIT60: Adult literacy rate in 1960.

REV: Number of revolutions and coups per year (1960–1985 or subsample).

ASSASS: Number of assassinations per million population per year (1960–1985 or subsample).

SOC: Dummy variable for socialist economic system.

MIXED: Dummy variable for mixed free enterprise/socialistic economic system.

PPPI60: 1960 PPP value for the investment deflator (U. S. = 1.0).

PPI60DEV: Magnitude of the deviation of PPPI60 from the sample mean.

PPPY60: 1960 PPP value for the GDP deflator (U. S. = 1.0).

AFRICA: Dummy variable for sub-Saharan Africa.

LAT. AMER.: Dummy variable for Latin America.

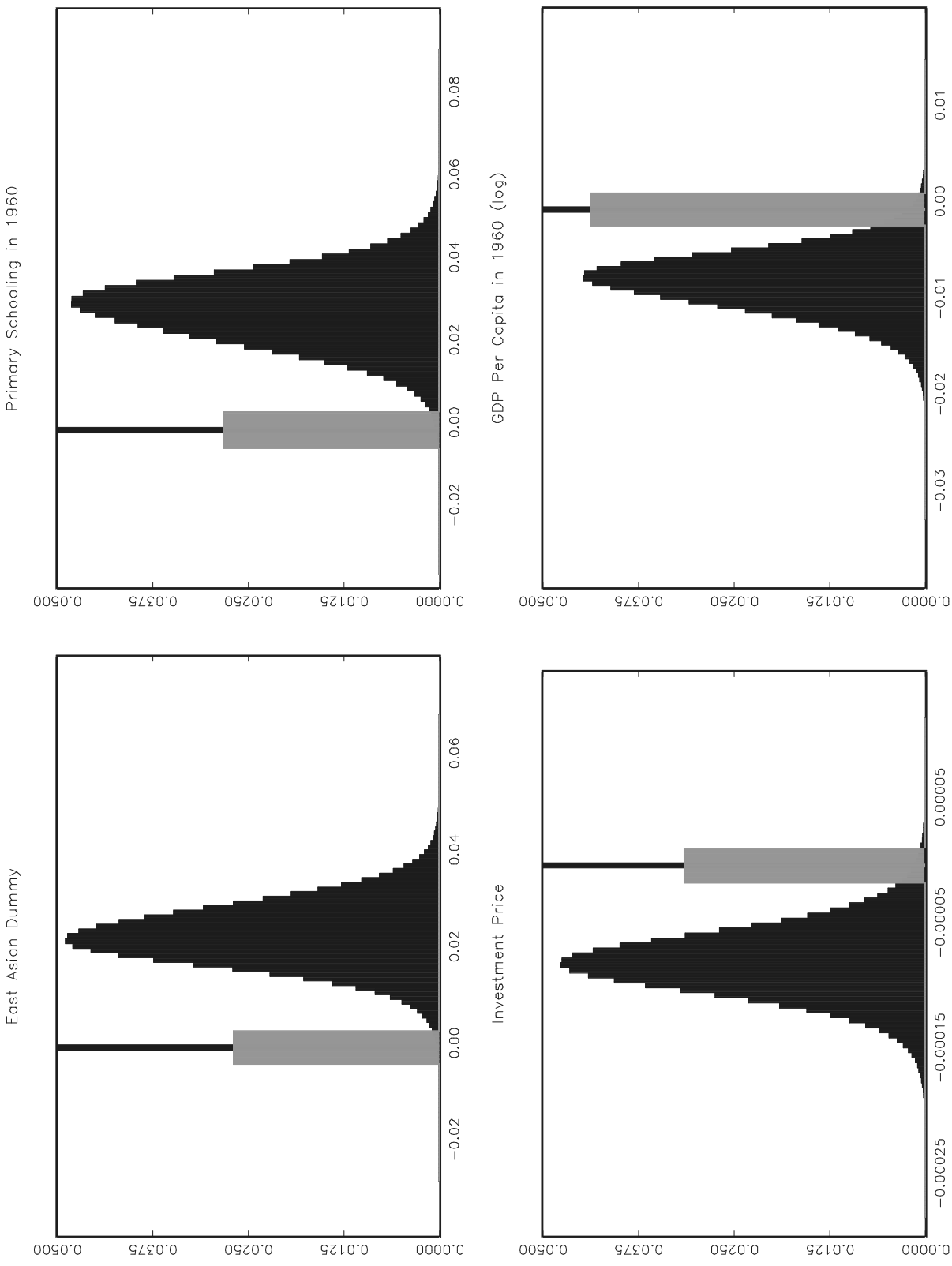
TABLE 1—MAIN RESULTS OF REGRESSIONS
(DEPENDENT VARIABLE = GROWTH)

Independent variable	(i) β	(ii) SD	(iii) CDF[a]
Equipment investment	0.2175	0.0408	1.000
Number of years open economy	0.0195	0.0042	1.000
Fraction Confucian	0.0676	0.0149	1.000
Rule of law	0.0190	0.0049	1.000
Fraction Muslim	0.0142	0.0035	1.000
Political rights	−0.0026	0.0009	0.998
Latin America dummy	−0.0115	0.0029	0.998
Sub-Saharan Africa dummy	−0.0121	0.0032	0.997
Civil liberties	−0.0029	0.0010	0.997
Revolutions and coups	−0.0118	0.0045	0.995
Fraction of GDP in mining	0.0353	0.0138	0.994
SD black-market premium	−0.0290	0.0118	0.993
Primary exports in 1970	−0.0140	0.0053	0.990
Degree of capitalism	0.0018	0.0008	0.987
War dummy	−0.0056	0.0023	0.984
Non-equipment investment	0.0562	0.0242	0.982
Absolute latitude	0.0002	0.0001	0.980
Exchange-rate distortions	−0.0590	0.0302	0.968
Fraction Protestant	−0.0129	0.0053	0.966
Fraction Buddhist	0.0148	0.0076	0.964
Fraction Catholic	−0.0089	0.0034	0.963
Spanish colony	−0.0065	0.0032	0.938

[a] Nonnormal.

Sala-i-Martin, X. (AER, 1997)

Sala-i-Martin, X. et. al. (2004) AER



we examine sample splits based upon the adult literacy rate of each country in 1960. The use of literacy as a segregating variable makes sense if one thinks of the potential regimes in the data as stemming from differences in the level of social and economic development rather than the current level of economic activity.[7] Alternatively, these variables may be interpreted as proxies for identifying threshold effects associated with the unobserved physical and human capital stocks.

Table I reports the results for several different data splits. Each entry represents the significance level of a Wald test of the null hypothesis that all parameters are equal across the subsamples under analysis.[8] The first panel of the table divides countries into two equal groups by segregating high and low initial output and initial literacy countries into separate categories. Each subgroup thus consists of 48 countries. The second panel divides countries into three equal groups of 32 using each of these variables. The third panel allows interactions between the variables. In this case, we divide the countries according to whether they lie in the high or low half of the sample according to the two controls. This segregation results in four categories: high-output/high-literacy (42 countries), high-output/low-literacy (6 countries), low-output/high-literacy (6 countries) and low-output/low-literacy (42 countries).[9]

As Table I indicates, there is substantial evidence that the laws of motion for growth within each subgroup are different. For three of the four initial output splits, equality of coefficients across the groups is rejected at the 3% level. When initial literacy represents the control variable, we reject in two of the four cases at about 1%.[10] Further, we strongly reject coefficient equality across splits for both the unconstrained and constrained regressions in the interactive four-regime specification. This change in the significance level indicates the importance of both variables in identifying data regimes.

Table II reports the original M–R–W regression along with estimates of the regressions

Table I. Specification tests for different regimes

Subsamples defined by	Unconstrained regressions	Constrained regressions
Two-way split based on		
$(Y/L)_{i,1960}$	0·009	0·218
$LR_{i,1960}$	0·011	0·112
Three-way split based on		
$(Y/L)_{i,1960}$	0·029	0·011
$LR_{i,1960}$	0·404	0·000
Four-way split based on both		
$LR_{i,1960}$ and $(Y/L)_{i,1960}$	0·000	0·000

This table shows the marginal significance levels for the Wald tests of the null hypothesis that the parameters of the indicated models are constant across the indicated subsamples. Splits are described in the text.

[7] This distinction is also relevant for coordination-based models with multiple regimes.

[8] Following Barro (1991) and others, we employ heteroscedasticity-corrected test statistics and standard error estimates based on White (1980), in order to permit error variances to differ across countries. White's heteroscedasticity test reveals some evidence against a homoscedastic null. Assuming homoscedasticity in the calculation of the Wald statistics increases the number of rejections of the single regime model.

[9] The two-way output splits are based on $(Y/L)_{i,1960} < \$1950$ and $\$1950 \leq (Y/L)_{i,1960}$; the three-way splits are based on $(Y/L)_{i,1960} < \$1150$, $\$1150 \leq (Y/L)_{i,1960} \leq \$2750$ and $\$2750 < (Y/L)_{i,1960}$. For initial literacy, the two-way splits are based on $LR_{i,1960} < 54\%$ and $54\% \leq LR_{i,1960}$; the three-way splits are based on $LR_{i,1960} < 26\%$, $26\% \leq LR_{i,1960} \leq 72\%$ and $72\% < LR_{i,1960}$. The data appendix records the three-way splits for various countries by identifying each as falling into a high (H), intermediate (I) or low (L) output or literacy class.

[10] See Rauch (1989) for corroborating evidence of literacy-based regime differences.

Table IV. Regression tree sample breaks: country classification

Terminal node number			
1	2	3	4
Burkina Faso	Algeria	Madagascar	Austria
Burundi	Angola	South Africa	Belgium
Ethiopia	Benin	Hong Kong	Denmark
Malawi	Cameroon	Israel	Finland
Mali	Central African Rep.	Japan	France
Mauritania	Chad	Korea	Federal Republic of Germany
Niger	Congo, People's Rep.	Malaysia	Italy
Rwanda	Egypt	Philippines	The Netherlands
Sierra Leone	Ghana	Singapore	Norway
Tanzania	Ivory Coast	Sri Lanka	Sweden
Togo	Kenya	Thailand	Switzerland
Uganda	Liberia	Greece	United Kingdom
Zaire	Morocco	Ireland	Canada
Burma	Mozambique	Portugal	Trinidad and Tobago
	Nigeria	Spain	United States of America
	Senegal	Costa Rica	Argentina
	Somalia	Dominican Republic	Chile
	Sudan	El Salvador	Uruguay
	Tunisia	Jamaica	Venezuela
	Zambia	Mexico	Australia
	Zimbabwe	Nicaragua	New Zealand
	Bangladesh	Panama	
	India	Brazil	
	Jordan	Columbia	
	Nepal	Ecuador	
	Pakistan	Paraguay	
	Syria	Peru	
	Turkey		
	Guatemala		
	Haiti		
	Honduras		
	Bolivia		
	Indonesia		
	Papua New Guinea		