GROWTH EMPIRICISM

EE 462 Development Macroeconomics

Semester 1/2014

Topics

- Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, *107*(2), 407-437.
- Easterly, W., & Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. *The World Bank Economic Review*, *15*(2), 177-219.

MRW (1992)

- MRW examines whether the "textbook" Solow model is consistent with the empirical evidence.
- It augments the Solow model by including *human capital accumulation* and capital accumulation, and tests this augmented Solow model.
- It also tests for both unconditional and conditional convergence in per capita income.
- Findings:
  - The prediction of the Solow model are consistent with the data.
  - The cross-country variation in per capita income can best be explained by an augmented Solow model.
  - There is convergence once the differences in saving and population growth rates are controlled for.

Augmented Solow Model

- Standard Solow model: k^*=[s/(n+g+δ)]$^{1/(1-\alpha)}$

➔ $$\ln\left(\frac{Y}{L}\right) = lnA(0) + gt + \frac{\alpha}{1-\alpha}\ln(s) - \frac{\alpha}{1-\alpha}\ln(n+g+\delta)$$

- Augmented Solow model:

$$k^* = \left[\frac{s_k^{1-\beta} s_h^{\beta}}{n+g+\delta}\right]^{1/(1-\alpha-\beta)}$$

$$h^* = \left[\frac{s_k^{\alpha} s_h^{1-\alpha}}{n+g+\delta}\right]^{1/(1-\alpha-\beta)}$$

➔ $$\ln\left(\frac{Y}{L}\right) = lnA(0) + gt + \frac{\alpha}{1-\alpha}\ln(s_k) - \frac{\alpha}{1-\alpha}\ln(n+g+\delta) + \frac{\beta}{1-\alpha}\ln(h^*)$$

where

h* = secondary school enrollment ratio x proportion of labor force of secondary school age

TABLE I
ESTIMATION OF THE TEXTBOOK SOLOW MODEL

Dependent variable: log GDP per working-age person in 1985			
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	5.48	5.36	7.97
	(1.59)	(1.55)	(2.48)
ln(I/GDP)	1.42	1.31	0.50
	(0.14)	(0.17)	(0.43)
$\ln(n + g + \delta)$	−1.97	−2.01	−0.76
	(0.56)	(0.53)	(0.84)
$\overline{R}^2$	0.59	0.59	0.01
s.e.e.	0.69	0.61	0.38
Restricted regression:			
CONSTANT	6.87	7.10	8.62
	(0.12)	(0.15)	(0.53)
$\ln(I/GDP) - \ln(n + g + \delta)$	1.48	1.43	0.56
	(0.12)	(0.14)	(0.36)
$\overline{R}^2$	0.59	0.59	0.06
s.e.e.	0.69	0.61	0.37
Test of restriction:			
p-value	0.38	0.26	0.79
Implied α	0.60	0.59	0.36
	(0.02)	(0.02)	(0.15)

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.

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

TABLE II (Cont'd)

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
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.

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)
$\overline{R}^2$	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.

Easterly and Levine (2001)

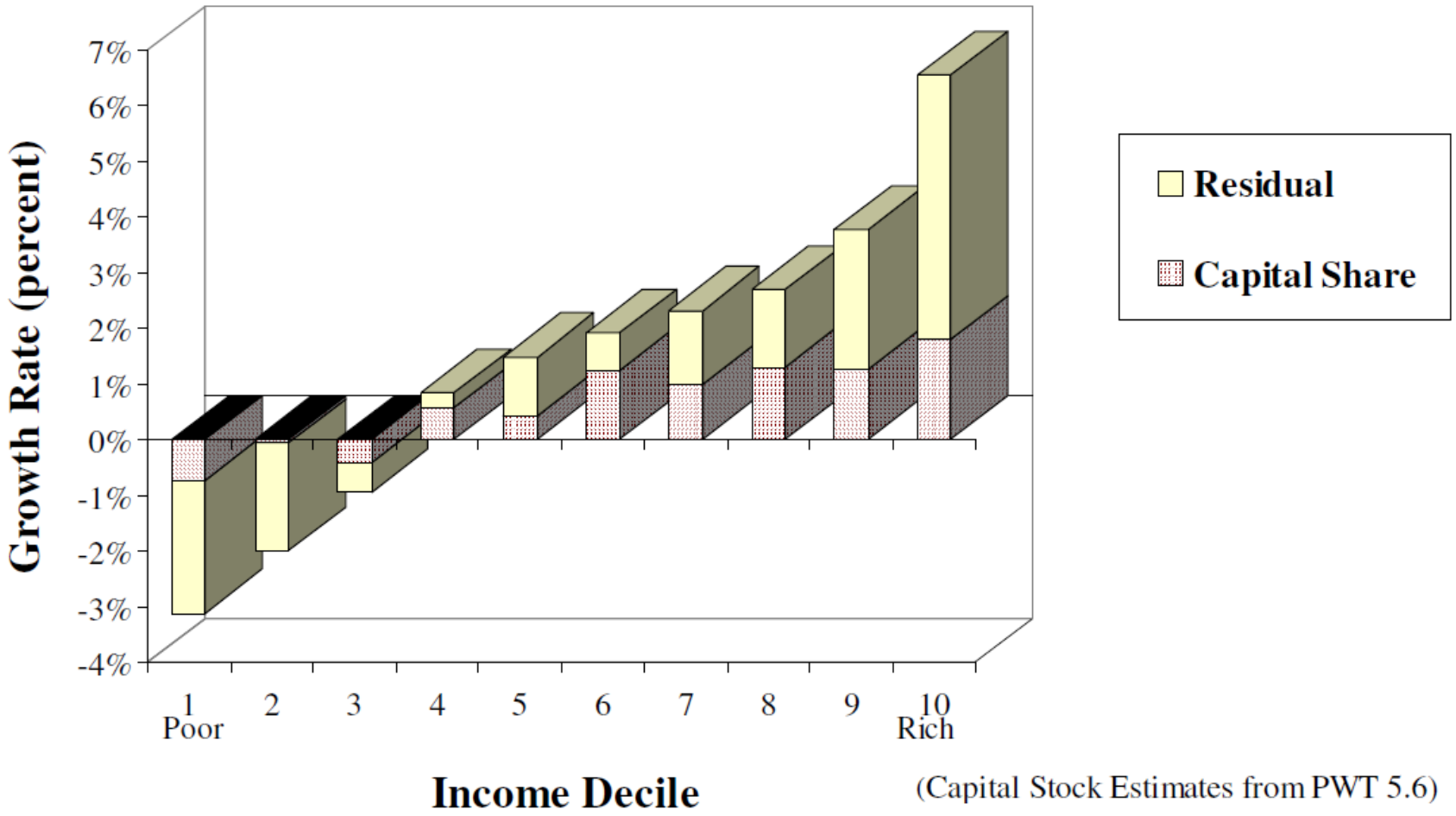
- This paper examines five stylized facts of economic growth.
  1. Factor accumulation does not account for most of the income and growth differences across countries; it is "something" else.
  2. Divergence – not conditional convergence – is the big story.
  3. Growth is not persistent over time, but capital accumulation is.
  4. All factors of production flow to the same places, suggesting important externalities.
  5. National policies influence long-run economic growth.

Fact #1: It's Not Factor Accumulation, It's TFP.

- Look at evidence on how growth rates in factor accumulation and TFP explain variations in economic growth rates in 3 dimension:
  1. Variation in growth rate over time within a given country
  2. Cross-country differences in economic growth rates
  3. Variations in growth differences over time
- Findings: TFP residuals accounts for most of the cross-country and cross-time variation in growth.
  - There must be "something else" besides factor accumulation.

Growth Accounting

FIGURE 1. Growth Accounting: Growth Rates by Decile



(Capital Stock Estimates from PWT 5.6)

TABLE 2. Variance Decomposition

	Contribution of		
	TFP growth	Capital growth	Covariance of capital growth and TFP growth
Without human capital[a]			
1960–92	0.58	0.41	0.01
1980–92	0.65	0.21	0.13
With human capital			
1960–92[b]	0.94	0.52	–0.45
1980–87[c]	0.68	0.20	0.12

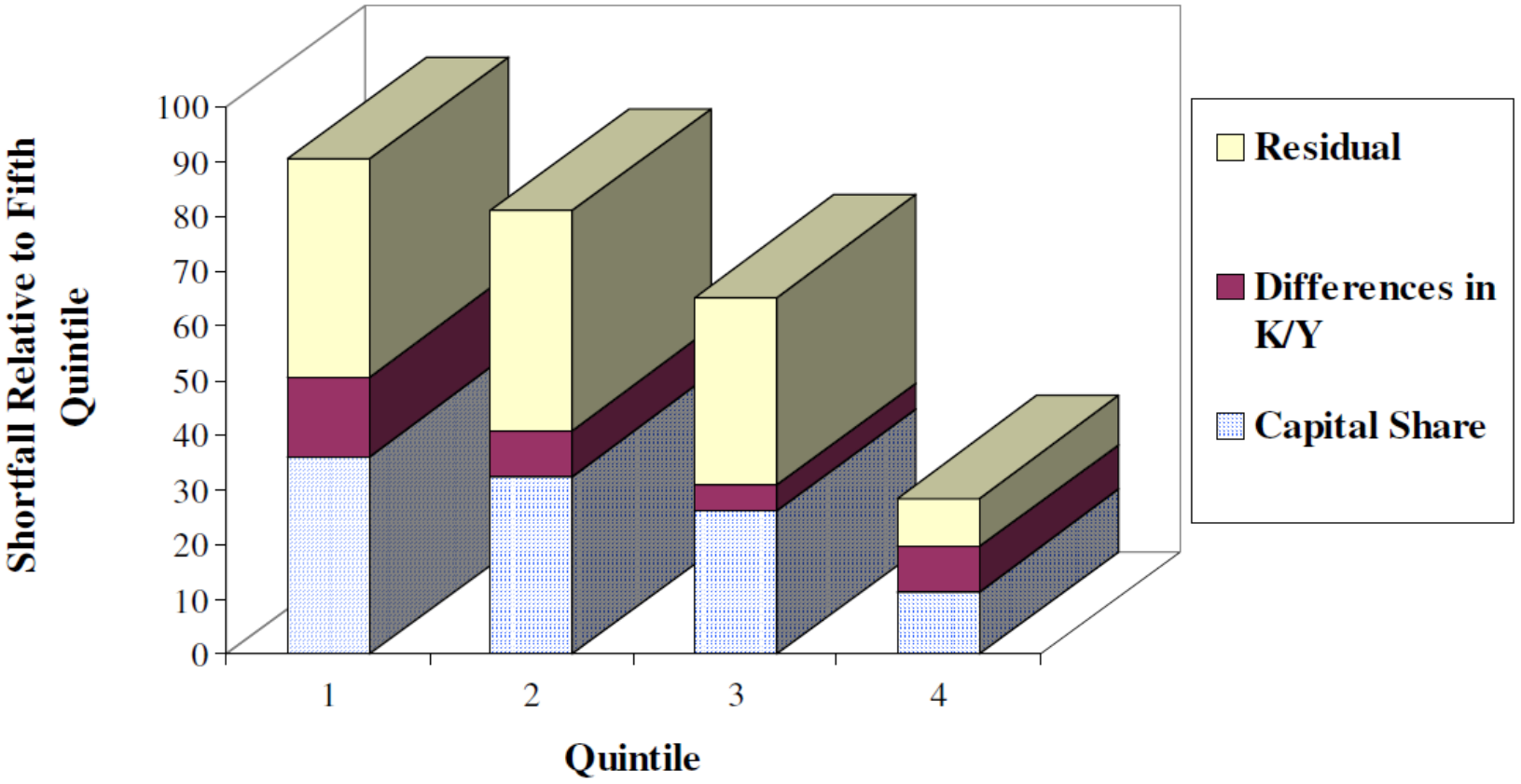
Variance decomposition of growth <u>without</u> human capital accumulation:

$$VAR(\Delta y/y) = VAR(\Delta TFP/TFP) + (0.4)^2\{VAR(\Delta k/k)\} + 2(0.4)\{COV(\Delta TFP/TFP, \Delta k/k)\}.$$

Variance decomposition of growth <u>with</u> human capital accumulation:

$$VAR(\Delta y/y) = VAR(\Delta TFP/TFP) + (0.7)^2\{VAR(\Delta f/f)\} + 2(0.7)\{COV(\Delta TFP/TFP, \Delta f/f)\},$$

FIGURE 2. Development Accounting by Income Quintiles
(57 Non-Oil-Exporting Countries)



Note: Data cover 57 non-oil-exporting countries.
Source: Authors' calculations based on Penn World Table 5.6 for capital stock estimates.

TABLE 4. MRW Least Squares Regression Including Human Capital, with Regional, Oil, and OECD Dummy Variables

Variable	Coefficient	Standard error	*t*-statistic	Probability
OECD	0.999172	0.126361	7.907255	0.0000
East Asia	8.040507	0.212161	37.89818	0.0000
South Asia	7.593671	0.184937	41.06093	0.0000
Sub-Saharan Africa	7.636055	0.207923	36.72545	0.0000
Western Hemisphere	8.285468	0.136361	60.76117	0.0000
Middle East and North Africa	8.345100	0.192838	43.27516	0.0000
Europe	8.222288	0.161656	50.86290	0.0000
OIL	0.618785	0.179383	3.449517	0.0008
MRW	0.168531	0.095305	1.768343	0.0796
MRWH	0.433868	0.089235	4.862086	0.0000
R^2	0.812286	Mean dependent variable		7.779659
Adjusted R^2	0.797722	Standard error of dependent variable		1.024315
Standard error of regression	0.460689	Akaike information criterion		1.363849
Sum of squared residual	24.61913	Schwarz criterion		1.588951
Log likelihood	–75.92250	*F*-statistic		55.77363
		Probability (*F*-statistic)		0.000000

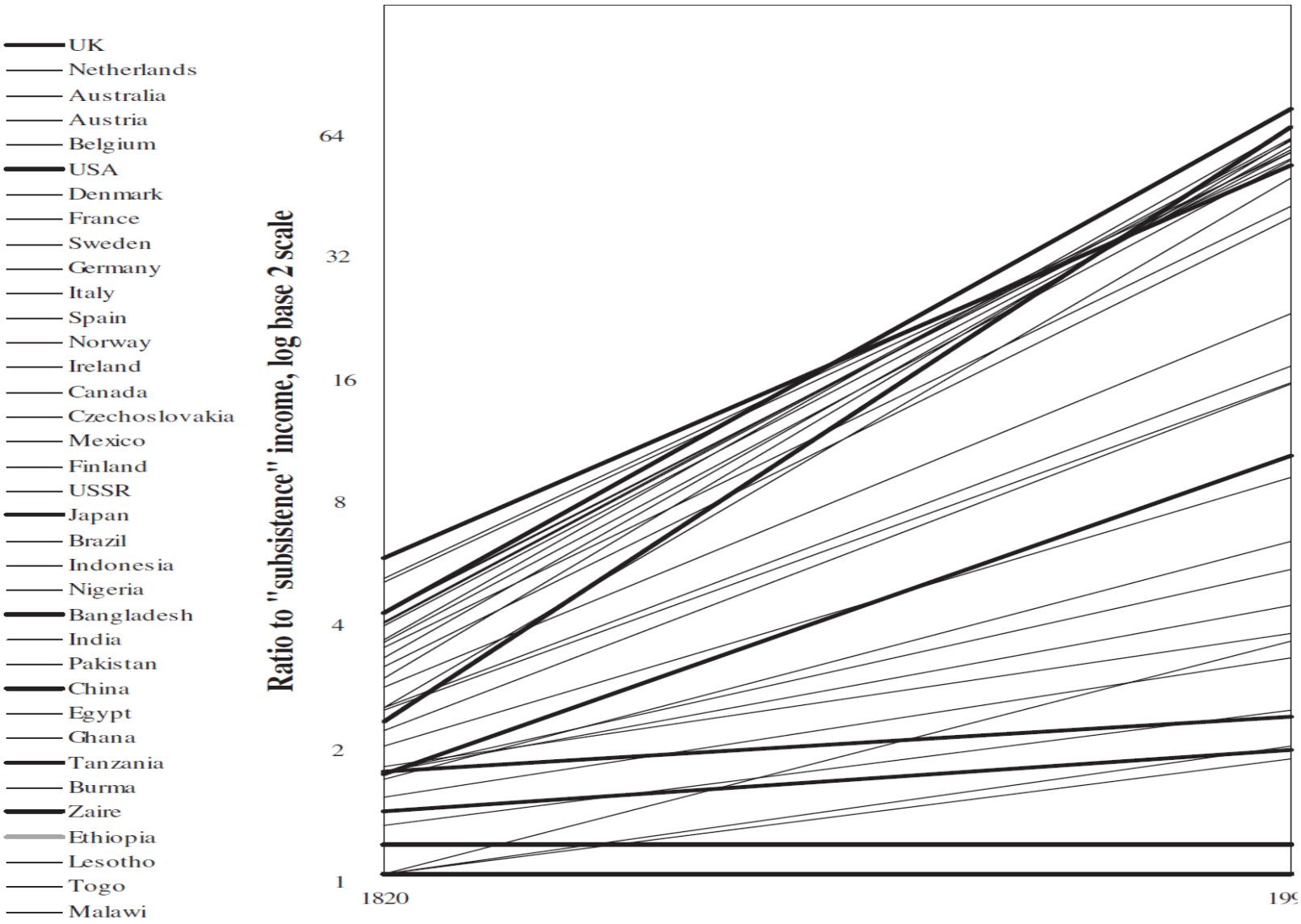
Note: Average log income per capita in 1960–95 is the dependent variable. Number of observations = 126. Standard errors and covariance are White heteroskedasticity-consistent.

Source: Authors' calculations based on World Bank data.

Fact #2: Divergence is the Big Story

- The poor stay the same, but the rich are getting richer a lot faster than the poor.
- Some data problem – lack of data from low- and middle-income countries.
  - Data from rich countries are over represented in the sample.
- Conditional convergence findings hold only after conditioning on "spillover" from the initial level of knowledge.
- Other evidence of divergence:
  - Growth rates of the richest countries have not slowed down (Romer, 1986).
  - Returns to capital in the US have not been falling over the last century (King and Rebelo, 1993).

FIGURE 3. Growth Rates Diverge between Rich and Poor: 1820–1992



Note: Order in 1820 from richest (top) to poorest (bottom).
Source: Maddison 1995.

TABLE 5. Rich Countries Grew Rapidly, Poor Countries Slowly in 1960–92

Income quintile	Average growth of income per person, 1960–92 (%)
Poorest fifth of countries	1.4
Second poorest fifth of countries	1.2
Middle fifth of countries	1.8
Second richest fifth of countries	2.6
Richest fifth of countries	2.2

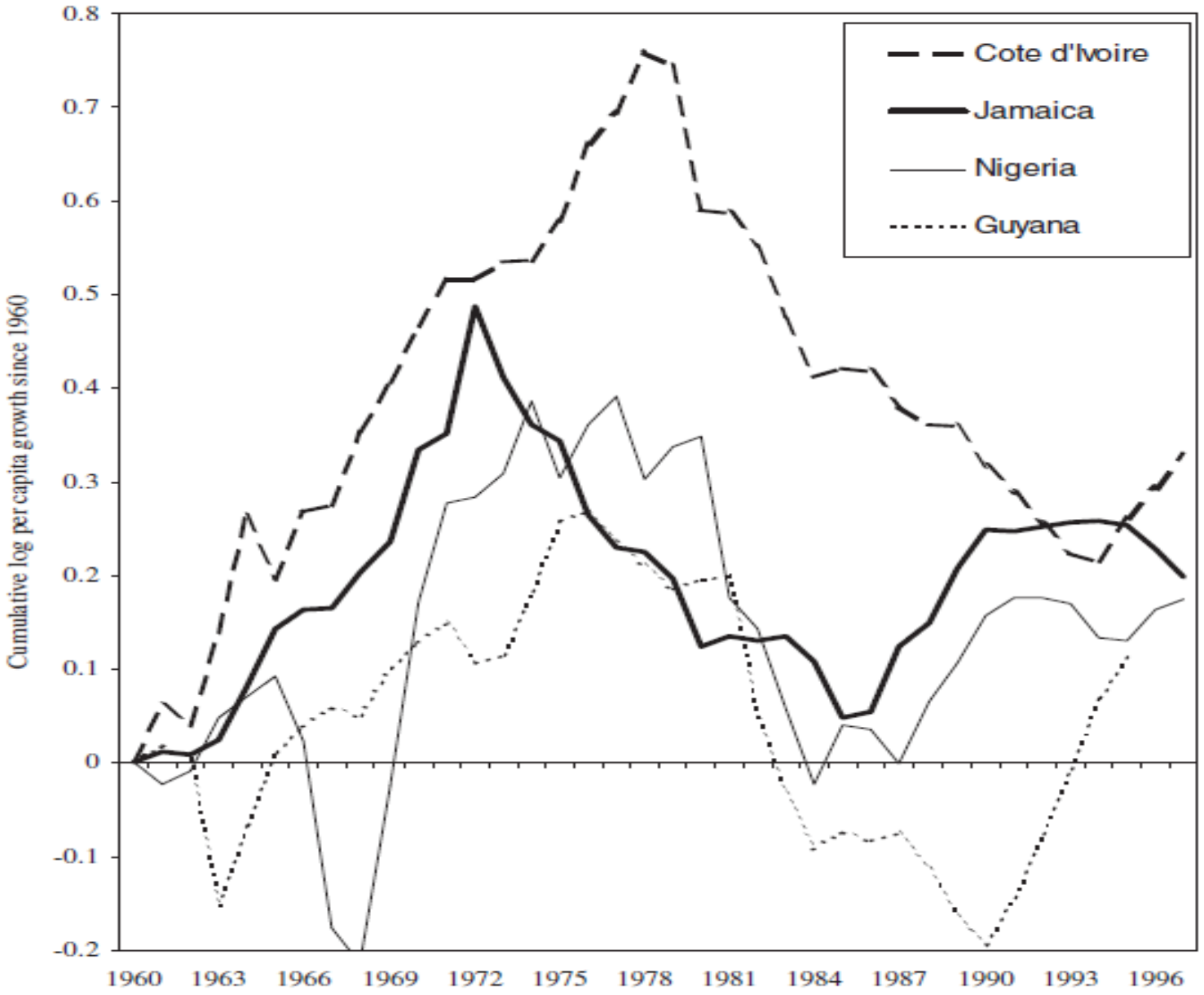
Note: Countries are classified by income per person in 1960.

Source: Authors' calculations based on Summers-Heston 1991 data with subsequent on-line updates.

Fact #3: Growth is Not Persistent, Capital Accumulation is

- Growth is unstable over time, but capital accumulation is
  - Based on the correlation of growth between different time periods.
- The idea of “steady-state” growth rate is questionable.
  - The “take-off into steady-state growth” is unlikely.
  - Stable growth may fit better in the context of industrial countries.
- Based on variance decomposition of growth of the same groups of countries over time, TFP accounts for 86% of the intertemporal variation in overall growth and 61% of the cross-sectional variation.

FIGURE 4. Examples of Variable Per Capita Income over Time: 1960–96

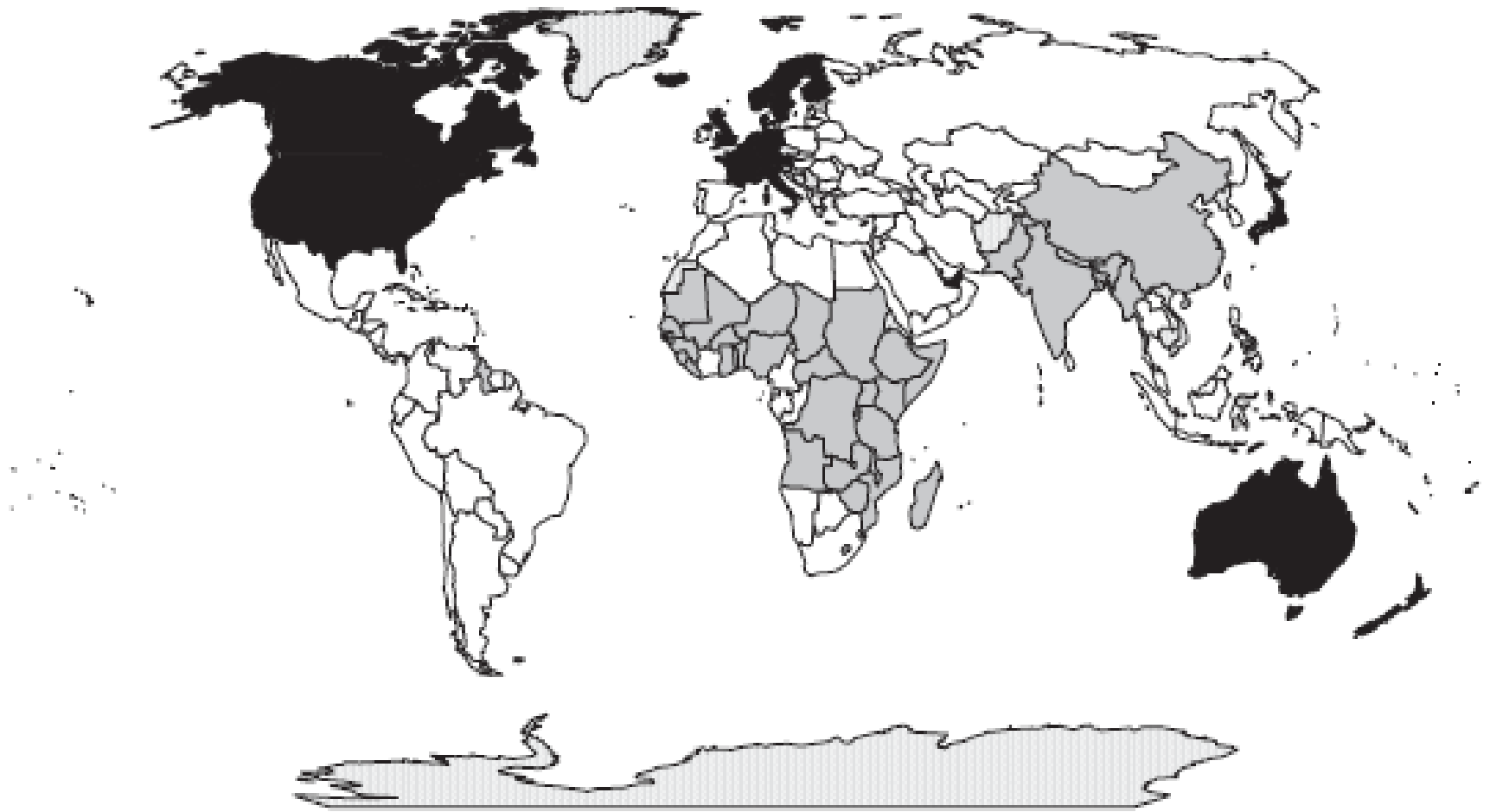


Source: World Bank data.

Fact #4: All Production Factors Flow to the Richest Areas

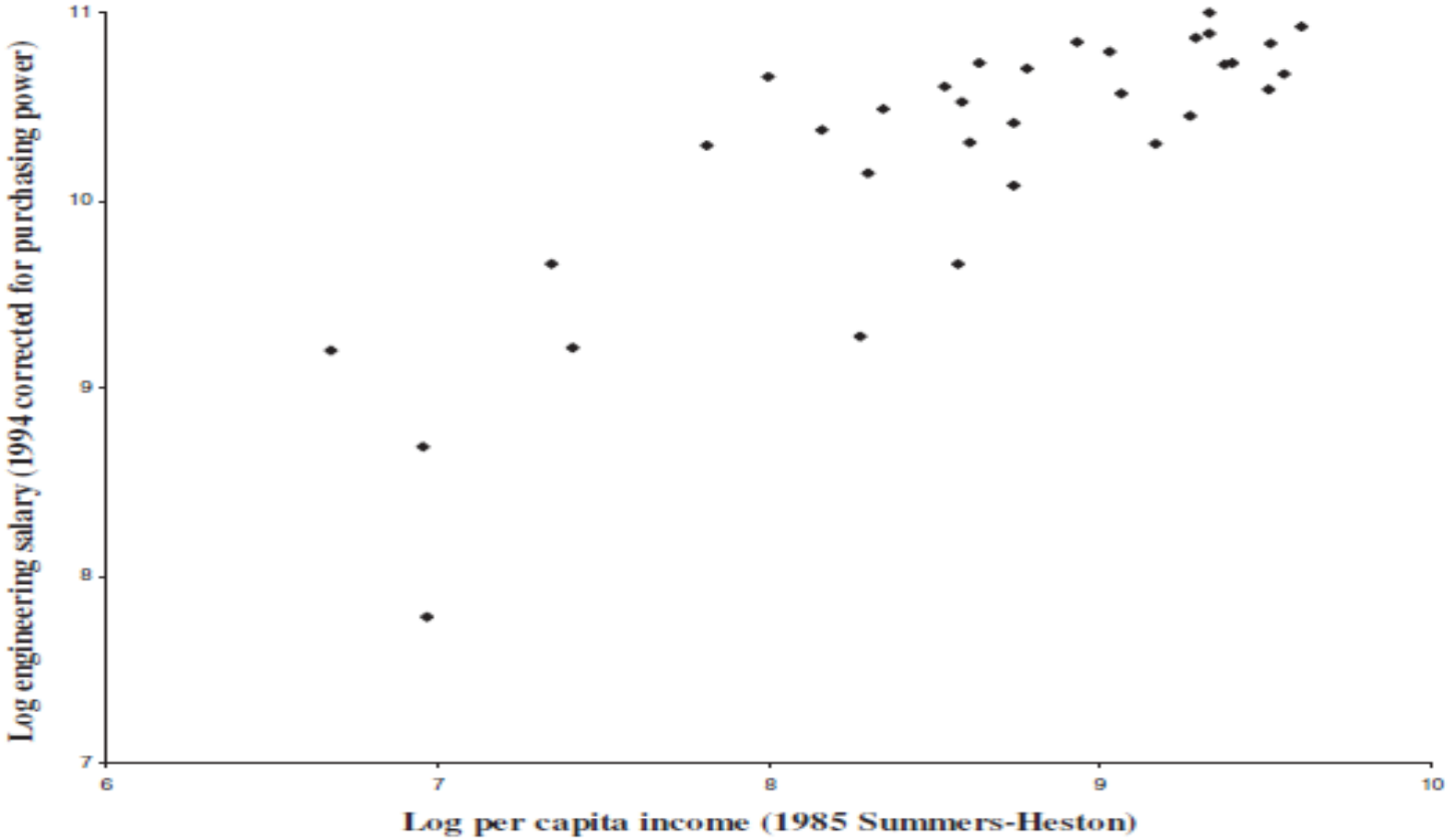
- Observations: Some regions have “something” that attracts all factors of production, whereas others do not.
  - Why? – Difference in national policies? Externalities?
- Some patterns:
  - Concentration in both wealth and poverty
  - Ethnic and related differentials
  - Factor movement toward richest areas
  - Skilled workers earn more in rich countries, but earn less in poor countries.
- Factor flow to rich areas → reinforcing the concentration.
- Need a better understanding of economic geography and externalities to build more realistic economic growth models.

Map 1. The Rich and the Poor



The countries in black contain 15 percent of world population but produce 50 percent of world GDP.
The countries in gray contain 50 percent of world population but produce 14 percent of world GDP.

FIGURE 5. Skilled Real Wage and Per Capita Income across Countries



Source: Authors' calculations based on Summers and Heston for per capita income and Union Bank of Switzerland for engineering salaries.

Fact #5: Policy Matters

- General findings: some indicator of national policy in strongly linked with economic growth.
- This paper examines the links between economic growth and a range of national policies:
  - Inflation rate
  - Gov't expenditure as a share of GDP
  - (X+M)/GDP
  - Black market exchange rate premium
  - Credit to private sector as a share of GDP
- Finding is consistent with policies having significant effects on national growth rates.

TABLE 7. Economic Growth and National Policies

Variable	Result
Constant	0.082
	(0.875)
Initial income per capita[a]	–0.496
	(0.001)
Average years of schooling[b]	0.950
	(0.001)
Openness to trade[a]	1.311
	(0.001)
Inflation[b]	0.181
	(0.475)
Government size[a]	–1.445
	(0.001)
Black market premium[b]	–1.192
	(0.001)
Private credit[a]	1.443
	(0.001)
Sargan test[c] (*p*-value)	0.506
Serial correlation test[d] (*p*-value)	0.803

Note: Numbers in parentheses are *p*-values. The dependent variable is real per capita GDP growth.