Development Policy

Week 3: Growth Theory and Empirics

Lecture 5: Cross-Country Evidence

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The Solow model yields ***two empirically testable predictions*** regarding cross-country differences in (a) the level and (b) rate of growth of per capita income:

1. Cross-country differences in the level of per capita income are explained by cross-country differences in the fundamental determinants of steady-state per capita income: (a) the saving rate, and (b) population growth rate.
2. Cross country differences in the rate of growth of per capita income are explained by cross-country differences in the initial level of income, conditional on differences in steady-state determinants.

Derivation of regression equation for the level of steady-state income across countries

Recall equation of motion in the Solow model: $\Delta k = s \cdot y - nk = s \cdot Ak^{\alpha} - nk$, which is =0 in steady-state. Solve for steady-state k (k*): $k^* = A\left(\frac{s}{n}\right)^{\frac{1}{1-\alpha}}$. Substitute k* into $y = Ak^{\alpha}$ to get steady-state y (y*): $y^* = A\left(\frac{s}{n}\right)^{\frac{\alpha}{1-\alpha}}$. If we take into account capital depreciation (at rate δ) and labor-augmenting technology change (at rate μ), then the equation for steady-state income is: $y^* = A\left(\frac{s}{n+\mu+\delta}\right)^{\frac{\alpha}{1-\alpha}}$. The estimation equation is obtained by taking the logarithm of y*:

$$Log(y^*) = \log(A) + \frac{\alpha}{1-\alpha}\log(s) - \frac{\alpha}{1-\alpha}\log(n+\mu+\delta) + \epsilon$$

Estimation Results for the Textbook Solow Model—Level of y

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)
$\bar{R}^2$	0.59	0.59	0.01
s.e.e.	0.69	0.61	0.38

Note:

1. The model explains differences in y across developing countries, but not across developed countries. What does this imply?
2. The investment rate and population growth rate explain about 60% of the cross-country variation in y! What does this imply?
3. The coefficients on (I/Y) and (n+μ+δ) are expected to be the same value, but opposite signs. They are opposite in sign, but their values are significantly different.

Estimation Results for the Augmented Solow Model—Level of y

MRW augment the textbook version of the model by incorporating human capital (H): $Y = AK^{\alpha}H^{\beta}L^{1-\alpha-\beta}$. Going through the same procedure as above yields:

$$\log(y) = \log(A) + \frac{\alpha}{1-\alpha-\beta}\log(s_K) + \frac{\beta}{1-\alpha-\beta}\log(s_H) - \frac{\alpha+\beta}{1-\alpha-\beta}\log(n+\mu+\delta)$$

Where s_K and s_H are shares of income invested in physical and human capital, respectively.

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)
$\bar{R}^2$	0.78	0.77	0.24
s.e.e.	0.51	0.45	0.33

Note: the explanatory power is greater and the signs are as predicted, but still the model does not explain cross-country variation in per capita income in developed countries.

Estimation Results for the Textbook Solow Model—Growth rate of y

The Solow model predicts convergence—poor countries grow faster than richer ones. The standard test for this prediction is simply to regress the rate of growth (g) over a relatively long period on the initial level of per capita income (y(0)): $g = a + b \cdot y(0)$. The coefficient on y(0) is expected to be negative ($\hat{b} < 0$).

Note: convergence obtains in developed, but not developing countries. What does this imply?

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)
$\bar{R}^2$	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.

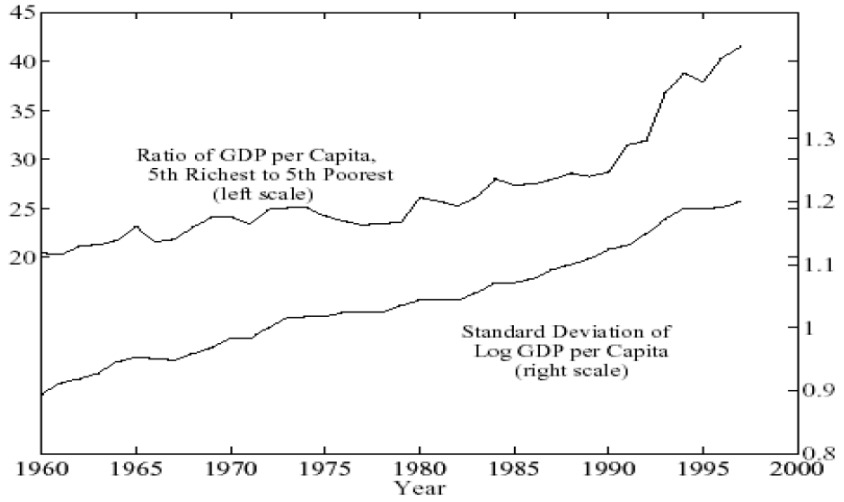
Estimation Results for the Augmented Solow Model—Growth rate

When the convergence equation is estimated, taking into account differences across countries in investment rate, population growth rate and schooling, convergence is found in developing countries, but it is relatively weak.

Dependent variable: log difference GDP per working-age person 1960–1985

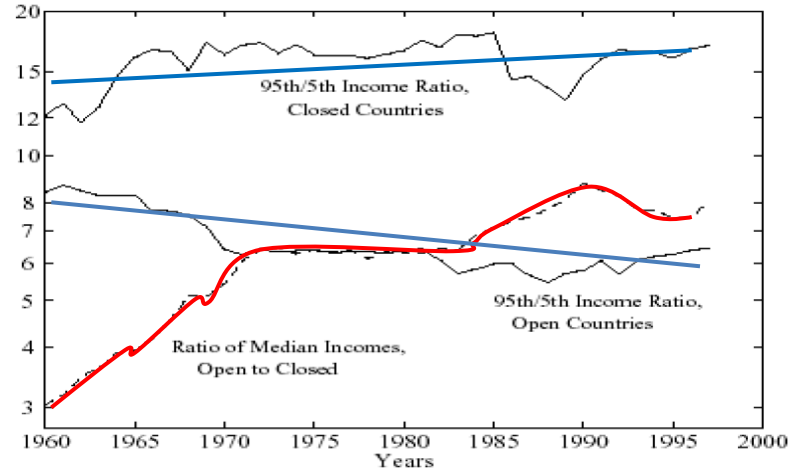
Sample:	Non-oil	Intermediate	OECD
Observations:	98	75	22
CONSTANT	3.04	3.69	2.81
	(0.83)	(0.91)	(1.19)
ln(Y60)	−0.289	−0.366	−0.398
	(0.062)	(0.067)	(0.070)
ln(I/GDP)	0.524	0.538	0.335
	(0.087)	(0.102)	(0.174)
$\ln(n + g + \delta)$	−0.505	−0.551	−0.844
	(0.288)	(0.288)	(0.334)
ln(SCHOOL)	0.233	0.271	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)

Reality: Divergence, not Convergence



Source: Author's calculation using the extension of the Penn World Tables created by Easterly and Yu (2000). 109 countries are represented.

Reality: Divergence between Open and Closed Economies



Source: Author's calculation using the extension of the Penn World Tables created by Easterly and Yu (2000). 33 countries are classified as open and 76 are classified as closed.