

Convergence and Modernization Revisited

Robert J. Barro

Harvard University

- “Iron Law” convergence rate of 2% per year in prior empirical work. 35 years to close half of gap, 115 years for 90%.
- Implies poor tend to catch up to rich but not rapidly.
- Absolute (unconditional) convergence in some contexts; e.g. U.S. States since 1880.

- Conditional convergence in other contexts; e.g. heterogeneous group of 100 countries since 1960. Holds fixed some (fixed or slowly changing) determinants of long-run positions.
- Poor may not tend to catch up if they do not improve basic growth determinants, such as quality of institutions and human capital.

- Revisit issue of convergence in empirical context of cross-country growth regressions.
- Many criticisms of approach—but, basically, it's the only game in town for some purposes.
- I think main results on convergence are robust & convincing.

- Two empirical settings studied.
- Panel of 80 countries since 1960, with information on many “X variables.”
- Long-term panel of 28 countries since 1870, using recently assembled national-accounts data. Few X variables available.

- Also use the two data sets to reassess “modernization hypothesis.” Idea that GDP per capita and schooling predict changes in democracy, rule of law, ...
- Focus present discussion on convergence results.

Country Fixed Effects

- Used routinely, but major issue for empirically gauging convergence rates.
- Usual empirical analysis features tradeoff between 2 major sources of bias: omitted variables and Hurwicz effect for lagged dependent variable.
- First tends to understate convergence. Second tends to overstate. Monte Carlo results in appendix (and Nickell formula).

- Two of empirical settings considered may yield satisfactory estimates of convergence rates, especially viewed jointly.
- First is panel regression for 80 countries since 1960 with rich array of X variables and no country fixed effects.
- Second is panel regression for 28 countries since 1870 with country fixed effects (and few X variables).
- Standard setting with $T=20-40$ years too short for fixed-effects approach to be satisfactory.

Neoclassical Growth Model

- Conceptual framework is neoclassical growth model of Solow, etc., extended to allow for endogeneity of saving rate, population growth rate, and technological progress (endogenous growth plus institutions).
- Setting features conditional convergence prediction for per capita GDP.

Panels since 1960s

- Dependent variable is growth rate of real per capita GDP for 80 countries over 5-year periods (or 10-year or annually).
- Lagged values of X variables as instruments.
- Results in Tables 1 and 3. Two biases important: omitted variables and Hurwicz.

**Table 1 Growth-Rate Regressions for Cross-Country Panel
Five-year periods: 1960-65, ..., 2005-09**

	No Fixed Effects	Fixed effects	No Fixed Effects	Fixed effects
Log(lagged per capita GDP)	0.0019 (0.0012)	-0.0326** (0.0048)	-0.0171** (0.0022)	-0.0447** (0.0051)
1/(life expectancy at birth)	--	--	-2.59** (0.65)	-1.15 (1.22)
Log(fertility rate)	--	--	-0.0340** (0.0046)	-0.0351** (0.0083)
Law & order (rule of law)	--	--	0.0165** (0.0059)	0.0045 (0.0103)
Investment ratio	--	--	0.021 (0.013)	0.014 (0.026)
Female school years	--	--	0.0035* (0.0014)	0.0062 (0.0037)
Male school years	--	--	-0.0036* (0.0015)	-0.0107** (0.0035)
Govt. consumption ratio	--	--	-0.021 (0.025)	-0.083 (0.059)
Openness ratio	--	--	0.0066* (0.0027)	0.0129 (0.0082)
Terms-of-trade change	--	--	0.103** (0.027)	0.092** (0.029)
Democracy indicator	--	--	0.054** (0.019)	0.021 (0.027)
Democracy squared	--	--	-0.055** (0.017)	-0.027 (0.024)
Inflation rate	--	--	-0.0138 (0.0087)	-0.0315* (0.0156)

- Table 1, Col. 1: Convergence coefficient positive (wrong sign) but near zero; omitted-variables effect.
- Col. 2: With country fixed effects (F.E.), estimated convergence rate 3.3% per year. Likely overstated because of Hurwicz bias (large in 40-year sample).
- Col. 3: With array of X variables and no F.E., convergence rate is 1.7%. Omitted-variables effect likely small and Hurwicz bias minor without F.E.
- Col. 4: X variables and F.E.—convergence rate 4.5%. Hurwicz bias large.

- Emphasize convergence-rate results with array of X variables & no F.E. (Table 1, col. 3).
- Estimate around 2% per year seems robust to which X variables considered.
- Endogeneity of some X variables may not have major effect on estimated convergence rate.

Table 3 Additional Growth-Rate Regressions for Cross-Country Panel

	OLS	Ten-year periods	Two sets of fixed effects	Polity variable
Log(lagged per capita GDP)	-0.0173** (0.0022)	-0.0163** (0.0023)	-0.0783** (0.0094)	-0.0164** (0.0023)
1/(life expectancy at birth)	-2.72** (0.61)	-2.65** (0.76)	-2.80 (1.77)	-2.75** (0.66)
Log(fertility rate)	-0.0307** (0.0046)	-0.0317** (0.0050)	-0.0328* (0.0137)	-0.0326** (0.0048)
Law & order (rule of law)	0.0159** (0.0056)	0.0161* (0.0066)	0.0217 (0.0161)	0.0124* (0.0059)
Investment ratio	0.041** (0.012)	0.011 (0.015)	0.010 (0.039)	0.010 (0.014)
Female school years	0.0035* (0.0014)	0.0030* (0.0014)	0.0092 (0.0058)	0.0026 (0.0015)
Male school years	-0.0037* (0.0015)	-0.0033 (0.0015)	-0.0111* (0.0054)	-0.0030 (0.0015)
Govt. consumption ratio	-0.026 (0.023)	-0.024 (0.028)	-0.114 (0.090)	-0.036 (0.026)
Openness ratio	0.0061* (0.0025)	0.0057 (0.0032)	0.0263* (0.0107)	0.0061* (0.0029)
Terms-of-trade change	0.101** (0.027)	0.100* (0.041)	0.094** (0.030)	0.120** (0.028)
Democracy indicator	0.039* (0.016)	0.031 (0.024)	0.051 (0.033)	0.031 (0.021)
Democracy squared	-0.039** (0.014)	-0.035 (0.022)	-0.056 (0.031)	-0.036 (0.019)
Inflation rate	-0.0198** (0.0040)	-0.0157 (0.0138)	-0.0091 (0.0250)	-0.0108 (0.0091)

- Table 3, col. 1: OLS versus INST. Coefficients on investment ratio & inflation rate affected. Convergence rate little changed.
- Col. 2: 10-year versus 5-year: little difference. Also true for annual. (Hurwicz bias with F.E. depends on sample length in years, not observation interval. Consistent with Nickell formula & Monte Carlo results.)
- Col. 3: 2 sets of fixed effects. Convergence rate 7.8%! Large Hurwicz bias with 20-year samples.

Table 4 Regressions for Indicators of Law & Order and Democracy

	Law & Order: 1985-90, ..., 2005-09,		Political Rights (Freedom House): 1970-75, ..., 2005-09,	
		Fixed effects		Fixed effects
Lagged dependent variable	0.708** (0.026)	0.332** (0.045)	0.796** (0.018)	0.456** (0.034)
Log(per capita GDP)	0.0248** (0.0066)	-0.0353 (0.0395)	0.0112 (0.0067)	-0.0262 (0.0349)
Female school years	-0.0093 (0.0062)	0.0316 (0.0299)	--	--
Male school years	0.0164* (0.0068)	-0.0195 (0.0283)	--	--
Female primary school years	--	--	0.0439** (0.0138)	0.0028 (0.0394)
Male primary school years	--	--	-0.0279 (0.0146)	-0.0202 (0.0423)
Female upper school years	--	--	-0.0367* (0.0153)	-0.0201 (0.0442)
Male upper school years	--	--	0.0344* (0.0142)	-0.0075 (0.0434)

Panels since 1870

- Use Ursua data on GDP. Covers 42 countries since 1913. Better than Maddison!
- Use sample of 28 countries, where GDP data start between 1870 and 1896. Use 5-year periods starting 1870-75.
- Limited X variables. Polity on Democracy. Can add measure of schooling (B.R. Mitchell).

Table 5
Panel Regressions with Long-Term Data: 1870-75, ..., 2005-09

	Dependent variable: Growth rate of per capita GDP			
	No Fixed Effects	Fixed effects	No Fixed Effects	Fixed effects
Log(lagged per capita GDP)	-0.0051** (0.0013)	-0.0251** (0.0043)	-0.0092** (0.0018)	-0.0244** (0.0041)
Polity democracy/ autocracy	--	--	-0.0431* (0.0017)	-0.0431* (0.0202)
Polity squared	--	--	0.0468** (0.0145)	0.0423* (0.0176)
p-value for Polity variables	--	--	0.001	0.046
	Dependent variable: Polity (democracy/autocracy)			
	No Fixed Effects	Fixed effects		
Lagged Polity (democracy/ autocracy)	0.817** (0.023)	0.743** (0.028)		
Log(per capita GDP)	0.0489** (0.0095)	0.0619* (0.0244)		

- Table 5, col. 1: No F.E., no X variables. Convergence rate 0.5%—omitted variables imply too low.
- Col. 2: F.E., no X variables. Convergence rate 2.5%. Long time series implies Hurwicz effect moderate. Monte Carlo results imply moderate overestimate.
- Cols. 3, 4: Add X variable (Polity). Small effects. Bigger impact when schooling also added.

- Put together convergence results from two data sets.
- Post-1960s. Convergence rate 1.7% with X variables and no F.E. Still some omitted-variables bias (downward) but likely small. (Monte Carlo implies Hurwicz effect negligible.)
- Post-1870. Convergence rate 2.4% with F.E. (and limited X variables). Still some Hurwicz bias (upward) but moderate with $T=139$.
- Two sets of results likely bracket “true” convergence rate. Iron-law rate of 2% falls into this interval.

Natural Experiments

- Two Koreas, two Germanys, plus others.
- Nice cases, but are they representative or chosen partly because they work? Case of Czechoslovakia division?
- Systematic approach to selection & analysis of natural experiments? Helps with endogeneity issues but still requires broad panel data.

Cross-Country Dispersion of GDP

- Declining standard deviation of $\log(\text{per capita GDP})$ across countries as indicator of “sigma convergence.”
- Beta convergence does not imply sigma convergence (as in Galton’s Fallacy for heights). S.D. tends to approach a long-run value.
- S.D. can be stable over time with large number of countries with independent shocks.

Figure 1: Cross-Country Dispersion of Log per capita GDP, 25 countries, 1870-2009

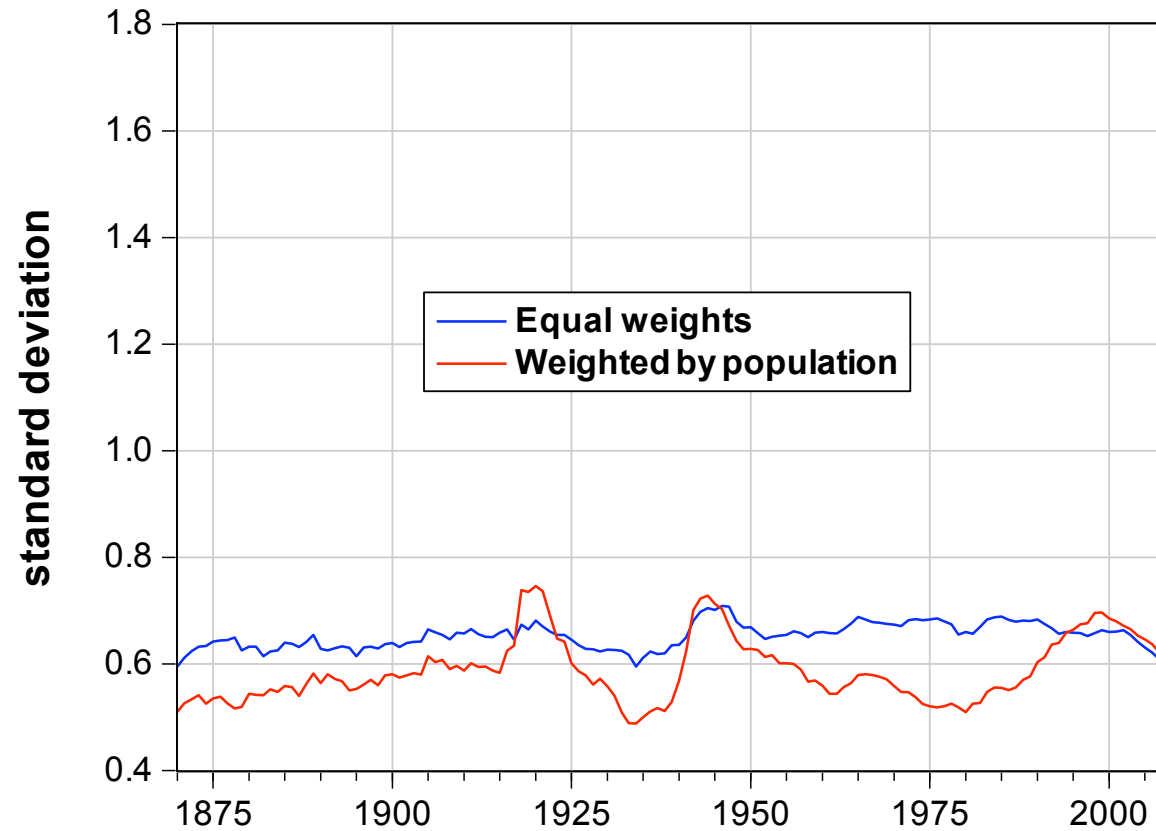
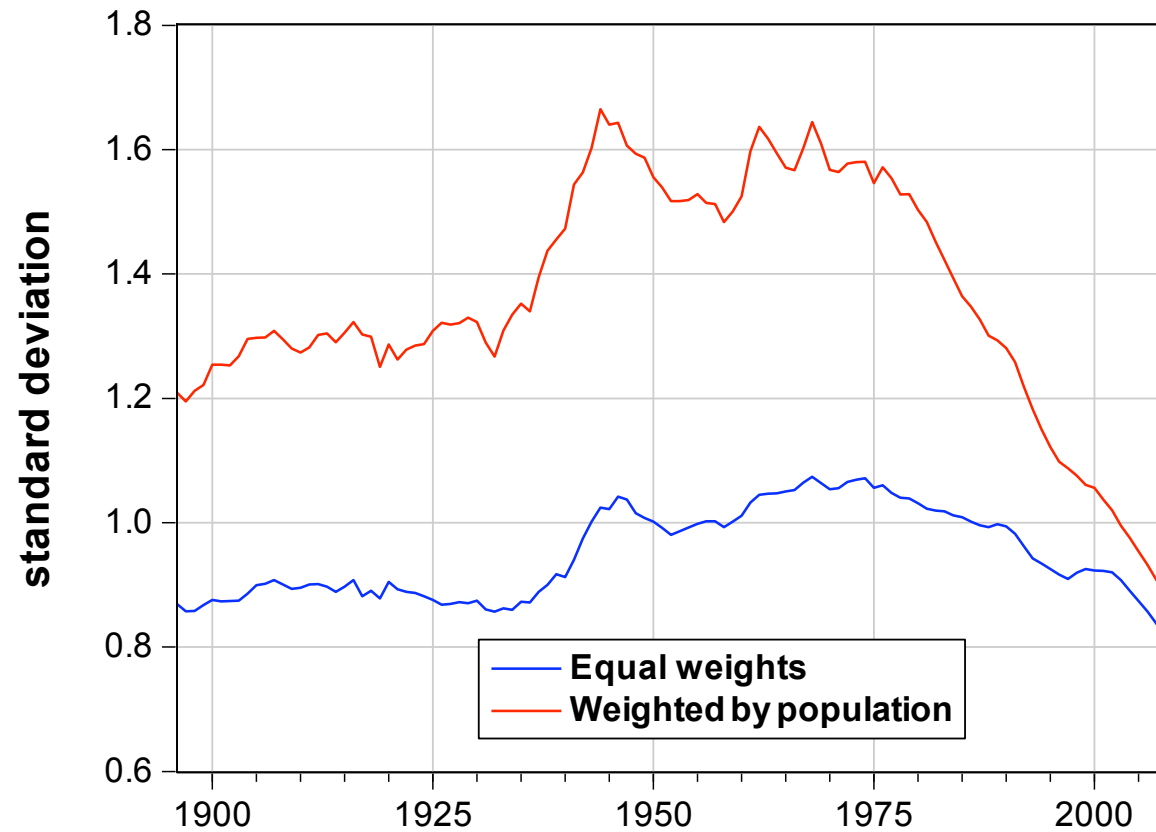


Figure 2: Cross-Country Dispersion of Log per capita GDP, 34 countries, 1896-2009



- Figure 1 shows stability of s.d. for 25 countries since 1870. Selection issue (based here on which countries have long-term data), analogous to Baumol?
- Figure 2 (34 countries since 1896) shows decline in s.d. since 1970s, especially population weighted. Incorporation of China & India into world market economy. Less selection issue here (mainly exclusion of sub-Saharan Africa).
- Figures 3 & 4 show patterns for C (Ursua data) and GDP similar. Have to start in 1919, 29 countries.

Figure 3: Cross-Country Dispersion of Logs of per capita GDP & Consumption, 29 countries, 1919-2009

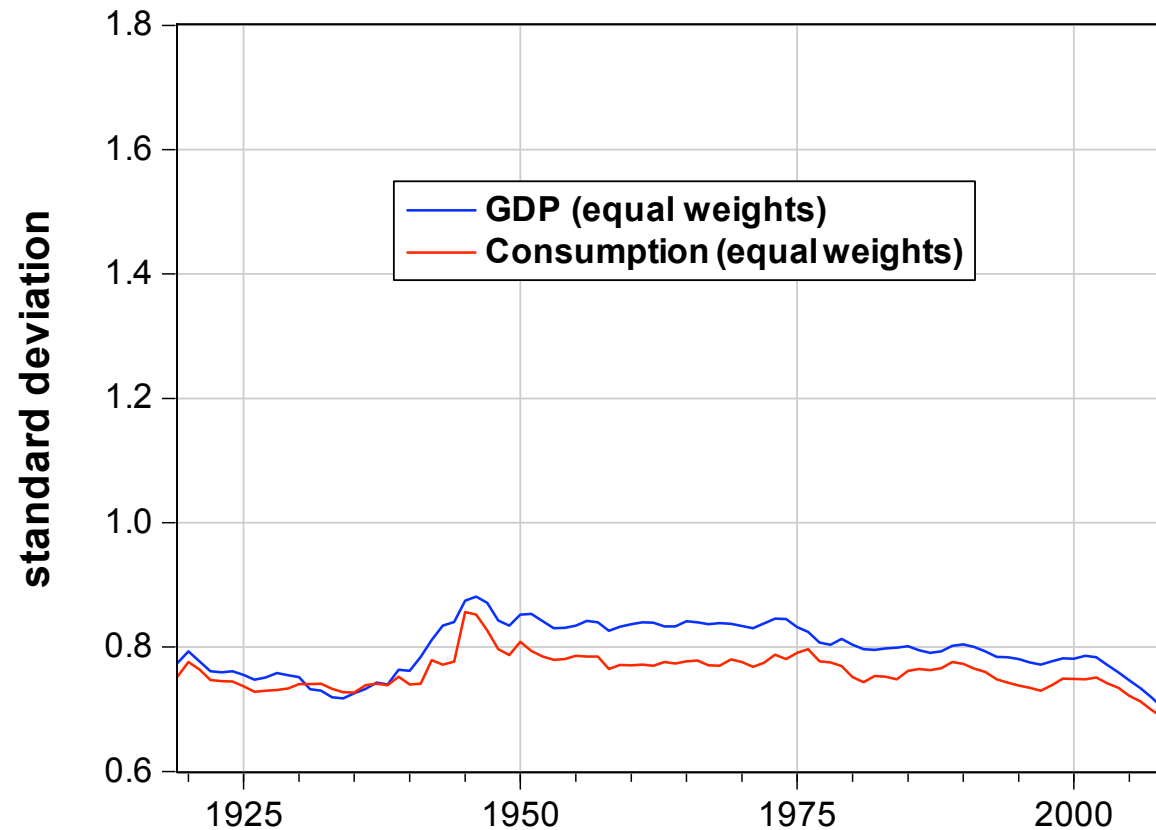


Figure 4: Cross-Country Dispersion of Logs of per capita GDP & Consumption, 29 countries, 1919-2009

