

The Neoclassical Revival in Growth Economics: Has It Gone Too Far?

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Motivation

$$Y = AX .$$

- Endogenous growth theories of Romer (1990) and Grossman and Helpman (1991) aimed at explaining the large cross-country income differences through differences in A across countries -“idea gaps/technology gaps”.
 - ▶ Differences in physical and human capital intensity, were not up to the quantitative task.
- Neoclassical studies of the 90s, however, show that differences in X - physical and human capital - can explain income differences.
 - ▶ Mankiw, Romer, and Weil (1992) - Solow model augmented to include human capital can explain 78% of cross-country variance of output per capita in 1985.
 - ▶ Alwyn Young (1994, 1995) - East Asian growth miracles were fueled more by growth in labor and capital than by rising productivity.
 - ▶ Barro and Sala-i-Martin (1995) - augmented Solow model is consistent with estimated speed of convergence across countries.

Objective

Present new evidence on the importance of productivity vs. physical and human capital in explaining international differences in levels and growth rates of output.

- Reexamine MRW's methodology for estimating human capital, and update their data and add data on primary and tertiary schooling, which was not available earlier.

Findings

- The authors find that
 - ① Productivity differences account for half or more of level differences in 1985 GDP per worker.
 - ② Differences in productivity growth explain the overwhelming majority of growth rate differences during 1960-85 in GDP per worker.
- Role of inputs, especially human capital is smaller because
 - ① Primary school attainment varies much less across than secondary school attainment does, the resulting estimates of human capital vary much less across countries than the MRW estimates.
 - ② Authors find that production of human capital is more labor-intensive and less physical capital-intensive than is the production of other goods. This further narrows country differences in estimated human capital stocks.

MRW's Setup

Production technology: $Y = C + I_K + I_H = K^\alpha H^\beta (AL)^{1-\alpha-\beta}$.

- $H = hL$, where h is human capital per worker.
- Implicit is a consumer whose time enters in the production function through L and h .
- Production of both, physical and human capital, uses the same technology. Furthermore, they have the same law of motion.

Competitive output and input markets and CRRA utility imply that higher A will induce proportionate increases in K and H . Therefore, MRW rearrange terms to express Y/L

$$\frac{Y}{L} = A \left(\frac{K}{Y} \right)^{\alpha/(1-\alpha-\beta)} \left(\frac{H}{Y} \right)^{\beta/(1-\alpha-\beta)} = AX .$$

- This form acknowledges variations in K and H generated by differences in A , and therefore contributions of K and H variations that are not induced by A are captured by variations in capital intensity X .

MRW's Data

- Y/L - MRW use the Summers-Heston GDP per capita in 1985.
- $K/Y = (I_K/Y)/(g + \delta + n)$, where I_K/Y is the average Summers-Heston investment rate in physical capital over 1960-1985.
- $g = 0.02$ is world average growth rate of Y/L .
- $\delta = 0.03$.
- n is the country's average rate of growth of its working-age population (15 to 64 year-olds) over 1960-1985 (UNESCO yearbook).
- $H/Y = (I_H/Y)/(g + \delta + n)$.
- $I_H/Y = (\text{secondary enrollment rate}) \cdot (\text{population } 12 - 17 / \text{population } 15 - 64)$ average over 1960-1985.

MRW's Result

- With the 1985 levels of Y/L , K/Y , and H/Y for 98 countries, MRW regress $\ln(Y/L)$ on $\ln(K/Y)$ and $\ln(H/Y)$.
- $Rsquare = 0.78$, and estimated coefficients are consistent with production elasticities of $\alpha = 0.30$ for physical capital and $\beta = 0.28$ for human capital.

Based on the high $Rsquare$, MRW conclude that most international differences in living standards can be explained by differences in accumulation of both human and physical capital.

Critique of MRW

- Measurement of H - why focus only on secondary school enrollment?
- Estimates of α and β may be inconsistent because of correlation between $\ln A$ and $\ln X$.
 - ▶ Independent calibration of α , Gollin (1996) for 31 countries, also gives a value of 0.30.
- Given that modified estimates of X and A will be correlated:

$$\frac{\text{var } \ln(Y/L)}{\text{var } \ln(Y/L)} = \frac{\text{cov}(\ln(Y/L), \ln(Y/L))}{\text{var } \ln(Y/L)} = \frac{\text{cov}(\ln(Y/L), \ln(X)) + \text{cov}(\ln(Y/L), \ln(A))}{\text{var } \ln(Y/L)}$$

$$\Rightarrow 1 = \frac{\text{cov}(\ln(Y/L), \ln(X))}{\text{var } \ln(Y/L)} + \frac{\text{cov}(\ln(Y/L), \ln(A))}{\text{var } \ln(Y/L)} .$$

- ▶ When we see 1% higher Y/L in one country relative to the mean of 98 countries, how much higher is the conditional expectation of X and how much higher is the conditional expectation of A ?

Critique of MRW: A versus X

Table 1 THE ROLES OF A AND X IN 1985 PROSPERITY^a

Source ^a	$cov[\ln(Y/L), \ln(Z)]/var \ln(Y/L)$			
	$Z = \left(\frac{K_Y}{Y}\right)^{\frac{\alpha}{1-\alpha-\beta}}$	$Z = \left(\frac{H_Y}{Y}\right)^{\frac{\beta}{1-\alpha-\beta}}$	$Z = X$	$Z = A$
MRW0	.29	.49	.78	.22
MRW1	.27	.49	.76	.24
MRW2	.31	.47	.78	.22
MRW3	.29	.11	.40	.60
MRW4	.29	.04	.33	.67

^aMRW0: from MRW (uses their data appendix). MRW1: MRW0 but with K_Y/Y instead of K/Y . MRW2: MRW1 but with L = worker instead of working-age population, 14 countries in/out. MRW3: MRW2 but with all enrollment rather than just secondary enrollment. MRW4: MRW3 but with (K, H, L) shares of $(0.1, 0.4, 0.5)$, not $(0.20, 0.28, 0.42)$, in H production.

- MRW3: primary schooling does not vary anywhere near as much with Y/L across countries as secondary schooling does. By focusing only on secondary schooling, one overstates variation in H across countries and its covariance with Y/L .
- MRW4: technology for producing human capital is more intensive in labor than is the technology for producing other goods.
 - 50% of investment H in US represents opportunity cost of student time. The remaining 50% is composed of expenditures on teachers (H) and facilities (K). Expenditures on teachers represent about 80% of all expenditures.

Human Capital Intensity, β

The results, so far, show that variations in technology across countries explains the bulk of cross-country variation in output per worker.

But, a sufficiently high β does generate results that still have the major part of international income variation explained by differences in levels of physical and human capital per worker.

- Doubling β from 0.28 to 0.56 yields a (51%, 49%) division. As, β rises toward $2/3$, the decomposition approaches 60% vs. 40%.

But what is the right value for β ?

- No independent estimates of the share of human capital.
- Exploit wage regressions to measure human-capital stocks in a way that does not depend on the value of β .

Incorporating Evidence from Mincer Regressions

- For a cross section of workers, Mincer (1974) ran a regression of worker log wages on worker years of schooling and experience.
- To incorporate this, adopt a life-cycle framework wherein individuals go to school first and then work full time.
- Technology for human capital: $h_s = (K_H/L_H)^{1-\phi-\lambda} (h_T)^\phi (Ae^{(\gamma/\lambda)s})^\lambda$.

$$\frac{H_y}{Y} = (e^{\gamma s})^{1/[1-\phi+\lambda\beta/(1-\alpha-\beta)]} \left(\frac{K_y}{Y} \right)^{[1-\phi-\lambda(1-\beta)/(1-\alpha-\beta)]/[1-\phi+\lambda\beta/(1-\alpha-\beta)]}$$

- Then, the percentage wage gain to a representative agent from one more year of schooling is $\beta\gamma/(1-\alpha)$.
 - ▶ Bils and Klenow (1996) - Mincer regression studies covering 48 countries find that wage gain associated with an additional year of education averages 9.5%.
 - ▶ This implies that $\gamma = 0.95(1-\alpha)/\beta$.

Evidence from Mincer Regressions: A versus X

- As with MRW4, $\alpha = 0.30$, $\beta = 0.28$, $\phi = 0.4$, $\lambda = 0.5$.
- BK1 uses the level implied by the enrollment rates used in MRW3 and MRW4: $s = 8 \cdot \text{primary} + 4 \cdot \text{secondary} + 4 \cdot \text{tertiary}$.

Table 2 THE ROLES OF A AND X IN 1985 PROSPERITY

Source ^a	$cov[\ln(Y/L), \ln(Z)] / \text{var} \ln(Y/L)$			
	$Z = \left(\frac{K_Y}{Y}\right)^{\frac{\alpha}{1-\alpha-\beta}}$	$Z = \left(\frac{H_Y}{Y}\right)^{\frac{\beta}{1-\alpha-\beta}}$	$Z = X$	$Z = A$
BK1	.29	.31	.60	.40
BK2	.23	.33	.56	.44
BK3	.23	.31	.53	.47
BK4	.23	.11	.34	.66

^aBK1: uses (7), i.e. Mincer evidence. BK2: calculates years of schooling s from Barro–Lee 1985 stocks instead of 1960–1985 flows. BK3: adds average years of experience. BK4: BK3 but with (K, H, L) shares of $(0, 0, 1)$ instead of $(0.1, 0.4, 0.5)$ in H production.

Evidence from Mincer Regressions: A versus X

- BK1: exponential form implies bigger absolute amount of human capital from the next year of schooling at higher levels of education, and therefore puts more weight on secondary school enrollment, moving us back toward MRW's 78% vs. 22% breakdown.
- BK2: assumption that 1985 K/Y and H/Y are steady-state levels may not hold.
 - ▶ K/Y : use accumulation equation for K and data on I/Y and Y over 1960-85.
 - ▶ H/Y : use Barro and Lee's (1993) data on average years of schooling for 25-64 year-old population in 1985.
- BK3: incorporates experience ($exp = (age - s - 6)$).

$$h_s = (K_H/L_H)^{1-\phi-\lambda} (h_T)^\phi \left(A e^{(\gamma_1 s + \gamma_2 exp + \gamma_3 exp^2)/\lambda} \right)^\lambda .$$

- ▶ $\gamma_1 = 0.095(1 - \alpha)/\beta$. Bils and Klenow (1996) report average estimated coefficients on exp and exp^2 across 48 countries of 0.0495 and -0.0007 , which implies that $\gamma_2 = 0.0495(1 - \alpha)/\beta$ and $\gamma_3 = 0.0007(1 - \alpha)/\beta$.
- BK4: in BK3 the elasticity of quality with respect to a country's Y/L is 0.95%, i.e. like GDP per worker, the quality of education varies by a factor of about 34 across countries in 1985.
 - ▶ Using 1970 and 1980 census data on the U.S. earnings of immigrants from 41 countries, Borjas (1987) estimates quality elasticity of only 0.12%. As an extreme case impose zero elasticity.

Correlations

Table 3 CORRELATION MATRICES

a. With MRW0 methodology

	$\ln(Y/L)$	$\ln(K/Y)$	$\ln(H/Y)$
$\ln(K/Y)$	.77		
$\ln(H/Y)$	.84	.67	
$\ln(A)$	.47	.00	.00

b. With BK4 Methodology

	$\ln(Y/L)$	$\ln(K/Y)$	$\ln(H/Y)$
$\ln(K/Y)$	.59		
$\ln(H/Y)$	.60	.02	
$\ln(A)$	.93	.28	.57

Conclusion: **A** versus **X**

- **Richer countries tend to have higher K/Y , higher H/Y , and higher A , with a dominant role for A , a large role for K/Y , and a modest-to-large role for H/Y .**
- **Theorizing about international output differences should center at least as much on differences in productivity as on differences in physical or human capital intensity.**
 - ▶ It is hard to imagine that policies discouraging K/Y and H/Y such as high tax rates-would not also discourage A . The positive BK4 correlations seem much easier to generate theoretically. For example, a high H/Y , say due to generous education subsidies, facilitates technology adoption.

Robustness Checks

- Imperfect substitutability between workers with different levels of education (and hence human capital).
 - ▶ No significant change in results - breakdown is (40%, 60%), tilted a little toward $\ln(X)$ relative to the BK4.
- Size of β .
 - ▶ Changing β results in an offsetting adjustment in γ to preserve the equality $\beta\gamma/(1-\alpha) = 9.5\%$. Indeed, there is zero effect.
 - ▶ But, Mincer regression coefficient on schooling captures only private gains from schooling. Productive benefits of economywide human capital, as proposed by Lucas (1988)? This leads to questions about their exact nature and transmission, and hence more research into the source of productivity differences across countries.

Growth Accounting

Table 4 THE ROLES OF A AND X IN 1960–1985 GROWTH

Source ^a	$cov[\Delta \ln(Y/L), \Delta \ln(Z)]/var \Delta \ln(Y/L)$			
	$Z = \left(\frac{K_Y}{Y}\right)^{\frac{\alpha}{1-\alpha-\beta}}$	$Z = \left(\frac{H_Y}{Y}\right)^{\frac{\beta}{1-\alpha-\beta}}$	$Z = X$	$Z = A$
BK2	.03	.12	.15	.85
BK3	.03	.12	.14	.86
BK4	.03	.06	.09	.91

^aBK2: calculates years of schooling s from Barro–Lee 1985 stocks instead of 1960–1985 flows. BK3: adds average years of experience. BK4: BK3 but with (K, H, L) shares of (0, 0, 1) instead of (0.1, 0.4, 0.5) in H production.

- Differences in growth rates of Y/L derive overwhelmingly from differences in growth rates of A .
- Studies that emphasize transition dynamics of the neoclassical growth model ignore the major source of differences in country growth rates. These results call for greater emphasis on models of technology diffusion and policies that directly affect productivity.

Correlations in Growth Rates

Table 5 CORRELATION MATRIX (BK4 GROWTH RATES)

	$\Delta \ln(Y/L)$	$\Delta \ln(K/Y)$	$\Delta \ln(H/Y)$
$\Delta \ln(K/Y)$	.04		
$\Delta \ln(H/Y)$	.28	-.50	
$\Delta \ln(A)$	.87	-.42	.34

- Countries with high growth in A have had unusually high growth rates of schooling. Thus it could be that high growth in economywide schooling attainment powerfully boosts growth through its effect on technology adoption.
- The negative correlations between the growth rate of K/Y and the growth rates of, respectively, H/Y and A are puzzling.

Summarizing

Productivity differences account for half or more of level differences in 1985 GDP per worker, and differences in productivity growth explain the overwhelming majority of growth rate differences.

- Careful reconstruction of human capital measure, relative to MRW, specifically inclusion primary enrollment rates and the more labor intensive nature of human capital production.
- Incorporates Mincer regression evidence to pin down human capital intensity.