Cross-country Income Convergence Revisited

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Abstract

We reassess the convergence properties of the cross-country distribution of income and of its determinants using the dataset constructed by Klenow and Rodriguez-Clare (2005) and our updated version of the same data. Consistently with the literature, the ergodic distribution of output per worker features separate convergence clubs. In contrast to previous findings, both capital-output ratio and productivity display convergence in the long-run; The long-run distribution of human capital is multi-modal.

KEYWORDS: convergence, development accounting.

JEL CLASSIFICATION: O40, O47.

1 Introduction

Whether the income of poor countries tends to catch up with the income of rich ones is a key question in the empirics of economic growth (Durlauf and Quah, 1999; Durlauf, Johnson, and Temple, 2005). We reassess the convergence properties of the cross-country distribution of income and the determinants of convergence using the dataset constructed by Klenow and Rodriguez-Clare (2005) and an updated version of the same data. We adopt distribution dynamics techniques in our empirical analysis (Quah, 2007).

In the analysis of a probability distribution's dynamics, a unimodal ergodic distribution can be interpreted as a necessary condition for convergence. Conversely, the more pronounced the multi-modality of the long-run distribution is, the stronger is the evidence of polarization. A common finding in the literature is multi-peakedness of the ergodic distribution of output per capita (or per worker). Most authors proceed then to try and uncover the causes of "club convergence", either by conditional distribution dynamics or by analyzing the ergodic distributions of the determinants of output per capita (physical/human capital and productivity).

Feyrer (2008) analyzes, using discrete Markov chains methods, the determinants of convergence across 95 countries over the 1970-89 period.[1] Feyrer finds a twin-peaked ergodic distribution of output. While the distribution of accumulable factors (physical/human capital) display long-run convergence, the stratification of the distribution of TFP in two modes is interpreted as responsible for the lack of convergence in output. Johnson (2005) extends Feyrer's analysis on the same data using a continuous state-space approach. The most important determinant of the bimodal ergodic distribution of output is capital accumulation. TFP, with a "nearly bimodal" long-run distribution, can still play a role.

We investigate cross-country convergence using the data constructed by Klenow and Rodriguez-Clare (2005) and our own updated dataset. Consistently with the literature, we find that the long-run distribution of output is multi-modal. However, output per worker in the long run clusters in three distinct groups, not two as found by other authors. Using the dataset by Klenow and Rodriguez-Clare (2005), both physical capital and productivity are bimodal in the long run; The ergodic distribution of human capital is

[1] The data are constructed in the same way as in Klenow and Rodriguez-Clare (2005) and our updated data relying on earlier versions of the Penn World Table and the Barro-Lee educational attainment data.

nearly single-peaked. With the more recent data we constructed, we find convergence of productivity, while human capital clusters around multiple modes.[2]

2 Convergence Revisited

2.1 Data and Methodology

In our empirical analysis we consider two datasets: The one constructed by Klenow and Rodriguez-Clare (2005) and an updated dataset which we built relying on Heston, Summers, and Aten (2009) and Barro and Lee (2010).[3] Assuming a standard Cobb Douglas production function, output per worker, Y/L, can be expressed as a function of the physical capital-output ratio, K/Y,[4] human capital per worker, H/L, and TFP, A:

$$\log\left(\frac{Y}{L}\right)_{i,t} = \frac{\alpha}{1-\alpha}\log\left(\frac{K}{Y}\right)_{i,t} + \log\left(\frac{H}{L}\right)_{i,t} + \log\left(A\right)_{i,t}. \tag{1}$$

TFP is recovered from equation (1) as a (Solow) residual. The capital-output ratio is constructed, given an initial condition, from a standard capital accumulation equation. The initial capital stock is computed from the steady-state relationship:

$$\left(\frac{K}{Y}\right)_{i,0} = \frac{\left(I/Y\right)_i}{g + n_i + \delta}, \tag{2}$$

where we assume a depreciation rate of 8%, i.e., $\delta = 0.08$. We set the growth rate of GDP per worker to the world average of 1.67%, i.e., $g = 0.0167$. For each country we set n_i and $\left(I/Y\right)_i$ to the the average growth rate of the economically active population and to the average investment share of GDP.

[2] In Barseghyan and DiCecio (2010), we also present results on the time dimension of the convergence process.

[3] Klenow and Rodriguez-Clare (2005) rely on an earlier version of the Penn World Table (Heston, Summers, and Aten, 2006) and of the educational attainment data (Barro and Lee, 2001).

[4] The Penn World Table menmonics are `rgdpwok` for Y/L and `ki` for K/Y. The economically active population, L, is computed from output per worker, output per capita (`rgdpch`), and the popuaption (`POP`) as follows: $L = \frac{\texttt{rgdpch*POP}}{\texttt{rgdpwok}}$.

As in Klenow and Rodriguez-Clare (2005), we construct human capital per worker from educational attainment data, $\log(H/L) \equiv \phi s$. We adopt the Mincerian return $\phi = 0.085$; s is the educational attainment of the age 25 and older population from Barro and Lee (2010). This data is constructed using information from consistent census data, disaggregated by age group, along with new estimates of mortality rates and completion rates by age and education level and it is more accurate than the earlier version in Barro and Lee (2001).

Our sample covers the period 1960-2007: 98 countries have data available since 1960, and 123 since 1970. The dataset constructed by Klenow and Rodriguez-Clare (2005) covers less countries: 73 starting in 1960; 78 starting in 1970.[5]

We assume that the distribution of the variable of interest, in logs and relative to its cross-sectional average, evolves according to the following first-order Markov process:

$$f_{t+\tau}(y) = \int_{-\infty}^{+\infty} g_\tau(y|x) f_t(x) dx, \tag{3}$$

where f_t denotes the density at time t and g_τ denotes the stochastic kernel relating the time-t and time-$(t+\tau)$ distributions. The ergodic distribution, f_∞, solves

$$f_\infty(y) = \int_{-\infty}^{+\infty} g_\tau(y|x) f_\infty(x) dx. \tag{4}$$

The joint distribution $g_\tau(y, x)$ is estimated by adaptive Gaussian kernel smoothing with $\tau = 1$. We estimate f_∞ as described in Johnson (2005).

2.2 Results

Figure 1 portrays the long-run distributions of output, productivity, physical and human capital estimated our updated dataset and Klenow and Rodriguez-Clare's dataset. Table 1 reports the modes of the long-run distributions. In all four samples, we find that the long-run distribution of is multi-modal. This is a common finding in the literature, at least since Quah

[5]Limiting the sample to 1996 would add 9 countries with complete data since 1960 and 11 since 1970. The results discussed below are robust to including these countries.

(1993). However, output per worker in the long run clusters in three distinct groups, not two as found by other authors.

The analysis of the long-run distributions of the determinants of output per worker can help shed some light on the culprit of the lack of convergence. Using the dataset by Klenow and Rodriguez-Clare (2005), both physical capital and productivity are bimodal in the long run; The ergodic distribution of human capital is single-peaked (1960-2000 sample) or nearly so (1970-2000 sample). These results are consistent with the findings in Feyrer (2008) and Johnson (2005). The picture emerging from our more comprehensive dataset is quite different. We find convergence of productivity across countries for both groups of countries/sample periods. The long-run distribution of physical capital is unimodal (1960-2000 sample) or nearly-unimodal (1970-2000 sample). Human capital instead clusters around three distinct modes. In short, the updated educational attainment data suggests that human capital plays an important role in determining club-convergence in the long run at the expenses of the role of productivity.

3 Conclusions

We updated the panel data for output, physical and human capital, and productivity in Klenow and Rodriguez-Clare (2005) relying on the most recent versions of the Penn World Table and educational attainment data. The latter data points to the preeminence of human capital in driving the long-run club-convergence behavior of the distribution of output per worker across countries. Conversely, productivity plays a minor role.

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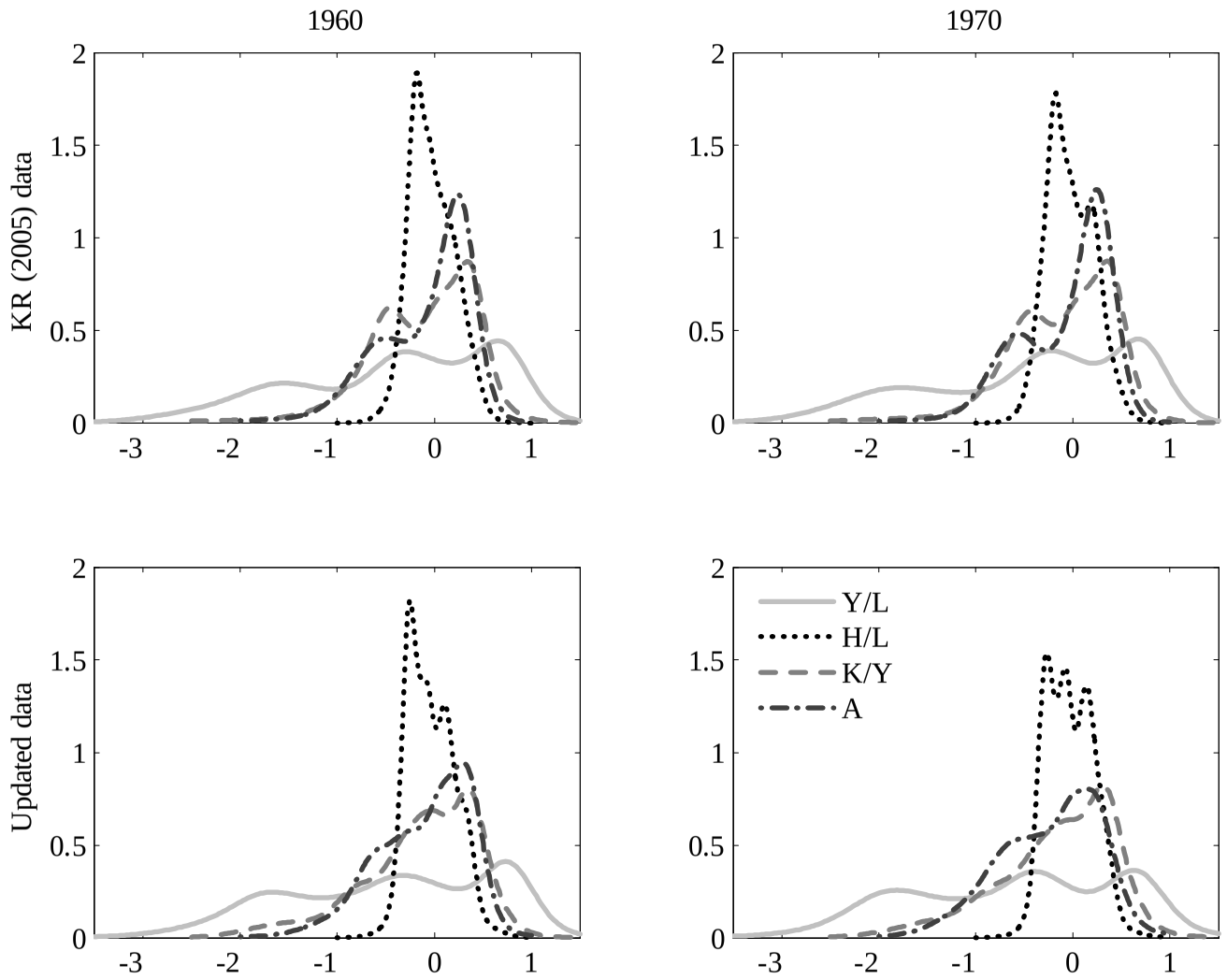

Figure 1: Ergodic distributions: Klenow and Rodriguez-Clare (2005) data (top row) and updated data (bottom row) starting in 1960 (left column) and in 1970 (right column).

	Data	Starting year	No. of countries	Y/L	H/L	K/Y	A
(1)	PWT 6.1, Barro-Lee 2001†	1960	73	-1.54, -0.28, 0.65	-0.18	-0.45, 0.34	-0.49, 0.25
(2)	PWT 6.3, Barro-Lee 2010‡	1960	98	-1.65, -0.32, 0.74	-0.25, -0.11, 0.11	-0.04, 0.35	0.29
(3)	PWT 6.1, Barro-Lee 2001†	1970	78	-1.77, -0.21, 0.67	-0.18, 0.18	-0.43, 0.35	-0.56, 0.25
(4)	PWT 6.3, Barro-Lee 2010‡	1970	123	-1.81, -0.39, 0.62	-0.27, -0.08, 0.14	0.31	0.14

† Klenow and Rodriguez-Clare (2005) data.
‡ Updated data.

Table 1: Modes of the ergodic distributions for various datasets.