Economic Growth and Convergence: Implications of Energy Transition Pathways

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Overview

The Solow growth model predicts that developing countries should catch up to the rich. The premise of the Solow model is simple, given access to the same technology, developing countries with lower capital stock should have a higher marginal product of capital and grow faster as they accumulate capital. While the conditional convergence hypothesis has found robust support in the data, unconditional convergence – that is, the hypothesis that subsequent growth rates should be unconditionally negatively related to initial per capita incomes - did not manifest in the data. For decades the literature could not find empirical evidence that supports the existence of unconditional convergence and was only found in specific sectors (see Rodrik (2013) and AlKathiri (2022)). This all changed after recent studies using the most recent data demonstrated that since the mid-1990s, the world has entered a new era of unconditional convergence (see Kremer et al. (2021) and Patel et al. (2021)).

This paper aims to contribute to the narrative of the observed unconditional convergence by assessing the role of energy. Specifically, did energy have a particular role to play in the observed unconditional convergence period? Our findings show that unconditional convergence in the last two decades is associated with higher growth of per-capita energy consumption of developing countries relative to rich ones, which was not the case in earlier periods. In addition, we exploit an extended production function specification that includes energy and show the different role of energy in impacting economic growth for countries of three income groups. The elasticity of GDP with respect to energy is higher in low-income countries relative to rich countries.

Methods

Let $\hat{y}_{i,t,t+\Delta t}$ be the growth rate of income per capita during the periods t and, $t+\Delta t$, and $log\ (y_{i,t})$ be the natural logarithm of income per capita for country i at time t. Consider the following model:

$$\hat{y}_{i,t,t+\Delta t} = \alpha + \beta \log (y_{i,t}) + \varepsilon_{i,t} \quad (1)$$

Suppose we estimate the coefficients and find $\beta < 0$, we say there is unconditional convergence in income, as developing countries tend to grow faster than rich ones. This paper investigates the role of energy in deriving patterns of cross-country income growth. Therefore, we look at the evolution of growth in per-capita energy consumption and how it relates to the initial income level. Let $e_{i,t}$ be the level of energy consumption per capita for a country and $\hat{e}_{i,t,t+\Delta t}$ be its annualized growth rate. We estimate the following regression to test for the contribution of energy to convergence during different periods:

$$\hat{e}_{i,t,t+\Delta t} = \alpha + \gamma \log (y_{i,t}) + \varepsilon_{i,t} \quad (2)$$

We say energy consumption contributes to cross-country income convergence if $\gamma < 0$. We also examine the energy consumption elasticity of income and whether it differs across income groups. Consider the following extended Cobb-Douglas production function $Y = F(L, K, E) = A\ L^{\beta_1}\ K^{\beta_2}\ E^{\beta_3}$ with output (Y) and three factors of production: Labor (L), capital (K), and energy (E). By taking the log of both sides, one can get the following estimation equation:

$$\log(Y_{it}) = \alpha_i + \beta_1 \log(L_{it}) + \beta_2 \log(K_{it}) + \beta_3 \log(E_{it}) + \varepsilon_{it} \quad (3)$$

Where the slope coefficients βs are elasticities of output with respect to each factor of production.

Results

Our analysis covers the period from 1980-2019 for 103 countries. We focus our convergence analysis on two periods, 1980-2000 and 2000-2019. Our results reconfirm the findings of recent studies that poorer countries tend to grow faster than rich countries for the 2000-2019 period, which was absent in the period before. During the pre-convergence period (1980-2000), average per-capita energy consumption growth tended to be similar for both developing and developed countries. On the other hand, the period of 2000-2019 is associated with faster per-capita energy consumption in developing countries relative to developed countries.

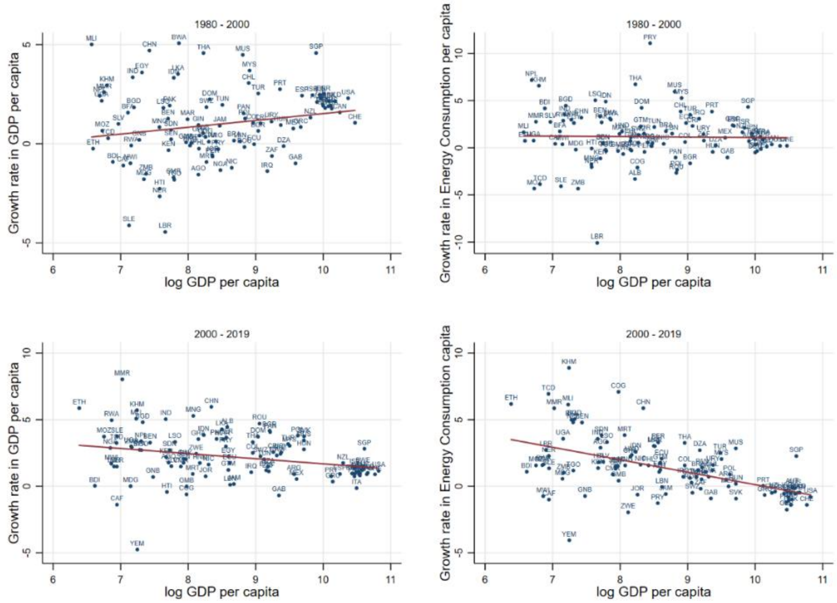

Figure 1: Scatter plots of 1) growth of income per capita on initial income (left) 2) growth of energy consumption per capita on initial income (right)

We also estimate the energy consumption elasticity of income. Table 1 shows the elasticities estimates for the total sample and income groups. On average, a 10 percent increase in energy consumption is associated with a 1.7 percent increase in GDP. Estimates by income group show that low-income countries have a higher elasticity than middle- and high-income countries.

Table 1: Regressions of GDP per capita on energy consumption per capita

	(1) All Countries	(2) Low Income	(3) Middle Income	(4) High Income
Energy (E)	0.17***	0.26***	0.08***	0.03
Capital stock (K)	0.49***	0.35***	0.55***	0.62***
Labor (L)	0.34***	0.42***	0.33***	0.68***
Constant	3.61***	4.45***	3.27***	1.98***
Obs.	4101	1031	2040	1030
R-squared	0.86	0.82	0.89	0.91

Note: All variables are in natural logarithms. The dependent variable is GDP (*Y*).
Standard errors are in parentheses *** p<0.01, ** p<0.05, * p<0.1

Conclusions

This paper emphasizes that the unconditional convergence observed in the last two decades is associated with higher growth of per-capita energy consumption of developing countries relative to rich ones. We also estimate the energy consumption elasticity of income and show that low-income countries have a higher elasticity than middle- and high-income countries. These findings demonstrate that energy access is imperative for developing countries to enable them to catch up to developed countries. The onset of COVID19 has accelerated the global climate agenda, and countries are speeding up the energy transition. However, transition efforts remain challenging due to constraints, lack of collective action, and coordination. As a result, consequences such as volatile energy prices and materials bottlenecks have ensued. If these trends continue, lower energy access will impede economic growth rates for many developing economies, which would undo decades of catching up and weaken policy action. It is critical to identify flexible options to transition without undermining the energy needs of low-income countries to grow their economies. The Circular Carbon Economy framework enables inclusive and smooth energy transition pathways to a sustainable and low carbon future, benefiting both developing and developed countries.

References

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