Energy and Economic Growth: The Stylized Facts

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What overall patterns, or stylized facts, characterize the relationship between economic growth and energy use both across countries and over time? Energy economists and economic historians have investigated these patterns, but existing research has either looked at how energy use and economic development vary across countries at one point in time – the cross-sectional dimension - or how they evolve over time in individual countries or groups of countries – the time dimension. Researchers have not linked these dimensions together despite their dependence on each other.

We investigate the links between the time and cross-sectional dimensions using two datasets and simple regression techniques. One of our datasets covers 99 countries from 1971 to 2010 using International Energy Agency and Penn World Table data. The other comprises historical data, extending back to as early as 1800, for the U.S., Canada, and a number of European and Latin American countries. These data were reconstructed in recent years by economic historians, including one of the authors of this paper - Mar Rubio. Though this second data source is more uncertain than the first, it can provide insights into the very long-run relationship between energy and economic development.

Our key finding from the first dataset, is that there has been a stable relationship between countries' GDP per capita and per capita energy use over the last 40 years. A 1% increase in income per capita is associated with a 0.7% increase in per capita energy use. This implies that energy intensity (energy use/GDP) is lower in richer countries, and, on average, a 1% increase in income per capita is associated with a 0.3% decrease in energy intensity. The relationship is also stable over the four decades. This means that the typical country only managed to reduce its energy intensity by increasing its income per capita. Our second main finding is that there has been convergence in energy intensity over time – energy intensity has tended to fall in countries with high intensities and has tended to rise in countries that had low energy intensity at the beginning of the period. Also, there is now less variation in energy intensity among countries at any given level of income. Though there has been some degree

of “decoupling” of energy and growth in some formerly energy intensive economies, including the United States and the United Kingdom, this has not been the common experience.

This picture is borne out in the second dataset too. For example, energy intensity appears to have declined the most in the United States, which was the most energy intensive economy in the 19th Century. On the other hand, energy intensity has been fairly stable in Spain, which was a very low energy intensity economy in the 19th Century.

There is also some evidence that the share of energy in costs declines over time. But this “stylized fact” is still more of a prediction than a proven regularity. As is well known, the quality of energy increases over time and with income as countries have transitioned from traditional biomass, to fossil fuels, to primary electricity over time. We also find that the energy/capital ratio, which is an alternative to energy intensity as an indicator of overall energy efficiency, behaves similarly to energy intensity.

Future theoretical models of the relationship between energy use and economic development will need to take these stylized facts into account and make sure that their predictions match the facts. The stylized facts might also be useful for developing simple business as usual energy use projections. Our findings also pose a challenge to ambitious policies that aim to reduce energy intensity at rates that are far faster than historical norms. Because energy intensity has improved far slower than the rate of economic growth, and energy use tends to increase with growth, ambitious energy efficiency policies will have to break this status quo in a dramatic way.