Energy Use and Economic Growth 1965 – 2012

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Abstract

Does energy use grow in tandem with GDP? Does it grow faster than GDP in poor than in rich countries? Does it grow more slowly relative to GDP as countries get richer? Has energy use grown more slowly as the price of oil has risen? The paper uses the BP Statistical Review of World Energy together with data on GDP from the World Bank to answer these questions. Given the strong link between energy use and economic growth, a further rise in the prosperity of nations will have to be sustained with increased use of energy. This is unlikely to be accommodated by renewable energy alone, and so we are unlikely to see a decline in the use of fossil energy.

Introduction

Economic growth and growth in the use of energy are closely related. Which causes which is a moot point; most of the things and even the services we produce require use of energy, but energy production gives rise to income which in turn results in demand for goods and services and, ultimately, for energy.

In this note we use energy and GDP statistics to investigate the said relationship. Does energy use increase one for one with growth in GDP? Is energy use more sensitive to GDP growth in poor than in rich countries? There is reason to believe this; poor but rapidly growing countries go through a process of industrialization where production of goods, which is typically energy intensive, takes precedence over provision of services, which are less energy intensive. If this is true, it should be reflected in a weakening of the relationship between growth in energy use and GDP growth as individual countries grow richer, and in a more rapid growth in energy use than in GDP in countries that are poor or only medium rich. Both of these will be investigated.

Energy has a price, and over time the price of energy, and in particular the price of oil, has risen substantially. This should have encouraged economizing on energy use, in particular the use of oil. The price of oil has an influence on the price of other forms of energy, in particular the price of natural gas, which is often indexed to the price of oil. This strengthens the negative influence one expects to find between the price of oil and the use of energy. We also investigate this by looking at whether a rising price of oil has weakened the relationship between the growth in energy use and GDP growth.

The Data

The data on primary energy are taken from the BP Statistical Review of World Energy 2013. They comprise commercial energy both from fossil fuels and renewable energy and are expressed in oil equivalents. The data series begins in 1965 and ends in 2012. Individual country data are not reported for many small, mainly developing countries. For GDP and GDP per capita we have used data from the World Bank, expressed in 2005 US dollars. We have omitted countries for which an unbroken record for the entire period 1965-2012 is not available, due to break up of countries (Pakistan and Bangladesh, Ethiopia and Eritrea, the Soviet Union) or unification (Germany). For three countries we have missing values for up to six years. Some countries are missing from the World Bank GDP-series. All in all we have data for 43 countries.

Analysis

We postulate the following relationship between the growth in energy use (Ge) and growth in GDP (Ggdp):

$$(1) \qquad G_e = a_o + a_1 G_{gdp} + a_2 GDPCAP + a_3 P$$

where GDPCAP is GDP per capita and P is the price of oil. We expect GDP to be less energy intensive the richer a country is, implying $a2 < 0$. We also expect energy use to become less sensitive to the GDP growth the higher is the price of oil (P), implying $a3 < 0$.

Our data covers 43 countries over 48 years (1965-2012), with twelve missing values divided among three countries. A regression for the entire panel gives the results shown in Table 1. All coefficients are significant and have the expected sign. The use of energy grows with GDP, but each percentage point of growth in GDP produces less than a percentage point of growth in energy use (a1 is significantly less than one, but greater than zero). The higher the GDP per capita or the higher the price of oil, the less sensitive is the growth in energy use to growth in GDP.

We shall not reproduce detailed results for all countries here, but the ones for the United States and Canada are illustrative (Table 2). In terms of signs of coef-

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GDP growth	GDP/capita	Price	Constant	R2
.5932005***	-8.52e-07***	-.0001989***	.0368004***	0.28
(.0280706)	(8.49e-08)	(.0000376)	(.002718)	

Table 1:Estimation of Equation (1) by ordinary linear regression for the entire sample.

	GDP growth	GDP/capita	Price	Constant	R2
United States	.7605614***	-2.17e-07	-.0003268**	.0121393	0.65
	(.1281457)	(3.41e-07)	(.0000971)	(.0118123)	
Canada	.60892***	-1.35e-06*	-.0000802	.0434096**	0.47
	(.1572832)	(5.61e-07)	(.0001179)	(.0161671)	

Table 2: Estimation of Equation (1) by ordinary linear regression for the United States and Canada.

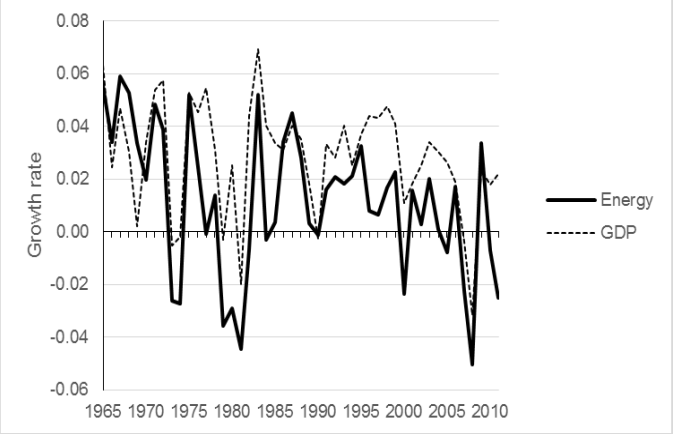

Figure 1: Growth rate of energy use and GDP in the United States 1965-2011.

ficients they are similar, but we see that for the US the effect of the price of oil on the growth in energy use is significant, but not the effect of GDP per capita, while for Canada it is the other way around. Most likely this is due to the correlation between GDP per capita and the price of oil; both have risen over time, so the effect of one gets confounded with the effect of the other (the correlation between the two is 0.4 for the US and 0.48 for Canada).

Figure 1 shows the rate of growth of energy use and GDP in the United States. Clearly they are closely related.

Summarizing the results for the individual countries, for most of them we get a significantly positive relationship between growth in energy use and GDP growth. For 14 countries a1 is not significantly different from zero, but only for only one country (Ecuador) do we get a negative (and insignificant) coefficient. For a2, the effect of GDP per capita on energy use, all but two significant coefficients are negative, the exceptions being Trinidad & Tobago and Venezuela. For a3, the effect of the price of oil on energy use, all but three significant coefficients are negative. The exceptions are Mexico, Ecuador and Algeria, all of which are oil producers, so the result is not altogether surprising; a substantial part of their GDP consists of oil production. Nevertheless we do not get this result for the other oil producing countries.

The countries with a greater growth in the use of energy tend to be the poorer ones; the dividing line is close to 20,000 USD (2005) per capita. China and India are two important exceptions; for both of these the growth in GDP outpaced the growth of energy use over the period 1965-2012. Other exceptions are Columbia, Chile and Hungary, in all of which GDP grew more than the use of energy. Belgium, Spain and Greece are the exceptions in the other direction; all are in the rich country league, with a greater growth in energy use than in GDP, but Greece is close to the dividing line of 20,000 USD. It is tempting to conclude that the use of energy rises faster than GDP in poor and medium rich countries going through the phase of industrialization, despite the results for India and China.

Conclusion

There is clearly a strong link between economic growth and energy use. It shows no signs of being "broken," but it seems to weaken somewhat as countries become richer, presumably because services are less energy intensive than manufacturing or commodity production. Nevertheless, this may be a chimera; what has happened over time is that manufacturing has been "outsourced" from rich countries to newly industrializing developing countries, China in particular. The loosening of the link between economic growth and energy use that we see occurring in rich countries is to some extent due this outsourcing (on an analysis of the UK economy, see Helm (2012)).

The implication is that further economic growth, and in particular further development of the still poor or only moderately rich countries of the world, will require a corresponding increase in the use of energy. Where is it going to come from? It is unlikely that it will come from wind and solar and certainly not from those alone; we are unlikely to be able to do without fossil fuels and even without an increase from those sources, with all the side effects this entails, if we want to maintain and raise the prosperity of all nations.

References

Chontanawat, Jaruwan, Lester C. Hunt and Richard Pierse (2008): "Does Energy Consumption Cause Economic Growth? Evidence from a Systematic Study of over 100 Countries". Journal of Policy Modeling 30:209-20.

Hannesson, Rögnvaldur (2002): "Energy Use and GDP Growth 1950 – 1997". OPEC Review 26:215-233.

Hannesson, Rögnvaldur (2009): "Energy and GDP Growth". International Journal of Energy Sector Management 3:157-170.

Helm, Dieter (2012): The Carbon Crunch. Yale University Press, New Haven.