REVISITING THE INCOME ELASTICITY OF ENERGY CONSUMPTION: AN OECD & NON-OECD COUNTRY PANEL ANALYSIS

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Overview

Estimating the relationship between economic development and energy demand and determining whether that relationship changes as levels of development change have been popular questions in energy economics (e.g., Judson et al. 1999; Medlock and Soligo 2001; and van Benthem and Romani 2009). The current paper contributes to the literature by assembling a wide panel dataset of energy consumption and prices for 50 OECD and non-OECD countries, employing estimation methods that address nonstationarity, heterogeneity, and cross-sectional dependence.

Data & Methods

Drawing from the International Energy Agency and some other sources (for price data) we assemble a panel dataset consisting of total final energy consumption per capita, real GDP per capita, and real energy price index. The dataset is particularly large considering the inclusion of country-specific energy prices—50 OECD and non-OECD countries. The unbalanced data spans 1960-2014, with the full 54 years of data for 17 countries and all countries having at least 14 years (e.g., 1995-2008).

We expect the data to exhibit both cross-sectional correlation and nonstationarity, and the relationships, possibly to be heterogeneous. At the same time, as mentioned above, the data is unbalanced and some cross-sections have relatively few time observations. Fixed effects estimation in OLS allows the analysis of variance overtime even when there are relatively few time observations. First differencing converts I(1) variables into stationary series. The mean group estimation approach addresses heterogeneity by first estimating cross-section specific regressions and then averaging those estimated cross-sectional coefficients to arrive at panel coefficients. The common correlated effects (CCE) approach accounts for both the presence of nonstationarity and unobserved common factors by including in the regression cross-sectional averages of the dependent and independent variables.

Hence, we employ several panel estimators and we partition the panel according to GDP and/or year. We estimate the following base equation:

$$ln\, TFC_{it} = \alpha_i + \beta_i^1 ln\, GDP_{it} + \beta_i^2 ln\, price_{it} + \varepsilon_{it} \qquad (1)$$

where subscripts *it* denote the *i*th cross-section and *t*th time period, *TFC* is total final energy consumption per capita, *GDP* is GDP per capita, and *price* is a measure of energy price, α is a cross-sectional specific constant, the βs are (potentially) cross-sectional specific coefficients to be estimated, and ε is the error term.

Results & Discussion

Table 1 reports the basic results for several different estimators. The GDP and price elasticities are always statically significant, have the expected signs (positive for GDP and negative for price), and are reasonably similar for all estimators. The GDP elasticity is always less than unity too. This result suggests that energy intensity (energy consumption/GDP) should decline with economic growth (in a BAU scenario). The residuals for fixed effects in levels are nonstationary. While the residuals for all other regressions are stationary, cross-sectional independence was rejected for each. However, cross-sectional dependence appears to be mitigated since the resulting mean correlation coefficient is considerably smaller compared to the fixed effects regression.

Table 1. Static models, 50 countries 1960-2014, unbalanced

	2-FE	FD-2W	MG-CCE	P-CCE	P-DOLS
GDP	0.772****	0.562****	0.478****	0.671****	0.639****
	[0.71 0.84]	[0.47 0.65]	[0.34 0.61]	[0.59 0.76]	[0.59 0.68]
Price	-0.182****	-0.076****	-0.191****	-0.088****	-0.391****
	[-0.21 -0.17]	[-0.11 -0.04]	[-0.29 -0.09]	[-0.13 -0.05]	[-0.46 -0.33]
Observations	1748	1697	1748	1748	1596
Root MSE	0.14	0.04	0.04	0.06	
CD (p) ρ	-4.2 (0.00) 0.53	-4.2 (0.00) 0.22	2.3 (0.02) 0.21	-3.2 (0.00) 0.28	14.9 (0.00) 0.33
CIPS	I(1)	I(0)	I(0)	I(0)	I(0)

Notes: 2-FE=fixed effects with time dummies; FD-2W=OLS with variables in first differences and cross-section and time dummies; MG-CCE=mean group common correlated effects; P-CCE=pooled (not MG) common correlated effects; P-DOLS=pooled dynamic OLS with one lead and one lag of each variable. **** indicates statistical significance at the 0.001 level. 95% confidence intervals in brackets.
Diagnostics: CD, (p), and ρ are the test statistic, corresponding p-value, and mean absolute correlation coefficient of the residuals from the Pesaran (2004) CD test, respectively. CIPS reports the order of integration of the residuals determined from the Pesaran (2007) CIPS test: I(0)=stationary.

In order to determine whether the income elasticity changed over-time or is different at different levels of development (i.e., GDP per capita), the sample was partitioned several times according to both time (e.g., 1970, 1980) and GDP level. Regressions using a pooled estimator typically did not produce significantly different elasticities for the different (according to time, GDP) panels. The only exception to those findings was when the pooled-DOLS estimator was used. In that case the income (GDP) elasticity was considerably/significantly smaller post-1985 than pre-1985.

Also, we allowed positive economic growth (first difference of GDP per capita) to impact energy consumption differently from negative economic growth. While the resulting coefficients were not identical, they were not statistically significantly different.

Before the Groningen meeting we will perform additional regressions/analysis. For example, we will collect more data, consider dynamic specifications, and further examine the possibility of different income elasticities over-time and across development levels.

References

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