***REVISITING THE LONG-RUN INCOME ELASTICITY OF ENERGY CONSUMPTION: AN 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 long, balanced panel dataset of energy consumption and prices for 17 OECD countries, employing state of the art methods that address nonstationarity, heterogeneity, and cross-sectional dependence, and considering several modeling approaches to nonlinearities beyond using polynomials of income. Ultimately, we find the income elasticity of energy consumption to be stable over-time, but perhaps, approximating an S-curve where at the highest levels of income the elasticity becomes statistically insignificant.

## Data, Model, & Methods

While including only 17 OECD countries, we assemble what is a relatively long (balanced) panel for energy consumption and price data spanning 1960-2014. (Those countries are Austria, Belgium, Canada, Denmark, France, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.) Several previous income-energy demand studies have considered (sometimes many) more countries, including some non-OECD ones; however, those studies have typically spanned merely 20-25 years. We collected from the International Energy Agency (IEA) data on real GDP per capita and total final energy, industry energy, and transport energy consumption, and on real price indices for overall energy, industry energy, and gasoline. (Data from Baade 1981 is used to extend IEA’s price series from 1971 to 1960.)

Like Medlock and Soligo (2001), we assume that energy consumption is a function of sector-specific energy prices, GDP per capita, and lagged energy consumption. Also, as in Medlock and Soligo we transform the variables by taking natural logs. We include country-specific constants and a common time trend to account for technical progress.

The mean group estimation approach address heterogeneity by first estimating cross-section specific regressions and then averaging those estimated cross-sectional coefficients to arrive at panel coefficients. Yet, the OECD countries are not independent and are likely to be linked by more than simply shared global shocks. The common correlated effects (CCE) approach accounts for the presence of unobserved common factors by including in the regression cross-sectional averages of the dependent and independent variables. However, the CCE estimator is not consistent in dynamic panels since the lagged dependent variable is no longer strictly exogenous. Chudik and Pesaran (2015) demonstrate that the estimator becomes consistent again when additional $\sqrt[3]{T}$ lags of the cross-sectional means are included. Hence, we employ the Dynamic Common Correlated Effects Estimator (DCCE) of Chudik and Pesaran (2015).

Rather than include polynomial transformations of GDP per capita, we examine the stability of the long-run income elasticity demand over-time by estimating the relationship at sequential time intervals of 25-30 years. In addition, we split the sample into income-based quartiles and estimate a pooled CCE regression for each of those quartiles.

## Results and Discussion

Figure 1 displays the long-run income elasticity of energy demand estimated at sequential 25 year-spans. The figure displays the 95% confidence intervals of those estimations as vertical bars. While there is variance in the estimation of the income elasticity, and even some instability (since the estimate is not significantly different from zero for two time spans), there is no evidence that the elasticity estimated from the later periods is significantly different from the elasticity estimated from the earliest periods (e.g., the 1960-1985 estimate is not significantly different from the 1990-2014 one).

Table 1 displays the results of the regressions run at the different income quartiles. The long-run income elasticity is similar for most income groups; however, at the highest quartile of income, the relationship between GDP per capita and energy consumption per capita is no longer significant (indeed, for this quartile, the coefficient for lagged energy consumption is not different from unity). The table suggests that the relationship between the income elasticity of energy demand and income level is similar to an elongated S-curve—a lower elasticity at lower income levels, followed by a fairly constant elasticity at most income levels, and a rather horizontal (i.e., no relationship) at the highest income levels.

Table 1. Income elasticity of energy demand at different income groups.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | GDP<19,250 | 19,250<GDP<26,600 | 26,600<GDP<35,600 | GDP>35,600 |
| Energy t-1 | 0.776\*\*\*\* | 0.415\*\*\* | 0.287\*\* | 0.990\*\*\*\* |
| GDP | 0.107\* | 0.485\*\* | 0.678\*\*\* | 0.017 |
| Price | -0.168\* | -0.357\*\*\*\* | -0.213\* | -0.040 |
| GDP, long-run | 0.479\*\*[0.092 0.866] | 0.828\*\*[0.096 1.560] | 0.951\*\*\*\*[0.467 1.436] | 1.655[-2.061 5.371] |
|  |  |  |  |  |
| Observations | 171 | 190 | 188 | 211 |

Notes: Statistical significance is indicated by: \*\*\*\* p <0.001, \*\*\* p <0.01, \*\* p <0.05, and \* p<0.10. 95% confidence intervals in brackets.

The results for transport energy consumption are mostly similar to the results for total final energy consumption. Yet, the results for industry energy consumption are quite different. For industry, the income elasticity is typically insignificant—both over time-spans and across income quartiles. Given both the variations within the industry sector across OECD countries and the structural changes that have occurred over time, perhaps the lack of a robust income-energy demand relationship is not surprising. The next phase of the project is to assemble a similar dataset for non-OECD countries to determine whether leap-frogging has occurred.

## References

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