Climbing the Energy Ladder: The Role of Economic Growth in Determining Energy Demand

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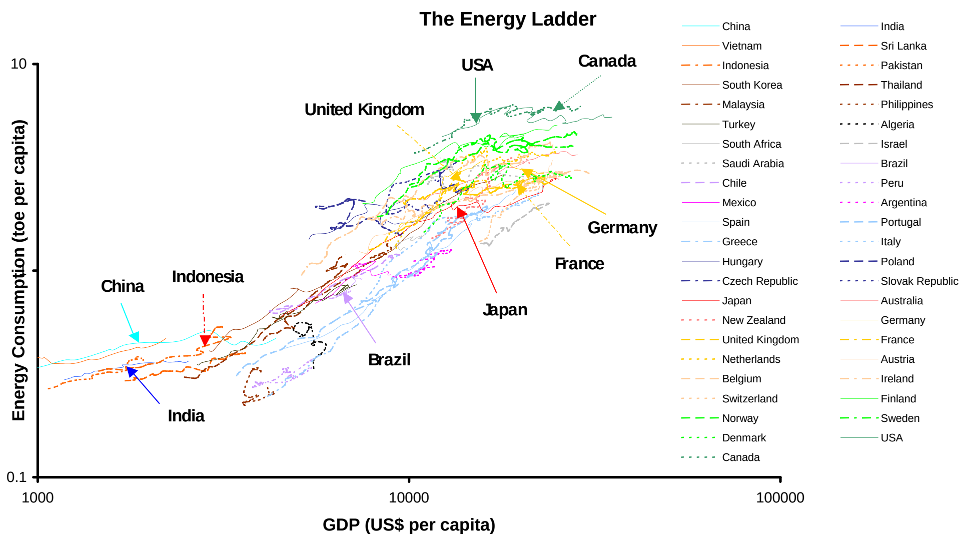
Introduction

The ‘energy ladder’ concept captures the idea that there is a systematic, nonlinear relationship between energy use and economic activity, illustrated in Figure 1 for the period 1960 - 2003. It exhibits a S-shaped relationship and provides evidence that countries across the world follow similar patterns as they climb the ladder (Galli, 1998; Judson et al, 1999; Medlock and Soligo, 2001). Despite these common patterns, there are important regional differences.

Figure 1: Per capita energy consumption versus GDP (1960 – 2003)



This paper presents an econometric panel data analysis to shed light on both the common elements of the energy to economic growth relationship, and the reasons for the discrepancies between countries.

Data and Methodology

We use data for 30 OECD countries and 19 non-OECD countries for the period 1978 – 2003 to estimate a fixed effects panel data regression equation:

$$(1) \qquad \ln\left(TFCPC_{ijt}\right) = \alpha_0 + \alpha_{0ij} + \alpha_1 \ln\left(GDPPC_{ijt}\right) + \alpha_2 \ln^2\left(GDPPC_{ijt}\right) + \alpha_3 \ln\left(DEP_{ijt}\right) + \varepsilon_{1ijt}$$

where *TFCPC* is per capita total final energy consumption, *GDPPC* is per capita GDP, *DEP* is an index of domestic end-use energy price. A squared per capita GDP term is included to allow for a non-monotonic relationship between energy consumption and GDP (Medlock and Soligo, 2001). The regression that aggregates across all non-OECD or OECD countries has trended error terms. A possible explanation is that the reduced form equation (1) cannot fully capture the effect of technological advances. Splitting the data in regions and/or sectors based on these error terms not only improves the error term behaviour, but also reveals that behind the common patterns lies a multitude of different experiences in different countries and sectors.

Main Results

Figure 2 plots the estimated income elasticities of energy demand for non-OECD countries (increasing dotted line), OECD countries (decreasing dotted line) and for 11 different countries/regions. It shows that the income elasticity reaches a maximum around a GDP of $8,000 - $13,000. Very poor countries start off with low elasticities, and elasticities for very rich countries converge to low levels as income increases. This provides evidence for the S-curve hypothesis. Besides the common S-curve patters, the graph reveals regional differences from the overall trend.

Figure 2: Income Elasticity per Region

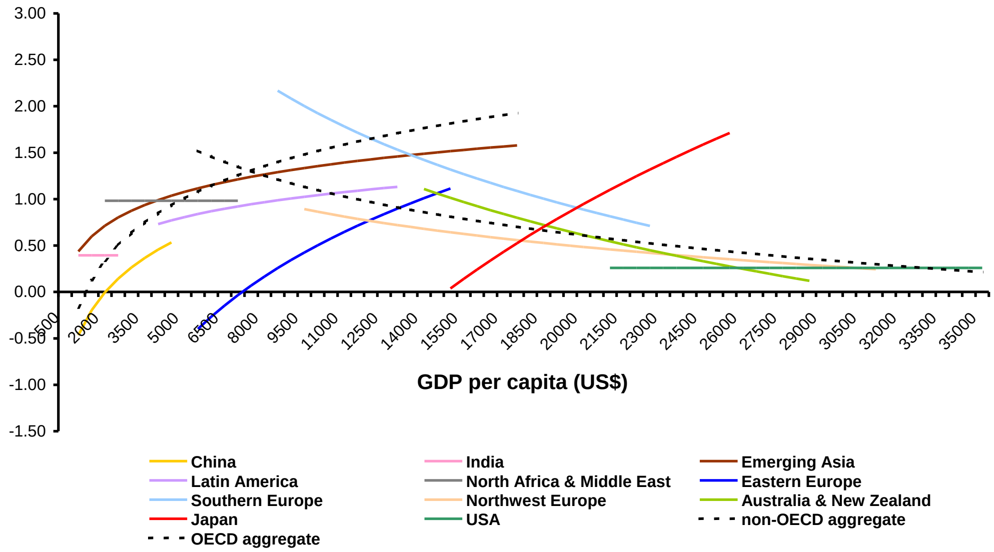
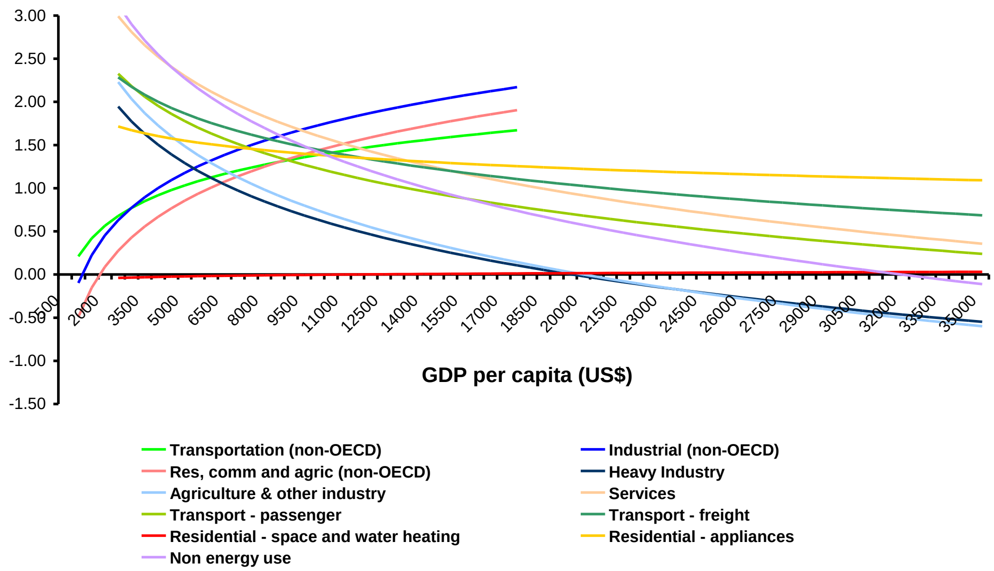


Figure 3 plots the income elasticities by sector, with a split for OECD vs. non-OECD countries. We observe additional evidence for the existence of the maximum around a GDP of $10,000. Interestingly, the OECD industrial sector's income elasticity declines sharply to negative levels, while "consumer choice" sectors (residential appliances and transport) have higher elasticities for higher income levels.

Figure 3: Income Elasticity per Sector (OECD vs. non-OECD)



Conclusions

By disaggregating the analysis to a regional and sector level this paper finds that, underneath some common patterns, countries and sectors have behaved in substantially different ways. This analysis provides for some important insights on future developments in emerging countries that have embarked on patterns of substantial economic growth.

References

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