Criticality of GDP measurement in energy modelling

R. Dean Foreman, Ph.D.
Chief Economist
American Petroleum Institute
(202)682-8530
ForemanR@api.org

1. Overview

To generate projections of global energy demand, energy modelling typically leverages main explanatory variables such as national GDP forecasts, income elasticity estimates, and anticipated energy efficiency improvements by end use sector. While extensive research has been done on elasticity estimation and efficiency-improving technologies, relatively less attention has been paid to the most basic input into most models – real GDP – and how its measurement affects the outcome.[1]

Aggregating and comparing economic output among countries requires that GDP data be converted onto a common basis, typically with global GDP expressed in U.S. dollars. The conversions can be based on observed market exchange (MER) rates or purchasing power parity (PPP) rates where, in the latter, corrections are made for relative price levels among countries (IPCC 2007). A central question in electing to use MER or PPP exchange rates is whether the correction for relative price levels helps to lessen distortions internationally and intertemporally when comparing GDP or the standard of living across economies (Lau 2004). Lau (2004) demonstrates that PPP exchange rates typically raise the measured GDP or low-income countries and lower those of high-income countries. Overall, the use of PPP instead of MER exchange rates tends to raise the level of global and regional GDP as well as the growth rates over time (Pant and Fisher 2007). When energy demand is projected using GDP as the main explanatory variable, the GDP conversions in international comparisons therefore can be particularly important due to three energy modelling conventions that are commonly employed in practice, including:

1) **Regional aggregation**, particularly among groups of emerging economies that individually are deemed not to be material (e.g., Other Asia Pacific);

2) **Adoption of cross-country or cross-sector analogues**, where elasticities and/or GDP growth rates may be assumed to be the same or follow similar trends; or,

3) **Simplified analytical approaches**, such as energy intensity ratio-driven modelling, where proper calibration may not be feasible due to sector data limitations among many emerging economies.

This note explores the energy modelling implications of GDP measurement under these three conventions. When used with PPP-based GDP, each convention can lead to biased projections of energy demand. When this occurs, energy modelers may attempt to compensate for the outcome by altering their conclusions about the extent of improvement in energy efficiency or intensity. This is particularly important because efficiency improvements and technology changes are traditionally estimated as a residual. Consequently, the conventions could affect expectations about energy efficiency gains, which in turn could influence energy investments and policies.

The key findings are as follows. MER-based income elasticities should be used when projecting energy demand from MER-based economic projections, and PPP-based income elasticities should be used when projecting energy demand from PPP-based economic projections. The consistency between the bases for the elasticities and the GDP assumptions may be more important than the choice of MER or PPP exchange rates.

Another key finding is that the income elasticities used in energy modeling should be based upon the region and end use sector being evaluated. If one projects demand for each country and sector before aggregating energy demand to regional or world totals, one should derive income elasticities for each country and sector. However, if one needs to aggregate some countries into a "residual" region, the income elasticities should be measured appropriately for the

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[1] Nordhaus (2007) offers an extensive treatment of alternative output measures in context with computable general equilibrium modeling. Newell et. al. (2018) and Newell (2015) offer thoughtful energy outlook comparisons by industry members. Kravis, Heston and Summers (1982) present a taxonomy of product and income measures.

group of countries and sectors. Finally, assumptions relating to aggregate energy efficiency at the economy level should be based initially upon understanding historical trends within each country or residual region under consideration. These trends can then be adjusted to incorporate new developments if necessary. Examples of new developments might include energy or environmental policies, increased efficiency, or structural market shifts versus past trends. But these additional assumptions need to be discussed and understood by all.

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