Criticality of GDP Measurement in Energy Modeling

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Objectives, scope and incentives

Objectives

➢ From a practitioner’s perspective, demonstrate the effects of using Purchasing Power Parity (PPP) GDP versus market exchange rate (MER) GDP to global energy modeling under three common conventions:
  ▪ Regional aggregation
  ▪ Adoption of cross-country or cross-sector analogues
  ▪ Analytical simplification via energy intensity ratios

Scope

➢ Elasticity-driven energy modeling, based on GDP and other structural variables
➢ Global modeling by country, fuel and end use sector
➢ Long-run annual projections

Incentives

➢ Provide guidance that can improve the quality, consistency and comparability of energy models that in turn may influence policies
PPP-based exchange rates result in a relatively larger global GDP and higher growth rates.

Global real GDP under alternative exchange rate bases

<table>
<thead>
<tr>
<th></th>
<th>Billion 2010 dollars</th>
<th>2018</th>
<th>2040</th>
<th>Avg. annual change 2018-2040</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MER</td>
<td>PPP</td>
<td>MER</td>
<td>PPP</td>
</tr>
<tr>
<td>Total OECD</td>
<td>51,203</td>
<td>50,334</td>
<td>72,140</td>
<td>72,177</td>
</tr>
<tr>
<td>Total Non-OECD</td>
<td>29,948</td>
<td>65,073</td>
<td>64,306</td>
<td>145,328</td>
</tr>
<tr>
<td>Total World</td>
<td>81,150</td>
<td>115,407</td>
<td>136,446</td>
<td>217,506</td>
</tr>
</tbody>
</table>

source: EIA IEO (2017)

Shares of the global economy by region

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td>2018</td>
<td>2040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total OECD</td>
<td>63%</td>
<td>44%</td>
<td>53%</td>
<td>33%</td>
</tr>
<tr>
<td>Total Non-OECD</td>
<td>37%</td>
<td>56%</td>
<td>47%</td>
<td>67%</td>
</tr>
<tr>
<td>Total World</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
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Background and basic model

Divergent opinions about PPP versus MER, depending on the context, for example:

- Nordhaus (2007) - environmental model applications

Example of a single-factor demand model

- If income were the only factor, next period’s demand changes based on the income elasticity ($\varepsilon_y$) and GDP, evaluated at PPP or MER-based foreign exchange (fx) rates

$$D_{t+1} = D_t + \varepsilon_y \cdot fx \cdot \%\Delta GDP \cdot fx$$

- The exchange rate basis should make no substantive difference if the income elasticity is properly calibrated to the data
Common conventions in practice that could bias energy projections or assumed efficiencies/energy intensity improvement

<table>
<thead>
<tr>
<th>Regional aggregation</th>
<th>Adoption of cross-country or cross-sector analogs</th>
<th>Analytical simplification via energy intensity ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model economies individually</td>
<td>Elasticities or GDP growth rates may be assumed to be the same or follow similar trends</td>
<td>Energy intensity ratio-driven modeling, where proper calibration may not be feasible due to sector data limitations among many emerging economies</td>
</tr>
<tr>
<td>Model aggregates of many emerging economies, e.g., Other Asia</td>
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</tbody>
</table>

**Implications**

- PPP biases estimated energy upwards, if elasticity not calibrated
- Will be biased, but direction depends on assumed elasticities
- Magnifies bias if combined with regional aggregation
- Will be biased, but direction depends on assumed pace of energy intensity improvement
1. Consistency between the bases for the elasticities and the GDP assumptions may be more important than the choice of MER or PPP exchange rates
   - Use MER-based income elasticities when projecting energy demand from MER-based economic projections
   - Use PPP-based income elasticities when projecting energy demand from PPP-based economic projections

2. Income elasticities used in energy modeling should be based upon the region and end use sector being evaluated
   - If one needs to aggregate some countries into a “residual” region, the income elasticities should be measured appropriately for the group of countries and sectors

3. 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
   - Trends can 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