

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

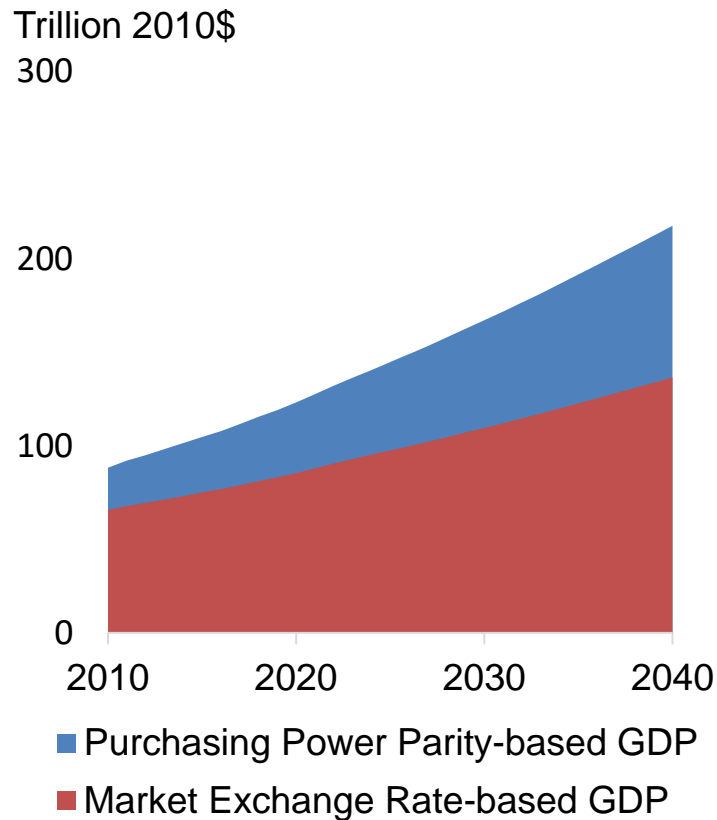
Incentives

- Provide guidance that can improve the quality, consistency and comparability of energy models that in turn may influence policies

Global real GDP based on PPP or MER exchange rates

- PPP-based exchange rates result in a relatively larger global GDP and higher growth rates

Global real GDP under alternative exchange rate bases



Billion 2010 dollars	2018		2040		Avg. annual change 2018-2040	
	MER	PPP	MER	PPP	MER	PPP
Total OECD	51,203	50,334	72,140	72,177	1.6%	1.7%
Total Non-OECD	29,948	65,073	64,306	145,328	3.5%	3.7%
Total World	81,150	115,407	136,446	217,506	2.4%	2.9%

source: EIA IEO (2017)

Shares of the global economy by region

Billion 2010 dollars	2018		2040	
Total OECD	63%	44%	53%	33%
Total Non-OECD	37%	56%	47%	67%
Total World	100%	100%	100%	100%

Background and basic model

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

- Lau (2004) – general economic model applications
- 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 (ϵ_y) and GDP, evaluated at PPP or MER-based foreign exchange (fx) rates

$$D_{t+1} = D_t + \epsilon_y^{fx} * \% \Delta GDP^{fx}$$

- 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

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

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

Conclusions

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