Incorporating (energy) poverty thresholds in IAMs

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Messages

• Energy demand pathways in IAM 2°C scenarios need ‘ground-truthing’
• Estimating energy for basic needs ‘bottom-up’ provides one such reality check
• Their comparison reveals expected growth inequality
In the SSPs, developing countries’ energy demand is below OECD at the same income level.

SSP: Shared Socioeconomic Pathways

CREDIT: B. van Ruijven
In a <2°C world, non-OECD energy demand stays almost flat...

In 2015: 35 GJ/cap

In 2050
In a <2°C world: 30-50 GJ/cap

Bauer et al. 2017
Messages

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• Estimating energy for basic needs ‘bottom-up’ provides one such reality check
• Their comparison reveals expected growth inequality
Energy requirements for “decent living standards” in India, Brazil and South Africa

• Universal standard, country-specific energy needs
  • Identical minimum nutrition, floor space, mobility
  • Different diets, construction methods, infrastructure

• Minimum energy needs to fill poverty gaps by 2030
  • With ‘development-first’ low-carbon options

• Comparison to national IAM SSP(1,2,4)-2.6 energy demand pathways

Rao et al., Nat. Energy, forthcoming
Compare IAM 2C scenarios to energy requirements for “decent living standards” in IND, BRA and ZAF

Rao et al., Nat. Energy, forthcoming
If countries were to provide for this minimum, what combinations of (energy) growth and inequality are implied by the IAM demand pathways?
More formally, we relate inequality, growth and minimum consumption

• For generalized income distribution $f_X(x)$
  • with mean $\mu_X$, Gini $G_X$

• Given a minimum threshold $D$

• Define growth as a scale-and-shift in $X$
  • giving $Z = kX + d$, where $d = D - k \cdot \min(X)$
  • with new mean $\mu_Z$ and Gini $G_Z$

• We can show that
  $$G_Z = \frac{k\mu_X}{k\mu_X + d} G_X = \frac{\mu_Z - d}{\mu_Z} G_X.$$
We can now examine this relationship empirically

• What rates of GDP growth are required in India to fill the DLS gap $d$ under two growth paths:

• Rising tide lifts all boats ($k \geq 1$, high growth, current inequality) $H$-Gr

• Redistributive growth ($k < 1$, modest growth, low inequality) $H$-Eq
India would require high sustained GDP growth rates to fill DLS gaps by 2030

SSP2 India GDP growth: 5.6%
Is unprecedented ‘equitable’ growth realistic?

• Gini is a slow-moving variable

<table>
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<tr>
<th>Country</th>
<th>Gini @ Year 0</th>
<th>Period</th>
<th>Avg ΔGini/decade (p.p)</th>
<th># of obs</th>
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</table>
Brazil and S. Africa don’t face the same challenge

Lines represent different population growth rates
Scenarios for achieving both DLS for all and meeting climate goals

• CDR technology saves all, even if energy demand exceeds expectations
• Demand-side technology (e.g. LED scenario) saves all, high activity levels beyond DLS
• Modest tech transfer, social transformation, less inequality
Further research for IAMs

• Interpret minimum thresholds for the SSPs
• Examine energy decoupling assumptions in developing countries

THANK YOU!

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Appendix

• Assume a generalized income distribution, $x$, with mean: $\mu$, cdf: $F(x)$ and its inverse: $Q(p))$

• Lorenz curve $L(r) = \frac{\int_0^r Q(p)}{\int_0^1 Q(p)=\mu}$

• For $\ddot{x} = kx + d$

\[
Q(\ddot{p}) = kQ(p) + d
\]
\[
\ddot{\mu} = k\mu + d
\]

Gives

\[
L(\ddot{r}) = \frac{1}{k\mu + d} (k\mu L(r) + d \cdot r)
\]

With Gini

\[
G = 1 - 2 \int_0^1 L(r)
\]

• We can show that

\[
\ddot{G} = \frac{k\mu}{k\mu + d} G = \frac{\ddot{\mu} - d}{\ddot{\mu}} G
\]