Macroeconomic rebound, Jevons' paradox, and economic development

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*(*Host office listed for identification purposes only. The opinions expressed herein are solely my own.)*

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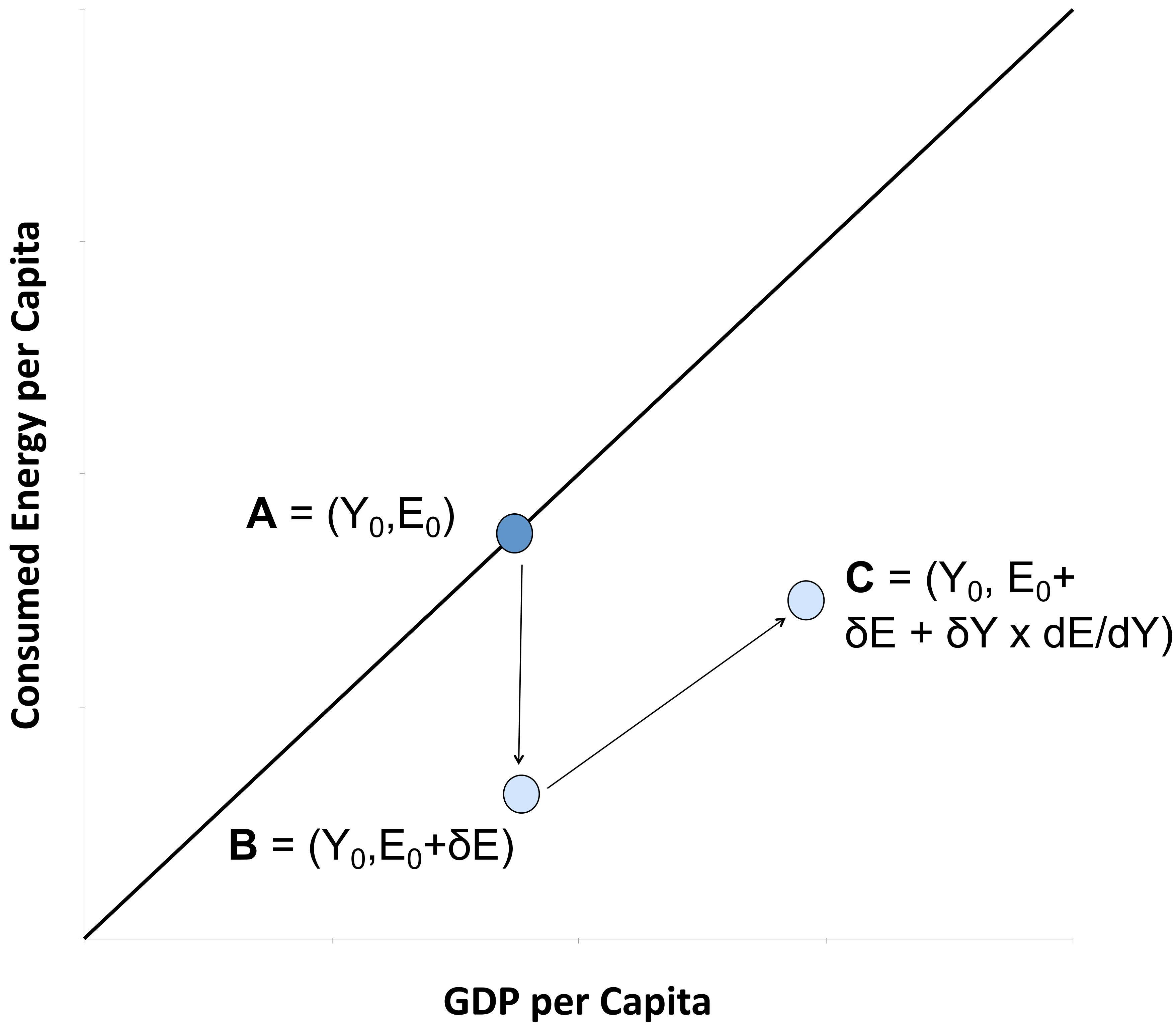
June 28, 2011

Introducing the macroeconomic rebound effect

By increasing GDP, energy efficiency measures “buy back” some of their energy savings. The *Jevons ‘paradox’* claims this buy back is large enough to cause a net increase in energy consumption.



A = initial condition

B = after EE policy, including direct rebound

C = after EE policy and macroeconomic rebound

William Stanley Jevons (1835-1882)

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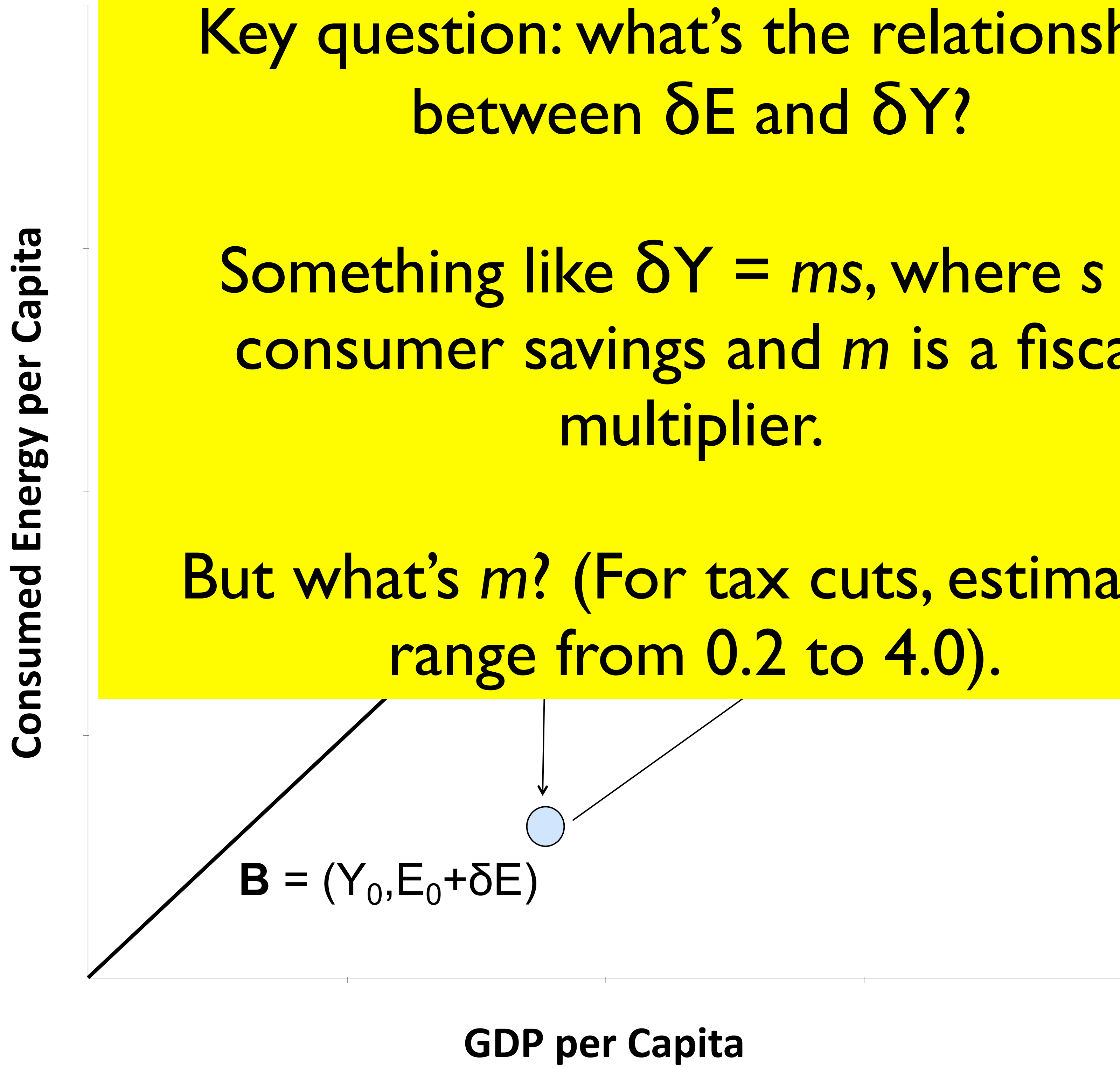

Key question: what’s the relationship between δE and δY?

Something like $\delta Y = ms$, where *s* is consumer savings and *m* is a fiscal multiplier.

But what’s *m*? (For tax cuts, estimates range from 0.2 to 4.0).

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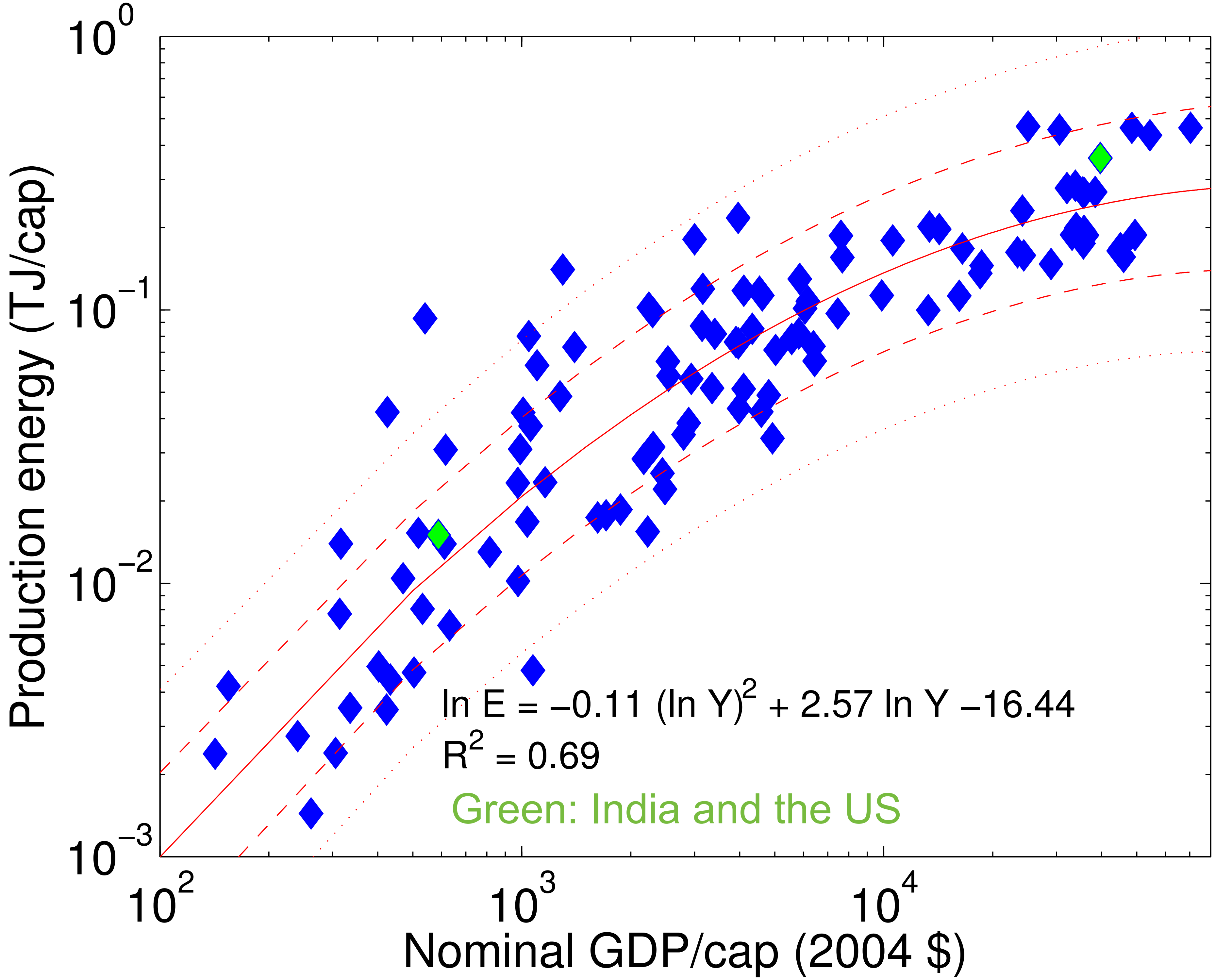
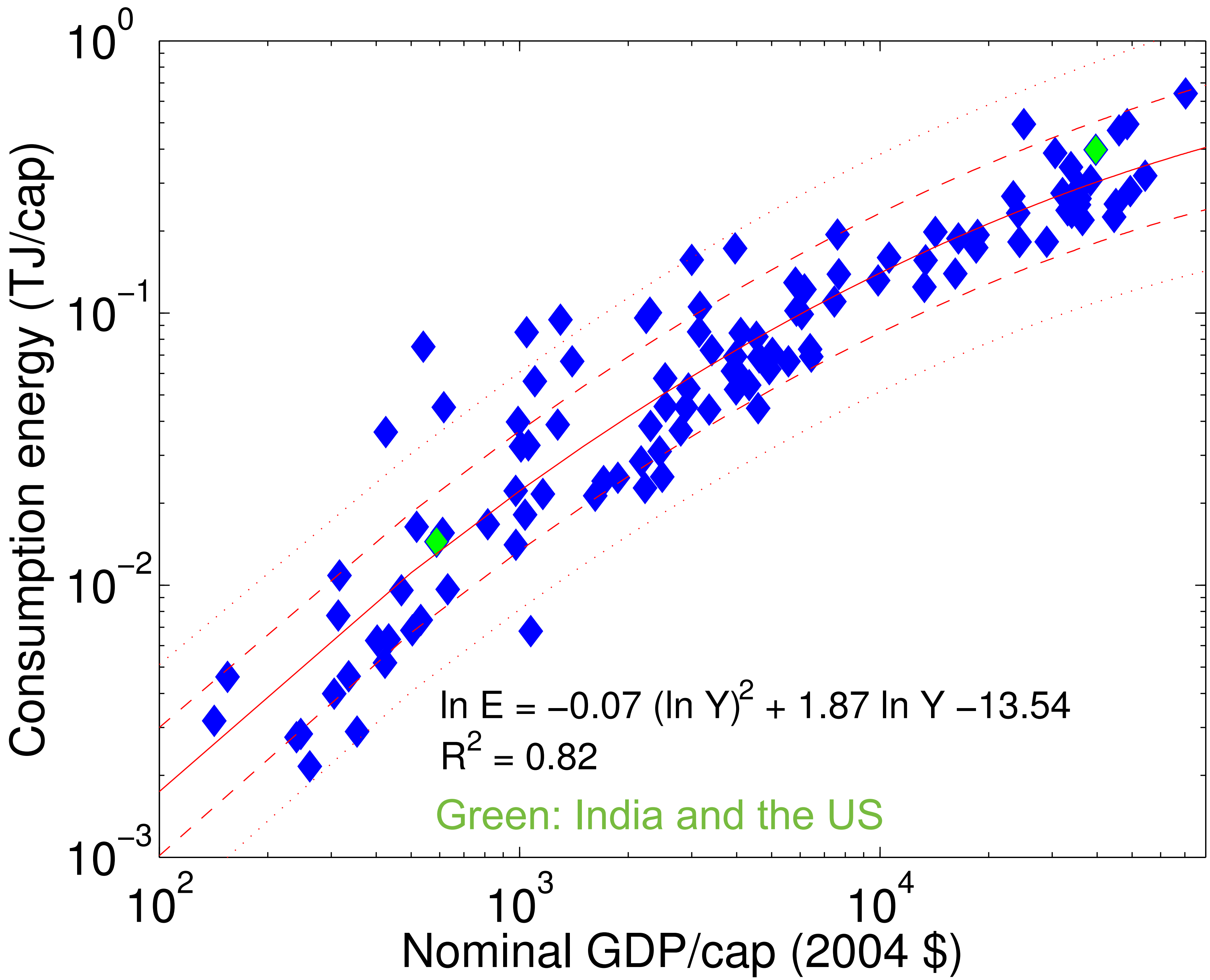
Examine the relationship between energy consumed per capita and GDP per capita

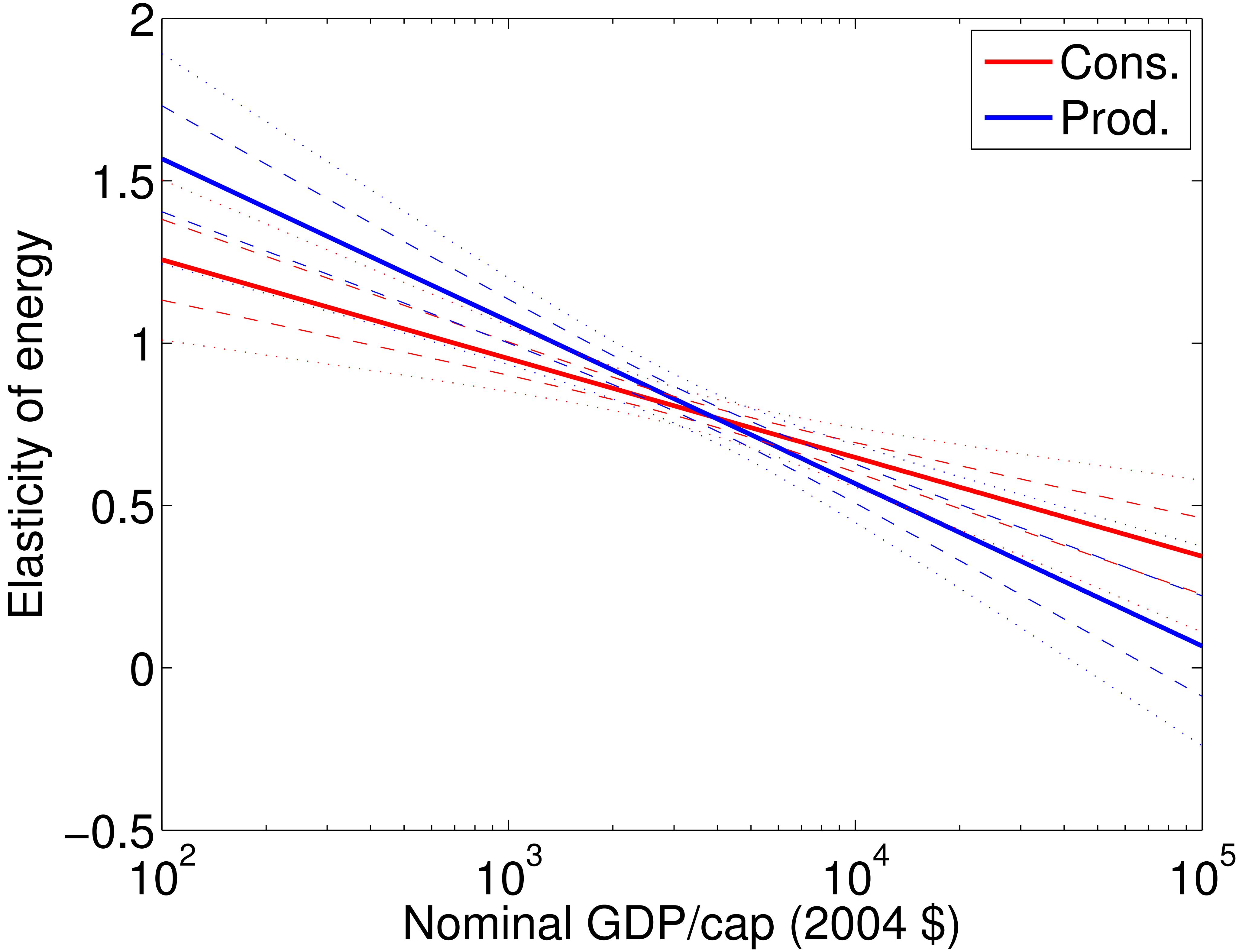


Examine the relationship between energy consumed per capita and GDP per capita

We draw upon Davis and Caldeira (2010)'s data set to correct for the effects of trade, improving the fit considerably.



Elasticity of consumption energy (β) as a function of wealth



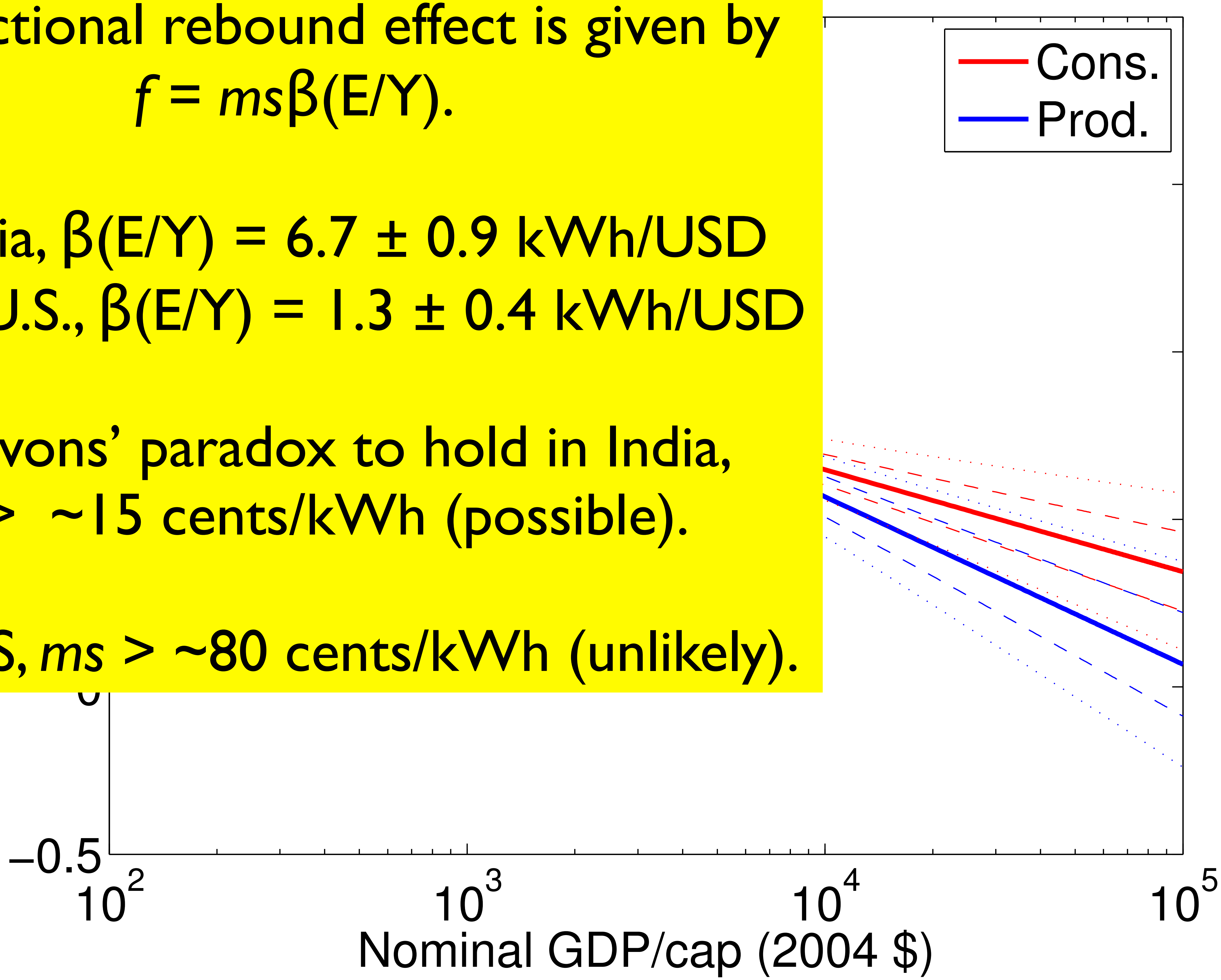
Elasticity of consumption energy (β) as a function of wealth

The fractional rebound effect is given by
$f = ms\beta(E/Y)$.

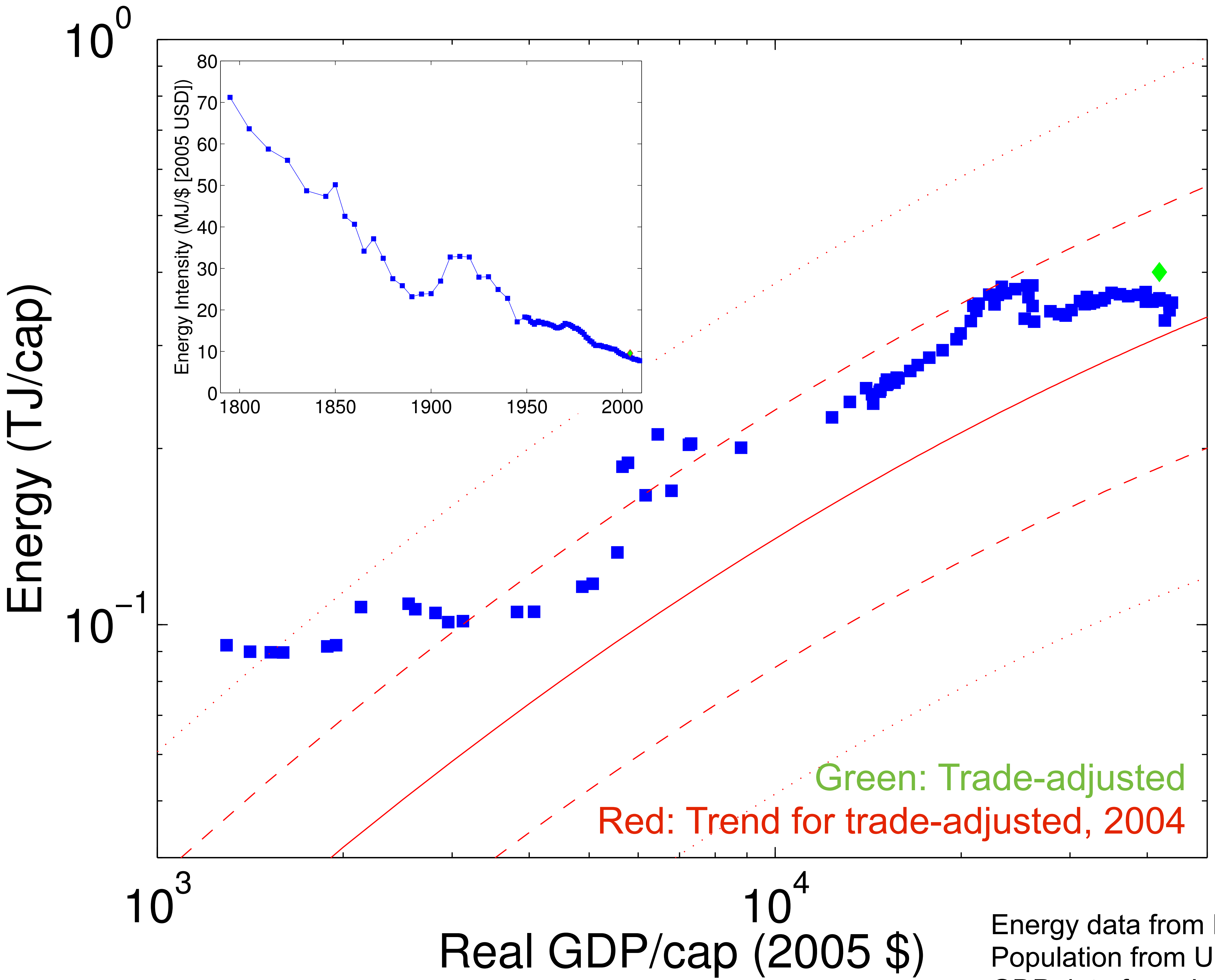
For India, $\beta(E/Y) = 6.7 \pm 0.9$ kWh/USD
For the U.S., $\beta(E/Y) = 1.3 \pm 0.4$ kWh/USD

For Jevons' paradox to hold in India,
ms > ~15 cents/kWh (possible).

In the US, *ms* > ~80 cents/kWh (unlikely).



Examine the relationship between energy consumed per capita and GDP per capita: Looking at historical data for the United States (1795-2009).



Energy data from EIA AEO 2010.
Population from US Census.
GDP data from Johnston & Williamson.

Consider India...

Figure 9: Business as Usual (BAU) Scenario 1 – Electricity Demand and Availability

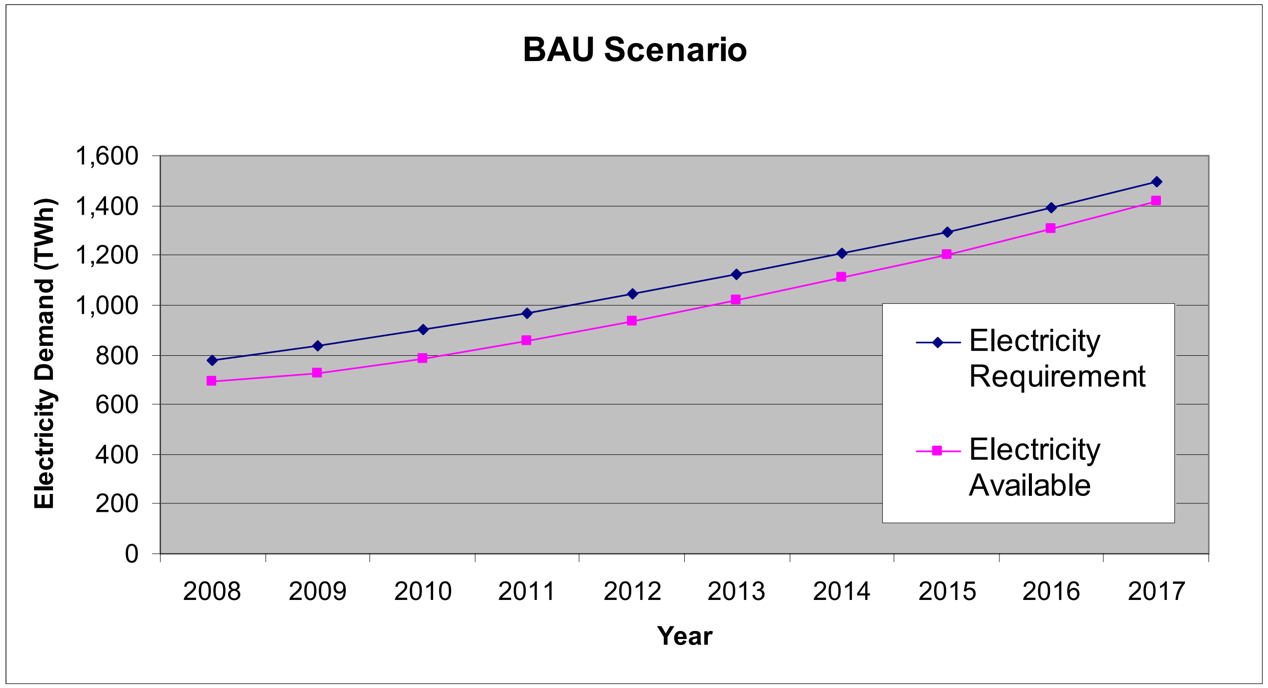
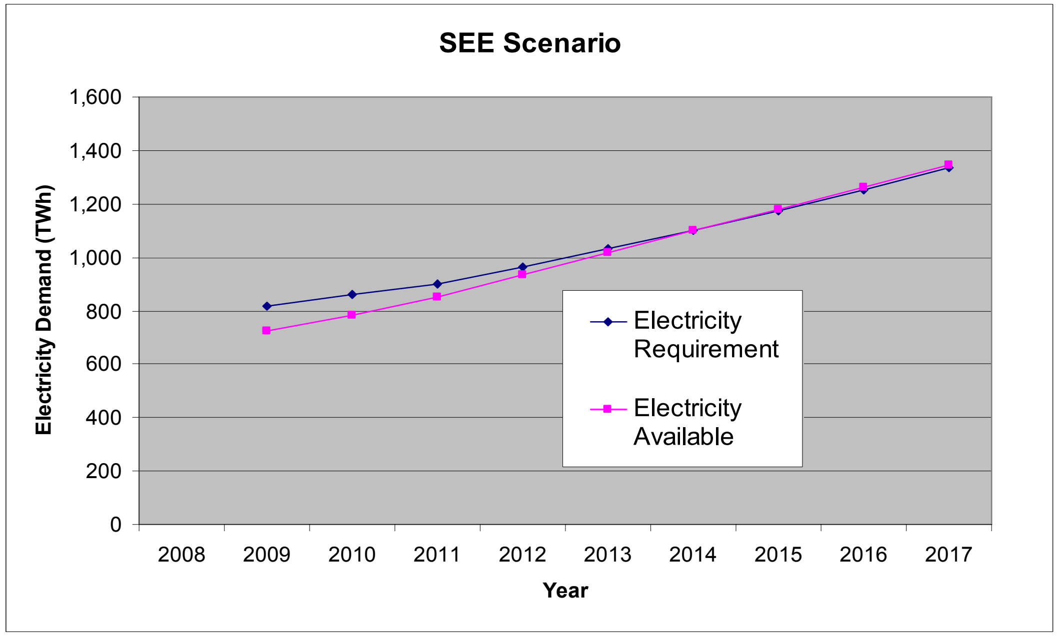


Table 7: Cumulative Benefits of SEE Scenario Compared to BAU Scenario

	2009-2017	2009-2020
Electricity Generation Savings (TWh)	81	411
Reduction in CO_2 Emissions (Million tons)	65	333
Reduction in SO_2 Emissions (Thous. tons)	410	2,100
Reduction in NO_x Emissions (Thous. tons)	410	2,100
Reduction in Fly Ash SPM Emissions (Thous. tons)	120	600
Imported Coal Savings (Million tons)	36	186
Operational Cost Savings (US $ Billions)	2.2	11.0
Increase in GDP (2007 US $ billions)$^{+}$	$505	$608

Note: +Values are based on an estimated 23% of C&LV-MV customers using self-generation and inverters in 2009 with the share increasing to 48% by 2020.

Figure 10: Supply with Energy Efficiency (SEE) Scenario 2– Electricity Demand and Availability



Sathaye & Gupta (2010)

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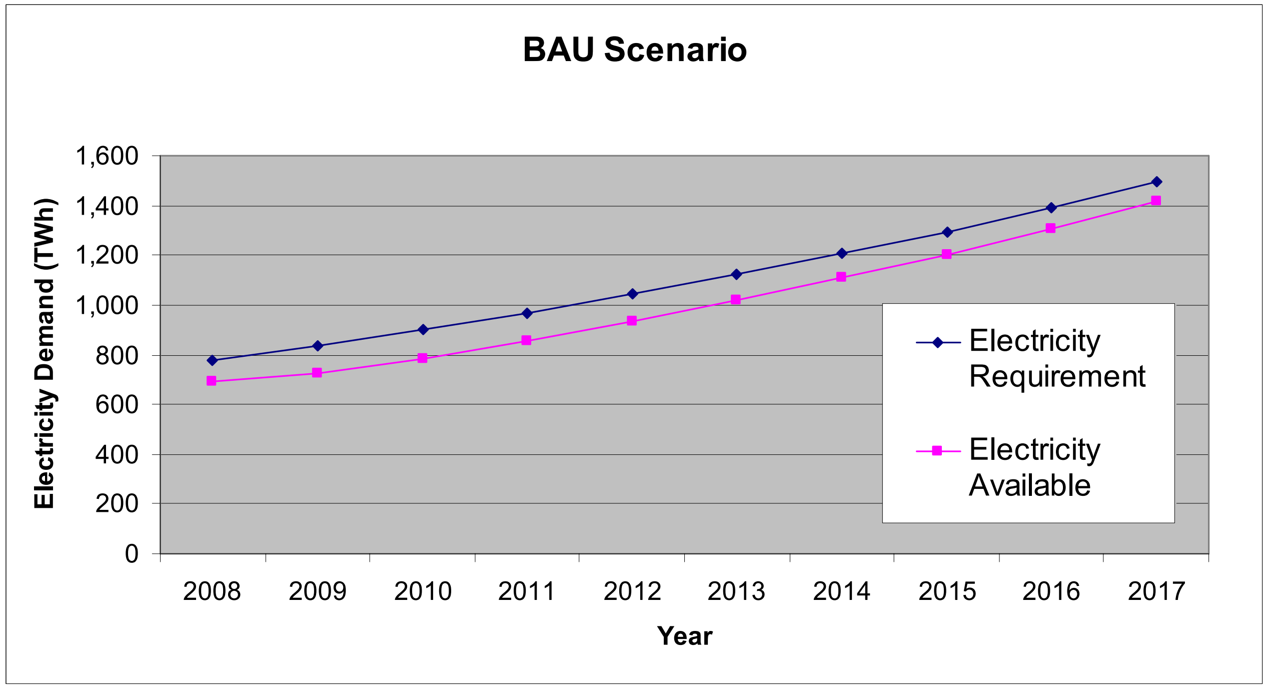

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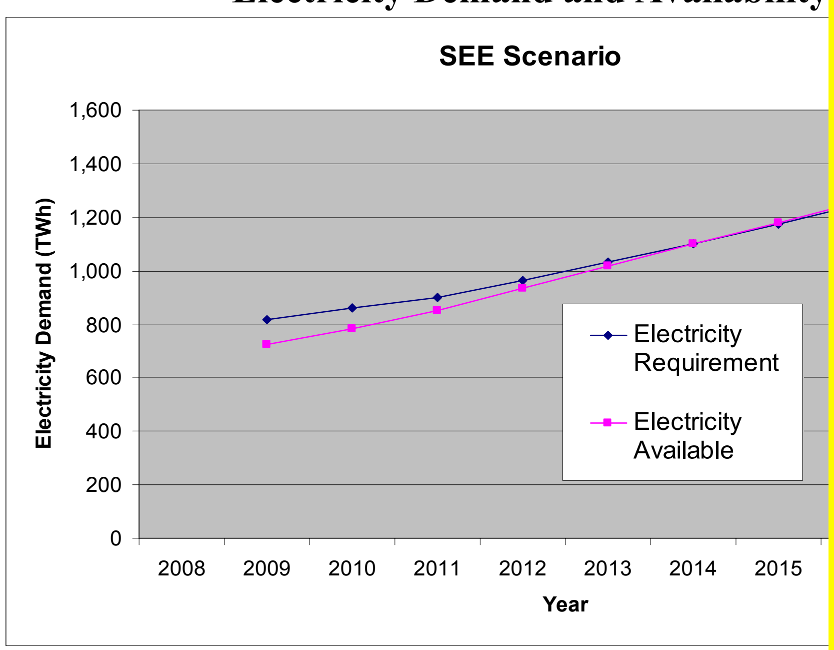

$505 billion GDP increase, electricity intensity of 0.5 kWh/$ leads to an electricity rebound of ~$250 billion -- three times larger than the nominal savings.

(Of course, rebound will prevent the full GDP effect from being realized.)

Sathaye & Gupta (2010)

Consider China...

The Standard 英文虎報 — Hong Kong's biggest circulation English daily

28 February 2011

"During the 12th five-year plan, we have set our economic growth at 7 percent [a year]," Wen said yesterday at an online forum ahead of the National People's Congress and the Chinese People's Political Consultative Conference plenary sessions.

This is because the government will focus on improving the quality of economic growth and benefits and use the results of development on people's livelihood, he added.

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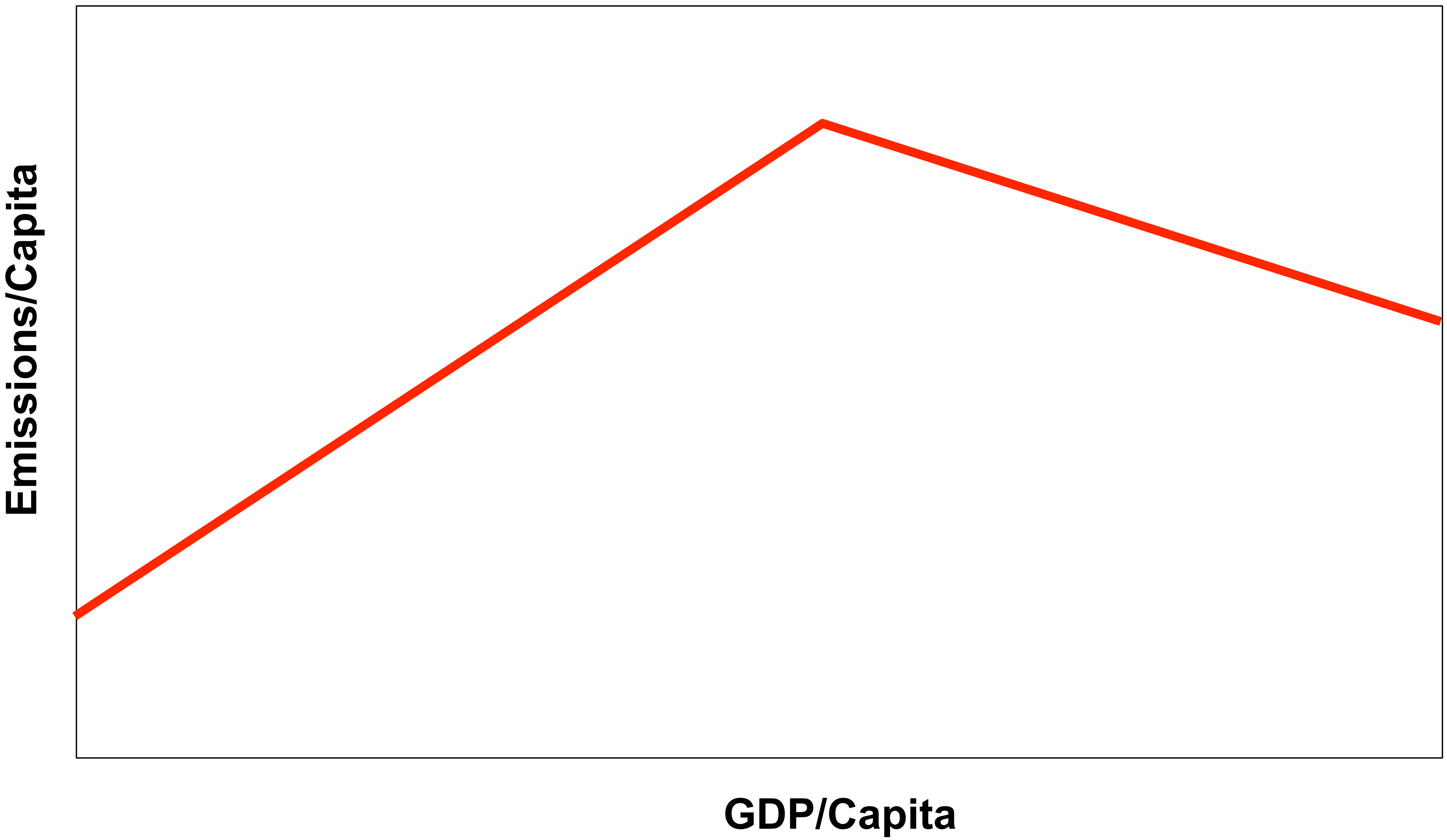
So where's the capital going instead? Need to consider when thinking about rebound...

A final thought: Is mitigative capacity a function of wealth?

(Do carbon dioxide emissions follow a Kuznets curve?)



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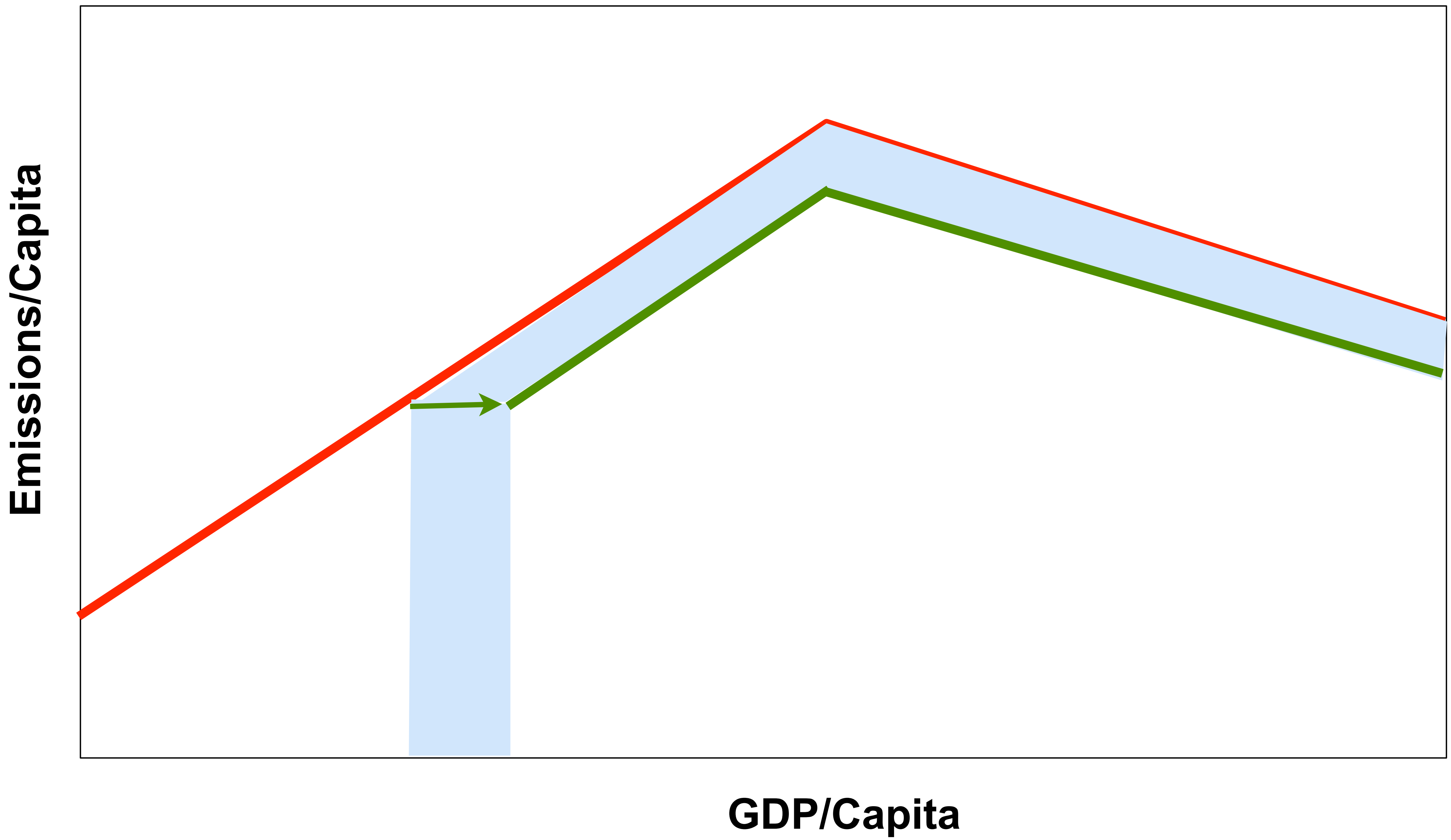

Then even with a strong rebound effect, energy efficiency measures will cause a net reduction in long-term cumulative carbon dioxide emissions.

Under what conditions should Jevons 'paradox' hold?

Let

E = energy of consumption per capita

Y = GDP per capita

δE = energy per capita saved by EE measure (net of direct rebound)

δY = GDP per capita increase from EE measure

k = the net cost of conserved energy ($k < 0$), in units of dollars per energy

m = macroeconomic multiplier associated with k

ΔE = energy per capita saved by EE measure (net of direct and macroeconomic rebound)

By construction

$$\delta Y = k\, m\, \delta E$$

$$\Delta E = \delta E + \delta Y\, (\mathrm{d}E/\mathrm{d}Y)$$

So

$$\Delta E = \delta E\, (1 + k\, m\, (\mathrm{d}E/\mathrm{d}Y)\,)$$

The fractional magnitude f of the macroeconomic rebound effect is given by

$$f = -\, k\, m\, (\mathrm{d}E/\mathrm{d}Y)$$

and the Jevons paradox holds if $f > 1$.

Note that if $E = \alpha Y^{\beta}$, then $\mathrm{d}E/\mathrm{d}Y = \beta(E/Y)$, and so

$$f = -k\, m\, \beta\, (E/Y).$$