Carbon Emissions and the Real Exchange Rate

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Motivation

- Huge literature on the determinants of CO_2 emissions
- Almost no work on the impact of exchange rate policy on climate issues, including CO_2 emissions
- Exception: our 2008 *JDE* paper on tropical deforestation: Depreciation of the REER in developing countries increases deforestation
- Strange: is it even reasonable to think that the relative price of tradables versus non-tradables has no effect on emissions?
- Even stranger for developing countries, who of course are not the main emitters

Hypothesis

REER depreciations will significantly increase CO_2 emissions, with a marginal effect that decreases with the level of development

Main empirical take-aways

- For developing countries (GDP per capita < $US 13,000) REER depreciation very significantly increases CO_2 emissions: 60% of observations
- The REER elasticity of CO_2 emissions is equal to -0.236
- Effect only becomes positive for GDP per capita > $US 79,000: 2% of sample

A Mickey Mouse model

- T: tradables, N: non-tradables
- Y: GDP, y : GDP per capita
- R= REER: proxy for relative price of non-tradables
- R^*: long-run equilibrium exchange rate
- $\widetilde{R}$: over- or under-valuation
- $R = R^* + \widetilde{R}$
- Carbon intensity of each sector: $c_T > c_N$
- Share of each sector in GDP: s_T and $s_N = 1 - s_T$

Total emissions: $C = [c_T s_T + c_N(1 - s_T)]Y = [(c_T - c_N)s_T + c_N]Y$

Testable hypotheses

Standard assumption: share of tradables in GDP is decreasing in R: $\frac{\partial s_T}{\partial R} \leqslant 0$

First testable hypothesis:

$$\frac{\partial C}{\partial R} = (c_T - c_N)\frac{\partial s_T}{\partial R} \leqslant 0$$

Effect of GDP per capita

Second assumption: $\frac{\partial(c_T - c_N)}{\partial y} \leqslant 0, \lim_{R\to\infty} \frac{\partial(c_T - c_N)}{\partial R} = 0$

Second testable hypothesis:

$$\frac{\partial C}{\partial y} = s_T \frac{\partial(c_T - c_N)}{\partial y} \leqslant 0$$

Third testable hypothesis:

$$\frac{\partial^2 C}{\partial y \partial R} = \frac{\partial(c_T - c_N)}{\partial y} \frac{\partial s_T}{\partial R} \geqslant 0$$

Bias is our friend…

- Should be estimating with $\widetilde{R}$, observe R instead
- The coefficient we should be estimating in a linear regression model is

$$\frac{\partial C}{\partial \widetilde{R}}$$

- 1st-order Taylor expansion: $\frac{\partial C}{\partial \widetilde{R}}(R - R^*) \approx \frac{\partial C}{\partial R} R$

$$\frac{\frac{\partial C}{\partial \widetilde{R}} - \frac{\partial C}{\partial R}}{\frac{\partial C}{\partial \widetilde{R}}} \approx \frac{R^*}{R}$$

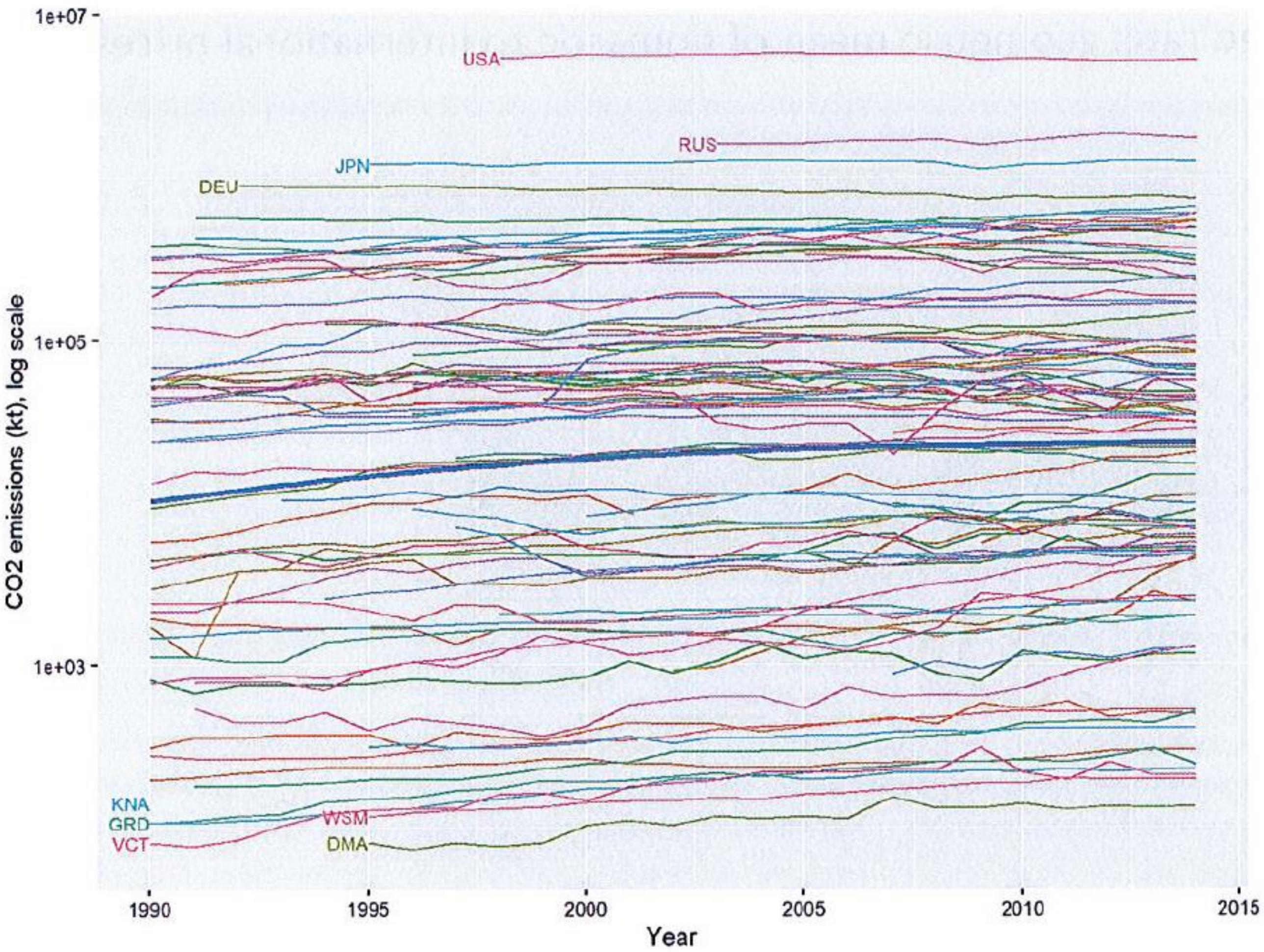
- So difference between theoretical and estimated coefficients will increasing in the LR equilibrium exchange rate, which is increasing in y
- Balassa-Samuelson effect is therefore picked up by $\frac{\partial C}{\partial R}$

The sample

- CO_2 emissions in kt
- Manufacturing value added in constant 2010 US$
- Forest cover sq. km
- GDP in constant 2010 US dollars
- REER: index where 2010 = 100

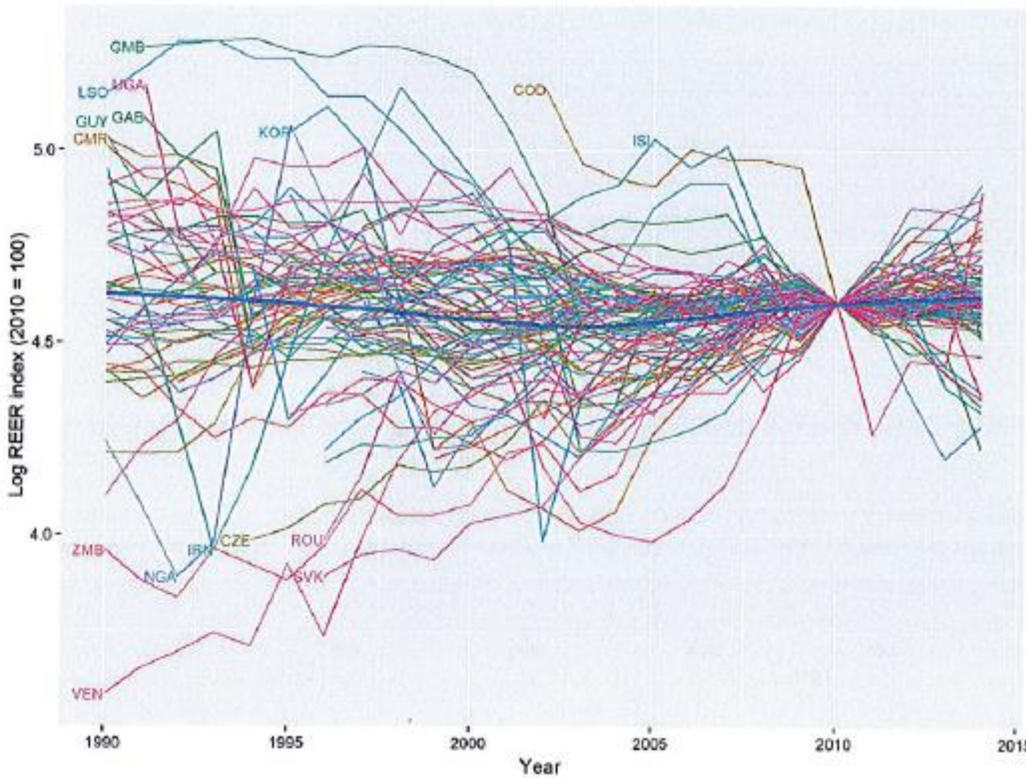
There are 88 countries in the dataset, each observed for an average of 21 years, for a total of 1840 country-years (observations)

Total carbon emissions

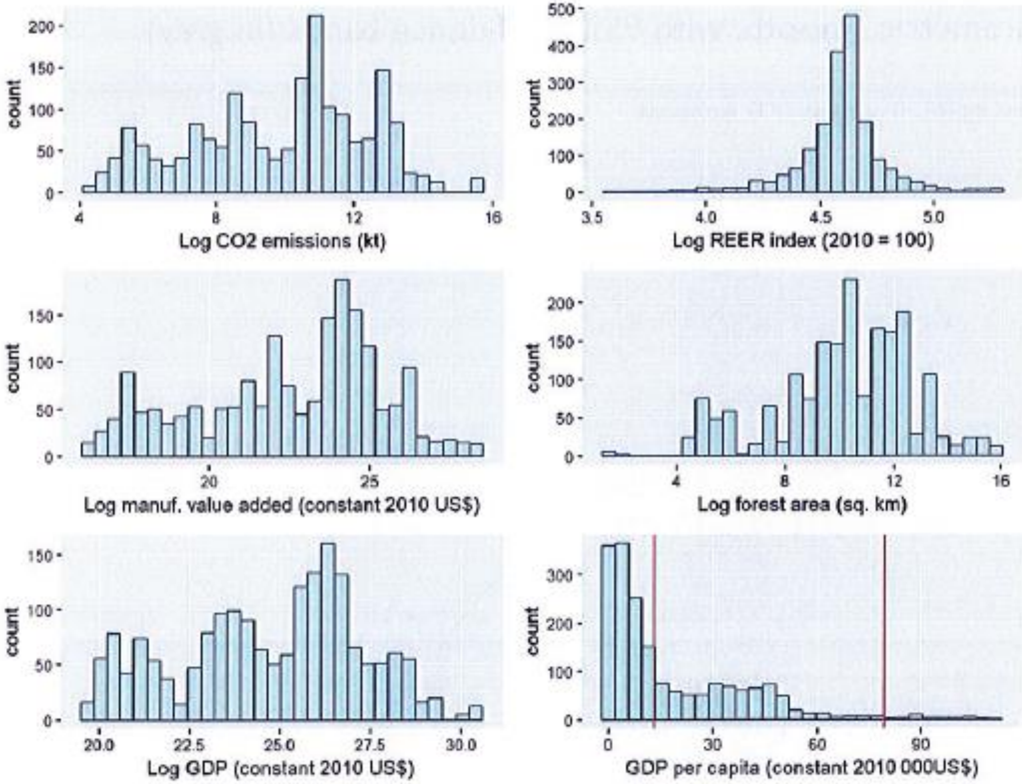


The REER

Real effective exchange rate: geometric mean of domestic to international prices

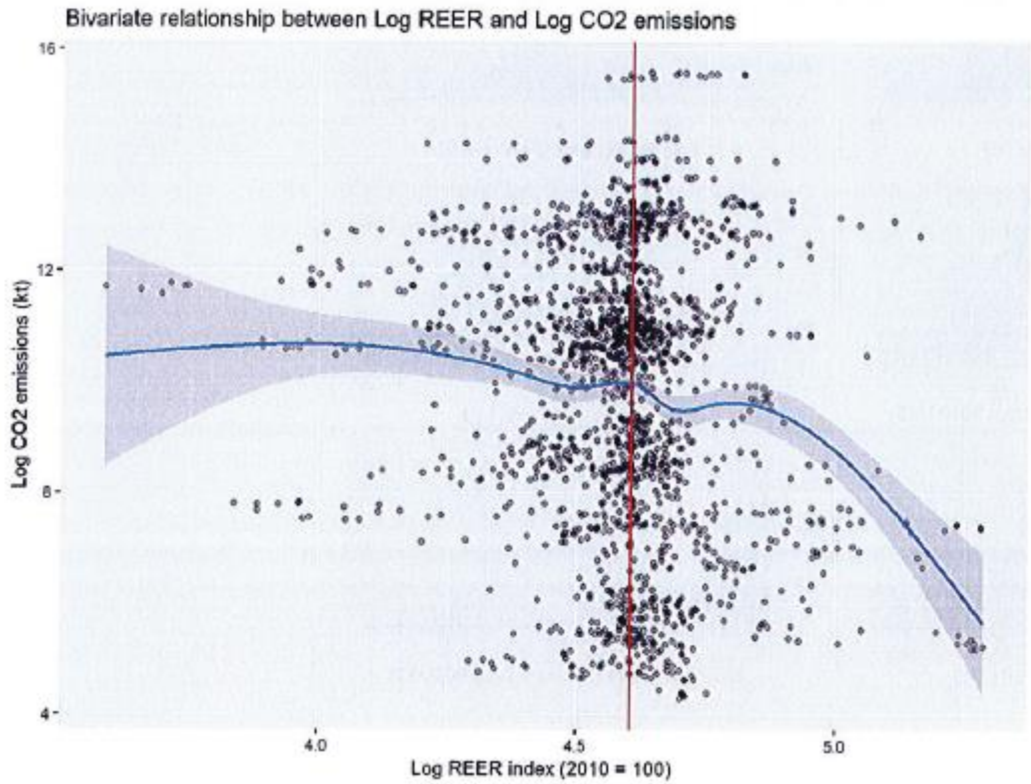


Descriptive statistics



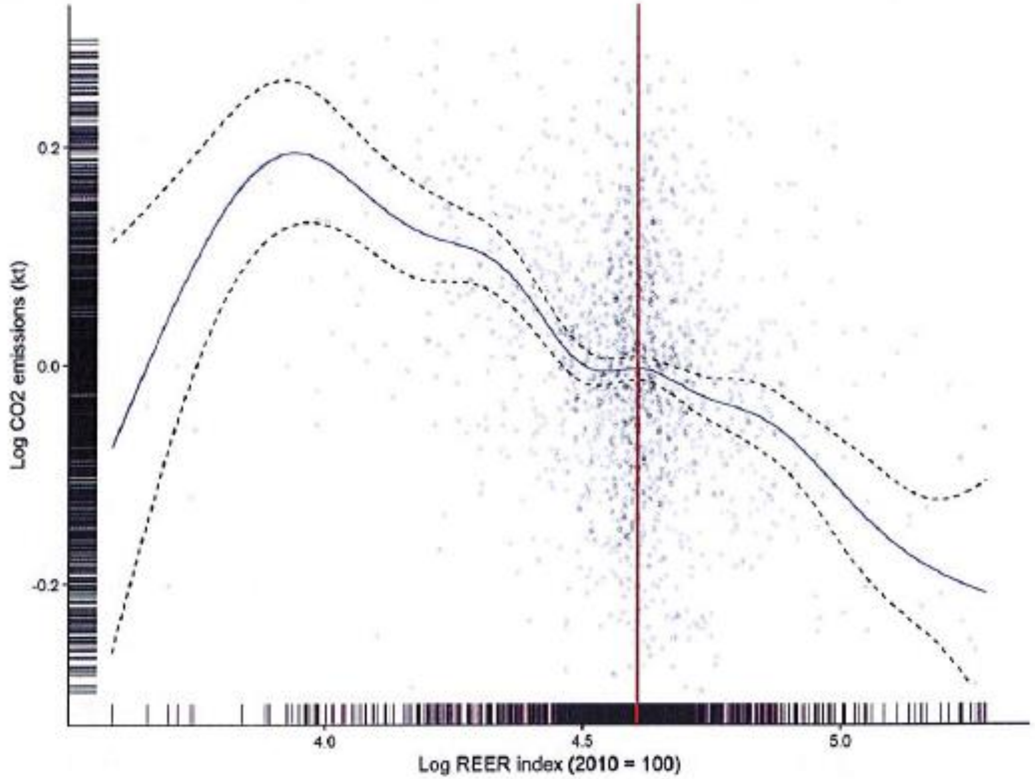
Log REER and CO2 emissions

Blue curve is a non-parametric smooth, with 95% confidence bands (in grey)



Semiparametrics

$$CO2_{it} = X_{it}\alpha + f(REER_{it}) + \lambda_i + \theta_t + \epsilon_{it}$$



Linear approximation

Clustering at country level

	(1)	(2)	(3)	(4)	(5)
Log REER index (2010=100)	-0.236 **	-0.248 ***		-0.274 **	-0.274 **
	(0.076)	(0.074)		(0.093)	(0.098)
Log REER * I[REER>60]			-0.244 ***		
			(0.071)		
Log REER * I[REER<60]			0.334		
			(0.396)		
GDP/cap (2010 000US$)				-0.072 **	-0.077 **
				(0.023)	(0.024)
Log REER * GDP/cap				0.011 *	0.011 *
				(0.004)	(0.005)
Log GDP (2010 US$)	0.894 ***	0.969 ***	0.905 ***	0.926 ***	0.973 ***
	(0.146)	(0.147)	(0.145)	(0.108)	(0.119)
Log forest area (sq. km)	-0.489 ***	-0.495 ***	-0.485 ***	-0.361 **	
	(0.147)	(0.150)	(0.147)	(0.131)	
Log man. val. add. (2010 US$)		-0.095			
		(0.060)			
N	1840	1840	1840	1840	1840
R2	0.997	0.997	0.997	0.997	0.997

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Comments

Column (1)

- A one percent increase in the REER decreases CO_2 emissions by 0.236 percent
- A one percent increase in forest cover decreases CO_2 emissions by 0.489 percent
- A one percent increase in GDP increases CO_2 emissions by 0.894 percent

Column (2)

- Size of the manufacturing sector has no impact on CO_2 emissions

Spline specification

Column (3): marginal effect of REER different above and below threshold of 60

$$CO2_{it} = REER_{it} \times 1[REER_{it} < 60]\beta_1 + REER_{it} \times 1[REER_{it} > 60]\beta_2$$
$$+ 1([REER_{it} < 60]\gamma_1 + 1([REER_{it} > 60]\gamma_2 + X_{it}\alpha + \lambda_i + \theta_t + \epsilon_{it},$$

- Marginal effect of REER on CO2 emissions = 0 when REER < 60
- For REER > 60, marginal effect is negative and estimated very precisely

Spline specification: column (3)

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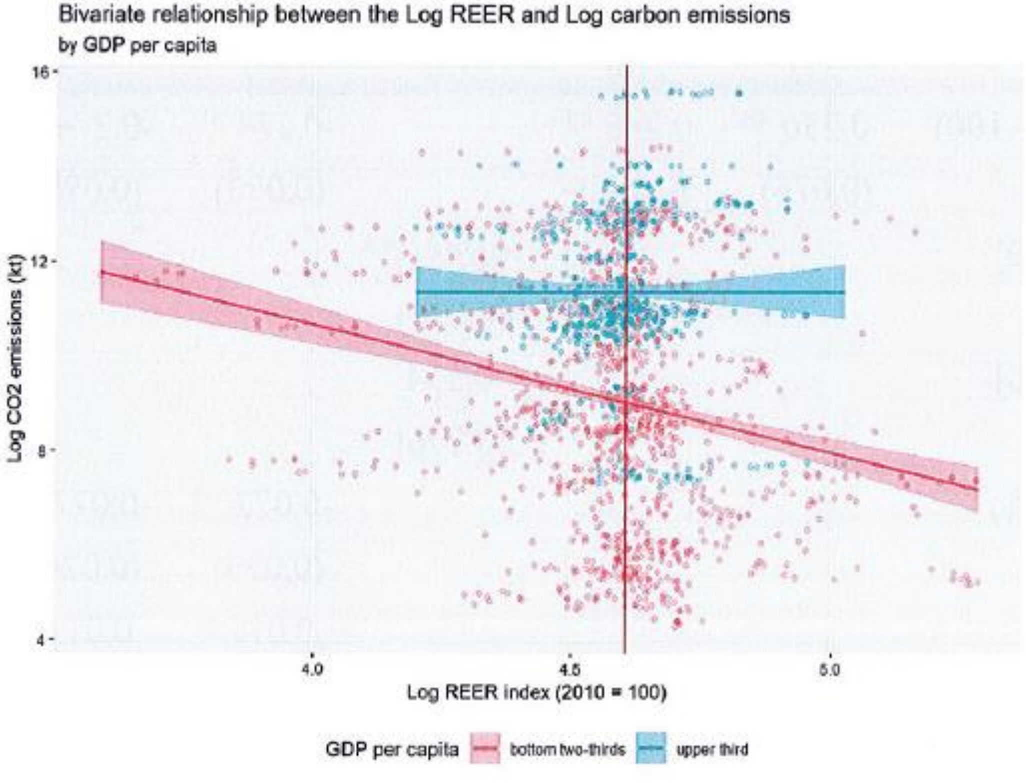
Varying marginal effect of REER?



Varying marginal effect of REER: column (4)

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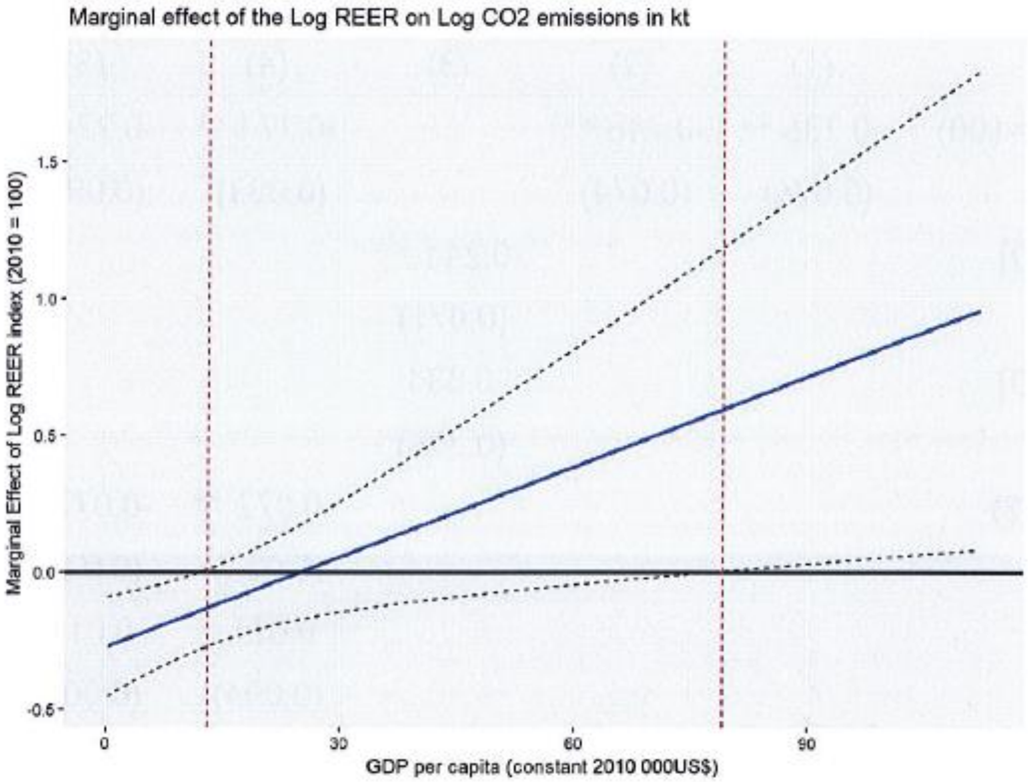
Marginal effect REER on CO2 emissions, as function of GDP / cap



- 60.3 percent of obs. < 13k, 1.7 percent of obs. > 79k

Marginal effect of GDP per capita