Australian National University

Modeling the Emissions-Income Relationship Using Long-Run Growth Rates

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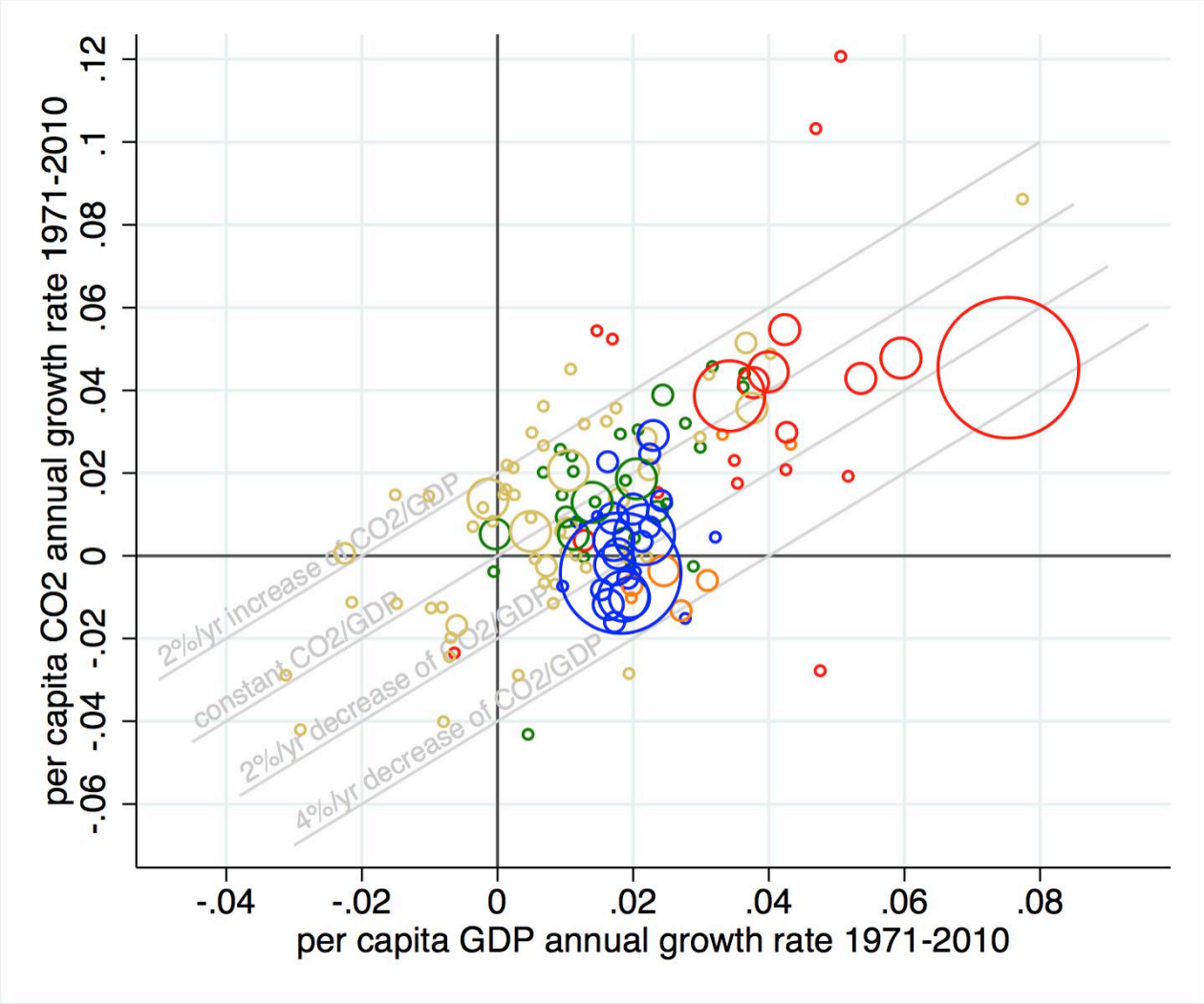
Carbon Emissions & Economic Growth



Alternative Models:

- IPAT
- Environmental Kuznets Curve
- Convergence/Green Solow Model

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- IPAT:

  Impact ≡ Population x Affluence x Technology

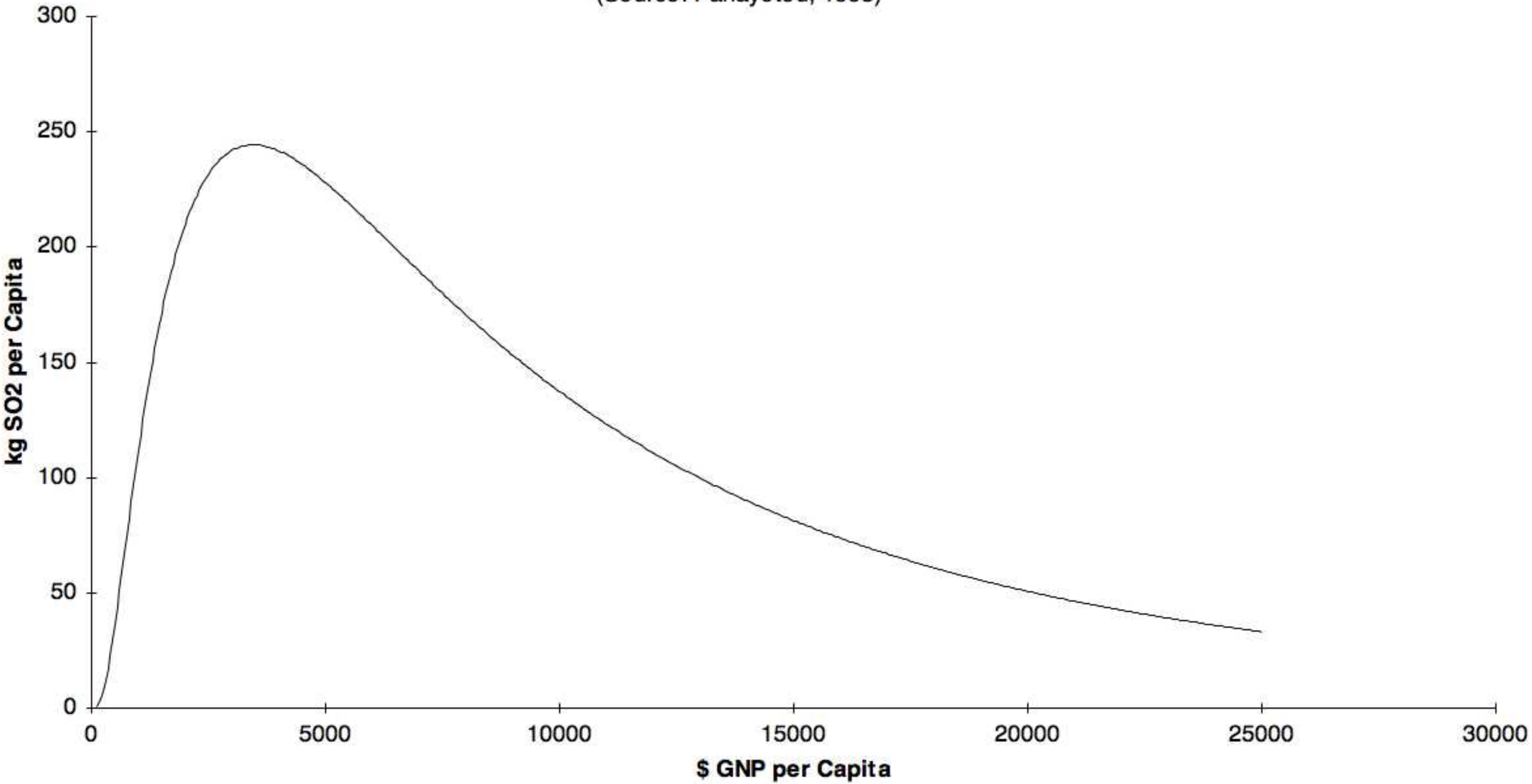
Alternative Models:

- Environmental Kuznets Curve:

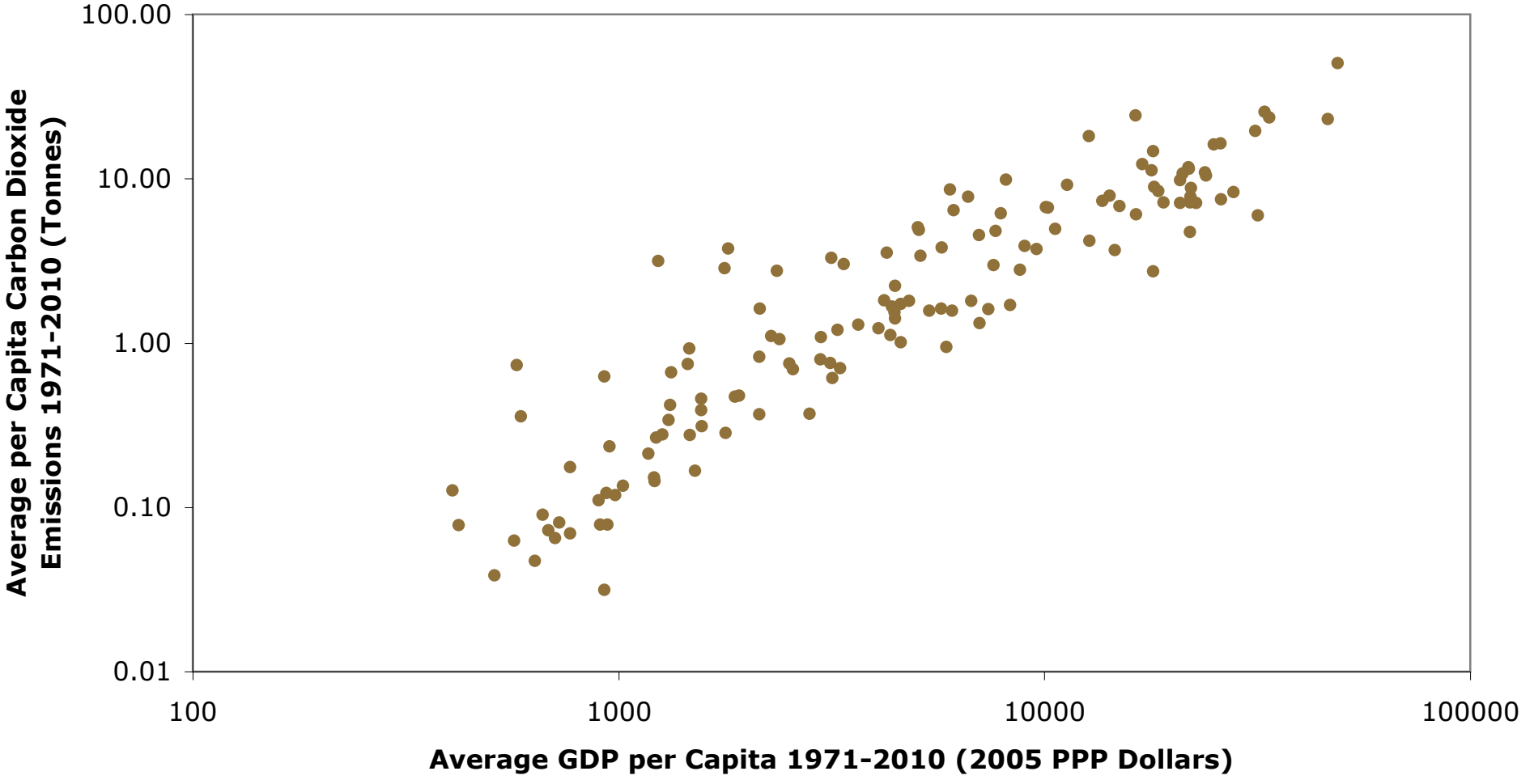
$$E_{it} = \alpha_i + \gamma_t + \beta_1 G_{it} + \beta_2 G_{it}^2 + \varepsilon_{it}$$

Environmental Kuznets Curve

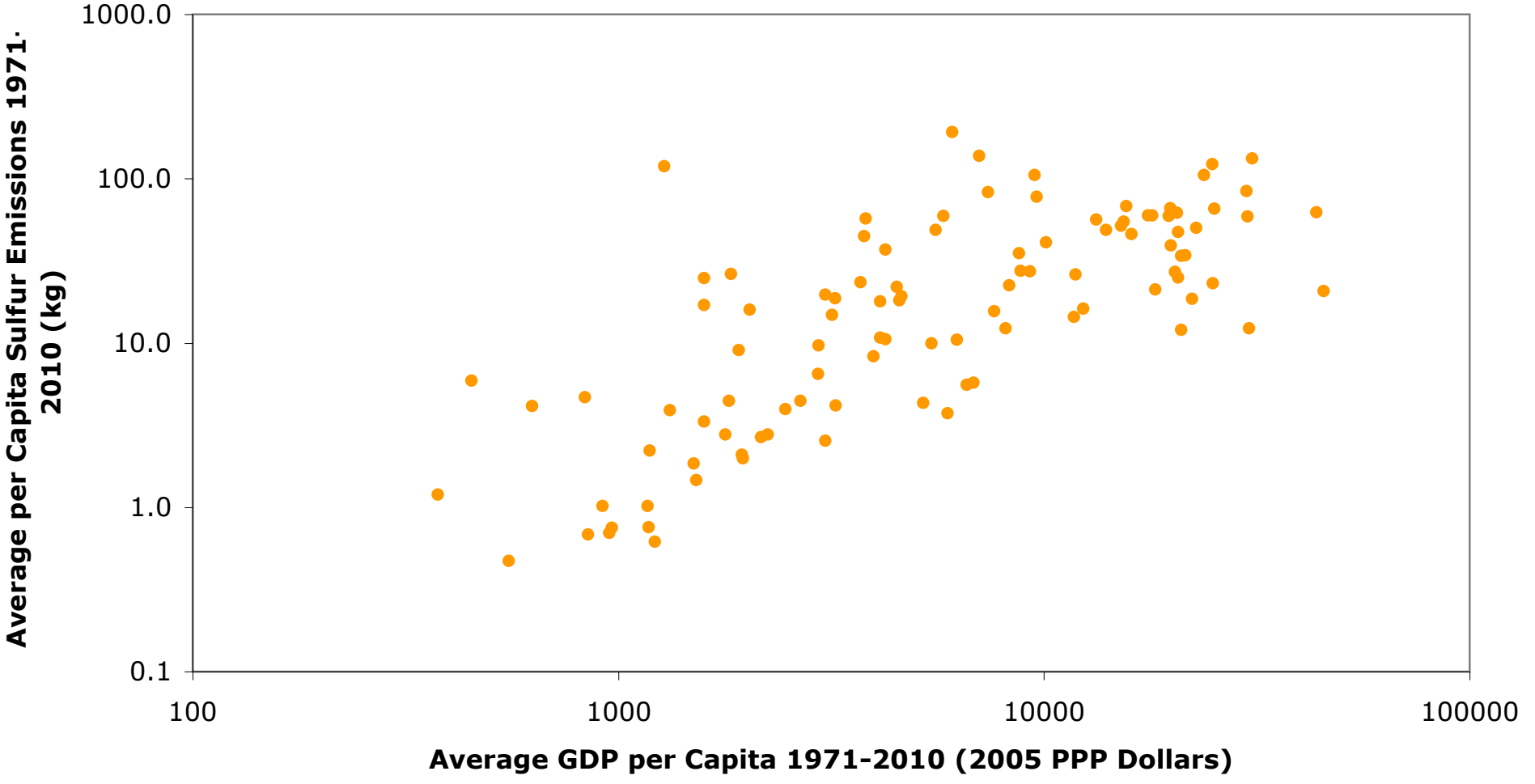
(Source: Panayotou, 1993)



Carbon Dioxide EKC



Sulfur EKC


1000.0
100.0
10.0
1.0
0.1
Average per Capita Sulfur Emissions 1971-2010 (kg)
100
1000
10000
100000
Average GDP per Capita 1971-2010 (2005 PPP Dollars)

Econometric Problems with the EKC

- Environmental Kuznets Curve:

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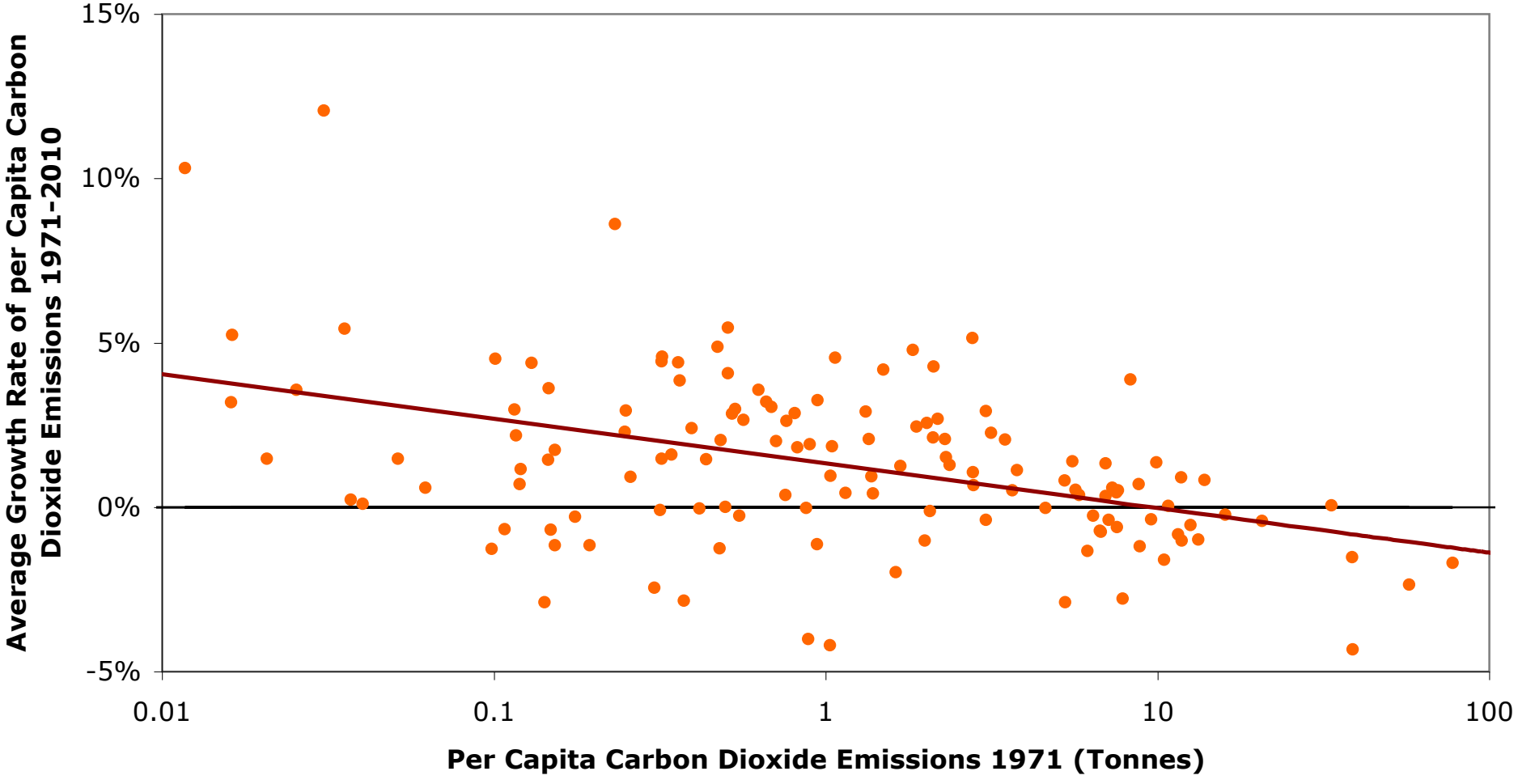
  - FE tends to converge to short-run effects (Stern, 2010, *EcoEco*)
  - Stern proposed **between estimator** as solution
    - Omitted variable bias is a serious issue with BE

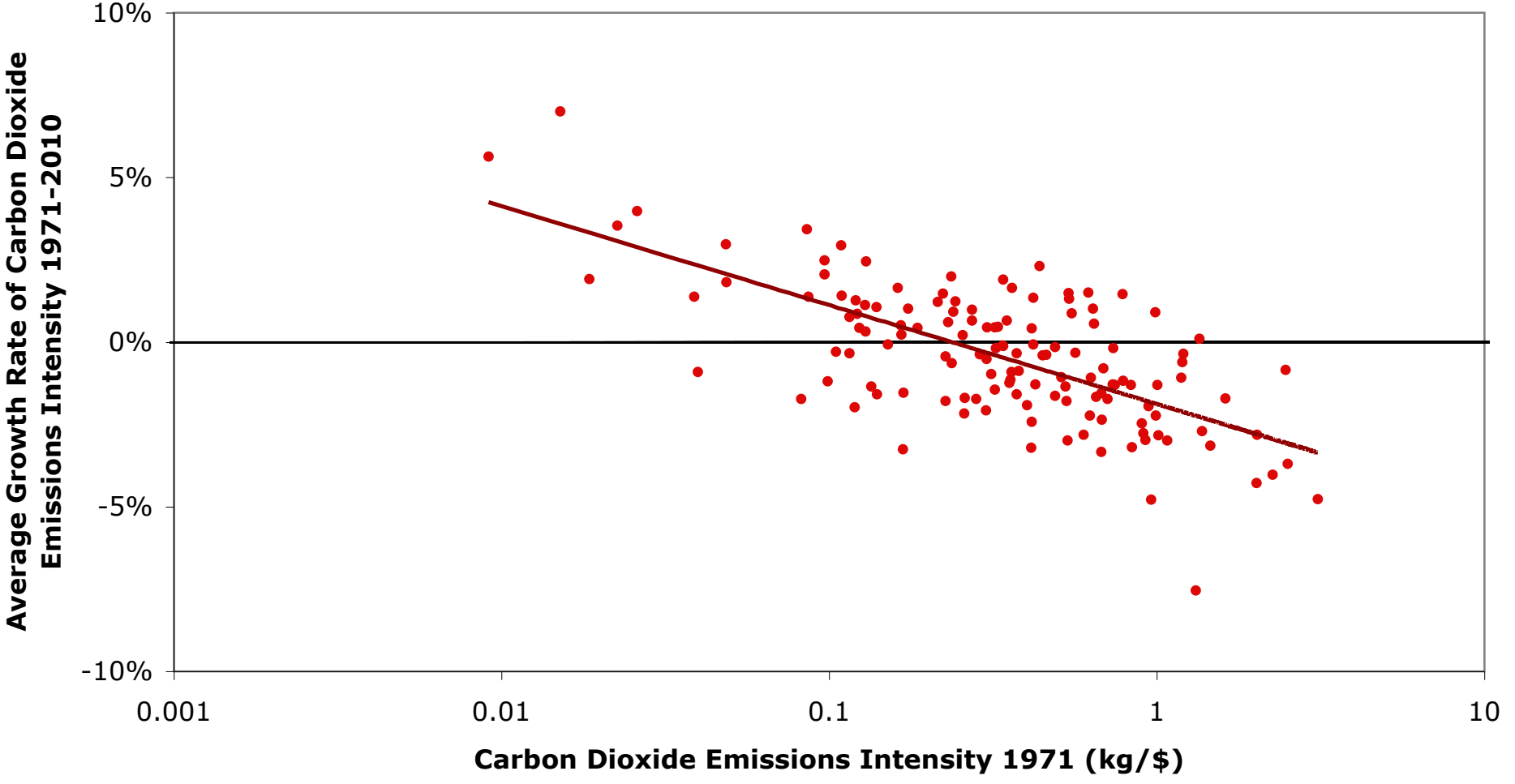
Alternative Models:

- Convergence/ Green Solow Model:
  - Brock and Taylor (2010) The green Solow model, *J. of Economic Growth* 15: 127-53.

Convergence: Emissions per Capita



Convergence: Emissions Intensity



Growth Rates Model:

$$\hat{E}_i = \alpha + (\beta_1 + \beta_2 \ln G_i)\hat{G}_i + \gamma \ln G_i + \delta \ln(E_{i0}/G_{i0}) + \mathbf{X}_i'\psi + \varepsilon_i$$

X variables:

- Legal origin/central planning
- Summer temperature
- Resource endowments: fossil fuels, water resources
- Population density

Growth Rates Approach: Advantages

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- Focuses on long-run variation (Chirinko *et al*., 2011, *JBES*)
- Time effect clearly defined

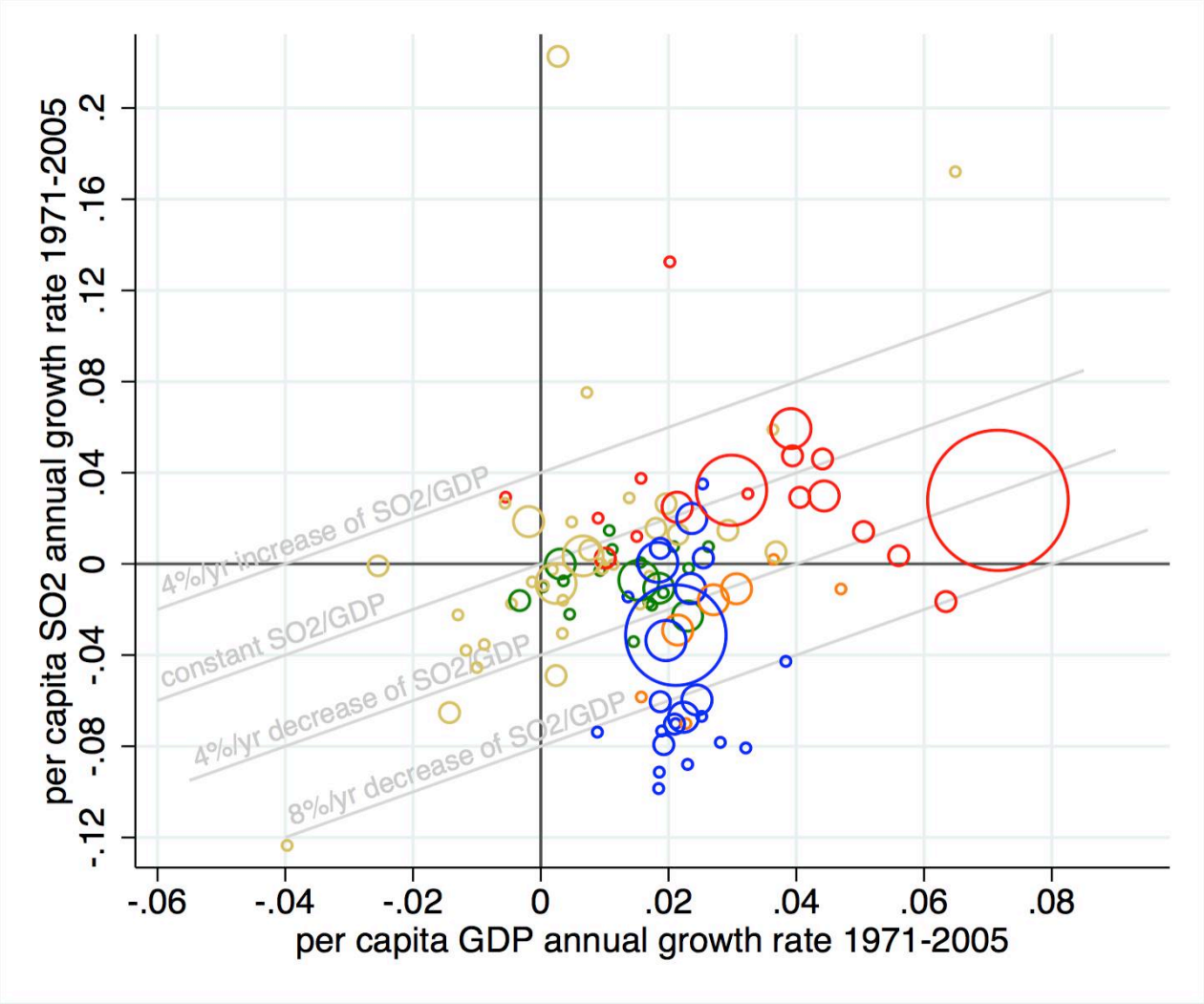
Growth Rates Approach: Advantages

- Unit roots differenced
- Levels country effects eliminated
- Focuses on long-run variation (Chirinko *et al*., 2011, *JBES*)
- Only average time effect estimated
- Nests convergence and EKC models

Data:

- CDIAC emissions: 136 countries, 1971-2010
- Penn World Table 8.0
- Smith et al. 2011 sulfur data: 103 countries, 1971-2005

Sulfur Emissions & Economic Growth



Econometric Results

	Carbon Dioxide	Sulfur Dioxide
Constant	-0.0046* (0.0023)	-0.0158*** (0.0055)
$\hat{G}_i$	0.9560*** (0.0958)	1.0869*** (0.1726)
$\hat{G}_i \ln G_i$	-0.0767 (0.0730)	-0.3623*** (0.1320)
$\ln(E_{i0}/G_{i0})$	-0.0153*** (0.0021)	-0.0159*** (0.0028)
French Legal Origin	0.0031 (0.0027)	-0.0108** (0.0053)
German Legal Origin	0.0033 (0.0056)	-0.0283** (0.0125)
Scandinavian Legal Origin	-0.0040 (0.0046)	-0.0472*** (0.0145)
Summer Temperature	0.0001 (0.0001)	0.0010** (0.0004)
Log Fossil Fuel Endowment per Capita 1971	0.0013*** (0.0004)	-0.0017* (0.0010)
Log Freshwater per Capita	-0.0013* (0.0007)	-0.0033** (0.0017)
Log Population Density	-0.0007 (0.0014)	-0.0098*** (0.0027)
EKC turning point ($1000's)	1.1E06 (1.4E07)	109 (154)

Conclusions:

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- No significant EKC effect or out-of-sample turning point
- Convergence effect very significant
- Time effects important for SO_2
- Resource endowment & legal origin effects confirmed
- Promising econometric approach

More information:

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Descriptive Statistics

	Country					**Global Aggregate**	**Population Weighted**
	Mean	Standard Deviation	Min	Median	Max		
Emissions per capita mean annual growth rate 1971-2010:							
CO_2	0.013	0.025	-0.043	0.010	0.121	0.005	0.025
SO_2	-0.007	0.050	-0.124	-0.005	0.223	-0.019	0.005
GDP per capita mean annual growth rate 1971-2010:							
CO_2	0.017	0.018	-0.031	0.017	0.077	0.020	0.036
SO_2	0.017	0.018	-0.040	0.018	0.072	0.021	0.034
GDP period mean income per capita 1971-2010:							
CO_2	$9,303	$10,508	$423	$4,833	$55,963	$7,184	$7,184
SO_2	$10,207	$10,360	$383	$5,819	$48,875	$6,636	$6,636

Results: Carbon Dioxide

	Growth Rates Model	EKC	Combined Model
Constant	-0.0015 (0.0021)	0.0002 (0.0022)	-0.0004 (0.0017)
$\hat{G}_i$	0.8338*** (0.1171)	0.8113*** (0.1103)	0.8351*** 0.0774)
$\ln G_i$			0.0033** (0.0014)
$\hat{G}_i \ln G_i$		-0.2601*** (0.0675)	-0.2049*** (0.0603)
$\ln(E_{i0}/G_{i0})$			-0.0136*** (0.0017)
EKC turning point		\$100k (\$93k)	\$260k (\$365k)
$\overline{R}^2$	0.3460	0.4165	0.6700

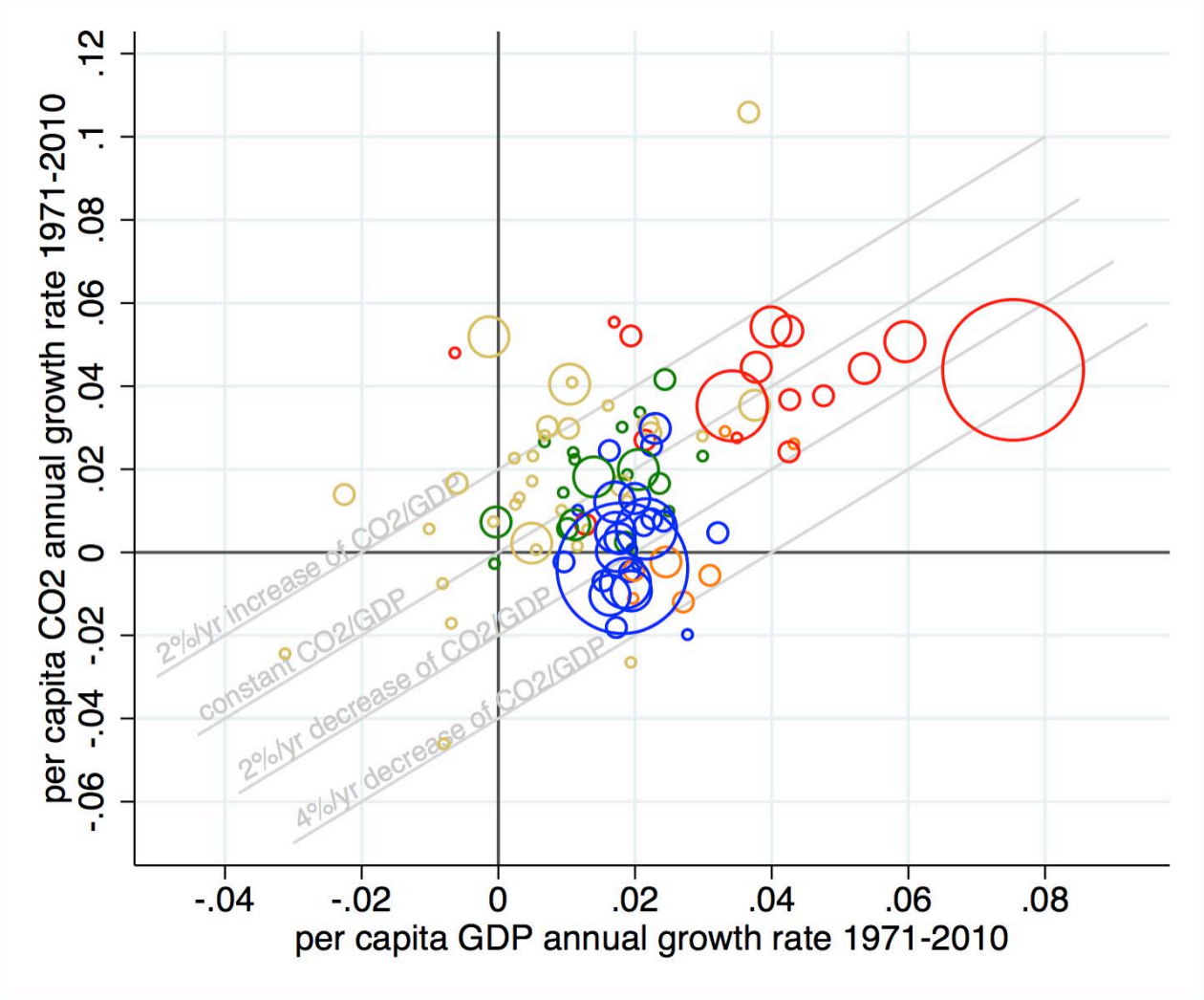
Results: Sulfur Dioxide

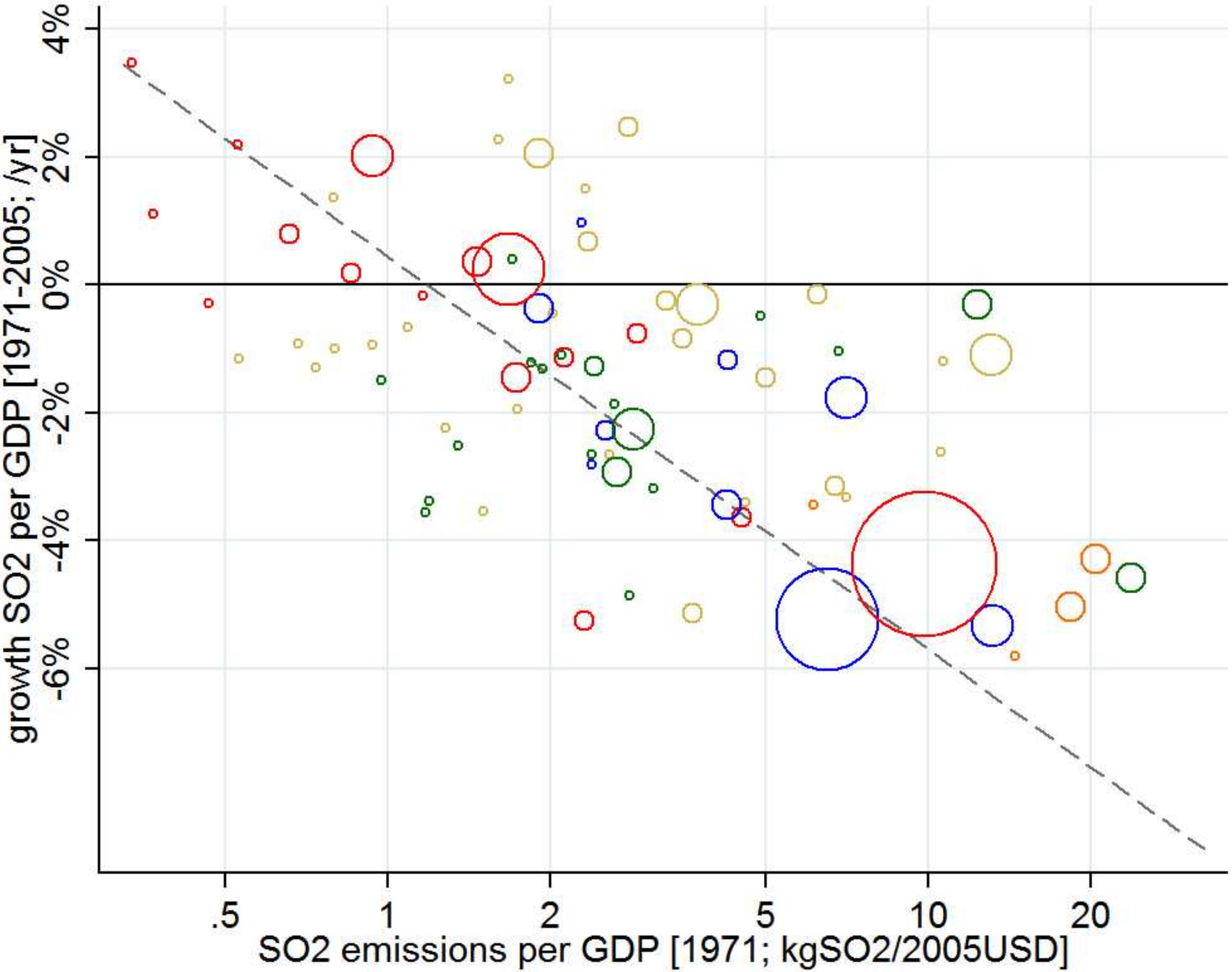
	Growth Rates Model	EKC	Combined Model
Constant	-0.0181** (0.0071)	-0.0139** (0.0058)	-0.0180*** (0.0044)
$\hat{G}_i$	0.6571** (0.3151)	0.6506** (0.2732)	0.7734*** (0.1644)
$\ln G_i$			-0.0030 (0.0028)
$\hat{G}_i \ln G_i$		-0.8909*** (0.1651)	-0.4598*** (0.1093)
$\ln(E_{i0}/G_{i0})$			-0.0231*** (0.0049)
EKC turning point		\$11.2k (\$3.5k)	\$29.1k (\$16.4k)
$\overline{R}^2$	0.0465	0.2556	0.5807

Results: Green Solow Model

	Carbon Dioxide		Sulfur Dioxide	
	Short Form	Long Form	Short Form	Long Form
Constant	0.0128***	0.0128***	-0.0067*	-0.0067**
	(0.0019)	(0.0018)	(0.0036)	(0.0033)
$\ln E_{i0}$	-0.0059***	-0.0084***	-0.0181***	-0.0187***
	(0.0012)	(0.0013)	(0.0031)	(0.0031)
$\ln s_i$		0.0203***		0.0402***
		(0.0057)		(0.0111)
$\ln(n_i + 0.05)$		-0.0298**		0.0554**
		(0.0116)		(0.0267)
$\overline{R}^2$	0.1872	0.3087	0.4388	0.5287

IEA Carbon & Economic Growth




growth SO2 per GDP [1971-2005; /yr]
4%
2%
0%
-2%
-4%
-6%
.5
1
2
5
10
20
SO2 emissions per GDP [1971; kgSO2/2005USD]