



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

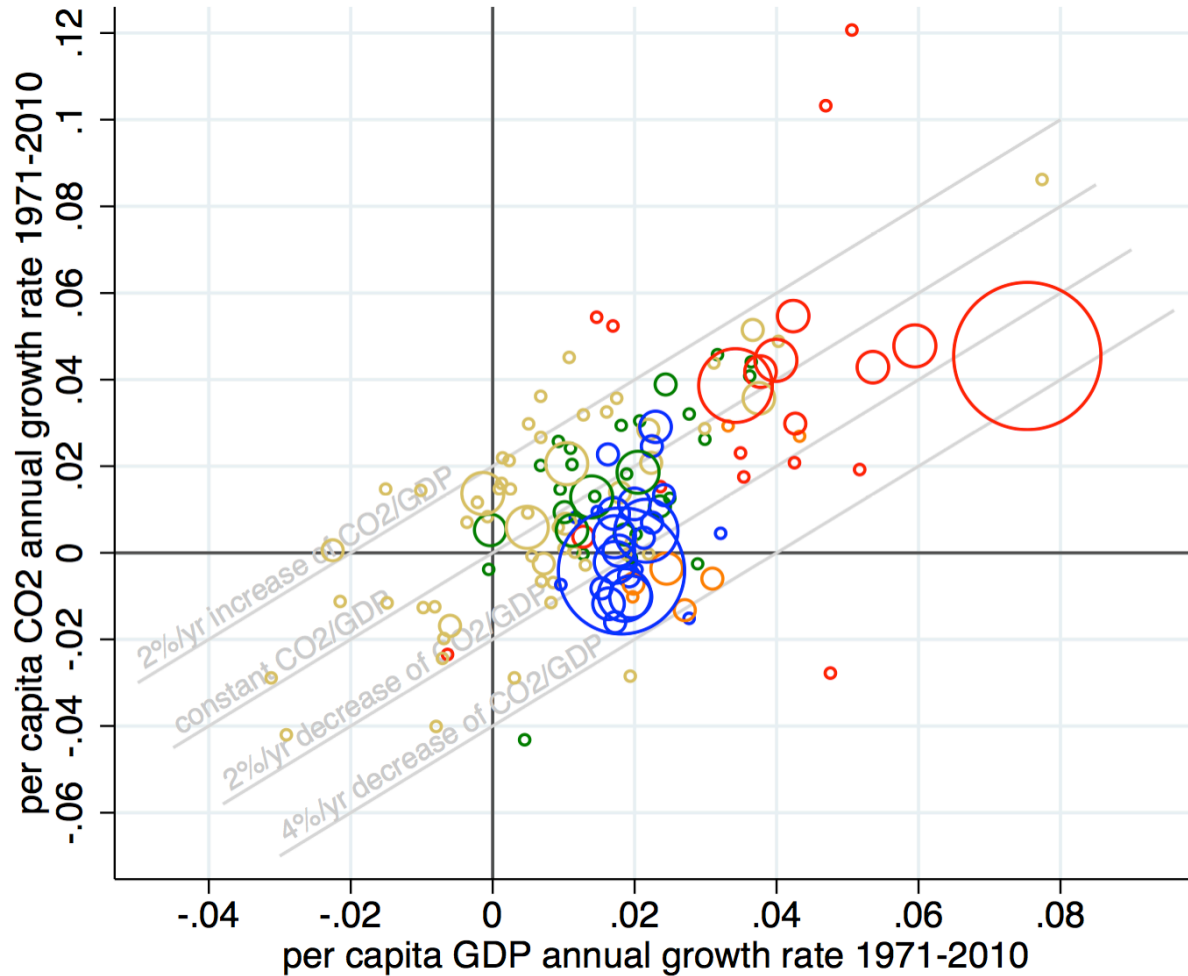
# Rethinking the Emissions-Income Relationship in Terms of Growth Rates

David Stern

Crawford School of Public Policy

AARES Annual Conference 2014, Port Macquarie, 6<sup>th</sup> February

# Carbon Emissions & Economic Growth





# Alternative Models:

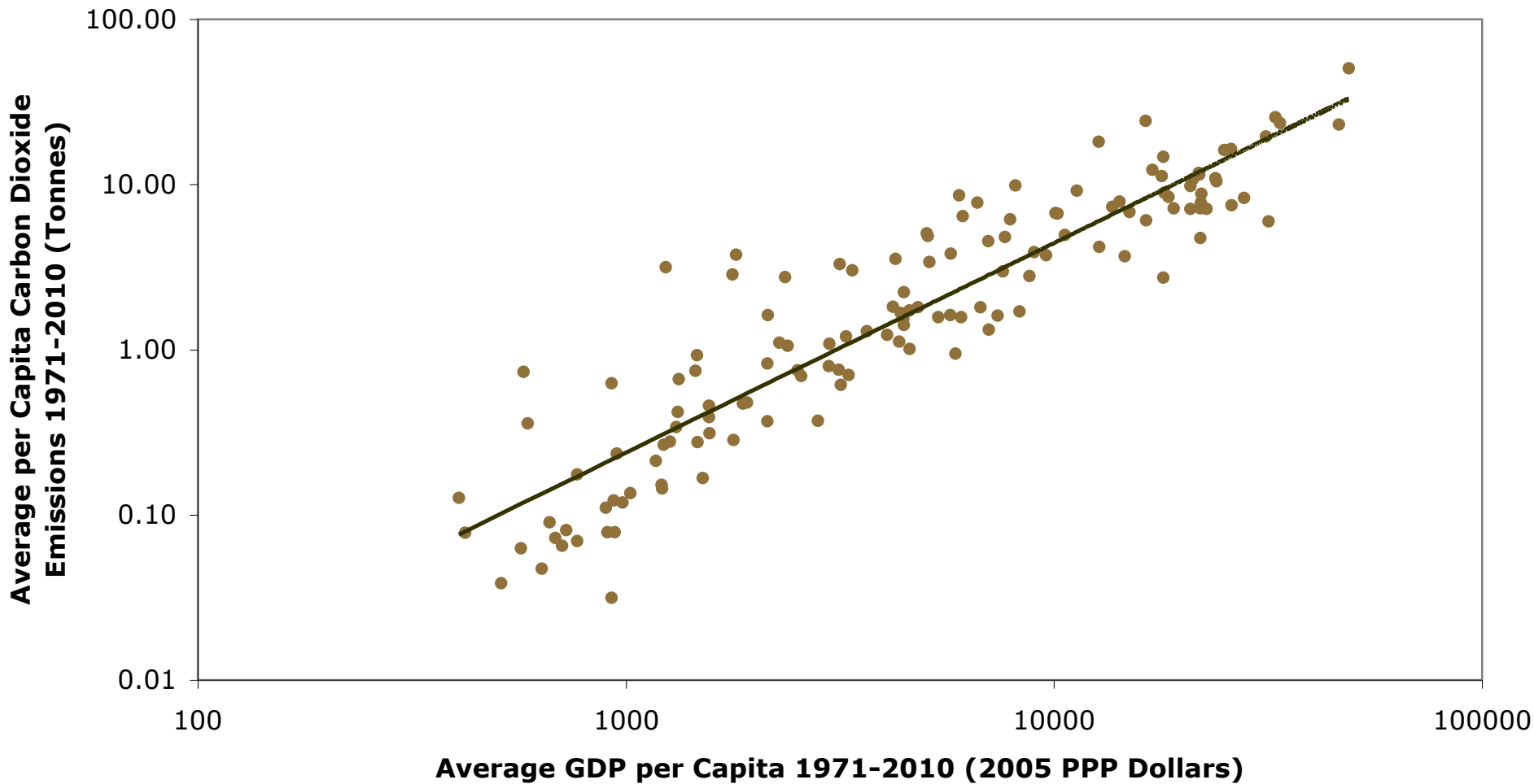
- IPAT / Kaya Identity



## Alternative Models:

- IPAT / Kaya Identity
- Environmental Kuznets Curve

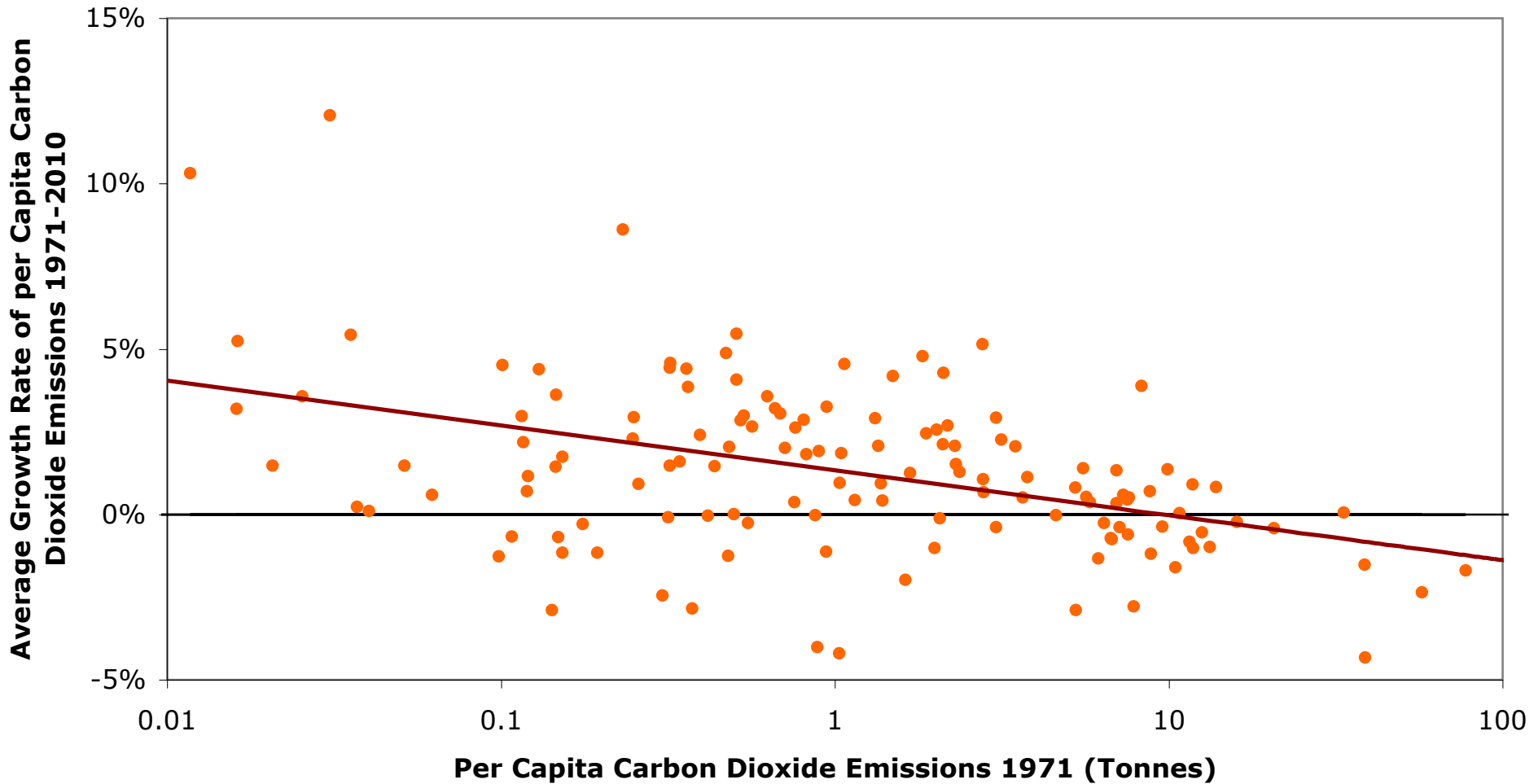
# Environmental Kuznets Curve



## Alternative Models:

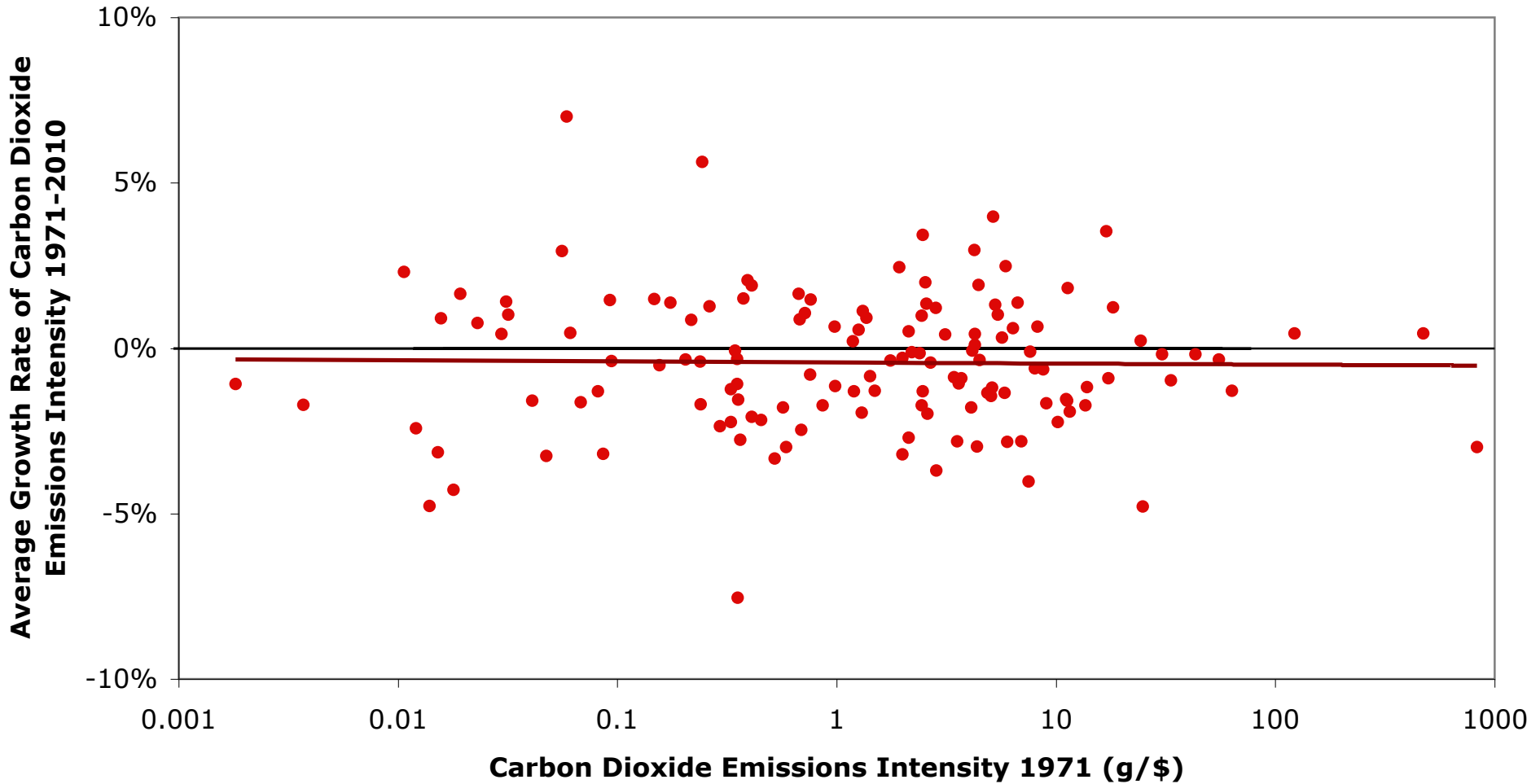
- IPAT / Kaya Identity
- Environmental Kuznets Curve
- (Empirical) Green Solow / Convergence

# Convergence: Emissions per Capita





# Convergence: Emissions Intensity



# Econometric Models:

- Growth Rates Model:

$$\hat{E}_i = \alpha + \beta \hat{G}_i + \varepsilon_i$$





# Growth Rates Approach: Theory

- Growth rates eliminate unit root problem (Wagner, 2008)

# Growth Rates Approach: Theory

- Growth rates eliminate unit root problem (Wagner, 2008)
- Also eliminate omitted variables in levels – problem with between estimator (Stern, 2010)

# Growth Rates Approach: Theory

- Growth rates eliminate unit root problem (Wagner, 2008)
- Also eliminate omitted variables in levels – problem with between estimator (Stern, 2010)
- But first differences focus on short-run dynamics – so LR growth rates

# Growth Rates Approach: Theory

- Growth rates eliminate unit root problem (Wagner, 2008)
- Also eliminate omitted variables in levels – problem with between estimator (Stern, 2010)
- But first differences focus on short-run dynamics – so LR growth rates
- LR growth rates identify time effects (Vollebergh *et al.*, 2009)

# Econometric Models:

- Growth Rates Model:

$$\hat{E}_i = \alpha + \beta \hat{G}_i + \varepsilon_i$$

- Environmental Kuznets Curve:

$$\hat{E}_i = \alpha + (\beta_1 + \beta_2 \ln G_i) \hat{G}_i + \varepsilon_i$$

# Econometric Models:

- Long-form Green Solow:

$$\hat{E}_i = \phi_0 + \phi_1 \ln E_{i0} + \phi_2 \ln s_i + \phi_3 \ln(n_i + 0.05) + \varepsilon_i$$

- Combined Model:

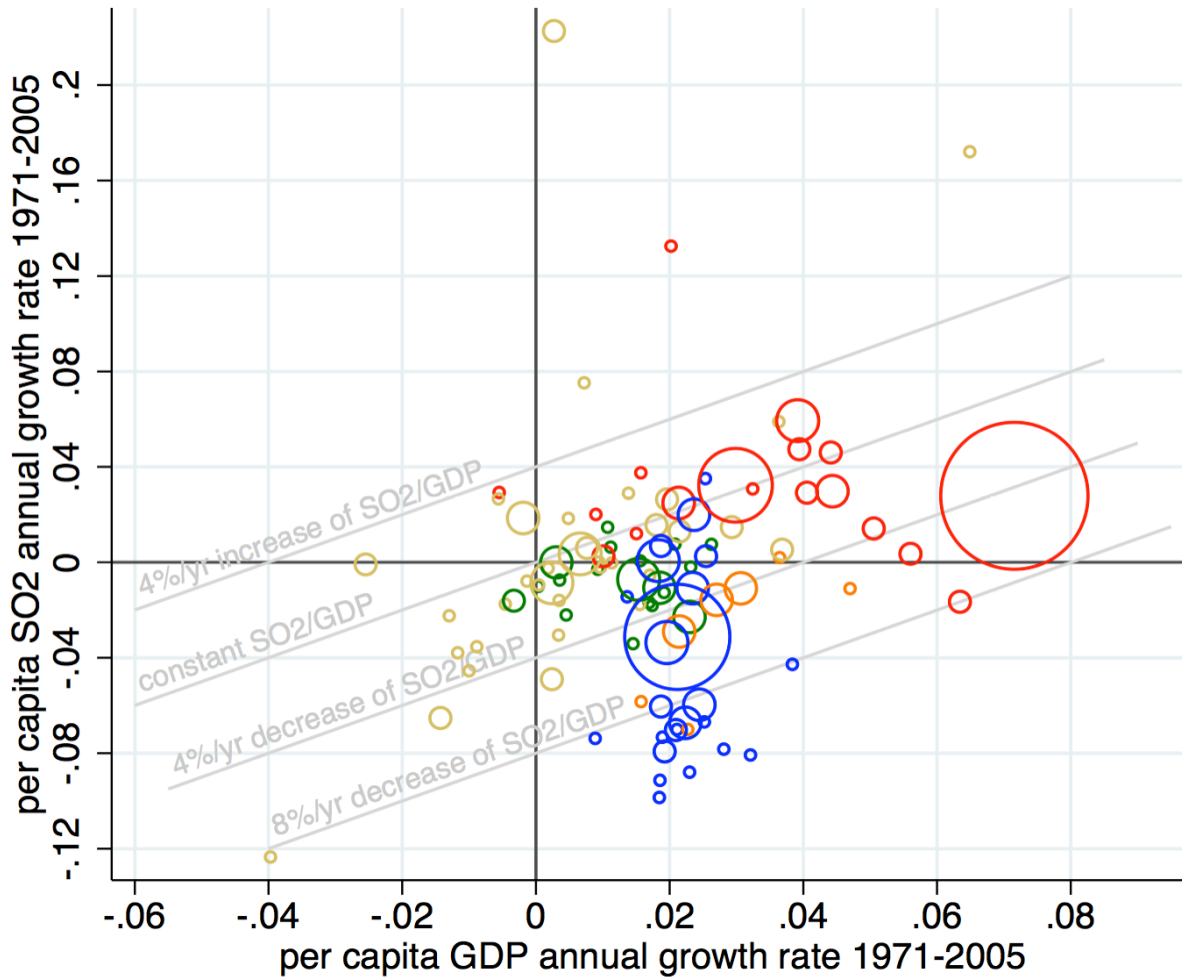
$$\hat{E}_i = \alpha + (\beta_1 + \beta_2 \ln G_i) \hat{G}_i + \gamma \ln G_i + \delta \ln(E_{i0} / G_{i0}) + \varepsilon_i$$



## Data:

- CDIAC emissions: 136 countries, 1971-2010
- Penn World Table 8.0
- Smith et al. 2011 sulfur data: 103 countries, 1971-2005
- Also use IEA carbon emissions: 99 countries

# Sulfur Emissions & Economic Growth



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

# Conclusions:

- Effect of growth on emissions is strongly positive

## Conclusions:

- Effect of growth on emissions is strongly positive
- EKC explains more than GSM for CO<sub>2</sub> *vice versa* for SO<sub>2</sub>

## Conclusions:

- Effect of growth on emissions is strongly positive
- EKC explains more than GSM for CO<sub>2</sub> *vice versa* for SO<sub>2</sub>
- Combined model superior for both CO<sub>2</sub> and SO<sub>2</sub>



## Conclusions:

- Effect of growth on emissions is strongly positive
- EKC explains more than GSM for CO<sub>2</sub> *vice versa* for SO<sub>2</sub>
- Combined model superior for both CO<sub>2</sub> and SO<sub>2</sub>
- Time effects important for SO<sub>2</sub>



## More information:

Website: [www.sterndavid.com](http://www.sterndavid.com)

Blog: [stochastictrend.blogspot.com](http://stochastictrend.blogspot.com)

E-mail: [david.stern@anu.edu.au](mailto:david.stern@anu.edu.au)

# IEA Carbon & Economic Growth

