

# REVISITING WORLD ENERGY INTENSITY CONVERGENCE: REGIONAL DIFFERENCES AND INSTITUTIONAL INFLUENCES

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## Outline

- Intro to convergence
- World energy intensity convergence
- Convergence among China's provinces

## Why Study Convergence

- Income & quality of life measures
  - One world or many?
- CO<sub>2</sub> emissions & energy
  - Convergence among developed countries may encourage developing countries to join global accords
  - Will a similar set of policies/global policy work?

## Goals & Findings

- Updates/expands Ezcurra (2007)
- Considers convergence across geography/development groups
- Examines determinants of convergence via conditioned distributions
  
- OECD & Eurasia converge; SSA converge amongst each other; LAC & MENA diverge
- Institutions that lead to stable economic growth linked to energy intensity convergence

## Types & Tools of Convergence

- Beta-convergence
  - Do countries catch up?
    - Regress rates of change on initial levels
- Sigma-convergence
  - Do cross-country differences decline?
    - Calculate coefficient of variation over time
    - Estimate kernel density or histogram over time

## Types & Tools of Convergence

- Gamma-convergence
  - Do countries move within the distribution?
    - Transition probability matrix or stochastic kernels (3D)
    - Rank concordance index
- Stochastic convergence
  - Are shocks permanent or temporary?
    - Panel unit root test

## Convergence Analyses

- GDP per capita (numerous studies)
  - Developed countries converge; primarily divergence at world-level
- Living standards (Neumayer 2003; Maza & Villaverde 2008)
  - Educational enrolment, literacy, & electricity consumption: high to some convergence
- Demographics (Wilson 2001)
  - Life expectancy & fertility converge

## Convergence Analyses

- CO<sub>2</sub> per capita (number of studies since 2003)
  - Developed countries converge; less developed countries diverge
- Energy productivity (Miketa & Mulder 2005)
  - Convergence in less energy intensive sectors; divergence to no convergence in more energy intensive sectors (non-ferrous metals)

## Other Convergence Analyses

- GDP per capita (numerous studies)
  - Developed countries converge; primarily divergence at world-level
- CO<sub>2</sub> per capita (number of studies since 2003)
  - Developed countries converge; less developed countries diverge

## Energy Intensity Convergence

- Ezcurra (2007): Limited sigma-convergence at world level which ceases/slows beginning in early 1980s
- Markandaya et. al. (2006): Eastern European countries converged toward EU average since 1992
- Liddle (2009): Among OECD countries commercial electricity intensity converging toward bell-shaped, but industry electricity intensity converging toward bi-modal distribution

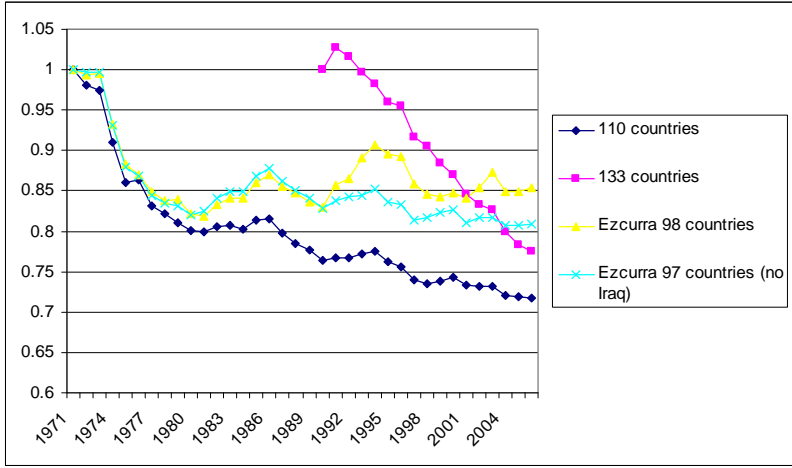
## Data

- Natural log TPES/real GDP (IEA)
- Ezcurra (2007): 98 countries, over 1971-2001
- 111 countries over 1971-2006
- 134 countries over 1990-2006

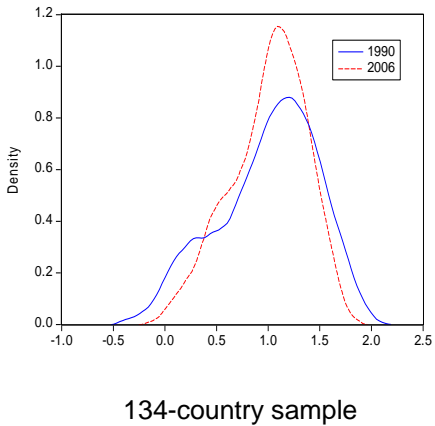
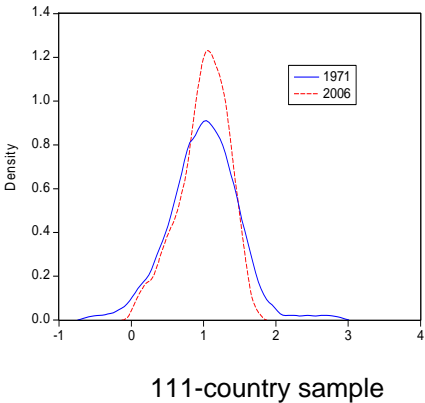
## Beta-Convergence

	Value	t-Statistic
1971-2006		
Constant	-0.034	-10.35
Beta	<b>-0.022</b>	<b>-11.05</b>
Adjusted R <sup>2</sup>	0.52	
N	111	
1990-2006		
Constant	-0.031	-7.67
Beta	<b>-0.016</b>	<b>-5.55</b>
Adjusted R <sup>2</sup>	0.18	
N	134	

# Sigma-convergence



# Sigma-convergence

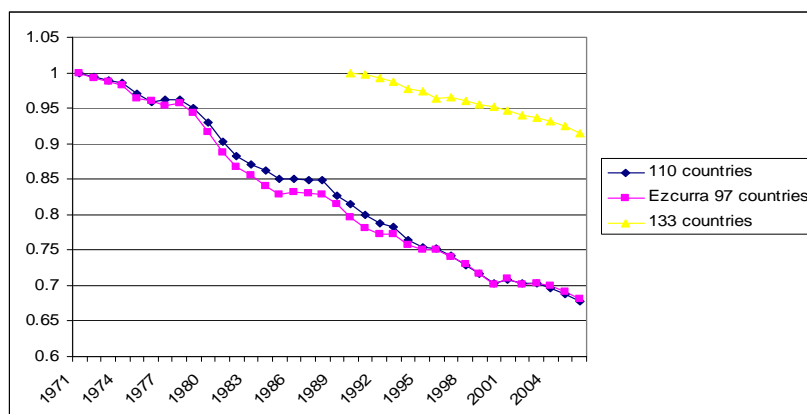


## Gamma-Convergence

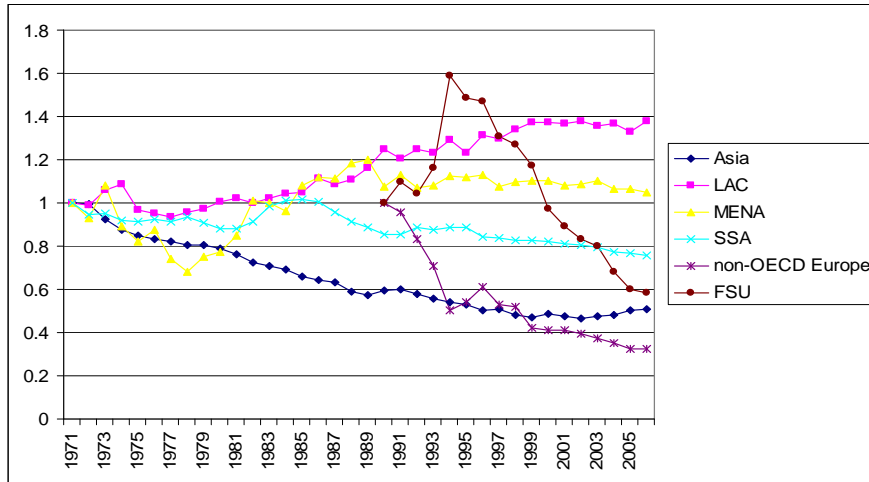
$$\gamma = \frac{\text{Variance} (AR(I)_{it} + AR(I)_{i0})}{\text{Variance} (2 * AR(I)_{i0})}$$

Boyle and McCarthy (1997)

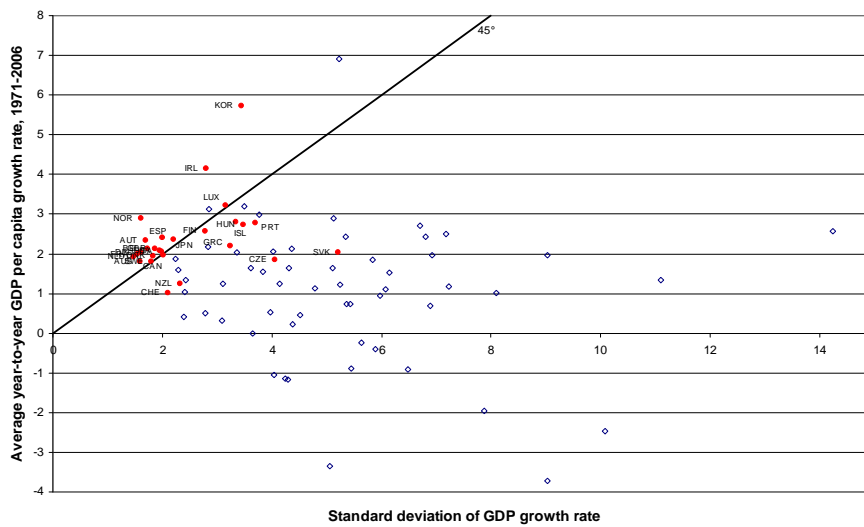
## Gamma-Convergence



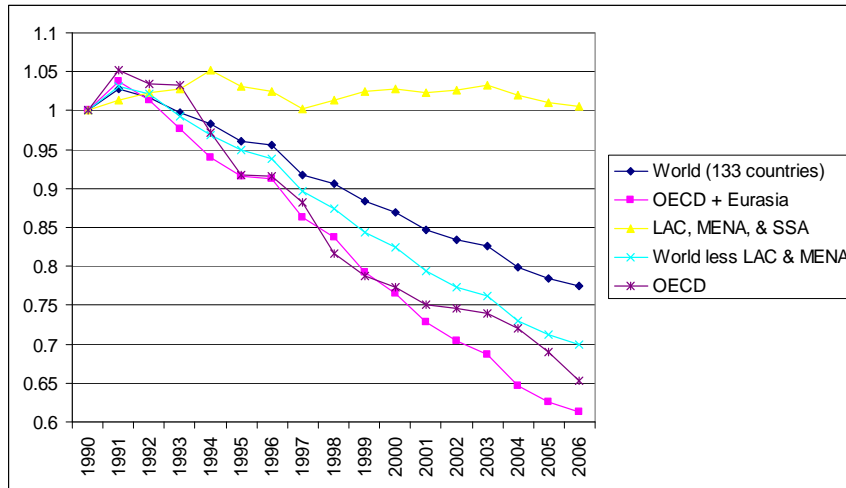
# Regional Sigma-Convergence



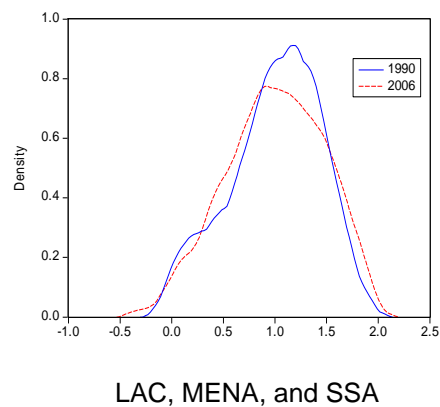
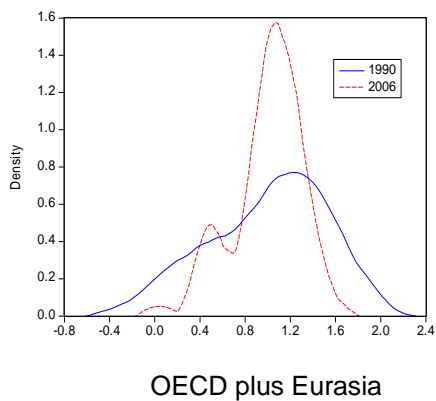
# Economic Growth Stability



## Regional Contributions to Sigma-Convergence



## Two Convergence Clubs



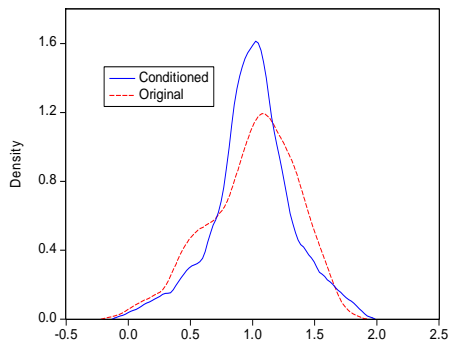
## Conditional Convergence

- Parametric
  - Beta-convergence
    - Multivariate regression
- Non-parametric
  - Sigma-convergence
    - Conditioned kernel density estimates (Quah)

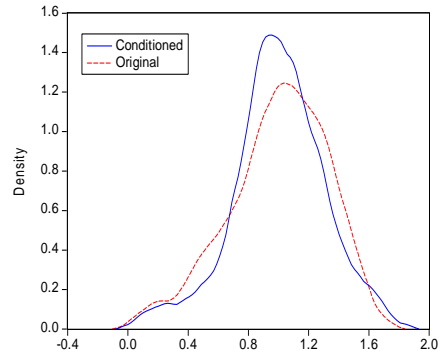
## Determinants of World Energy Intensity Convergence

- Important
  - Share of services & manufacturing in GDP
  - Stability (CV) of economic growth
  - Quality of governance
- Not important/Marginal importance
  - GDP per capita
  - GDP per capita growth
  - Share exports in GDP
  - Share electricity in energy consumption

## Conditioned Kernel Density Functions, 2006

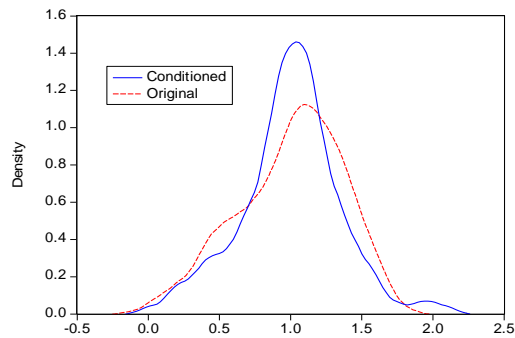


Share of services & manufacturing



CV annual GDP per capita growth, 1971-2006

## Conditioned Kernel Density Functions, 2006

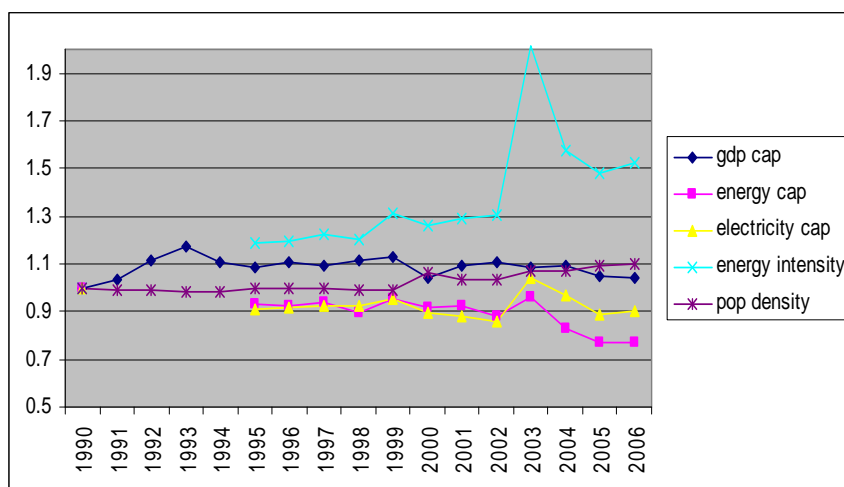


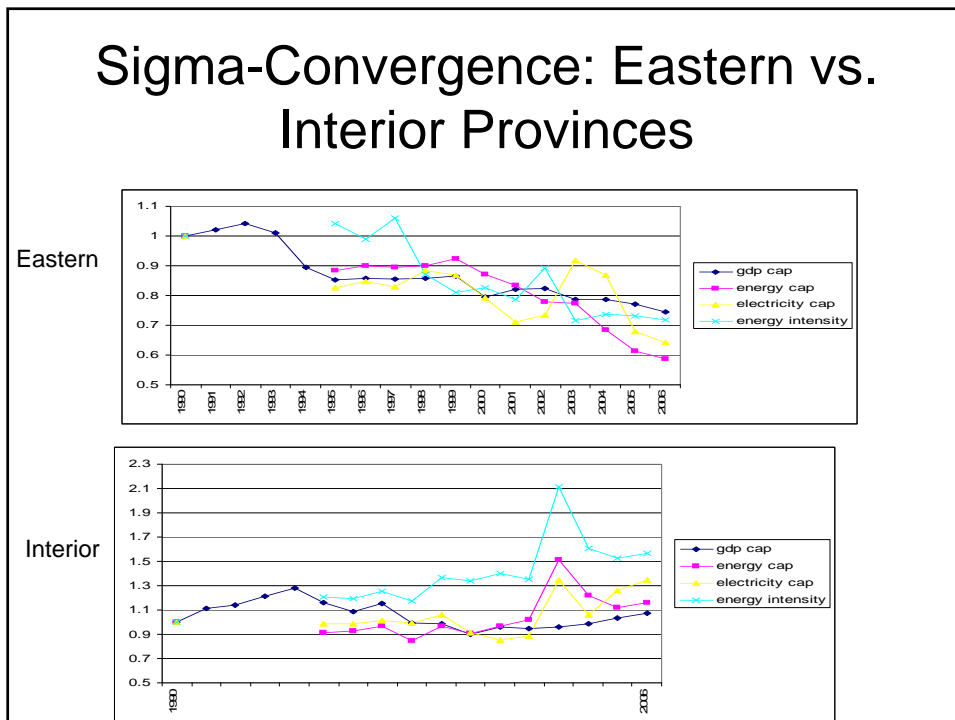
Index of quality of governance

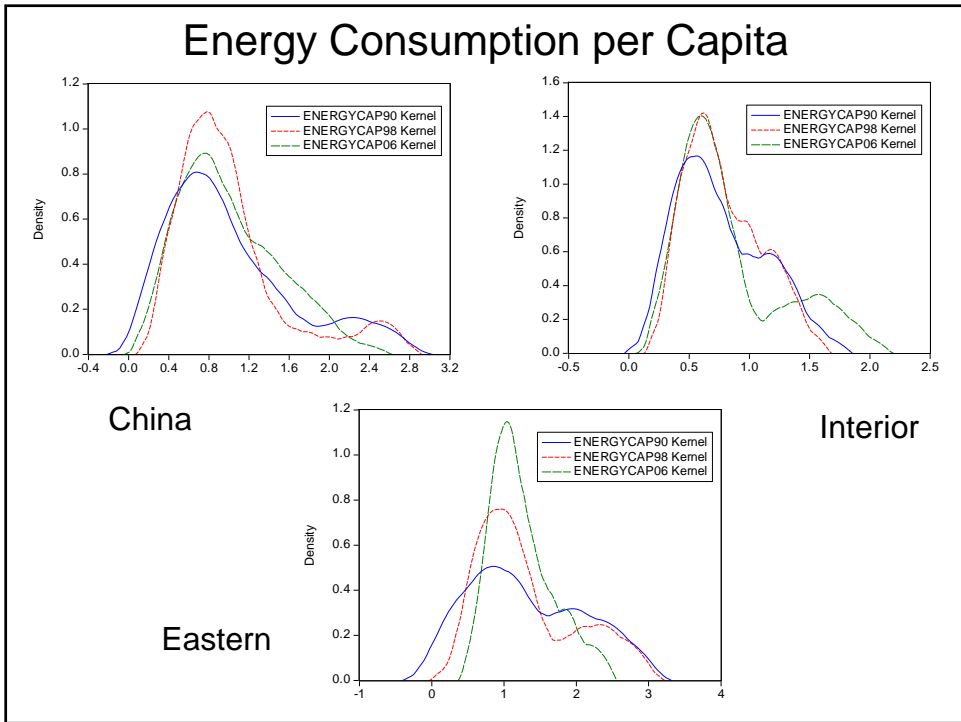
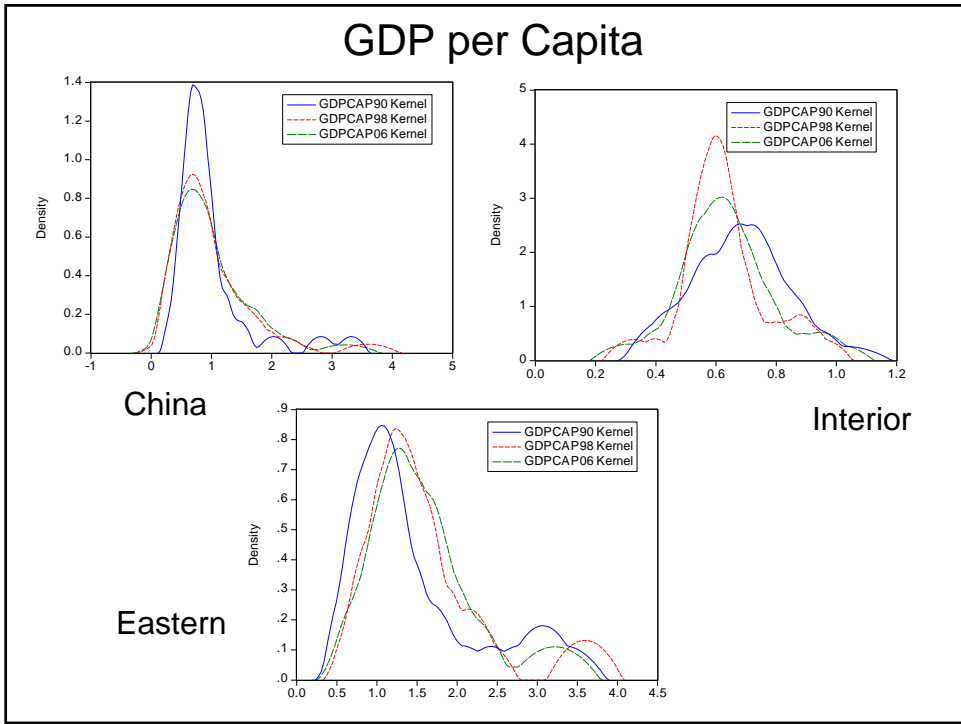
## Conclusions

- Continued world convergence in energy intensity, however,...
- Two clubs forming:
  - Limited to no convergence among LAC, MENA, SSA
  - Substantial convergence among OECD & Eurasia
    - Contribution of Central Asia & North Korea reflects extremely high initial energy intensity
- Energy intensity convergence analogous to economic growth convergence
  - Economic structure, growth stability, & quality governance all matter
- Excluding Iraq but including former Soviet Baltic countries & new Balkan countries (former Yugoslavia) increases convergence

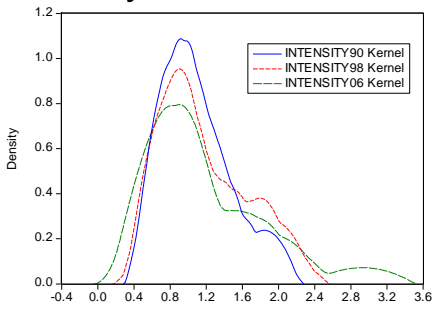
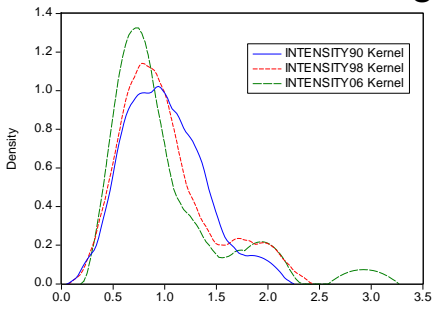
## Sigma-Convergence in China's Provinces





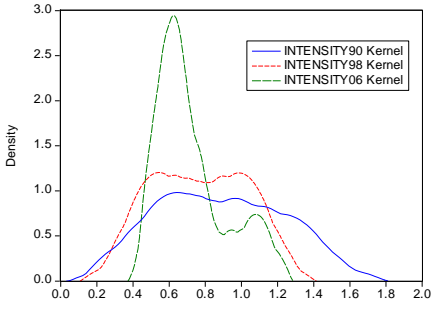


# Energy Intensity



China

Interior



Eastern