

**THE EVALUATION OF STANDARD OF LIVING AND  
THE ROLE OF HOUSEHOLD ELECTRICITY  
CONSUMPTION:  
A PANEL COINTEGRATION ANALYSIS**

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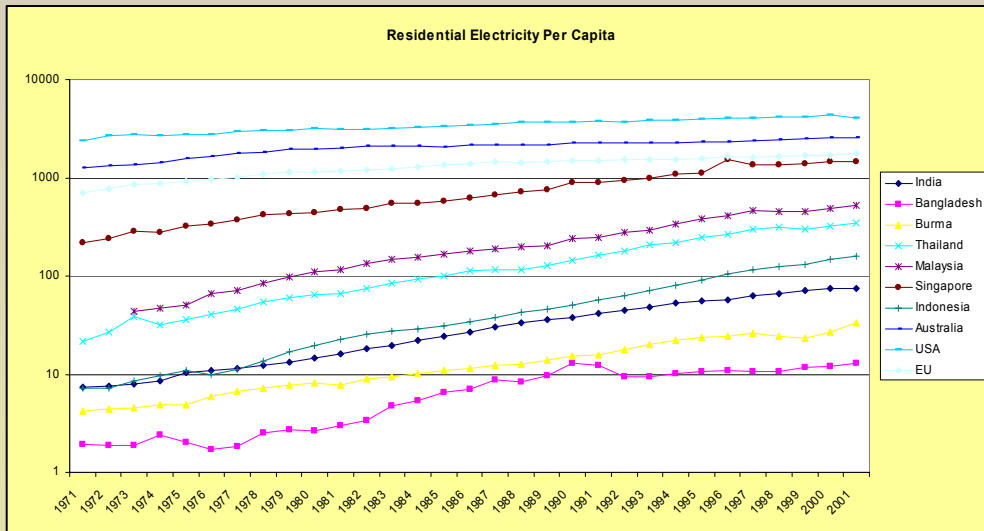
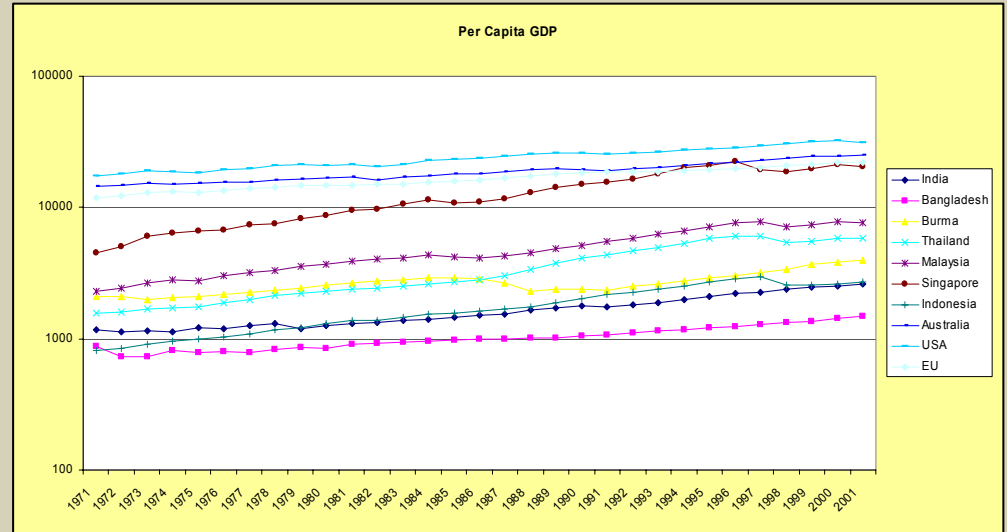
# Outline

- Motivation
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# Motivation

PPP-GDP per capita

Deviations in rankings



Deviations in ranking changes and relative positions over time

Res. Electricity per capita

# Motivation

## Average annual compound growth rates for GDP and Residential Electricity Consumption - 1971-2001

	India	Bangladesh	Burma	Thailand	Malaysia	Singapore	Indonesia
GDP	2.71	1.74	2.13	4.39	3.76	5.04	4.01
Res.Elec.	7.77	6.36	6.90	9.23	8.93	6.30	10.35
RE/GDP	2.87	3.65	3.24	2.10	2.37	1.25	2.58

# Literature review

## Energy-Income causality

- Kraft and Kraft (1978)
- Akarca and Long (1980)
- Yu and Choi (1985)
- Masih and Masih (1996,1997)
- Soytas and Sari (2003)

## Energy-Income information content

- United Nations and World Bank documents
  - Goldemberg and Johansson (1995)
  - Barnes (1995)
  - Dziouvinski and Chipman (1999)
  - Sanghvi and Barnes (2001)
- McGillivray (1991)
- Ripple (2000)

# Data

- International Energy Agency (IEA), internet data service
- Data Series:
  - residential electricity consumption,
  - PPP-adjusted GDP, and
  - population
  - Also:
    - total energy consumption and (ktoe)
    - total electricity consumption (gwh)
- Time period: 1971-2001
- Countries – Panel:
  - India, Indonesia, Burma, Bangladesh, Malaysia, Thailand, Singapore,
  - Also: Australia, the United States, and the European Union

# Methodology

## ➤ Panel Unit Root Tests

Levin, Lin, and Chu (2002)

$$\Delta y_{i,t} = \alpha_i + \delta_i t + \theta_t + \rho_i y_{i,t-1} + \sum_{L=1}^{p_i} \gamma_{iL} \Delta y_{it-L} + \zeta_{i,t}$$

Im, Pesaran, and Shin (2003)

Choi (2004)

# Panel Unit Root Tests (per capita)<sup>a</sup>

Tests Variables	Trend				No Trend			
	LLC rho	LLC t	LLC ADF	IPS ADF	LLC rho	LLC t	LLC ADF	IPS ADF
<b>PPP GDP</b>	-1.870*	-0.707	-0.817	-0.646	1.763	2.047	1.766	2.395
<b>Residential Electricity</b>	-1.623	-0.525	-1.099	-2.619	1.512	1.388	2.094	2.267
<b>Electricity</b>	-1.155	-0.093	-0.830	-1.070	1.586	1.538	3.093	3.117
<b>Total energy</b>	0.720	-0.199	-0.407	-1.134	1.297	1.116	1.638	1.905

**a** - All tests statistics are asymptotically distributed as  $N(0,1)$ . \* Rejects at 5% level. All tests are one-sided tests, thus values of the test statistic in the left tail of the standard normal distribution are evidence for rejection of the null of a unit root. Exact 5% critical values for the IPS tests are -2.07 without trend and -2.69 with trend (obtained from IPS (2003) Table 2 with  $N = 7$  and  $T = 30$ ).



# Choi (2004) Panel Unit Root Tests (per capita)<sup>a</sup>

Tests Variables	Inverse normal: Z	Modified inverse chi-squared: $P_m$	Modified logit: $L^*$
PPP GDP	1.304	-1.404	1.218
Residential Electricity	-0.847	0.867	-0.951
Electricity	0.018	-0.101	-0.021
Total energy	0.436	0.356	0.400

**a** - All test statistics are asymptotically distributed as  $N(0,1)$ . All tests are one-sided tests, thus values of the test statistic in the left tail of the standard normal distribution are evidence for rejection of the null of a unit root.

# Methodology - continued

## ➤ Panel cointegration tests

The tests applied in this analysis are single equation tests which have been developed by Pedroni (1997, 2003)

Pedroni (1999) uses the following model:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1it} + \dots + \beta_{Ki} x_{Kit} + e_{it}$$

where there are K regressors, which are allowed to be endogenous.

The tests for the null of no cointegration are based on testing whether the error process is stationary.

$$\hat{e}_{it} = \rho_i \hat{e}_{it-1} + v_{it}$$

# Methodology - continued

- Pedroni constructs two non parametric and one parametric test statistics that take autocorrelation into consideration, for both a panel class and a group class:
  - A Phillips-Perron (1988) (PP) type  $\rho$  statistic
  - A Phillips-Perron (1988) (PP) type t-statistic
  - A Dickey-Fuller (1979) (ADF) type t-statistic

In addition, he develops a non-parametric panel variance ratio test statistic, for a total seven panel cointegration test statistics.

Of these seven test statistics for data sets with small T ( $T < 100$ ), the group ADF test performs best, followed by the panel ADF test; the panel variance test and the group  $\rho$  test perform poorly.

# Panel Cointegration tests

Panel Cointegration Tests: per capita <sup>a</sup>						
	GDP and Residential Electricity		GDP and Total Electricity		GDP and Total Energy	
	Intercept	Intercept and trend	Intercept	Intercept and trend	Intercept	Intercept and trend
panel v-stat	-1.295	1.6111	-0.332	3.39033*	0.02087	-0.3823
panel rho-stat	1.328	1.0966	0.43671	0.82179	0.55364	1.99295
panel pp-stat	0.8671	-0.16	-0.3055	-0.1551	-0.3323	1.88888
panel adf-stat	0.4992	-0.021	-0.1309	-0.1181	-1.2213	0.99212
group rho-stat	1.9815	1.1177	1.13745	1.49593	1.4503	2.28026
group pp-stat	1.1965	-0.547	-0.3925	-0.0248	-0.2279	1.74398
group adf-stat	0.7728	-0.851	0.08368	0.45972	-1.1281	0.62464

**a** - All tests statistics are asymptotically distributed as  $N(0,1)$ . \* Rejects at 5% level. All tests are one-sided tests: for the panel variance test the right tail of the standard normal distribution is used to reject the null of no cointegration and for the other six tests the left tail is used.

# Individual Country Cointegration Tests

## Residential Electricity vs Income (per capita)

### Engel-Granger

Relationships	Trend		No trend	
	Without Dummy 97	With Dummy 97	Without Dummy 97	With Dummy 97
<b>Bangladesh</b>	No cointegration	No cointegration	No cointegration	No cointegration
<b>Burma</b>	No cointegration	No cointegration	No cointegration	No cointegration
<b>India</b>	No cointegration	No cointegration	No cointegration	No cointegration
<b>Indonesia</b>	No cointegration	No cointegration	No cointegration	No cointegration
<b>Malaysia</b>	No cointegration	No cointegration	No cointegration	No cointegration
<b>Singapore</b>	No cointegration	Cointegration (dummy insignificant)	No cointegration	No cointegration
<b>Thailand</b>	cointegration	Cointegration (dummy insignificant)	No cointegration	No cointegration

### Johansen tests

Relationships	
<b>Bangladesh</b>	No cointegration
<b>Burma</b>	No cointegration
<b>India</b>	No cointegration
<b>Indonesia</b>	cointegration
<b>Malaysia</b>	No cointegration
<b>Singapore</b>	No cointegration
<b>Thailand</b>	cointegration

# Conclusions

- For these seven countries, it is reasonable to conclude that cointegration does not exist between PPP-GDP and residential electricity consumption (nor with respect to total electricity or total energy).
- This result implies that no long-run economic relationship exists between these pairs of variables.
- The lack of cointegration implies that the information content of residential-level energy consumption (or its changes) cannot be adequately captured by typical income-based standard of living measures.
- Additional research is called for to extend these analytical techniques to a broader set of countries.
- Additional research is called for to derive a standard of living measure that does adequately capture the effects of household energy consumption.

# ADF Tests for Unit Roots (per capita)<sup>a</sup>

Country	PPP GDP			Residential Electricity		
	lags	$\tau_\tau$	$\tau_\mu$	lags	$\tau_\tau$	$\tau_\mu$
<b>India</b>	0	-2.555	(-1.628)	0	-0.133	-1.385
<b>Bangladesh</b>	0	-6.992*	(0.856)	0	-1.309	-0.792
<b>Burma</b>	1	-1.596	-0.428	0	-2.795	-0.060
<b>Thailand</b>	1	-1.6743	-1.092	0	-3.849*	(-1.788)
<b>Malaysia</b>	0	-1.692	-1.499	0	-1.723	-2.223
<b>Singapore</b>	0	-1.764	-2.418	1	-2.591	-1.601
<b>Indonesia</b>	0	-0.669	-1.875	0	-2.368	-0.276
<b>Australia</b>	0	-1.703	0.866	2	-3.451*	(-3.319*)
<b>USA</b>	0	-2.889	-0.814	0	-4.515*	(-2.482)
<b>EU</b>	0	-2.871	-0.962	1	-2.832	(-3.181*)

a - is the t-statistic with constant and trend,  $\tau_\mu$  is the t-statistic with constant.

10% MacKinnon (1991) critical values for  $\tau_\tau$  is -3.224 and for  $\tau_\mu$  is -2.624.

\* - Rejects at 10% significance level the null of a unit root.

A number in parenthesis for  $\tau_\mu$  indicates that for that variable the null hypothesis of a trend and a unit root was rejected, and therefore the relevant statistic is the one with the constant and trend included.