Linking Forests and Economic Well-being: A Four-Quadrant Approach

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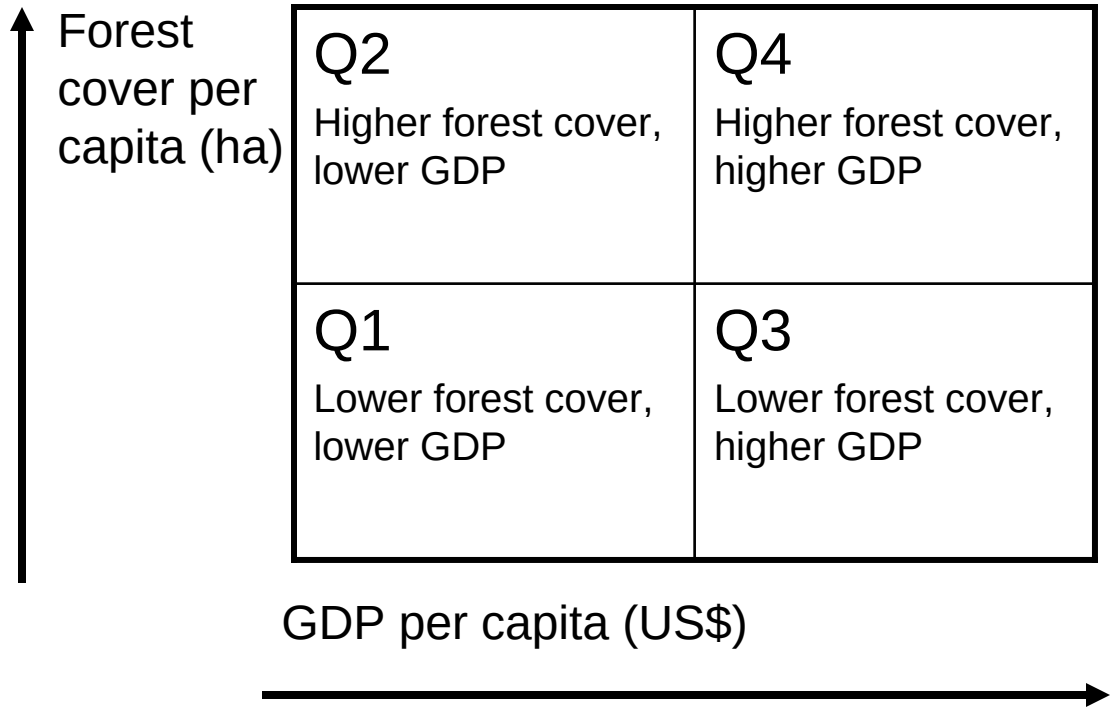
Introduction

- Explore the hypothesized relationship between forest cover and GDP per capita at the country level.
- Benchmark years: 1990, 2000, 2005
- Data mainly from United Nations (FAO and National Accounts Main Aggregates Database).

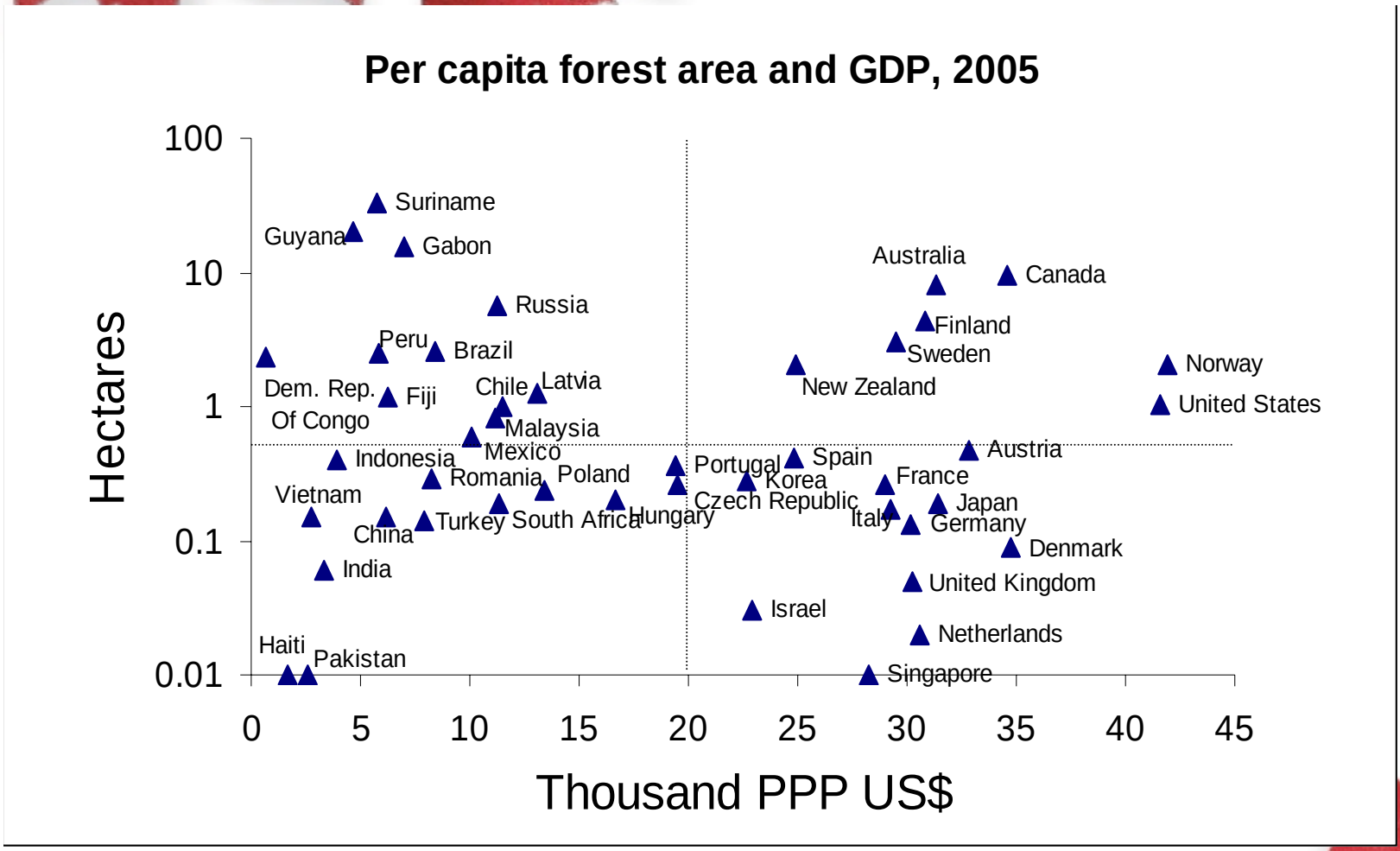
Framework

- Environmental Kuznet's Curve?
- Maini's 4-Quadrant Approach

The 4-Quadrant Framework



A visual example of selected countries



Normative arguments

- Countries in Q1 – the “worst-off”
- Countries in Q4 – the “best-off”
- With all else equal, countries desire higher forest cover or higher per capita GDP, or both.
- Not possible to trade-off forest cover with income.
- Optimal direction is North-Easterly

First, a look at the raw data

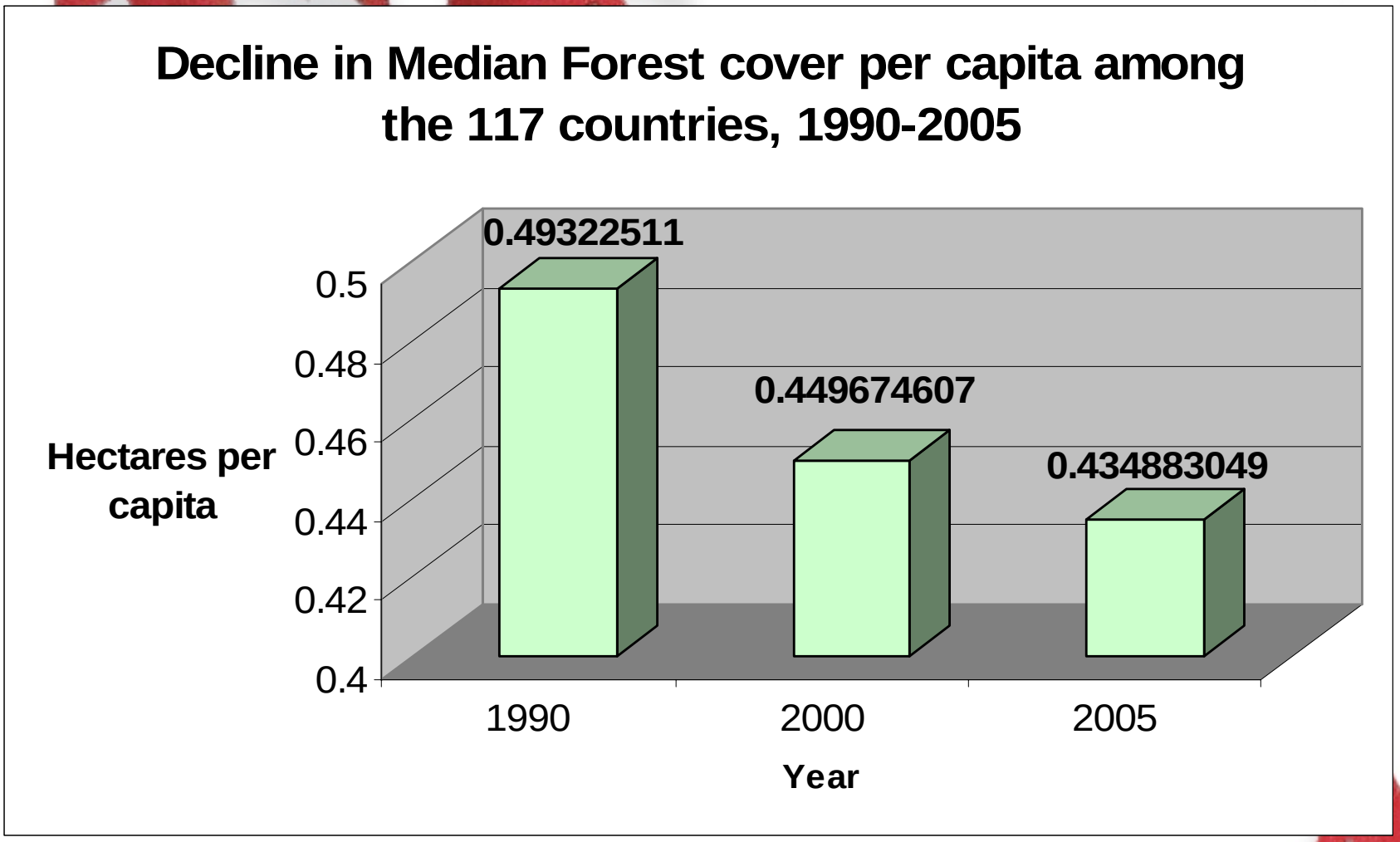
Change in Global Population, Forest Cover and GDP, 1990-2005

	Year			*Annual % change*		
	1990	2000	2005	1990-2000	2000-2005	1990-2005
World's population (10^6)[a]	5,279	6,085	6,464	1.43	1.22	1.36
World's total forests (10^6 ha)[b]	4,077	3,988	3,952	-0.22	-0.18	-0.21
Forests per capita (ha)[c]	0.77	0.66	0.61	-1.53	-1.56	-1.54
World's GDP, (constant, $US 10^9)[d]	21,944	28,786	31,811	2.75	2.53	2.69
World's constant per capita GDP (US$)[d]	4157	4730	4979	1.30	1.29	1.30

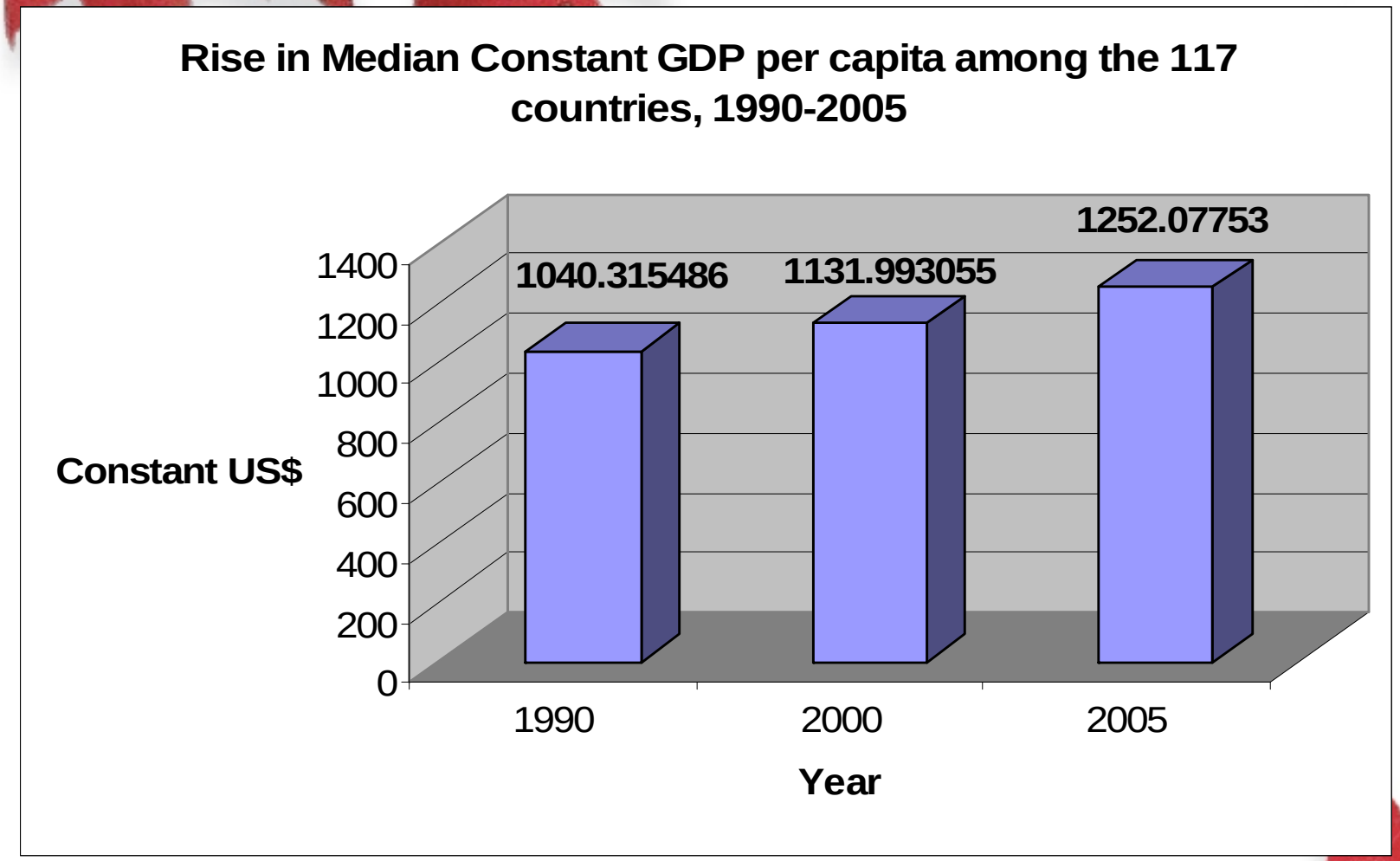
Per Capita Forest Cover and Change over Time

	Per capita forest cover (ha)			*Annual % change*		
Continent/ Year	1990	2000	2005	1990-2000	2000-2005	1990-2005
Africa	1.129	0.817	0.699	-3.182	-3.072	-3.146
Asia	0.175	0.149	0.147	-1.550	-0.361	-1.155
Europe	1.429	1.429	1.357	-0.003	-1.026	-0.345
North America	1.473	1.280	1.366	-1.391	1.309	-0.499
Oceania	0.250	0.215	0.213	-1.467	-0.242	-1.060
South America	3.116	2.550	2.216	-1.984	-2.763	-2.245

Forest Cover per capita, 1990-2005



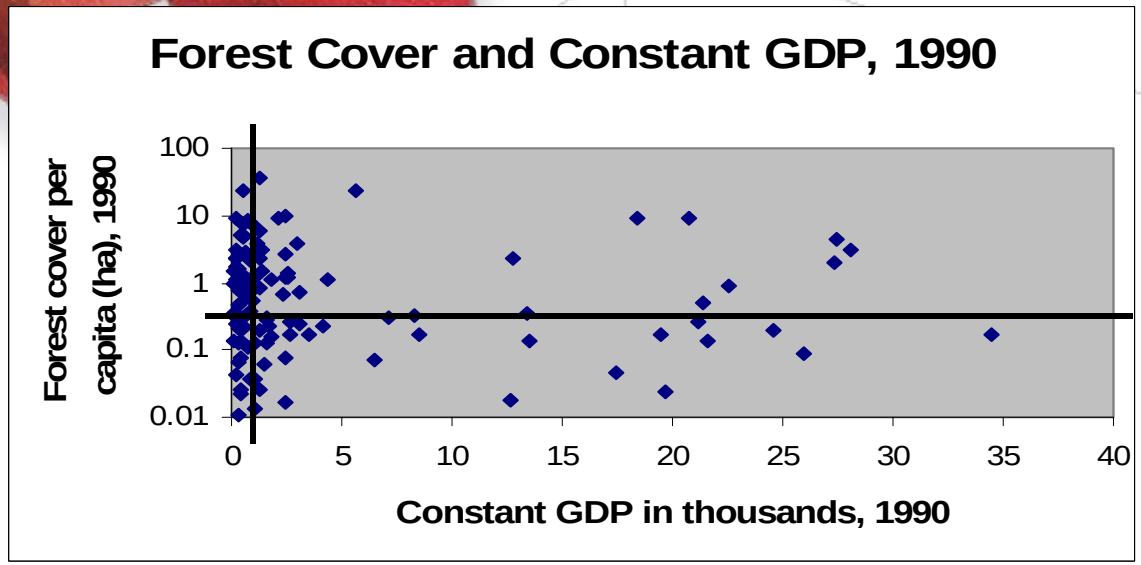
Constant GDP per capita, 1990-2005

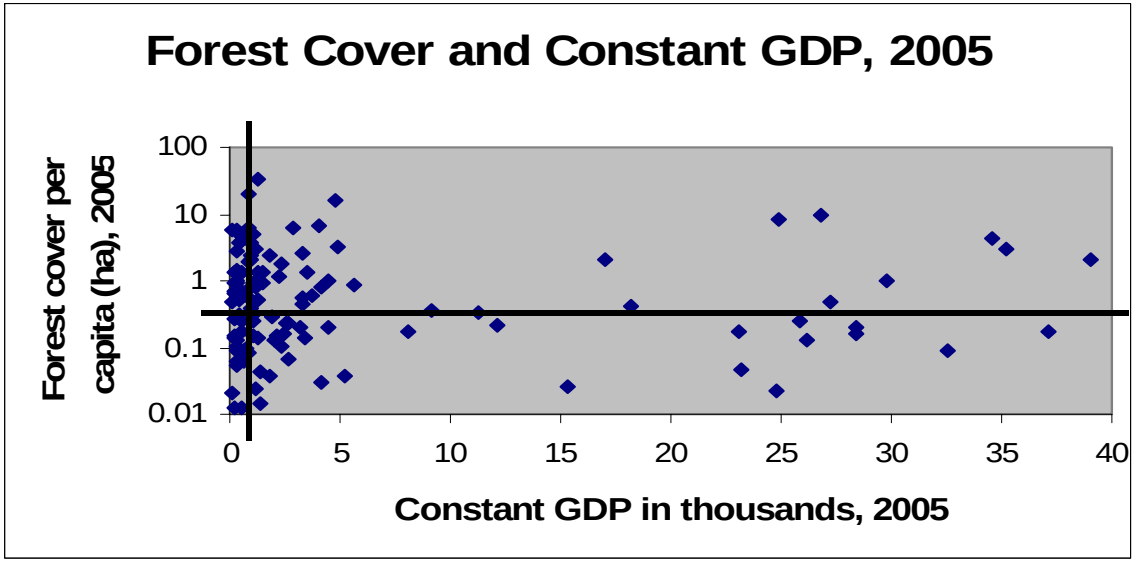


The 4-Quadrants

- Static demarcation lines or dynamic demarcation lines?
- Average or Median setting the demarcation lines?
- Some countries switched quadrants between 1990-2005
- All countries experienced movement within quadrants

Data from 117 Countries





Measure of association

- An empirical question
- Multiple regressions to determine the hypothesized association between forest cover and GDP
- Four models:

(A) $f_{it} = \beta_0 + \beta_1 L_i + \beta_2 y_{it} + \beta_3 (y_{it})^2 + \beta_4 EZ_{it} + e_{it}$

(B) $F_{it} = \beta_0 + \beta_1 L_i + \beta_2 P_{it} + \beta_3 Y_{it} + \beta_4 (Y_{it})^2 + \beta_5 EZ_{it} + e_{it}$

(C) $TF_{it} = \beta_0 + \beta_1 L_i + \beta_2 P_{it} + \beta_3 Y_{it} + \beta_4 (Y_{it})^2 + e_{it}$

(D) $NTF_{it} = \beta_0 + \beta_1 L_i + \beta_2 P_{it} + \beta 3 Y_{it} + \beta 4 (Y_{it})^2 + e_{it}$

Variables

Dependent Variables	
f_{it}	Forested area per person (ha)
F_{it}	Total forested area (‘000s ha)
TF_{it}	Forested area in tropical countries (‘000s ha)
NTF_{it}	Forested area in non-tropical countries ('000s ha)
Independent Variables	
L_i	Land (‘000s ha)
y_{it}	GDP per person (constant $US)
$(y_{it})^2$	GDP per person squared (constant $US)
Y_{it}	Total GDP (constant $US 10^6)
$(Y_{it})^2$	Total GDP squared (constant $US 10^6)
P_{it}	Population (‘000s)
EZ_{it}	Ecological zone (=1 if Tropical, 0 Non-tropical)

Regressions A and B

- 3 benchmark years and 117 countries, for a total of 351 observations.
- In regressions A and B, the Ecological Zone variable is a dummy variable (Tropical = 1; non-tropical = 0).

Regressions C and D

- Regression C only includes countries (97) that contain 50% or greater of its forested area in a tropical/subtropical ecological zone.
- Regression D only includes countries (20) that contain 50% or greater of its forested area in a temperate or boreal ecological zone.

Regression results: A and B

- Results are limited
- Regression A: Poor fit – very low R^2
- Regression B: As expected, total forest cover shows positive relationship with L_i and negative relationship with P_i
- Positive and statistically significant relationship between F_i and Y_i

Regressions C and D

- All independent variables show statistical significance (except quadratic GDP in D)
- A positive relationship is shown between total GDP variable and total forest cover.
- Total GDP quadratic term in C shows a statistically significant negative relationship.

Goodman-Kruskal's gamma

- Verifies existence of correlation between two variables
- $\gamma = (ad - bc)/(ad + bc)$
- It is possible to measure correlation between the benchmark years.

The four cells, a,b,c and d, correspond to the four quadrants.

Q2,b	Q4,d
Q1,a	Q3,c

Goodman-Kruskal's gamma

Year	Gamma value
1990	γ = -0.187
2000	γ = -0.084
2005	γ = -0.187

Discussion/Conclusion

1. Preliminary findings suggest the 4-Q approach is a useful but limited framework in understanding the association between GDP and forest cover.
2. Clearly, the choice of demarcation lines have a big impact on quadrant occupancy.

Discussion/Conclusion

3. South-Easterly direction is the current trend.
4. Contradictory results in regressions.
5. Future research will involve understanding country movements within and between quadrants by use of regression analysis.
6. Goodman-Kruskal's gamma indicates a degree of negative association.