Tracking the Anthropogenic Drivers of CO_2 Emissions Growth in India: A State-Level Analysis

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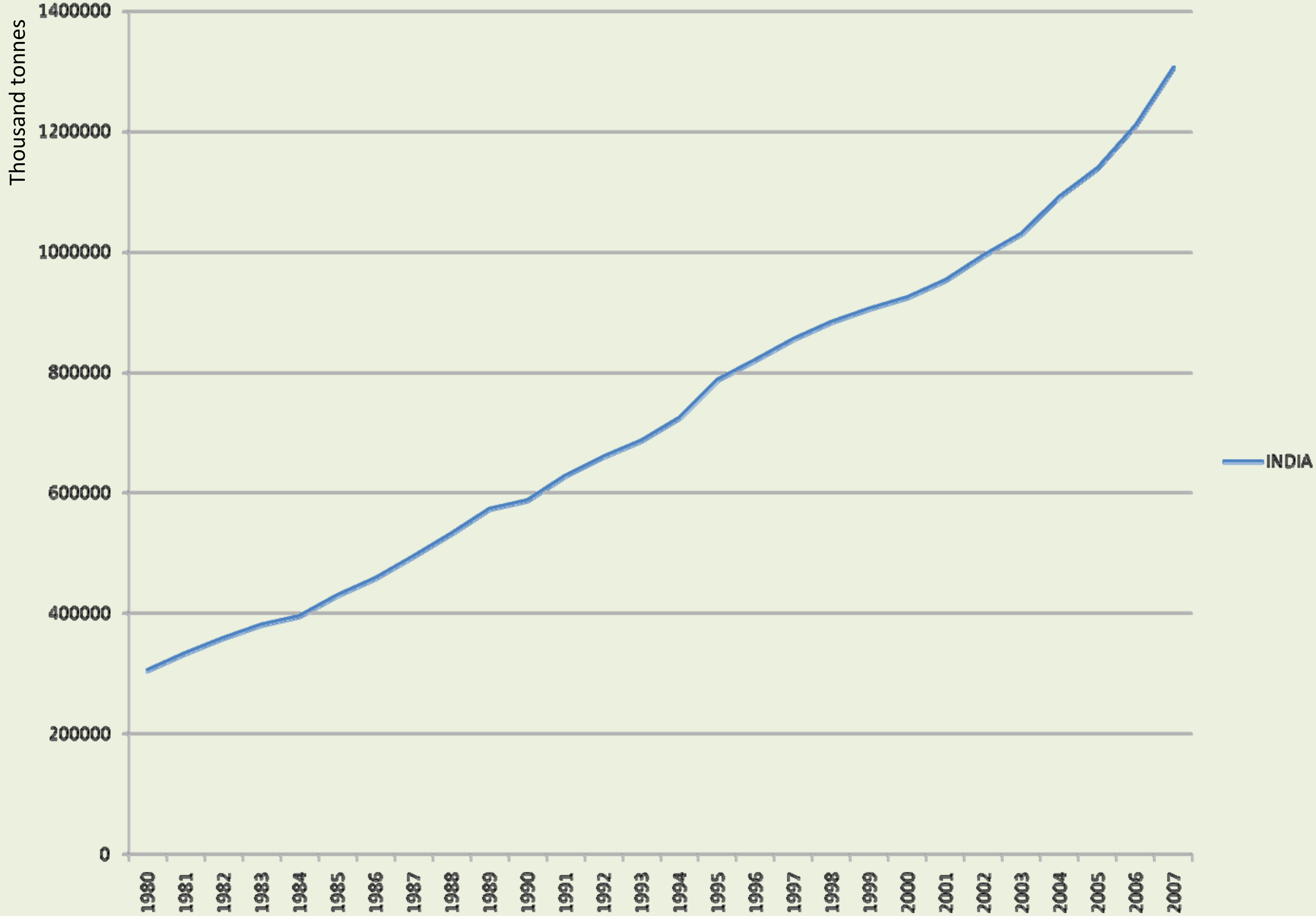
Objectives

- State-wise analysis of CO_2 emissions
  - Construction of inventory
- Identification of drivers behind emissions
  - IPAT identity
  - STIRPAT model
- Projection of emissions for 2020
  - Two alternate scenarios

Emissions trend: India



State-level analysis: Rationale

- India: wide geographical, socio-economic diversities
- Aggregates may hide details: disaggregated analysis required for policy analysis
- Federal nature of polity: “polluting” sectors such as transport and industry are state-level areas
  - Information at the state-level indispensable to design effective mitigation strategies

Inventory Estimation: Observations

- Fourfold increase in emissions for India in the aggregate
- Low-income states
  - High relative share of population
  - High emissions due to concentration of polluting industries
  - Less resources to invest in "clean technology"
- Middle-income states
  - Steadily increasing emissions
- High-income states
  - Maharashtra, Gujarat, Tamil Nadu: high emissions
  - Delhi, Kerala, Himachal Pradesh: low emissions

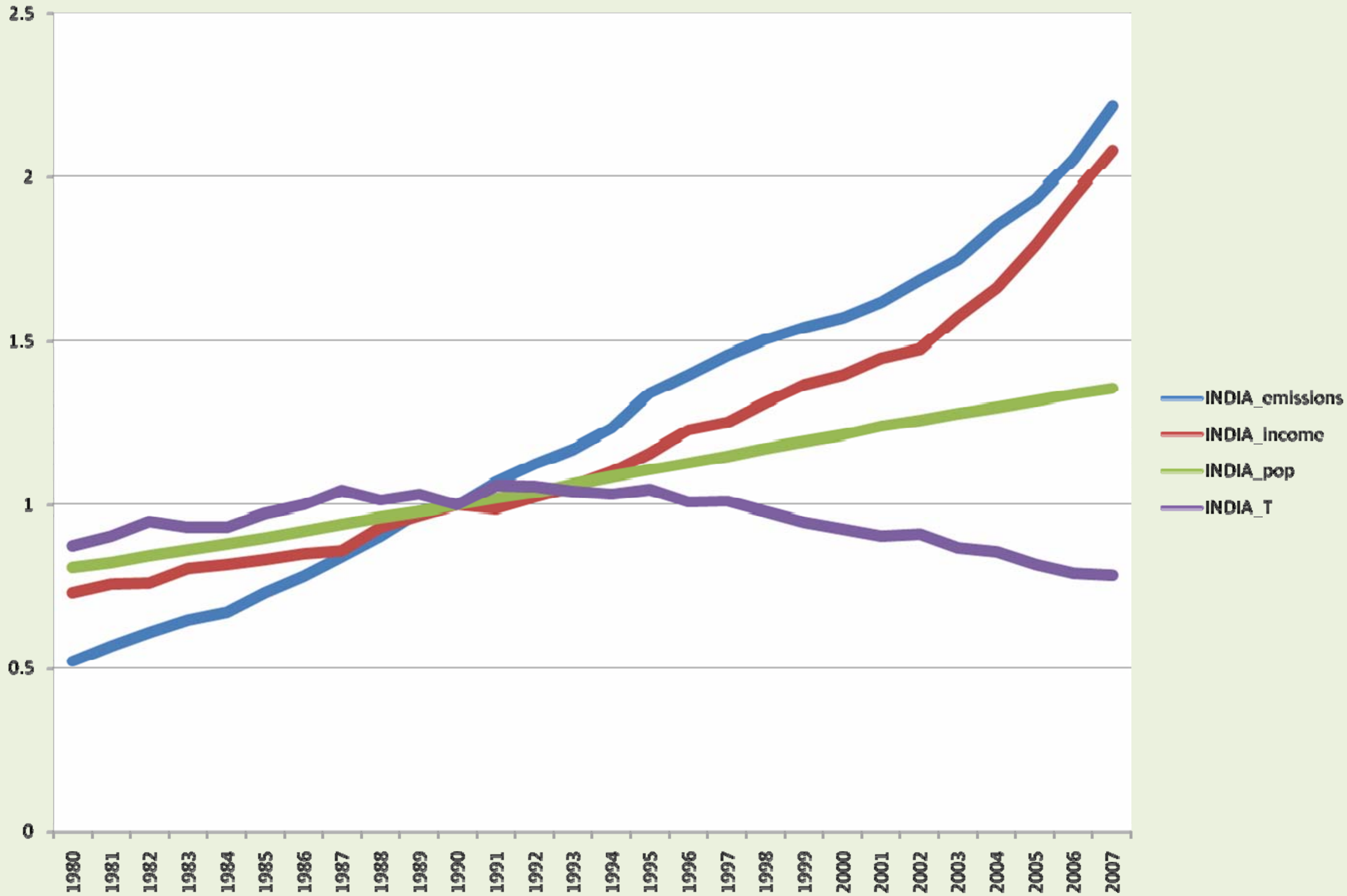
Policy Implications

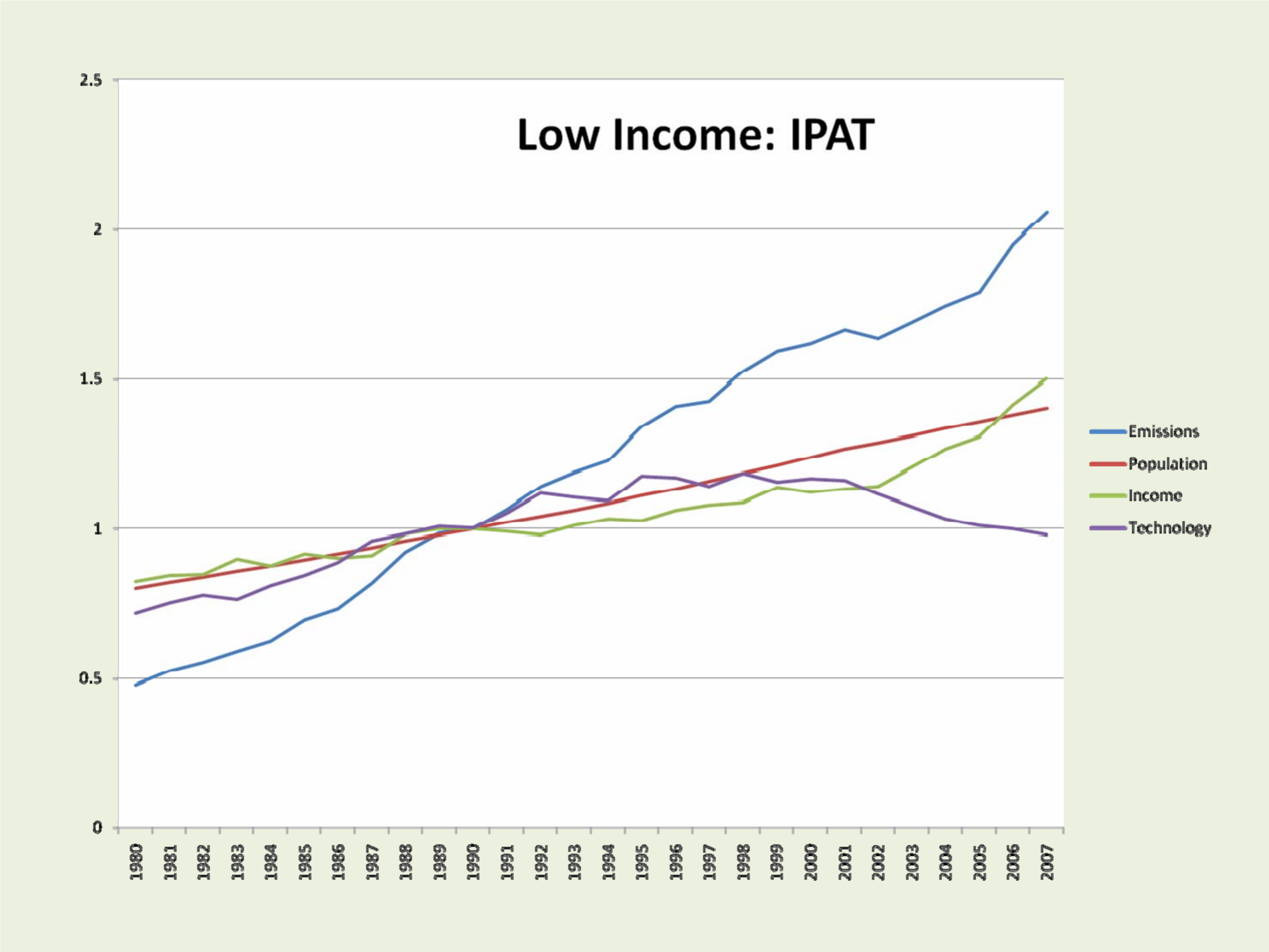
- States with high per-capita income should take stringent measures
- Important role of environment federalism in attributing responsibility of mitigation across regions

Drivers of emissions

- IPAT identity
  - Impacts are a product of income, population and technology (“other” factors)
  - I=PAT
- Technology coefficients calculated
- Income appears to be the primary driver of emissions

Drivers of emissions: India





Low Income: IPAT
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Emissions
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Income
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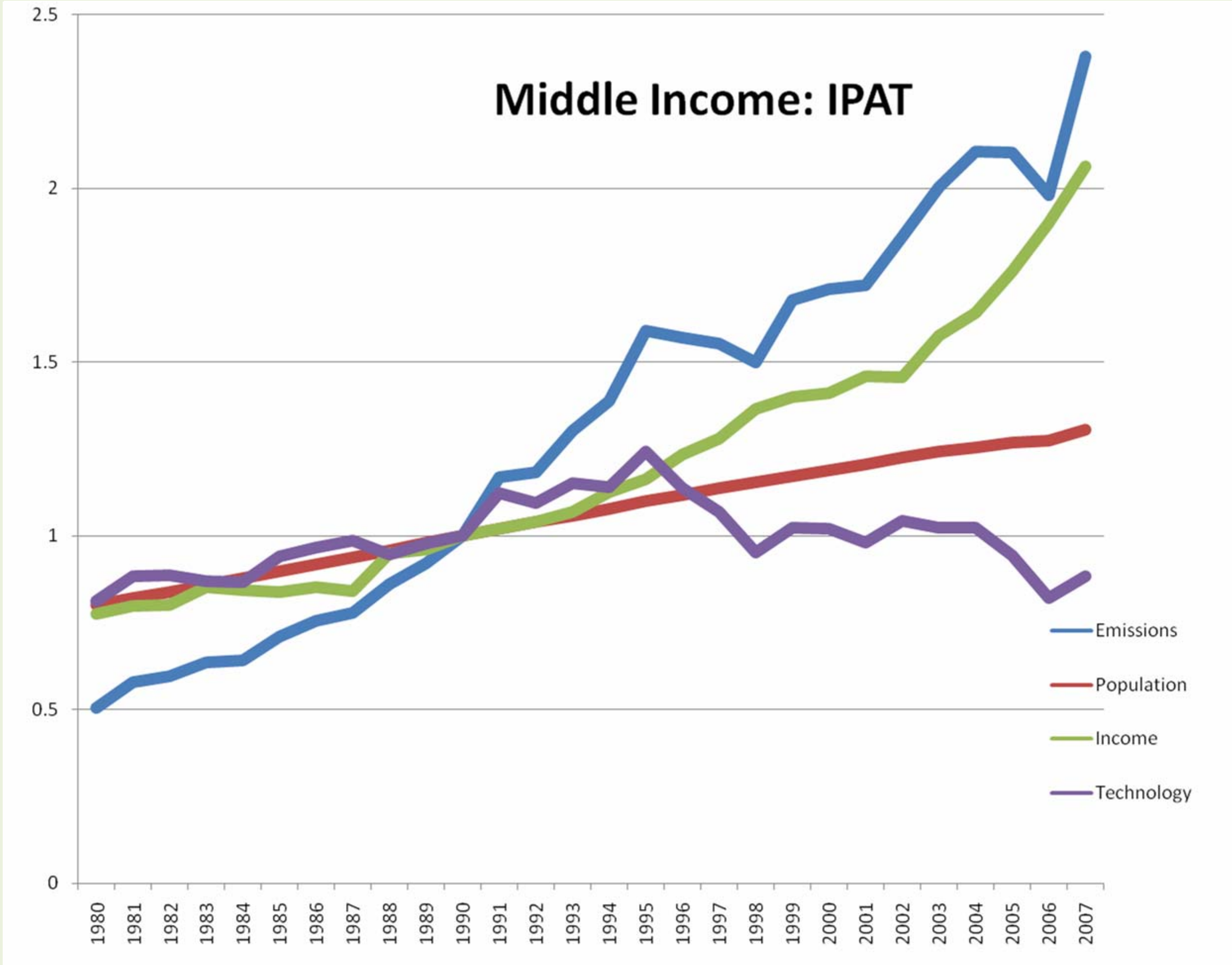

Middle Income: IPAT
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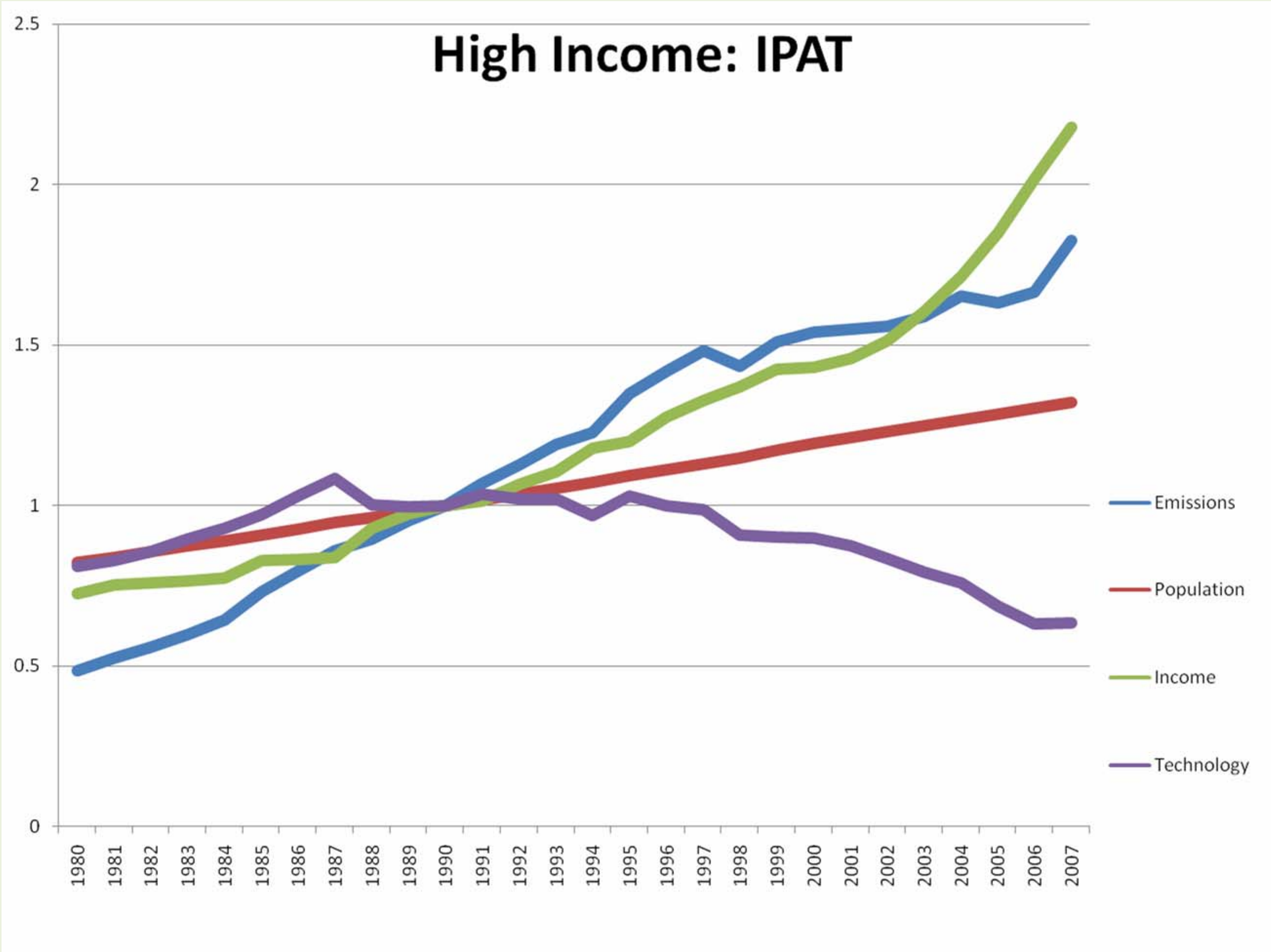
High Income: IPAT
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Emissions
Population
Income
Technology

Observations

- Intensity (T) has been high and increasing, but lately it has started to decline
  - Overall carbon efficiency is low
- Income can be identified as a primary driver for most states
  - Decoupling of growth can be seen in high income states

STIRPAT model

- Limitations of IPAT (Kaya, 1997)
  - Can’t be used for hypotheses testing
  - Proportional effect of drivers assumed
- STIRPAT (Dietz and Rosa, 1994)
  - Stochastic model
  - Used to test hypotheses
  - Allows for non-proportionality of drivers

STIRPAT: Formal Specification

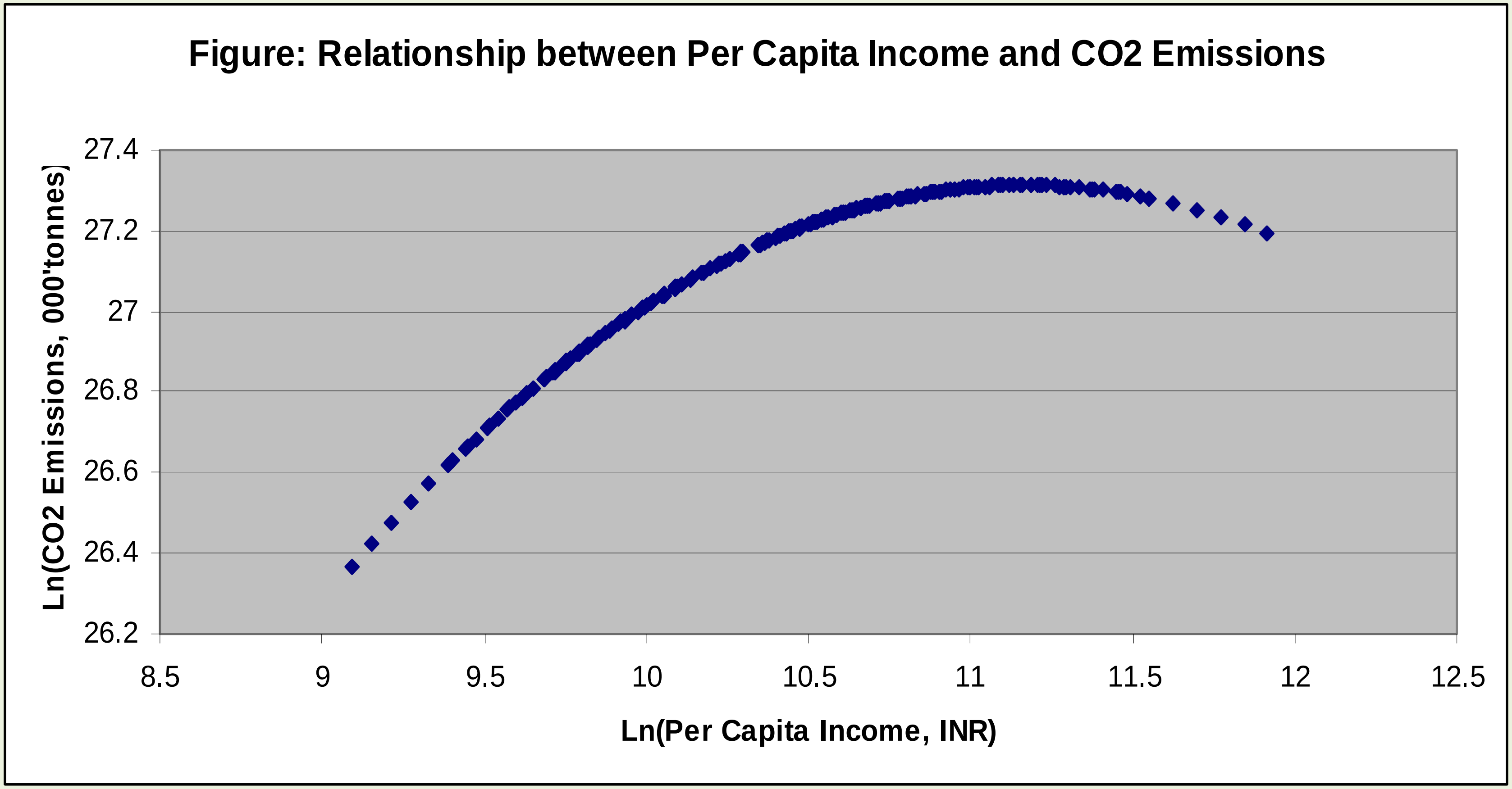
- Log I= a + b log A + c log P + e
- ‘e’ captures the “other” factors: analogous to ‘T’ in the IPAT formulation
- Specification used:
  - $\text{Log } I_i = a + b \log A + c (\log A)^2 + d \log P + S_i + e$
- Estimates of coefficients obtained to assess the contribution of each factor towards emissions

STIRPAT results

Estimated Coefficients of STIRPAT Model Using Fixed Effects Model

Variable	Coefficient	t-statistic
Log A	4.89***	4.31
(Log A)^2	-0.21***	-3.81
Log P	0.88***	5.66
Constant	-17.55***	-3.15
Adj R^2		0.986
No. of Observations		306

Possible Existence of EKC relation



Projected emissions for 2020

- Two alternate scenarios for intensity considered
  - Constant intensity (business-as-usual)
  - Reduced intensity
    - 20% reduction from 2005 level
- Scenarios for population and income
  - Growth rates of respective states
- 1841638 thousand tonnes under BAU
- 1473311 thousand tonnes under reduced intensity
- 368328 thousand tonnes reduction achieved if intensity reduction target met

Conclusions

- Vast diversity in state-wise emissions trend
  - States with high per-capita emissions have greater scope of reducing emissions
  - Low-income states which are also heavy polluters will need technology transfer and financial support from the centre and richer states
- Future emissions expected to be high
  - Possibility of EKC further substantiates this hypothesis
  - Further reduction in intensity by encouraging efficiency and cleaner technologies is the key
- Environmental federalism plays an important role
  - Containing state-level emissions will strengthen India's position on the global carbon market and international forums
  - Centre and states need to coordinate and cooperate to achieve low-carbon growth trajectory

References

- Alcott, B. (2010). Impact caps: why population, affluence and technology strategies should be abandoned. *Journal of Cleaner Production* , 552-560.
- Commoner, B., Corr, M., &Stamler, P. J. (1971). The causes of pollution. *Environment*,2-19.
- Dietz, T., Rosa, E.A. (1994). Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review* 1, 277-300.
- Dietz, T., Rosa, E.A. (1997). Effects of population and affluence on CO2 emissions, *Proceedings of the National Academy of Sciences of the USA* 94, 175-179.
- Ehrlich, P. &Holdren, J. (1970). The people problem. *Saturday Review* 4, 42-43.
- Centre for Monitoring Indian Economy, Energy : March, 2010
- Garg A., Bhattacharya S., Shukla P.R. and Dadhwal V.K. (2001). Regional and sectoral greenhouse gases emissions for India. *Atmospheric Environment* 35, 2679-2695.
- Ghoshal, T., & Bhattacharya, R. (2008). State level carbon dioxide emissions of India: 1980-2001. *Contemporary Issues and Ideas in Social Sciences* .
- INCCA. (May 2010). *India: Greenhouse Gas Emissions 2007.* Ministry of Environment and Forests, Government of India.
- IPCC, (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Editors: JT Houghton, LG MeiraFilho, B Lim, K Treanton, I Mamaty, Y Bonduki.
- IPCC, (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories , editors: J Penman, D Kruger, I Galbally, T Hiraishi, B Nyenzi, S Emmanul, L Buendia, R Hoppaus, T Martinsen, J Meijer, K Miwa and K Tanabe. Published for the IPCC by the Institute for Global Environmental Strategies, Japan ISBN 4-88788-000-6.
- IPCC, (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. Edited by Jim Penman, Michael Gytarsky,TakaHiraishi, Thelma Krug, Dina Kruger, RiittaPipatti, Leandro Buendia, Kyoko Miwa, Todd Ngara, Kiyoto Tanabe and Fabian Wagner. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC ISBN 4-88788-003-7.
- Rapauch, M. R., Marland, G., Ciais, P., Le Que, C., Canadell, J. G., Klepper, G., et al. (2007). Global and regional drivers of accelerating CO_2 emissions. *Proceedings of the National Academy of Sciences of the USA, 104* (24), 10288-10293.
- VrijeUniversiteit Amsterdam (2010). Nationally Appropriate Mitigation Actions (NAMAs) in developing countries: Challenges and opportunities
- York, R., Rosa, E. A., &Dietz, T. (2003). STIRPAT, IPAT and ImPACT: analytical tools for unpacking the driving forces of environmental impacts. *Ecological Economics* , 351-365.

Questions? Comments?

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