

Final Progress Report
Sustainability Science Program
Term: September 1, 2013 – August 1, 2014

Name:

Anant Sudarshan

Your fields:

Environmental Economic, Engineering

Your degree program, institution and graduation date:

Ph.D, Management Science and Engineering, Stanford University, 2011

Faculty host at Harvard name and department:

Rohini Pande, Kennedy School of Government

Description of SSP-related research activity:

A particulate emissions trading scheme for India: Evaluating the impact of information and markets

Abstract:

A leading environmental concern in India involves the impact of particulate matter emissions on human health. Nearly a third of the urban population lives in areas with ambient particulate standards exceeding health standards. Industrial emissions form an important part of this problem with many industry burning solid fuels with high polluting potentials. Regulation is difficult with limited industry compliance in light of infrequent manual monitoring. At the same time the costs of complying with air pollution standards may be significant for a growing industrial sector. This project will proceed in two phases. The first part involves testing the impact of real time emissions information provided to regulators and the public through the use of continuous emissions monitoring systems. The hypothesis is that better information could lead to more effective regulation and greater industry compliance with existing laws. Public disclosure may create an additional source of pressure on industry to operate as cleanly as possible. Phase two of the project involves the design and evaluation of a pilot emissions trading system for particulates in India and measurement of its effects on source-level emissions and abatement costs using a randomized-controlled trial. This rigorous design provides extremely reliable estimates of the effects of the pilot trading scheme and will help build public support for market-based environmental regulation. By increasing monitoring and transparency in a regulatory framework that fixes clear goals, emissions trading may also have benefits for the political economy of regulation. A robust trading scheme can attract climate change financing to developing countries by demonstrating reliable verification of total emissions.

Identification of the problem you address:

Environmental regulation in India suffers from three key problems. The first is legal – regulators have limited ability to impose financial penalties on polluters and instead are restricted to initiating criminal proceedings in court. This makes the pollution-penalty link high cost for the regulator and often disproportionate to the degree of the offense. Second, poor monitoring of emissions (exacerbated by limited trained staff and a high number of small industry with strong incentives to violate norms) creates a severe compliance problem. Lastly, a reliance on command and control regulation increases abatement costs on industry much more than necessary leading to a sharpened conflict between environmental objectives and economic growth.

Key question asked about the problem:

The project I am working on involves the design of a first of its kind emissions market in particulate matter based on continuous emissions monitoring (CEMS) data transmitted in real time to the regulator. CEMS data is used to enforce a cap expressed in total load of particulates emitted over a year with industries able to trade permits to emit pollutants over a compliance period. This market based regulatory mechanism will be

rolled out on a pilot group of industries in two phases with industries randomly allocated to treatment and control groups during the first phase. A randomized control trial design is used to estimate (i) compliance improvements and regulator actions owing to continuous emissions monitoring data (ii) the impact of public disclosure and peer comparison on emission levels and (iii) the gains to trade in terms of changes in abatement costs.

The methods by which you answered that question:

The primary research methodology involves field surveys and a randomized control trial design for clean identification of treatment effects. A secondary methodology involves the use of a market simulation model and engineering estimates based on a survey of industry.

Presently three parts of the primary intervention are in field. Industrial plants in Maharashtra and Gujarat are being equipped with continuous emissions monitors and data is being gathered to track the impact of this intervention on regulator and plant behavior. In addition a detailed baseline survey of plants intended to be included in the pilot Emissions Trading Scheme is in the field and will be used to generate detailed measures of the gains to trade expected from a pilot ETS. Finally, a randomized control trial will begin shortly in Maharashtra where manual emissions data is being used to create report cards for plants on their environmental performance. This will be placed online and regulator and plant outcomes tracked in parallel to try and measure the impact of this publicly disclosed information on environmental outcomes.

Principle literature upon which the research drew:

Incentive based environmental management, instrumental engineering, statistical inference in environmental management, governance impacts of information disclosure

Empirical data acquisition description:

Baseline survey of industry in the field and continuous emissions monitoring data from industry sites

Geographical region studied:

India - Surat (Gujarat), Aurangabad, Chandrapur and Jalna (Maharashtra)

Recommendations that might be relevant for your problem:

NA

A description of the final product(s) you have/are aiming to produce:

Detailed technical and regulatory specification enabling the use of continuous emissions monitoring to underpin an emissions trading scheme (completed and published by India's Central Pollution Control Board)

Data handling software system specification for real time emissions data transfer (completed and published by India's Central Pollution Control Board)

Working paper for publication in a science journal outlining how statistical inference and regulatory design can enable the use of low cost, high noise instrumentation for high quality emissions monitoring

Working paper on the impact of information disclosure on polluter behavior and regulator efficiency

Description of major other intellectual or professional advancement activity(ies) over the past academic year:

Journal Publications

- (i) Deconstructing the Rosenfeld Curve: Making sense of California's low electricity intensity. 2013. Energy Economics, 39, 197-207.

Conference Presentations (peer reviewed)

- (ii) 2013: "The Economic Impacts of Temperature on Industrial Productivity: Evidence from Indian

- Manufacturing'. November 3-4, 2013. North-East Universities Development Consortium Conference, Harvard University
- (iii) 2013: "The Behavioral Effects of Monetary Contracts: Using peer comparisons and financial incentives to reduce electricity demand in urban Indian households". September 23-25, 2013. Stanford Institute for Theoretical Economics: Psychology and Economics
- (iv) 2014: "The Economic Impacts of Temperature on Industrial Productivity: Evidence from Indian Manufacturing". July 21-22, 2014. NBER Summer Institute.

Job Appointment:

Beginning September, 2014:

India Director, Energy Policy Institute at Chicago

Sr. Research Associate, Department Of Economics, University Of Chicago

Please list citations for reports, papers, publications and presentations that built on your fellowship research:

1. Central Pollution Control Board (Government of India) Official Publication:
[SPECIFICATIONS AND GUIDELINES FOR CONTINUOUS EMISSIONS MONITORING SYSTEMS \(CEMS\) FOR PM MEASUREMENT WITH SPECIAL REFERENCE TO EMISSION TRADING PROGRAMS \(CPCB/e-PUBLICATION/2013-14\)](#)

This specification underpins an ongoing rollout of continuous emissions monitoring systems in the project states – the first such use of low cost monitoring technology to enable the accurate monitoring of particulate matter. The monitoring specification is designed for an emissions trading platform.

Please describe any collaborative activities with other SSP Fellows that you are involved with.

Nick Ryan:

1. *Reducing electricity distribution losses in Bihar*

(with Michael Greenstone, Robin Burgess, Nick Ryan).

Implementation Partners: North and South Bihar Power Distribution Company

2. *Investigating the nature of demand for decentralized electricity in rural India*

(with Michael Greenstone, Robin Burgess, Nick Ryan)

Implementation Partners: Husk Power Systems

Can decentralized solar micro-grids pay for themselves? What is the nature of consumer demand for power and how does access to even a small amount of electricity impact the lives of the poor.

Santosh Kesavan

Monetary and non-monetary incentives to encourage the use of public transportation

(with Santosh Kesavan, Rohini Pande)

Implementation Partners: Rapid Metro Gurgaon Ltd.

How can financial and non-financial incentives change levels of adoption and use of public transportation?

This project evaluates different programs aimed at encouraging the use of a new Metro rail line in Gurgaon.

Principal collaborators outside Harvard (list name and institution):

1. Michael Greenstone, MIT Economics
2. Robin Burgess, LSE Economics
3. Meenu Tewari, University of North Carolina
4. E Somanathan, Indian Statistical Institute
5. R Somanathan, Delhi School of Economics
6. Sebastien Houde, University of Maryland, Agricultural Economics
7. Sagnik Dey, Department of Atmospheric Sciences, IIT Delhi

List any awards or grants that you have received this year for the current or coming year:

2014: Lighting Up Bihar: Electricity Service Delivery as a Collection Action Problem. Urban Services Initiative, J-PAL, \$160,675

2014: Welfare Impacts of Rural Decentralized Electricity. Climate Works. \$38,230

2013: Building Environmental Regulation that Enables Growth (International Growth Centre - India) - \$168,000

2013: Lighting Up Bihar: Electrification to Sustain Economic Growth (International Growth Centre - Bihar) - \$160,000

2013: Shaping Environmental Policy for Co-benefits (Shakti Sustainable Energy Foundation, Climateworks) - \$45,000

2013: Pilot Project to Design and Evaluate Incentive Schemes to Promote Sustainable Urban Transportation in India (J-PAL Urban Services Initiative) - \$44,000

If you are moving to a new position, please list your contact information there:

India Director, Energy Policy Institute At Chicago

Sr. Research Associate, Department Of Economics, University Of Chicago

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