



# **The Economic Effects of Electricity Deregulation: An Empirical Analysis of Indian States**

**Anupama Sen**

**Oxford Institute for Energy Studies  
& Department of Land Economy, University of Cambridge**

**Tooraj Jamasb**

**Electricity Policy Research Group, Faculty of Economics,  
University of Cambridge**

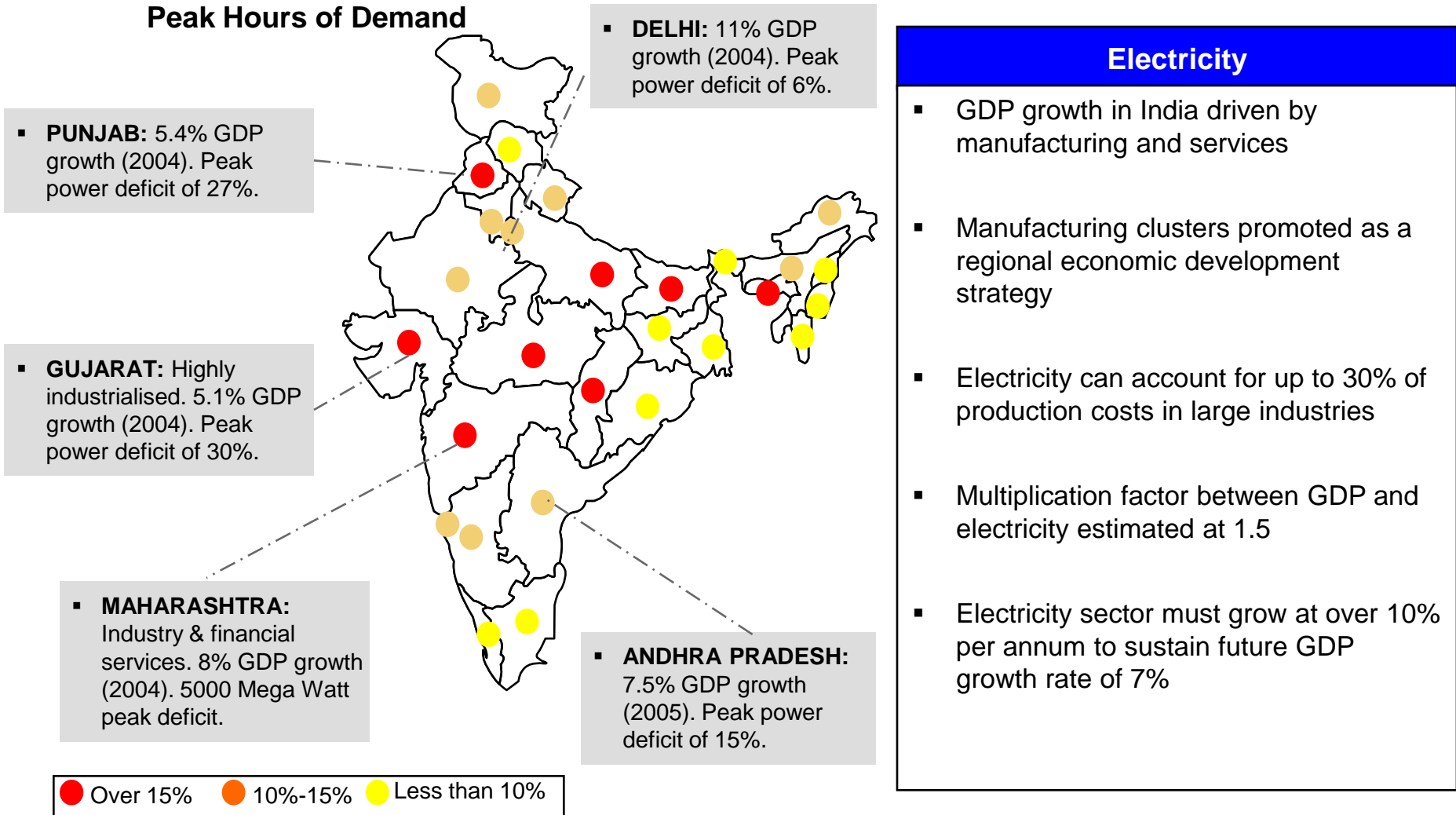


## Presentation outline...

- Background and Motivation**
- Research Questions
- Indian Electricity Reforms
- Methodology
- Findings
- Insights & Conclusions

# A serious electricity crisis exists in India today, making electricity reforms crucial for future growth & investment

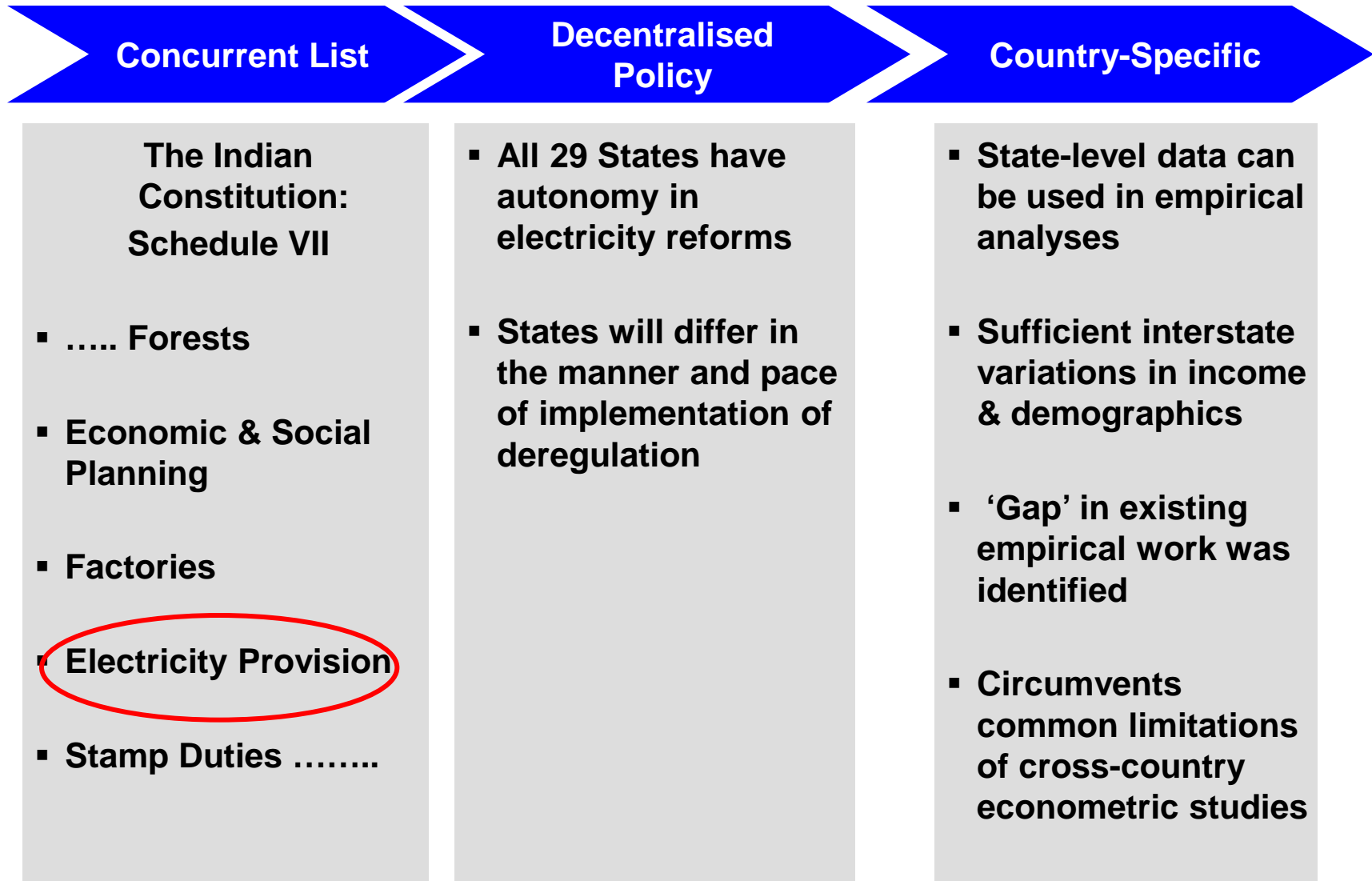
## Power Deficit During Peak Hours of Demand



### Electricity

- GDP growth in India driven by manufacturing and services
- Manufacturing clusters promoted as a regional economic development strategy
- Electricity can account for up to 30% of production costs in large industries
- Multiplication factor between GDP and electricity estimated at 1.5
- Electricity sector must grow at over 10% per annum to sustain future GDP growth rate of 7%

# In addition to being a highly topical area of research, a study on India helps us get closer to “real” issues in reform





- Background and Motivation
- Research Questions**
- Indian Electricity Reforms
- Methodology
- Findings
- Insights & Conclusions

# The main research question was analysed in components to lend itself more readily to empirical analysis

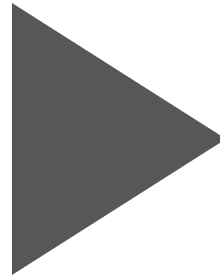
**Broad**

**How do different regional regulatory regimes in electricity provision lead to differing impacts on the regional (state) economy, in developing countries in general, and India in particular?**

## Two-Stage Approach

### Stage I

- How does deregulation & reform affect key micro and macroeconomic variables?
- What does the available evidence suggest conditions the nature of these impacts?



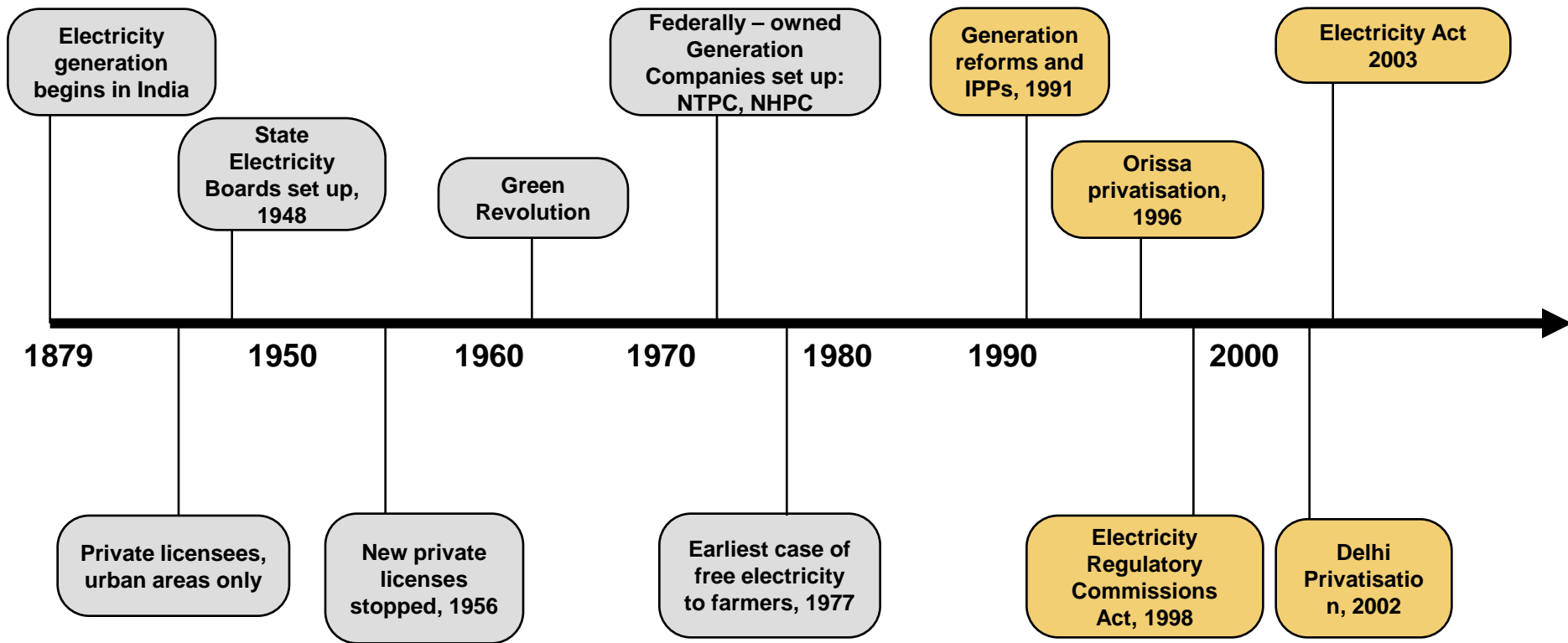
### Stage II

- How might these economic impacts produce regionally differentiated outcomes in circumstances where regional governments adopt different approaches to reform?



- Background and Motivation
- Research Questions
- Indian Electricity Reforms**
- Methodology
- Findings
- Insights & Conclusions

# A timeline of reforms shows they have been progressive



# The reform process culminated in the consolidation of all policy on power, in a set of core measures (Electricity Act 2003)

	Description
<b>INDEPENDENT POWER PRODUCERS</b>	<ul style="list-style-type: none"><li>▪ Power purchase agreements</li></ul>
<b>REGULATOR</b>	<ul style="list-style-type: none"><li>▪ The establishment of a State independent electricity regulator</li></ul>
<b>UNBUNDLING</b>	<ul style="list-style-type: none"><li>▪ Splitting up the state-owned company</li></ul>
<b>TARIFF REFORM</b>	<ul style="list-style-type: none"><li>▪ Setting prices according to the cost of supply</li></ul>
<b>OPEN / THIRD PARTY ACCESS</b>	<ul style="list-style-type: none"><li>▪ Allowing access to the transmission grid by private producers</li></ul>
<b>COMPETITION IN DISTRIBUTION</b>	<ul style="list-style-type: none"><li>▪ Private participation in distribution; no explicit mention of 'privatisation'</li></ul>

**But political economy has long influenced electricity provision in India; and any analysis needs to be interpreted in this context**

## **Political Economy Electricity Used As a 'Carrot'**

### **Agricultural Tariffs**

- Agricultural consumers promised free or very cheap electricity
- Industries charged very high rates to cross-subsidise agriculture
- Tariffs not cost reflective

### **Hidden Losses**

- Unmetered agricultural consumption
- Wastage
- No funds for maintenance
- State Electricity Boards financially insolvent
- T&D losses clubbed with agricultural consumption

### **Theft**

- Whole communities sometimes collude in obtaining electricity illegally.



- Background and Motivation
- Research Questions
- Indian Electricity Reforms
- Methodology**
- Findings
- Insights & Conclusions

# A set of commonly-observed impacts was identified from existing literature; data on these was gathered and tested for Indian states

## Empirical Work

- Identified the impacts that are most commonly observed in existing literature & probed these for Indian states

## Main Potential Impacts

**Efficiency improves**

**Prices decrease for industry**

**Cross-subsidies decrease  
(corrections in pricing)**

**Reinvestment in the system**

**New investment inflows**



## Method

- Specific hypotheses for each potential impact, explored using regression techniques
- Panel dataset of variables on electricity and economic indicators, containing between 17 to 19 cross sections (states), representing over 80% of the population.
- Models used
  - Fixed effects estimators for static models:  
Robust Variance Estimates  
AR (1)
  - Bias-corrected Least Squares Dummy Variables estimator (LSDVC) for dynamic models (Bruno, 2005):  
Anderson-Hsiao  
Arellano-Bond  
Blundell-Bond
- Standard tests carried out for each estimation



- Background and Motivation
- Research Questions
- Indian Electricity Reforms
- Methodology
- Findings**
- Insights & Conclusions

# The empirical work required construction of a Reform Index, based on the Indian experience

Reform Index (0 / 1)	
<b>IPPS</b>	▪ The existence of an operational Independent Power Producer
<b>REG</b>	▪ The establishment of an Independent Regulator
<b>UNB</b>	▪ Unbundling of the state-owned monolith
<b>TAR</b>	▪ Tariff rationalisation through the passing of tariff orders
<b>OPREG</b>	▪ The implementation of Open Access to the transmission network
<b>DPVT</b>	▪ The privatisation of distribution



Bacon (1999)
<ul style="list-style-type: none"> <li>▪ Set of six reform measures to indicate progress of a reform programme in a cross country study.</li> </ul>

Additional Reform Indicators	
<b>PRATIO1</b>	▪ Ratio of Industrial to Domestic Electricity Prices (adjusted for inflation)
<b>PRATIO2</b>	▪ Ratio of Industrial to Agricultural Electricity Prices (adjusted for inflation)

# H1: The role of electricity within infrastructure

H1

Alongside other infrastructure types, the stock of electricity infrastructure in an Indian state makes a positive and significant contribution to its industrial economic output.

$$INDGDP1_{it} = \alpha + \gamma_i + \beta ELEC_{it} + \beta RDS1_{it} + \beta TEL_{it} + \beta RAIL_{it} + \beta INTER1_{it} + \beta INTER2_{it} + \beta POPN_{it} + \varepsilon_{it}$$

Dependent Variables	
INDGDP1	<ul style="list-style-type: none"> <li>State Industrial GDP at Constant (1993-94) Prices (Million Rupees)</li> </ul>

Independent & Control Variables	
ELEC	<ul style="list-style-type: none"> <li>Length of T&amp;D lines in a state (ckt km)</li> </ul>
RDS1	<ul style="list-style-type: none"> <li>Length of national highways in a state (km)</li> </ul>
TEL	<ul style="list-style-type: none"> <li>Growth in number of fixed telephone lines in a state (%)</li> </ul>
RAIL	<ul style="list-style-type: none"> <li>Length of railway track in a state (km)</li> </ul>
INTER1	<ul style="list-style-type: none"> <li>ELEC * RAIL</li> </ul>
INTER2	<ul style="list-style-type: none"> <li>ELEC * RDS1</li> </ul>
POPN	<ul style="list-style-type: none"> <li>Population of a state (millions)</li> </ul>





## H2: The efficiency impacts of reform

H2

Indian states that have implemented a greater number of reform measures are more likely to have experienced improvements in technical & operating efficiency of their electricity sectors.

	Dependent Variables
PLF	<ul style="list-style-type: none"> <li>Plant Load Factor of grid connected thermal stations (%)</li> </ul>
TDR	<ul style="list-style-type: none"> <li>Transmission &amp; distribution losses in a state (%)</li> </ul>
GRGEN	<ul style="list-style-type: none"> <li>Gross generation of thermal power plants in a state (Million KWh)</li> </ul>

	Independent & Control Variables
Reform Index	<ul style="list-style-type: none"> <li>Six measures</li> </ul>
PRATIO 1	<ul style="list-style-type: none"> <li>Ratio of Industrial to Domestic Electricity Prices (adjusted for inflation)</li> </ul>
PRATIO 2	<ul style="list-style-type: none"> <li>Ratio of Industrial to Agricultural Electricity Prices (adjusted for inflation)</li> </ul>
PCGDP	<ul style="list-style-type: none"> <li>State GDP per capita at Constant (1993-94) Prices (Million Rupees)</li> </ul>
HYDRO1	<ul style="list-style-type: none"> <li>% hydroelectric generation capacity in a state</li> </ul>

# H3: The price impacts of reform

H3

Electricity sector reforms have had a substantive impact on electricity prices for the end-consumer.

$$PRICE_{it} = \gamma L.PRICE_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

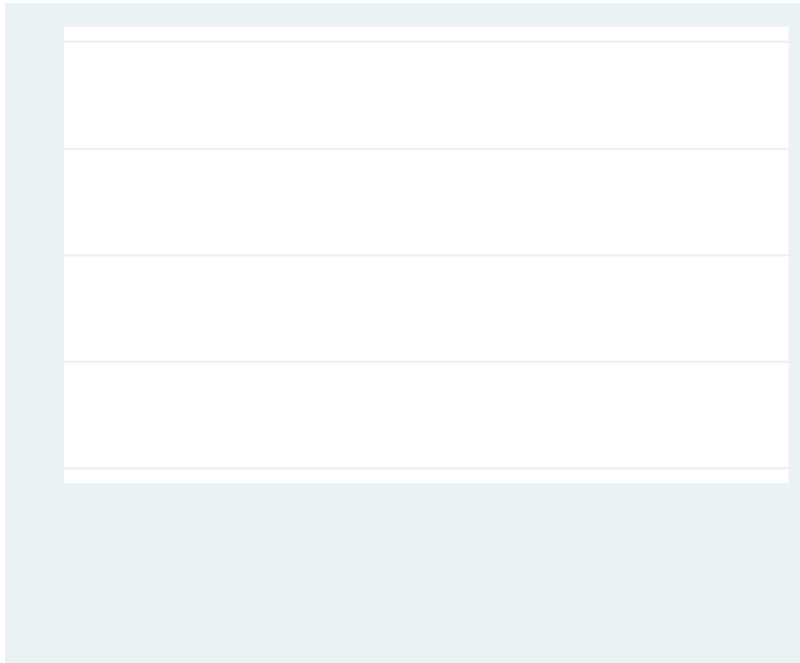
$$INPRICE_{it} = \gamma L.INPRICE_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

	Dependent Variables
PRICE	<ul style="list-style-type: none"> <li>Average price of electricity in a state, adjusted for inflation (Rupees per unit)</li> </ul>
INPRICE	<ul style="list-style-type: none"> <li>Average industrial price of electricity in a state, adjusted for inflation (Rupees per unit)</li> </ul>

	Independent & Control Variables
Reform Index	<ul style="list-style-type: none"> <li>Six Measures</li> </ul>
L.PRICE	<ul style="list-style-type: none"> <li>Lag of PRICE</li> </ul>
L.INPRICE	<ul style="list-style-type: none"> <li>Lag of INPRICE</li> </ul>
PCGDP	<ul style="list-style-type: none"> <li>State GDP per capita at Constant (1993-94) Prices (Million Rupees)</li> </ul>

# Impact on Prices

**Average Electricity Price versus Reform Index**



**Average Electricity Price for Industry versus Reform Index**

# H4: The pricing impacts of reform

H4

Electricity reforms in Indian states have had a substantive effect on pricing of electricity in those states.

$$PRATIO1_{it} = \gamma L.PRATIO1_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

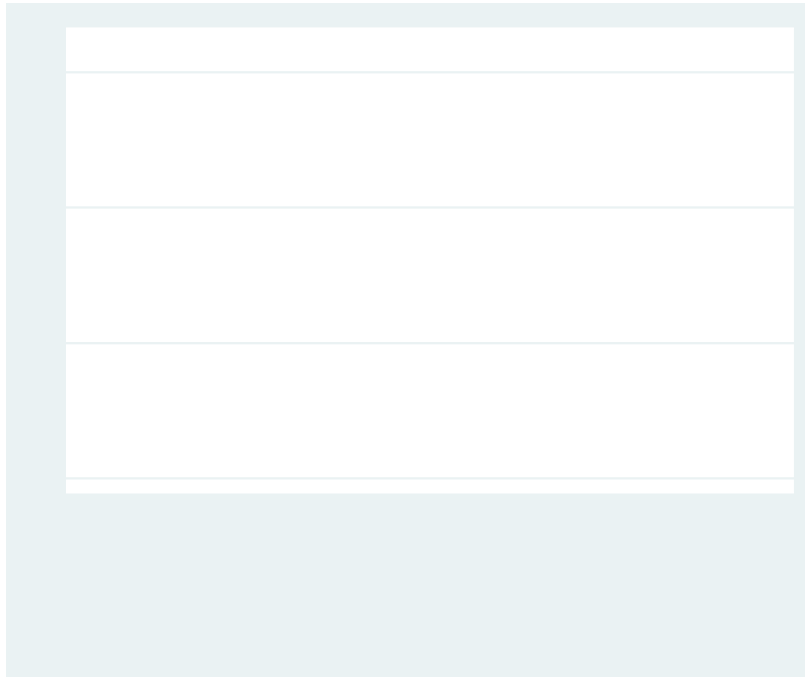
$$PRATIO2_{it} = \gamma L.PRATIO2_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

	Dependent Variables
PRATIO1	<ul style="list-style-type: none"> <li>Ratio of Industrial to Domestic Electricity Prices (adjusted for inflation)</li> </ul>
PRATIO2	<ul style="list-style-type: none"> <li>Ratio of Industrial to Agricultural Electricity Prices (adjusted for inflation)</li> </ul>

	Independent & Control Variables
Reform Index	<ul style="list-style-type: none"> <li>Six Measures</li> </ul>
PCGDP	<ul style="list-style-type: none"> <li>State GDP per capita at Constant (1993-94) Prices (Million Rupees)</li> </ul>

# Impact on Pricing

**Ratio of Industrial  
to Domestic Price of Electricity versus Reform  
Index**



**Ratio of Industrial to Agricultural  
Price of Electricity versus Reform Index**

# H5: The impacts of reform on reinvestment

**H5**

Electricity reforms in Indian states have enabled further investments into improving the supply and availability of electricity, which has associated economic benefits.

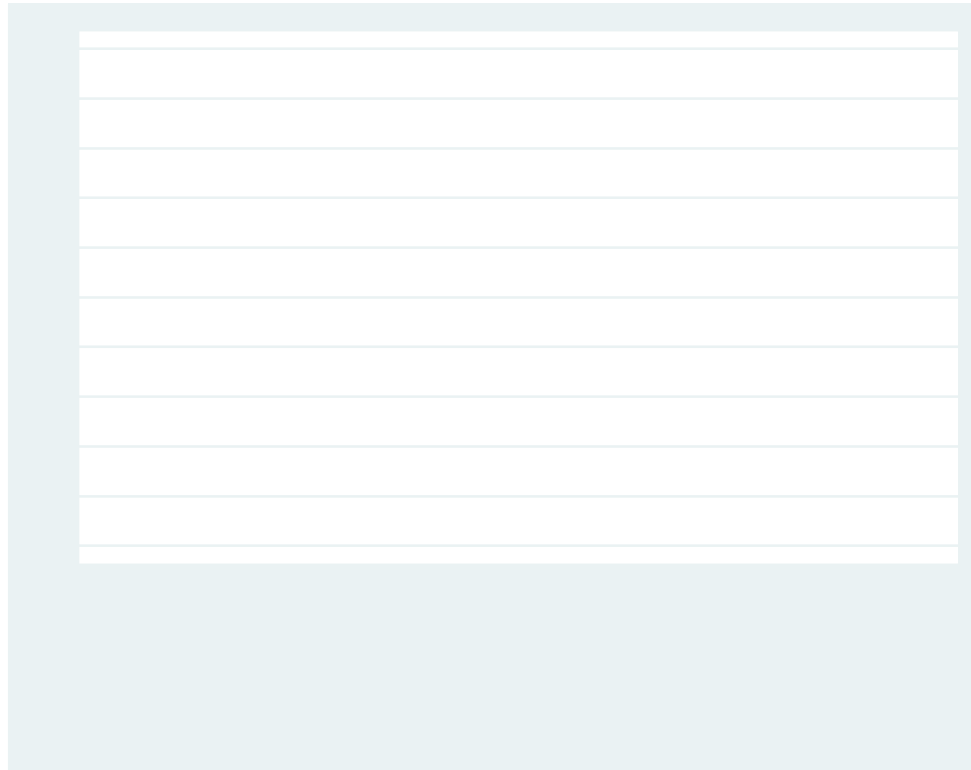
$$PWDF_{it} = \gamma L.PWDF_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

	Dependent Variables
PWDF	<ul style="list-style-type: none"> <li>Percentage Energy Deficit in States</li> </ul>

	Independent & Control Variables
L.PWDF	<ul style="list-style-type: none"> <li>Lag of PWDF</li> </ul>
Reform Index	<ul style="list-style-type: none"> <li>Six Measures</li> </ul>
PRATIO1	<ul style="list-style-type: none"> <li>Ratio of Industrial to Domestic Electricity Prices (adjusted for inflation)</li> </ul>
PRATIO2	<ul style="list-style-type: none"> <li>Ratio of Industrial to Agricultural Electricity Prices (adjusted for inflation)</li> </ul>
PCGDP	<ul style="list-style-type: none"> <li>State GDP per capita at Constant (1993-94) Prices (Million Rupees)</li> </ul>

# Impact on Network Reinvestment

**Total Energy Deficit  
versus Reform Index**



# H6: The impacts of reform on investment flows

H6

Electricity reforms and deregulation have led to substantive changes in the consumption of electricity by the industrial consumer segment.

$$INDCON_{it} = \gamma L.INDCON_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

$$INDPC_{it} = \gamma L.INDPC_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$$

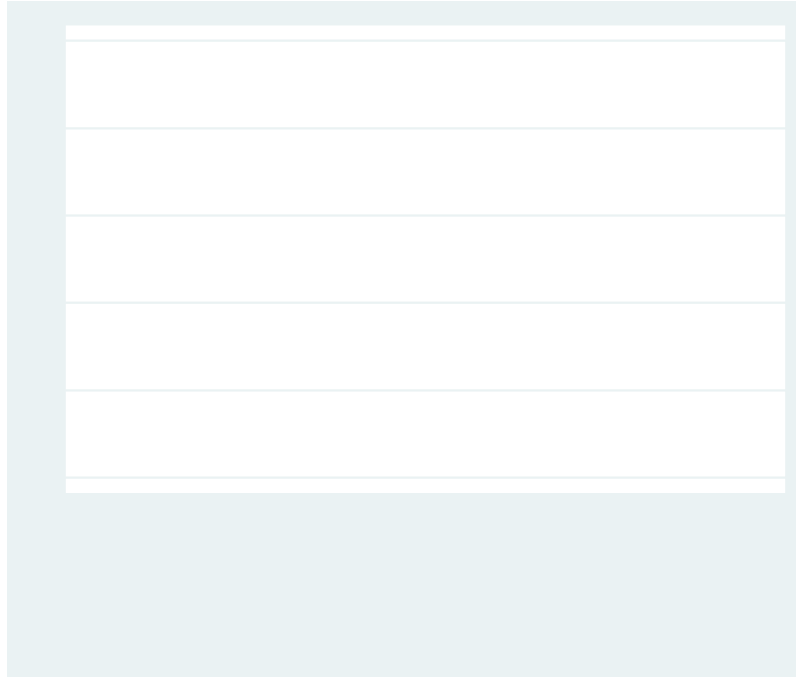
	Dependent Variables
INDCON	<ul style="list-style-type: none"> <li>Industrial consumption of electricity in a state (Million KWh)</li> </ul>
INDPC	<ul style="list-style-type: none"> <li>Per capita industrial consumption (KWh)</li> </ul>

	Independent & Control Variables
L.INDCON	<ul style="list-style-type: none"> <li>Lag of INDPC</li> </ul>
L.INDPC	<ul style="list-style-type: none"> <li>Lag of INDPC</li> </ul>
Reform Index	<ul style="list-style-type: none"> <li>Six Measures</li> </ul>
PRATIO1	<ul style="list-style-type: none"> <li>Ratio of Industrial to Domestic Electricity Prices (adjusted for inflation)</li> </ul>
PRATIO2	<ul style="list-style-type: none"> <li>Ratio of Industrial to Agricultural Electricity Prices (adjusted for inflation)</li> </ul>
PCGDP	<ul style="list-style-type: none"> <li>State GDP per capita at Constant (1993-94) Prices (Million Rupees)</li> </ul>

# Impact on Investment Flows

**Total Industrial Consumption  
versus Reform Index**

**Per Capita Industrial Consumption  
versus Reform Index**





- Background and Motivation
- Research Questions
- Indian Electricity Reforms
- Methodology
- Findings
- Insights & Conclusions**

# The results throw up some interesting insights...

---

## POLITICAL ECONOMY

- Outcomes are counterintuitive and unconventional. Deregulation leads to an initial deterioration (in early stages).

## DIFFERENTIAL IMPACTS

- Individual measures affect key economic variables differently.

## *BASELINE* LEVEL

- The outcomes may improve as deregulation progresses beyond a *baseline* level.

## CROSS SUBSIDY VARIABLE

- PRATIO2 reflective of consumer behaviour.

## DEATH OF CROSS SUBSIDIES?

- Open Access (OPREG) leads to higher industrial electricity prices. OPREG has been received successfully and resulted in positive outcomes. Does this signal the natural demise of cross-subsidies?

## INVESTMENT

- States at upper end of reform spectrum have lower per capita industrial consumption; counterintuitive, but justifiable.

# This research has significant future potential...

<b>CONCEPTUAL</b>	<ul style="list-style-type: none"><li>▪ Concept of measuring progress or 'milestones' in Indian reforms</li><li>▪ Concept of an <u>indicator for cross-subsidies</u></li></ul>
<b>ACADEMIC</b>	<ul style="list-style-type: none"><li>▪ Fills gap in <u>direct assessments of spatial impacts</u> of electricity reforms</li><li>▪ Versatile Applicability (other infrastructure sectors, industry)</li><li>▪ Uses political economy in interpreting econometric results</li></ul>
<b>POLICY &amp; FUTURE RESEARCH</b>	<ul style="list-style-type: none"><li>▪ Research required on <u>different ways to achieve the 'baseline' level</u>; results will be tested again to determine lag times to outcome</li><li>▪ What has happened in non-reforming states?</li><li>▪ Reveals that the sequencing of reform might matter</li></ul>