The Effectiveness of Cap-and-Trade Programs in the United States

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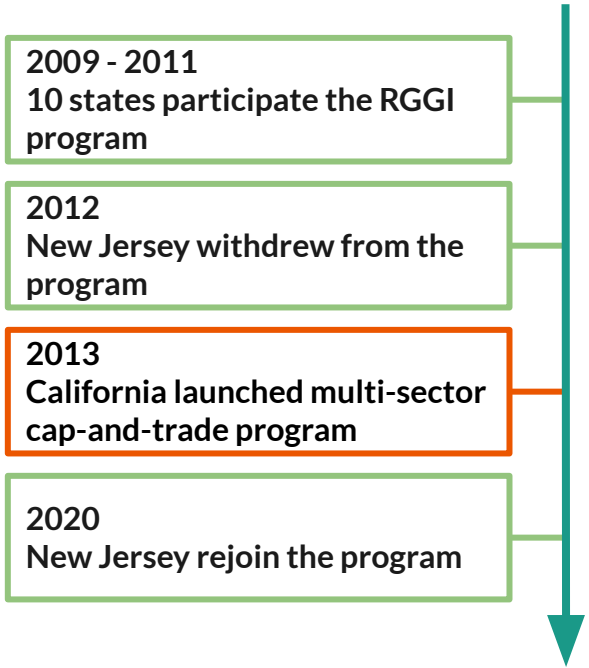
Market Failure & Theory of Change

- Greenhouse-gas (GHG) externality
  - Negative external effects, especially for future generations
  - Lack of incentives to reduce GHG emissions
- GHG reduction policy approaches
  - Carbon pricing
  - Technology subsidies
  - Performance standards.
- Our targeted policy is Cap-and-Trade (CAT)

Timeline



RGGI Overview

- The Regional Greenhouse Gas Initiative (RGGI) is the first mandatory cap-and-trade program in the United States to limit carbon dioxide from the power sector.
- 11 states currently participate in RGGI: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia.
- California is one of the two states in the U.S. that passed a law of multi-sector CAT and launched in 2013, covering virtually all economic sectors.
- New Jersey withdrew from the program in 2012 and rejoined in 2020.

Research Design - Research Questions

- Is a multi-sector CAT program more effective than a single-sector one?
- Are there any crowd-out effects of single-sector CAT on other sectors?
- Are there any cross-border effects of CAT programs (both single-sector and multi-sector)?

Research Design - Hypothesis

- Is a multi-sector CAT program more effective than a single-sector one?
  - H0: The multi-sector CAT program is worse than single-sector programs at reducing GHG emissions or slowing growth.
- Are there any crowd-out effects of single-sector CAT on other sectors?
  - H0: Power-sector CAT programs would not result in the GHG-emission reduction or growth slowdown in non-power sectors.
- Are there any cross-border effects of CAT programs (both single-sector and multi-sector)?
  - H0: There is no significant difference in the reduction of GHG emissions or growth slowdown between CAT adopter's neighbor states compared to non-neighbor states.

Methodology - Difference in Difference

$$Emission_{it} = \beta_0 + \beta_1 CAP_i + \beta_2 Post_t + \beta_3 CAP_i \times Post_t + \beta_4 Year_t + \varepsilon_{it}$$

RQ#1 Is multi-sector is more effective than single sector in reducing emission?

	Pre treatment	Post treatment
Treatment: California companies	2010 - 2013	2013 - 2016
Controlled :other 9 states' companies	2010 - 2013	2013 - 2016

RQ#2 Are there any crowd-out effects of single-sector CAT on other sectors?

	Pre treatment	Post treatment
Treatment: NJ power sector companies	2019 - 2020	2020- 2021
Controlled: NJ non-power sector companies	2019 - 2020	2020 - 2021

*2009 data is not available so we leverage the fact that NJ rejoined the RGGI.

RQ#3 Are there any cross border effects of CAT?

	Pre treatment	Post treatment
Treatment: companies in States adjacent to California	2010 - 2013	2013 - 2016
Controlled: Companies in states not adjacent to California and not in the RGGI	2010 - 2013	2013 - 2016

Data

- The greenhouse gas report program (GHGRP) requires reporting of greenhouse gas (GHG) data from large GHG emission sources, fuel and industrial gas suppliers, and CO2 injection sites in the United States.
  - GHG emissions exceed 25,000 metric tons CO2e per year
  - Supply of certain products would result in over 25,000 metric tons CO2e of GHG emissions
- No other related information, such as revenue and energy-efficiency.

- Collect emission data from small facility and other related information - Recall Survey

Data - Recall Survey

- Contact companies on the list of GHGRP
- Collect emission data and information highly related to emission from 2010 to 2016 and 2019 to 2021 (only for New Jersey)
  - GHG emission, including Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Fluorinated GHGs (such as HFCs, PFCs, and SF6)
  - Revenue - productivity level
  - Energy-Efficiency
  - Research & Design investment
  - Whether developed new technology between 2010 and 2013 (before the CAT)

Data - Recall Survey

- Basic information - location, company name, and facility ID.

text	Location	Facility Location
select_one state	State	Which state the facility/entity locates
integer	Zip	The zip code of the facility location

- Emission and information highly related to emission

begin repeat	Year	Calender year of the emission
integer	year	Calender year
integer	N20	N2O Emission in millions of tons
integer	CH4	CH4 Emission in millions of tons
integer	CO2	CO2 Emission in millions of tons
integer	HFC_143a	HFC_143a Emission in millions of tons
integer	PFC_PFE	PFC_PFE Emission in millions of tons
integer	HFC_365mfc	HFC_365mfc Emission in millions of tons
integer	HFC_43_10mee	HFC_43_10meeEmission in millions of tons
integer	HFC_245fa	HFC_245fa Emission in millions of tons
calculate	total_emission	total emission in that calender year

Data - Survey Design

- Data validation
  - **Range checks:** set up range checks for all numeric data to ensure that the data entered falls within a specified range.
  - **Validation expressions**: set up validation expressions for Zip code to ensure that the data entered meets certain criteria.
  - **Required questions**: set up required questions to ensure that respondents answer all emission questions before submitting the survey.
  - **Dynamic checks:** set up dynamic checks to ensure the number of the repeated groups matches with the previous True-and-False questions

```
${Emission_2010}+${Emission_2011}+${Emission_2012}+${Emission_2013}+${Emission_2014}+${Emission_2015}+${Emission_2016}
```

- Quality Control Checks
  - Duplicate data: use unique email address to identify and remove duplicate data.

Limitations and threats: Clustering

- **Minimum Sample Size** required to ensure 80% of power

Total sample size	Sample size in each state, sector, and year	Clustering	Power
1512	2	No	0.94
3780	5	No	0.94
7560	10	No	1
15120	20	Yes	0.79
18900	25	Yes	0.74
22680	30	Yes	0.8

Limitations and threats: Clustering

- **Minimum Detached Effect (MDE)** to ensure 80% of power

Total sample size	Sample size in each state, sector, and year	Clustering	MDE	Power
1512	2	No	3	0.76
1512	2	No	4	0.82
1512	2	No	5	0.88
22680	30	Yes	4	0.75
22680	30	Yes	5	0.79
22680	30	Yes	6	0.86

Other Limitations and Threats

1) **Internal Validity:** Unobserved CAT-related events may affect the control and treatment groups differently. If it's true, the difference between the treatment and control groups could be due to other factors instead of exposure to the CAT.

2) **External Validity**: The fact that only California implemented multi-sector CAT requires cautions to apply the implications of multi-sector CAT from this research to other cases

Questions?