Environmental Benefit Cost Analysis and The National Accounts.

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    - Benefit Cost Analysis (BCA) is a common tool for policy evaluation.
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- Do conventional measures of performance (GDP) reflect policy?
    - Overlap between market indicators and BCA depend on policy context.

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  - *New York Times, 2011; U.S. Chamber of Commerce, 2012; Forbes, 2012; Bloomberg, 2014.*

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    - Argues that incentives embodied in Clean Air Act (broadly, air pollution policy) yield FGD installation.
    - Compares EVA growth to GDP growth, by state, with and without FGD.

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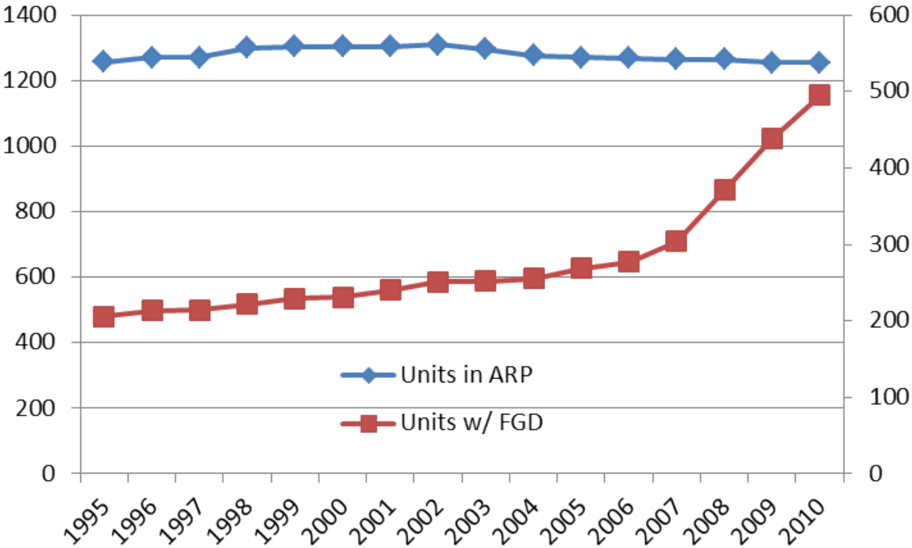
- Requires 1% - 5% plant electricity to operate.

Trends in flue gas desulfurization: EGUs in the U.S.



Outline of the Talk.

- **Methods:**
    - **Conceptual Model.**
    - Empirical Model.
- Results.
- Conclusions

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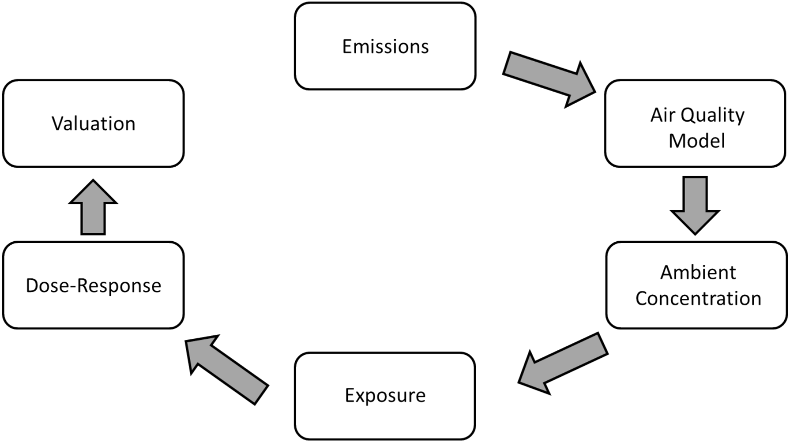

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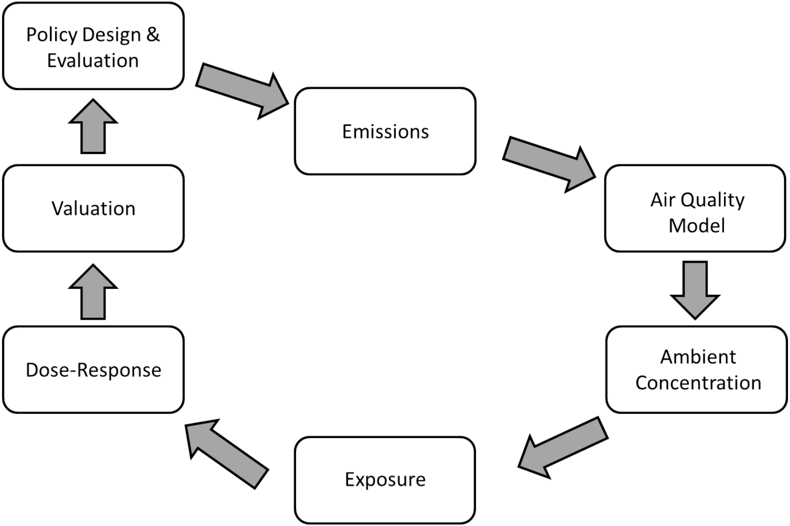

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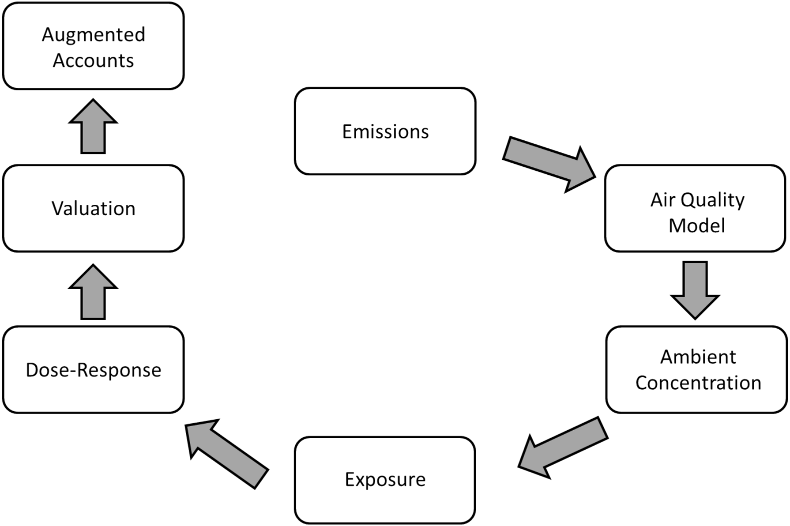

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- Repeat across other sources adding scrubbers, and over 2008, 2011 data years.

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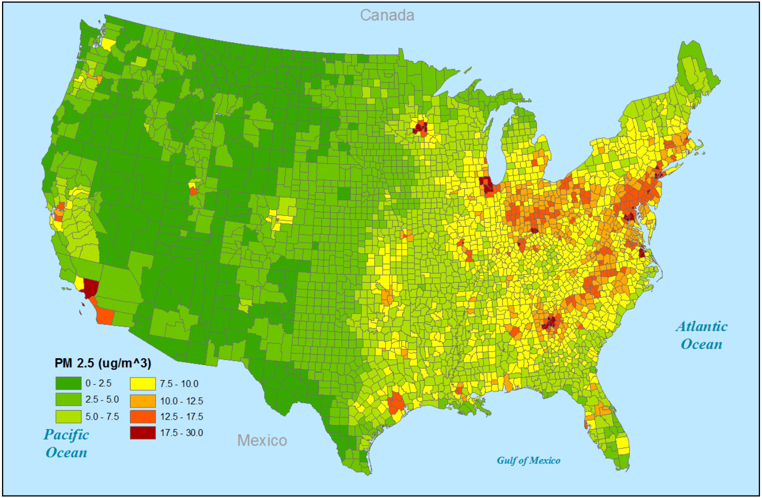

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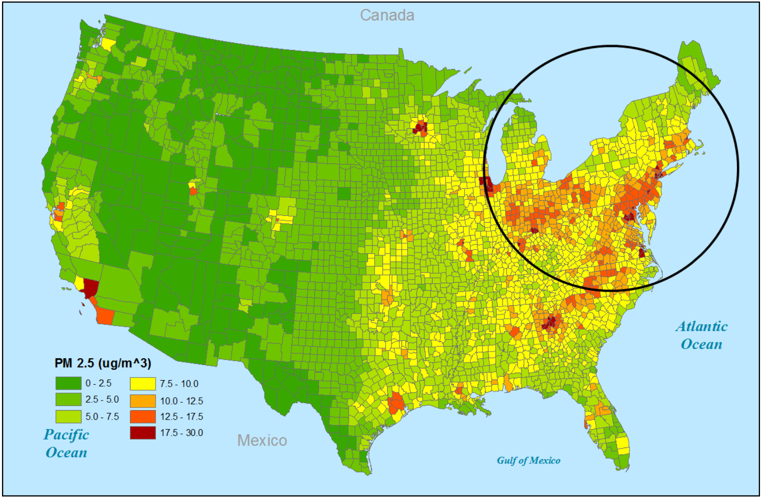

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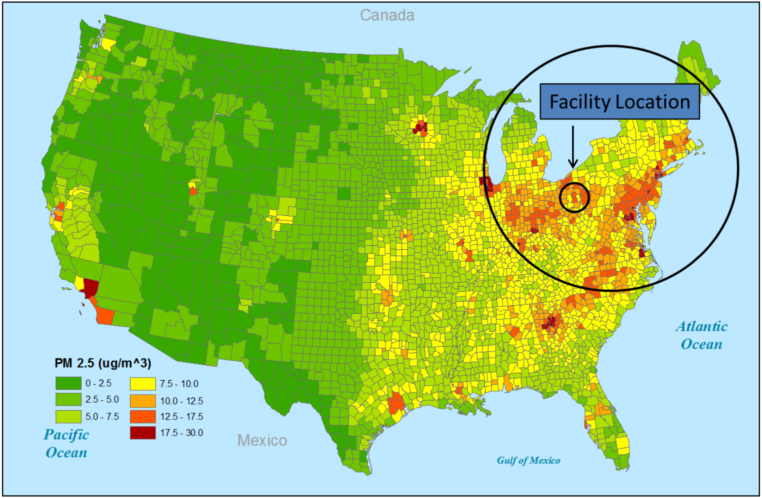
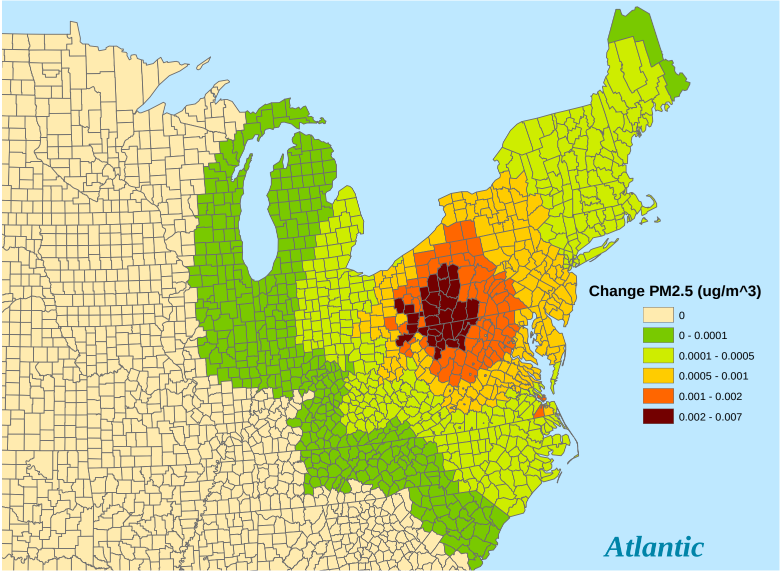


Empirical Model: Marginal damages PM2.5 at RE Burger.



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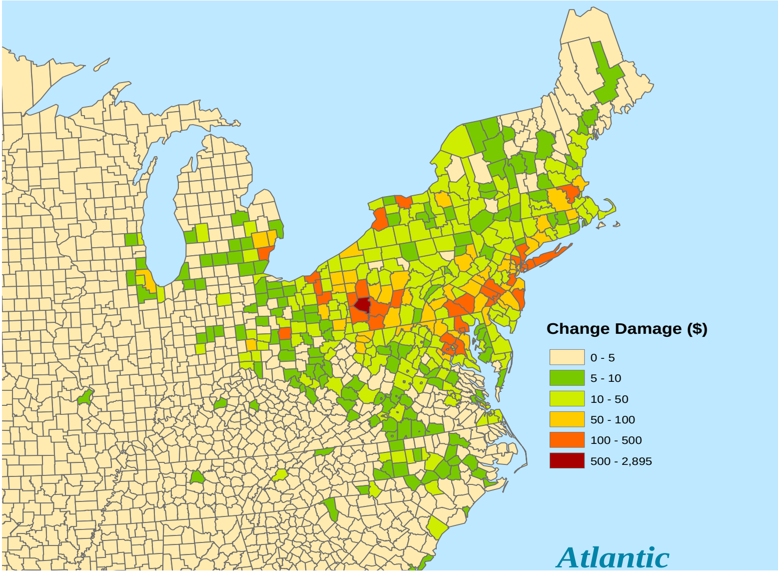

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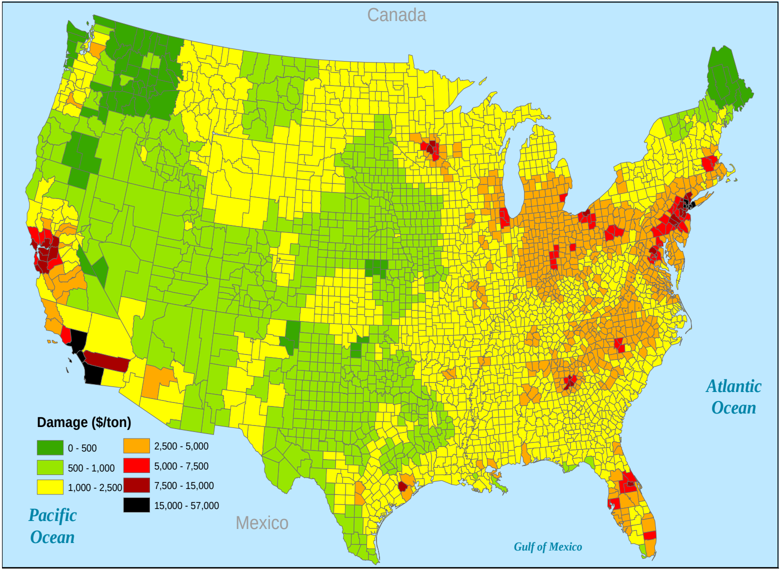

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  - No change: already shows up as income to FGD manufacturers.

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Real GED/GDP and Rates of Growth All Sectors: 1999 - 2011.

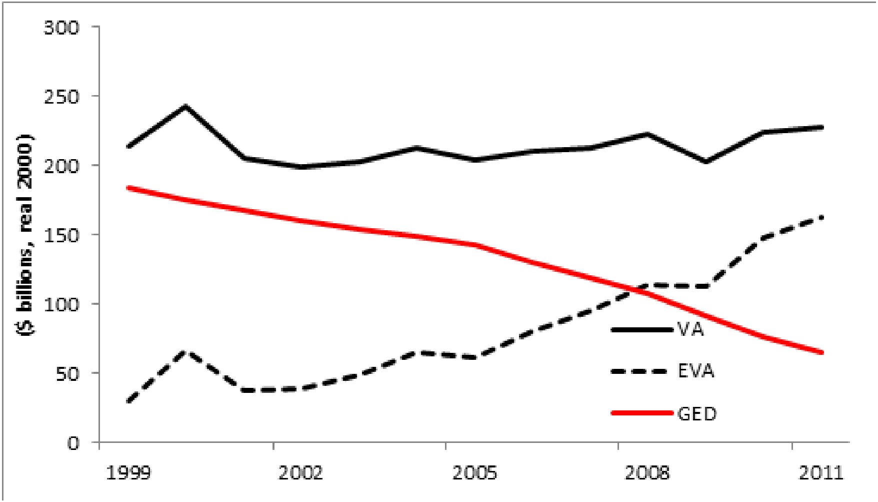
GED/GDP	1999	2002	2005	2008	2011
GED (Air Pollution)^{A}	0.06	0.05	0.04	0.03	0.02
GED (Air Pollution, GHG^{B})	0.08	0.06	0.06	0.05	0.04
GED (Air Pollution, GHG - 95^{th})^{C}	0.09	0.08	0.08	0.07	0.06
Annual Rate of Change		2002	2005	2008	2011
GDP		2.5	2.8	1.2	2.1
EVA (Air Pollution^{A})		3.1	3.0	1.5	2.4
EVA (Air Pollution, GHG^{A,B})		3.1	3.0	1.5	2.4
EVA (Air Pollution, GHG^{C})		3.1	2.9	1.5	2.4

A = Results from 1999 - 2008 reported in Muller (2014a)

B = Social cost of carbon value if \$28/ton CO_2 (OMB, 2013)

C = Social cost of carbon value if \$78/ton CO_2 (OMB, 2013)

Utility Sector: Real EVA, VA, and GED.

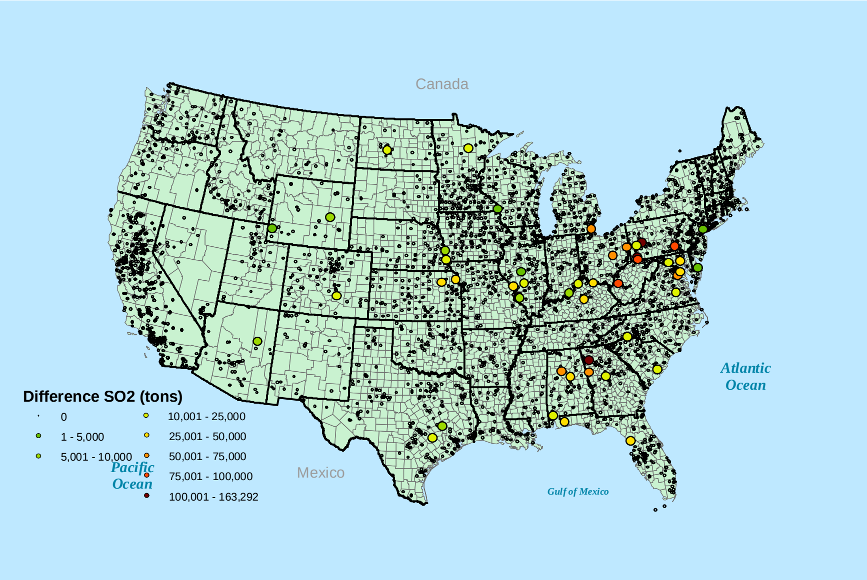


Costs and Benefits of FGD Installation: 2008 to 2011.

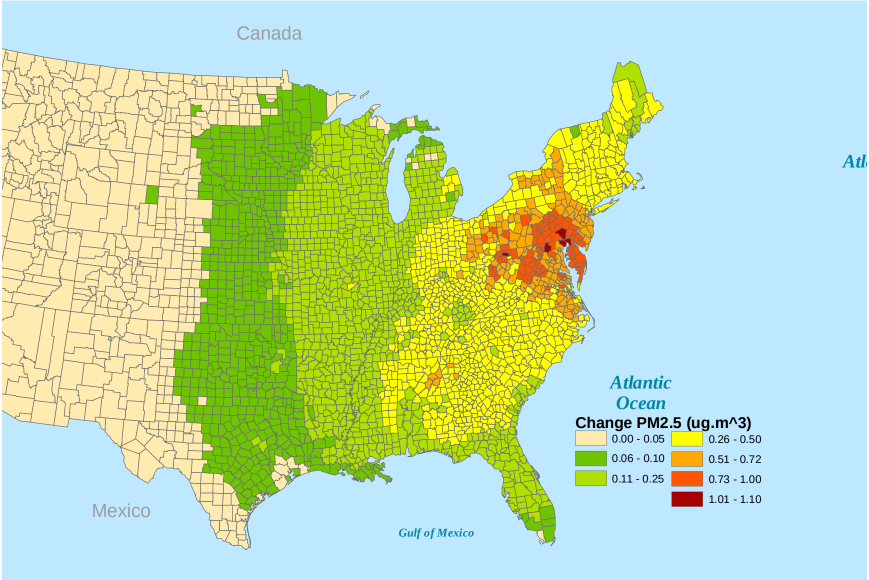
State	Cost	GED	GED (No FGD)	Benefit	$\frac{B}{C}$
New Jersey	3	24	131	107	39:1
Delaware	0	154	161	7	33:1
Ohio	24	2,080	2,830	742	31:1
North Carolina	30	132	1,030	903	30:1
Pennsylvania	192	1,090	6,350	5,260	27:1
National (30 States)	892[A]	8,700	28,470	19,770	22:1

A = All values expressed in real $millions, "high" cost scenario

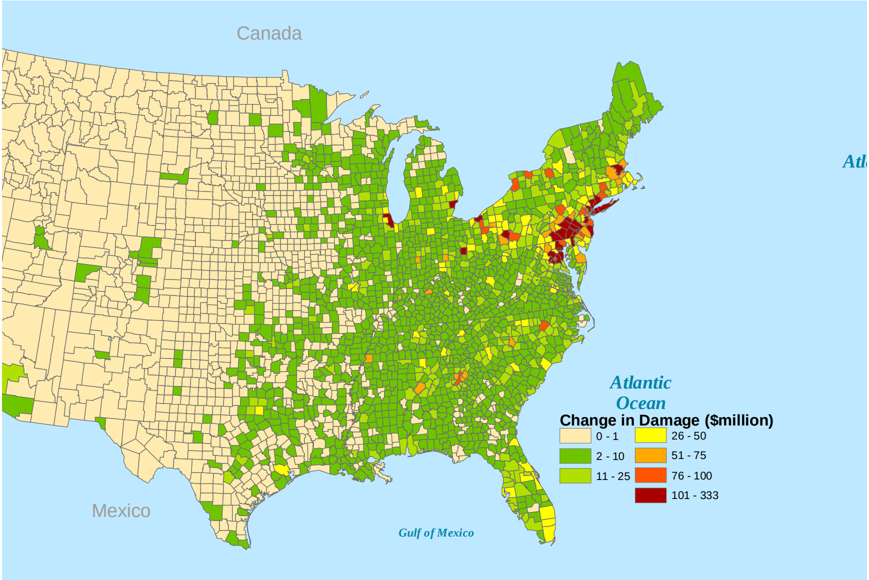
Change in SO2 Emissions Due to FGD Installation: 2011.



Change in PM2.5 Due to FGD Installation: 2011.



Change in Damage Due to FGD Installation: 2011.

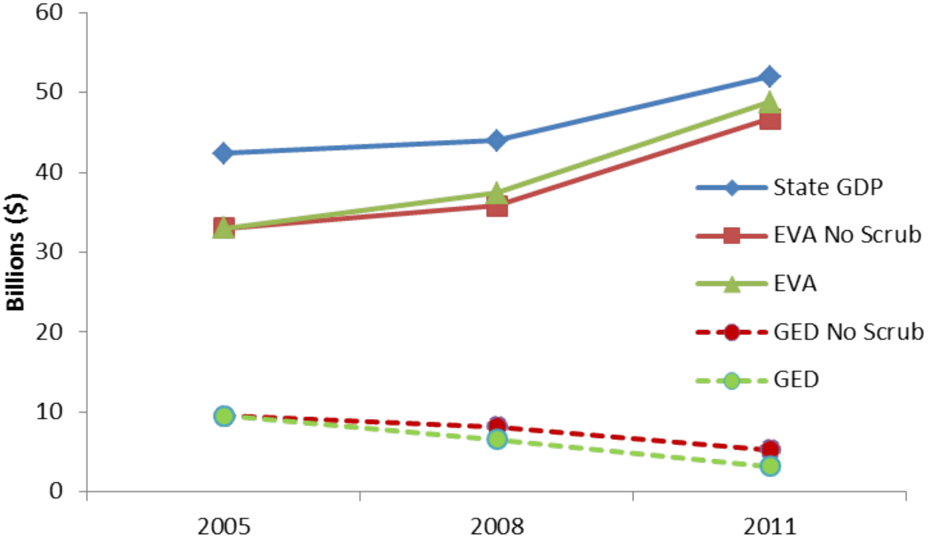


FGD Installation and GDP, GED, and EVA Growth from 2008 to 2011.

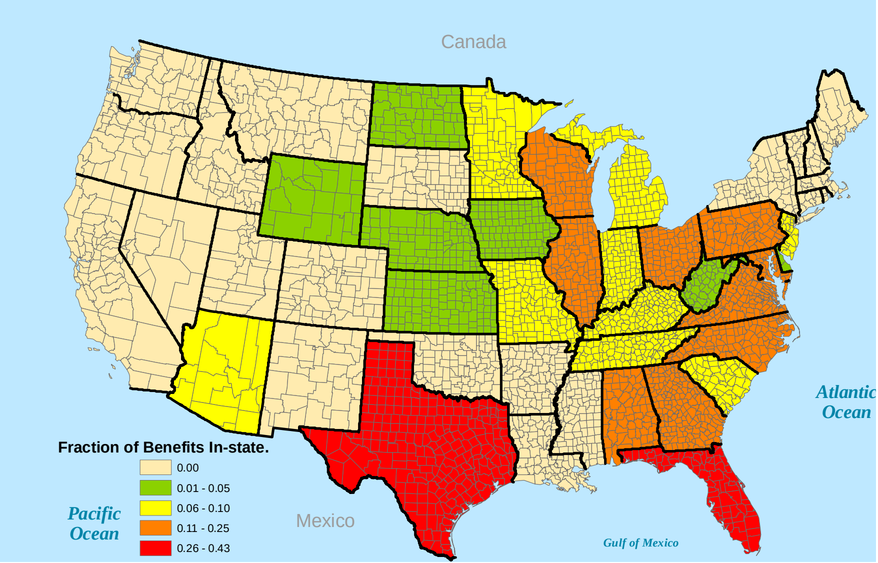
State	GDP	GED	GED No FGD	EVA (No FGD)	Diff. EVA
West Virginia	4.24	-16.72	-4.81	6.86 (5.65)	1.20
Pennsylvania	1.72	-13.81	-7.75	2.61 (2.33)	0.28
North Dakota	5.48	3.44	6.24	5.66 (5.42)	0.24
Kentucky	2.19	-4.91	-1.11	2.68 (2.44)	0.24
Maryland	1.76	-12.84	-4.99	2.22 (2.01)	0.21
National (30 States)	1.08[A]	-5.78	-3.58	1.27 (1.21)	0.06

A = Annual rates of change (%).

Oberved and No-Scrub Counterfactual: West Virginia.



Fraction of Benefits Occurring In-State 2011.

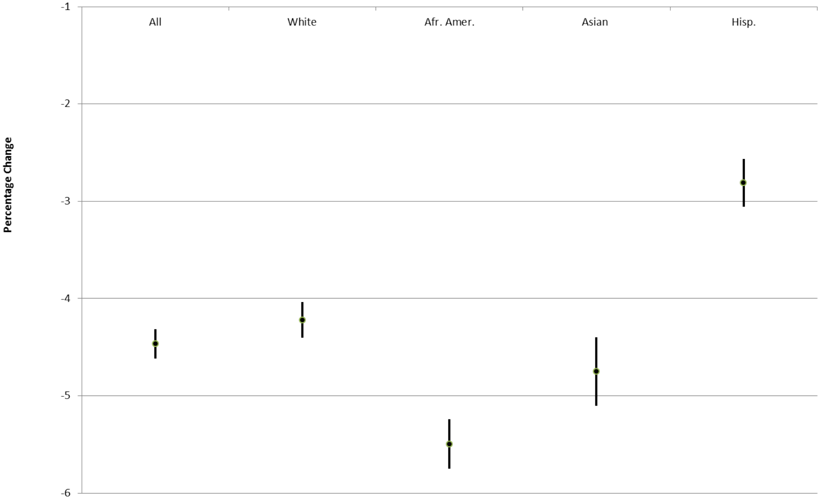


EVA Growth between 2008 to 2011 with In-State Benefits.

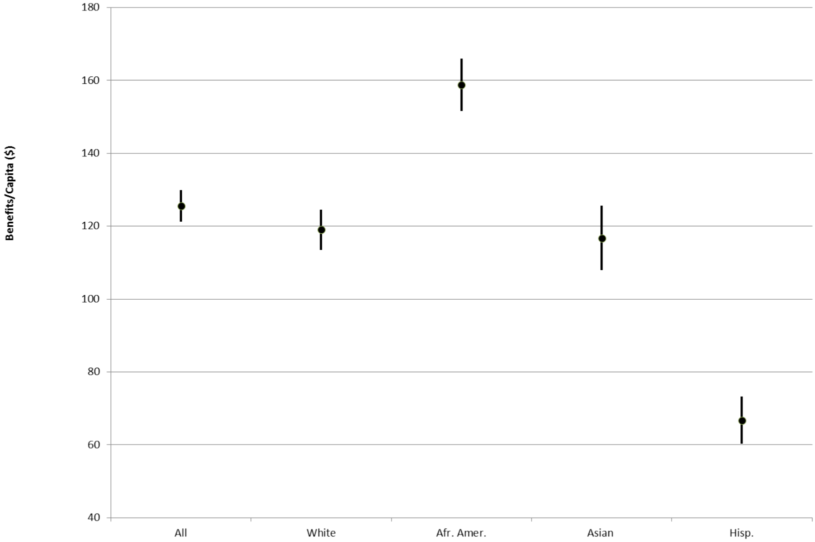
	Total Benefits		In-State Benefit	
State	EVA (No FGD)	Diff. EVA	EVA (No FGD)	Diff. EVA
National (30 States)	1.27 (1.21)	0.06	1.27 (1.26)	0.01
West Virginia	6.86 (5.65)	1.20	6.86 (6.84)	0.01
Pennsylvania	2.61 (2.33)	0.28	2.61 (2.55)	0.06
North Dakota	5.66 (5.42)	0.24	5.66 (5.67)	-0.01
Kentucky	2.68 (2.44)	0.24	2.68 (2.67)	0.01

A = Annual rates of change (%).

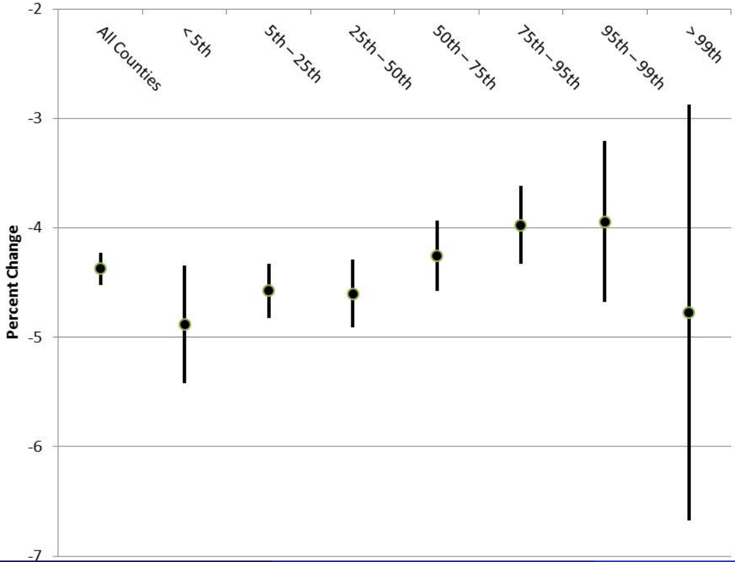
Change in Ambient Concentration and County Demographics: 2011.



Benefit Per Capita and County Demographics: 2011.



Change in Ambient Concentration and County Income: 2011.



Outline of the Talk.

- Methods:
    - Conceptual Model.
    - Empirical Model.
- Results.
- **Conclusions.**

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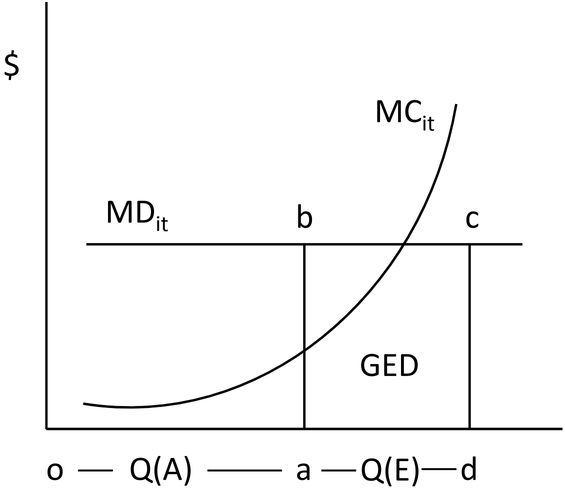
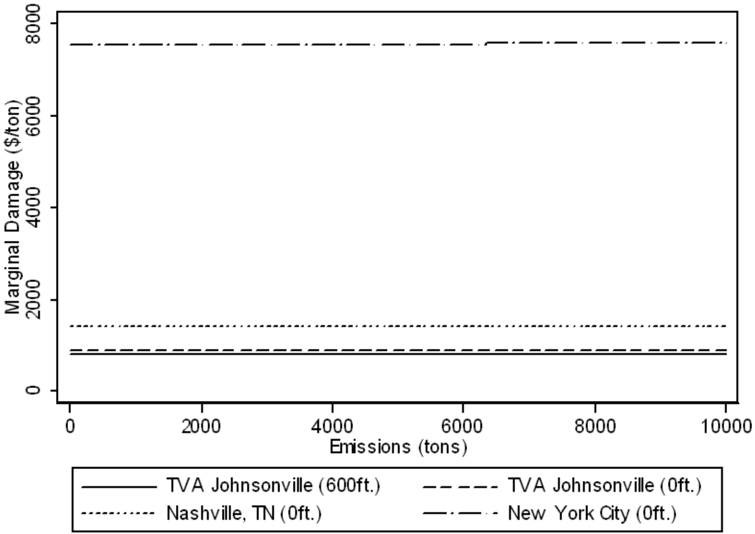
- Caveats: External validity and causation.

Conceptual Model.

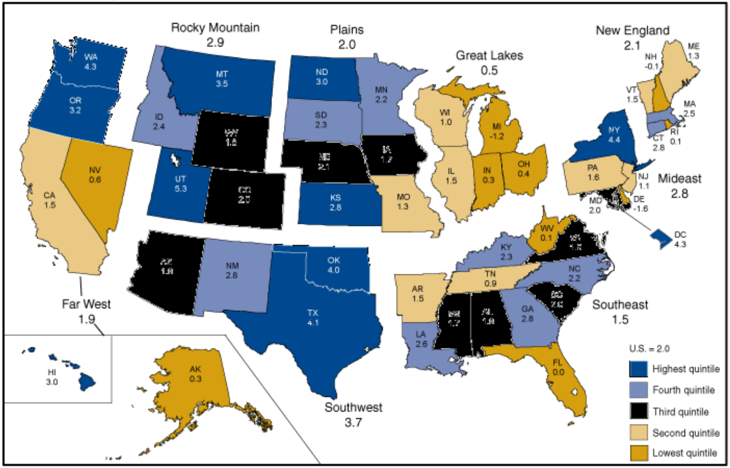


Marginal Damage Functions for SO2.



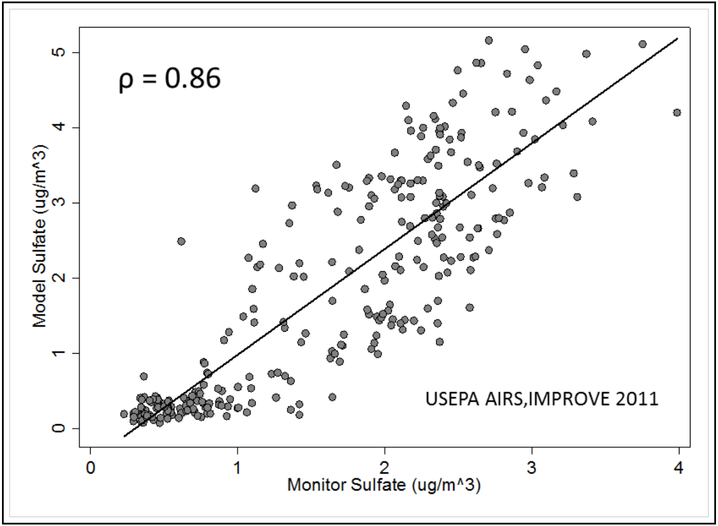
USBEA Regions.

Chart 1. Percent Change in Real GDP by State, 2006-2007



U.S. Bureau of Economic Analysis

Empirical Model



Marginal Damage for Sulfur Dioxide.

Year	Model	mean	sd	min	max
2008	Base	10,980^{A}	3,209	3,158	16,154
2011	Base	11,534^{B}	5,996	948	38,832
2008	Roman	17,583	5,031	4,967	25,430
2011	Roman	18,384	9,470	1,493	61,204
2008	$2M VSL	4,373	1,213	1,329	6,278
2011	$2M VSL	4,638	2,389	425	15,291

A = ($/ton), for plants installing scrubbers between 2005 and 2008.
B = ($/ton), for plants installing scrubbers between 2008 and 2011.

All Sectors: Regional Rates of Growth and Pollution Intensity.

	1999-2011				GED/GDP	
Region	GED	EVA	GDP	EVA-GDP	1999	2011
New England	-9.35[A]	1.79	1.63	0.15	0.024	0.006
Mideast	-8.08	2.34	1.96	0.38	0.060	0.017
Southeast	-7.61	2.32	1.82	0.50	0.081	0.025
Great Lakes	-6.54	1.32	0.79	0.53	0.099	0.040
Plains	-3.80	2.41	2.08	0.32	0.071	0.034
Rocky Mountains	-4.12	2.96	2.96	0.22	0.044	0.017
Southwest	-3.49	3.52	3.52	0.21	0.041	0.019
Far West	-4.45	2.07	2.07	0.18	0.039	0.017
National	-6.63	2.32	1.96	0.36	0.064	0.023

A = Annualized rates of change (%).

Benefit Incidence and County Demographics: 2011.

	$PM_{2.5}$		Monetary Benefit		Benefit/
Race	% Change	Abs. Change	% Change	Abs. Change	Capita
All Counties	-4.5 (4.2)	-0.4[A] (0.3)[B]	-4.2 (3.9)	11.7[C] (35.0)	125.6 (122.4)
White	-4.2 (4.3)	-0.3 (0.3)	-4.0 (4.0)	7.2 (20.9)	119.0 (127.6)
Afr. American	-5.5 (3.7)	-0.5 (0.3)	-5.1 (3.5)	22.7 (53.2)	158.7 (105.0)
Asian American	-4.8 (4.7)	-0.4 (0.4)	-4.4 (4.4)	34.3 (65.8)	116.8 (118.3)
Hispanic	-2.8 (3.4)	-0.2 (0.3)	-2.6 (3.2)	16.9 (51.1)	66.7 (90.2)

A $= \frac{ug}{m^3}$.

B = standard deviations in parenthesis.

C = ($ millions).

All Sectors: State Rates of Growth and Pollution Intensity.

	1999-2011				GED/GDP	
State	GED	EVA	GDP	EVA-GDP	1999	2011
West Virginia	-11.87[A]	5.68	2.30	3.38	0.364	0.061
North Dakota	-5.17	7.66	5.48	2.18	0.277	0.078
Wyoming	-4.29	7.91	6.89	1.03	0.142	0.038
Kentucky	-7.22	2.10	1.17	0.93	0.152	0.054
Indiana	-6.35	1.82	1.55	0.88	0.149	0.056
National	-6.33	2.32	1.96	0.36	0.064	0.023

A = Annualized rates of change (%).

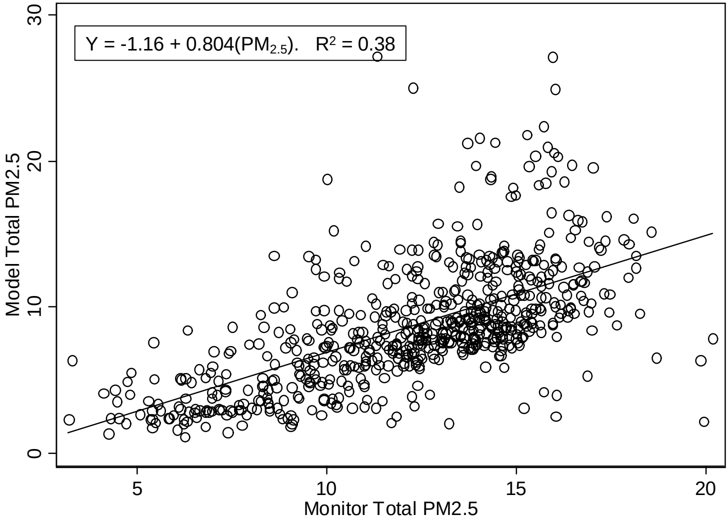
Utility Sector: Rates of Growth and Pollution Intensity.

	1999-2011				GED/VA	
Region	GED	EVA	VA	EVA-VA	1999	2011
New England	-11.49[A]	1.40	-0.70	2.10	0.276	0.070
Mideast	-10.11	7.04	-0.56	7.60	0.669	0.199
Southeast	-10.20	B	-0.31	B	1.140	0.325
Great Lakes	-7.83	B	-1.41	B	1.448	0.646
Plains	-5.22	8.79	0.10	8.69	0.781	0.405
Rocky Mountains	-2.97	0.99	-0.03	1.02	0.302	0.212
Southwest	-5.07	3.60	0.83	2.77	0.427	0.207
Far West	-5.70	0.68	0.45	0.23	0.051	0.024
National	-5.75	16.06	0.42	15.64	0.860	0.284

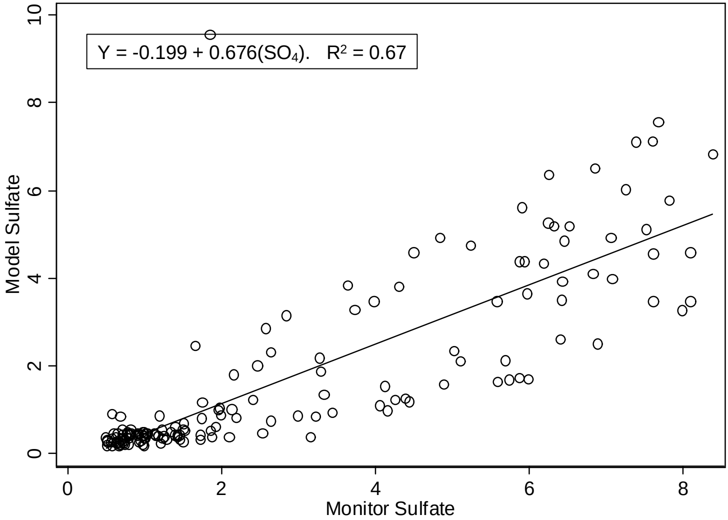
A = Annualized rates of change (%).

B = EVA changes sign from 1999 to 2011. No growth rate reported.

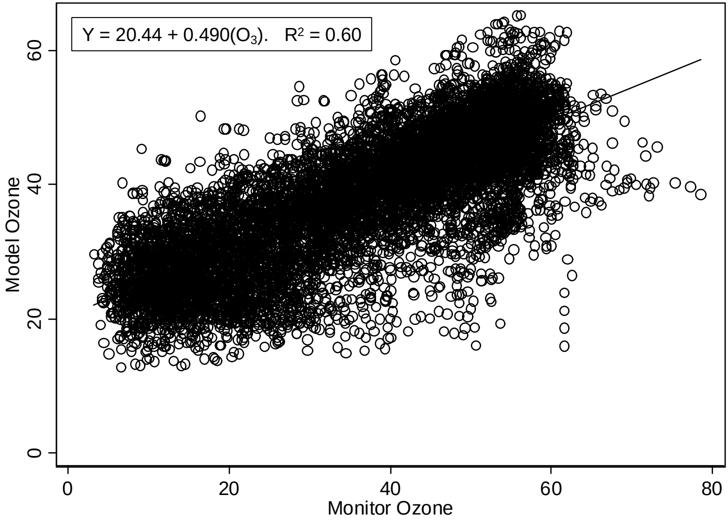
Empirical Model: Comparison of Monitor Data and APEEP Prediction (PM2.5).



Empirical Model: Comparison of Monitor Data and APEEP Prediction (Ammonium Sulfate).



Empirical Model: Comparison of Monitor Data and APEEP Prediction (Ozone).



Empirical Model: Comparison of Monitor Data and APEEP Prediction: 2005.

Pollutant/Species	MFE	MFB	Rho	n
Total $PM_{2.5}$	0.072	-0.016	0.63	673
Ammonium Sulfate	0.105	0.013	0.87	153
Ammonium Nitrate	0.245	-0.067	0.50	153
Organic Carbon	0.130	0.084	0.37	153
Elemental Carbon	0.100	0.011	0.66	153

Source: Muller, 2011; USEPA AIRS, 2011; AQS IMPROVE, 2011

Boylan, Russell, 2006: MFE $\leq$ 50%, MFB $\leq$ 30%.