Regulating Mismeasured Pollution: Implications of Firm Heterogeneity for Environmental Policy

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Any opinions and conclusions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed.

Overview

- **Motivation**: many environmental policies target industries
  - Clean Air Act, Clean Water Act, climate change
  - Potentially inefficient if within-industry heterogeneity in externalities
- **Research question**
  - How large is within-industry heterogeneity in energy, CO_2 productivity?
- **Approach**
  - Administrative, confidential data on entire U.S. manufacturing sector
- **Results**
  - Heterogeneity in energy and CO_2 productivity is enormous
  - Exceeds heterogeneity in other kinds of productivity (TFP, labor productivity)
  - Generates important errors in policy like industry-based carbon tariff

What is New Here

- Implications of firm heterogeneity for environmental policy (Carlson et al. 2000; Goulder and Parry 2008; Shapiro and Walker 2016)
- Efficiency of imperfectly targeted environmental policies (Jacobsen et al. 2017)
- Heterogeneous TFP within narrowly-defined or homogenous industries (Syverson 2011)
- Carbon tariffs (Cosbey et al. 2017; Kortum and Weisbach 2017)
- Heterogeneity in industrial energy productivity in specific industries like glass (Boyd and Pang 200)

Main innovation: first estimates of within-industry heterogeneity in energy and CO_2 productivity for entire U.S. manufacturing sector.

Overview

- **Methodology**
- Data
- Results
- Conclusions

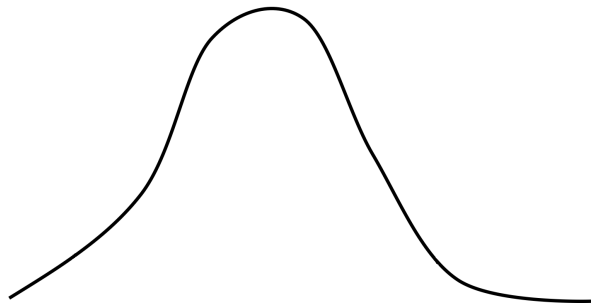
Methodology

1. Measure productivity of each plant in an industry
   - e.g., energy productivity $= \ln(Y/E)$
2. Measure distribution of productivity across plants within this industry
3. Calculate measure of dispersion (90-10 ratio, or standard deviation)
4. Calculate this dispersion measure for each of 375 industries, separately
5. Report the mean of this dispersion measure across 375 industries

Methodology

1. Measure plant-level productivity
2. Measure distribution of productivity across plants within one industry

Figure: Productivity of Plants in the Carbon Black Industry



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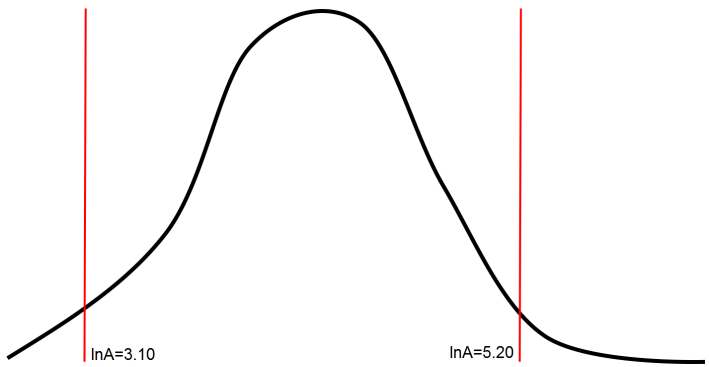

Carbon black industry: 90-10 ratio is $ln(A^{90}/A^{10}) = 2.10$

4. Calculate this dispersion measure for each of 375 industries, separately
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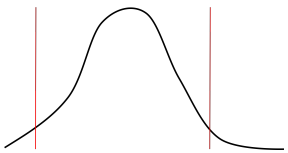
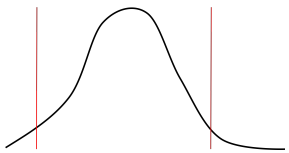
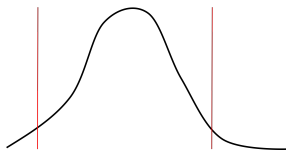


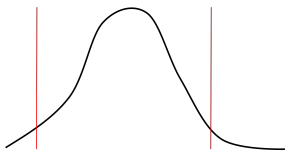
Carbon Black
90-10 $\approx$ 2.10



Ethyl alcohol
90-10 $\approx$ 1.85



Cookware
90-10 $\approx$ 1.5



Carpets
90-10 $\approx$ 2.2

5. Report the mean of this dispersion measure across 375 industries

Methodology

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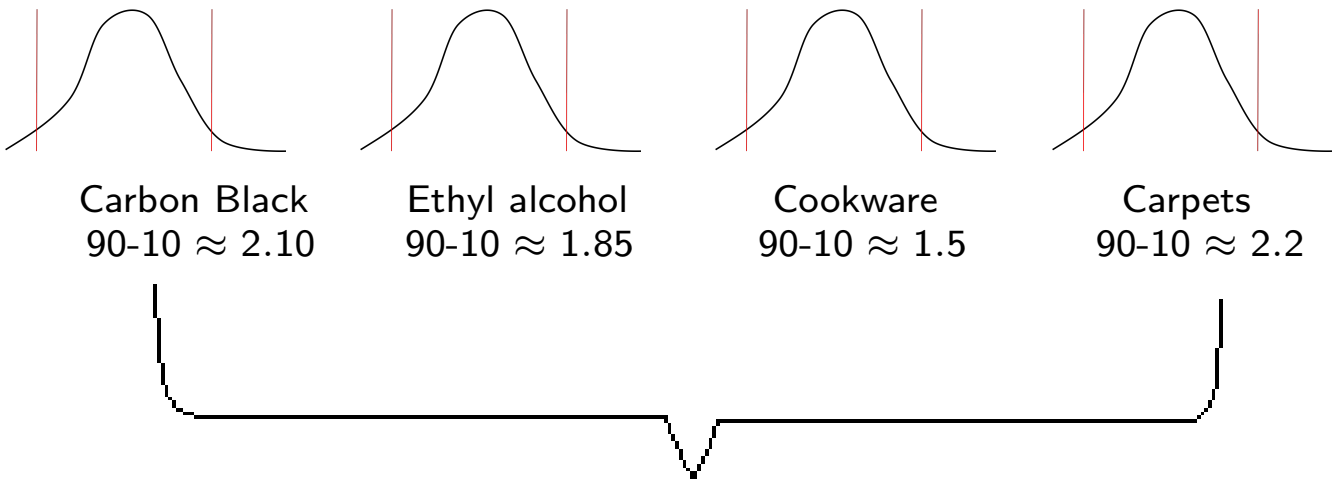

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Data: Direct Emissions

- **Census of Manufactures (CM)**
  - Year 2007, $\approx$ 350,000 plants
  - All $\approx$ 375 6-digit NAICS industries (carbon black; ethyl alcohol)
  - Reports expenditure on fuels, kWh electricity, output, capital, labor, etc.
- **Manufacturing Energy Consumption Survey**
  - Year 2006, survey of $\approx$ 15,000 plants
  - Reports physical quantity of oil, coal, gas, etc.
  - Convert to CO_2 using physical emissions rates

Data: Indirect Emissions (Last Part of Paper Only)

- **Input-output table (BEA)**
  - First approach to calculating "indirect emissions", in last part of paper only
  - Combine make, use tables
  - Split oil, gas industries
  - Exclude feedstock uses of fossil fuels
- **CM Materials Trailer**
  - Second approach to calculating "indirect emissions", in last part of paper only
  - Each plant's expenditure on each intermediate material input, with industry codes
  - New approach to measuring indirect emissions

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Results: Productivity Statistics

Table: Industry-Wide Mean Productivity

	Direct Energy (1)	CO_2 [CM] (2)	CO_2 [MECS] (3)	Labor (4)	Capital (5)	Materials (6)	TFP (7)
Mean	4.16	8.42	8.80	4.51	1.01	0.95	1.81
SD	0.94	1.16	1.15	0.83	0.95	0.66	0.56

Results: Productivity Statistics

Table: Within-Industry 90-10 Difference in Productivity, Mean Across Industries

	Direct Energy (1)	CO_2 [CM] (2)	CO_2 [MECS] (3)	Labor (4)	Capital (5)	Materials (6)	TFP (7)
Mean	1.92	2.27	2.27	1.63	2.22	1.34	0.92
SD	0.47	0.57	1.17	0.45	0.50	0.61	0.39
p90-10	1.21	1.46	3.01	1.16	1.27	1.58	0.99

Results: Productivity Statistics

Table: Within-Industry Standard Deviation of Productivity, Mean Across Industries

	Direct Energy (1)	CO_2 [CM] (2)	CO_2 [MECS] (3)	Labor (4)	Capital (5)	Materials (6)	TFP (7)
Mean	0.75	0.89	0.89	0.64	0.87	0.52	0.36
SD	0.18	0.22	0.46	0.18	0.19	0.24	0.15
p90-10	0.47	0.49	1.14	0.44	0.43	0.55	0.33

Results: Productivity Statistics

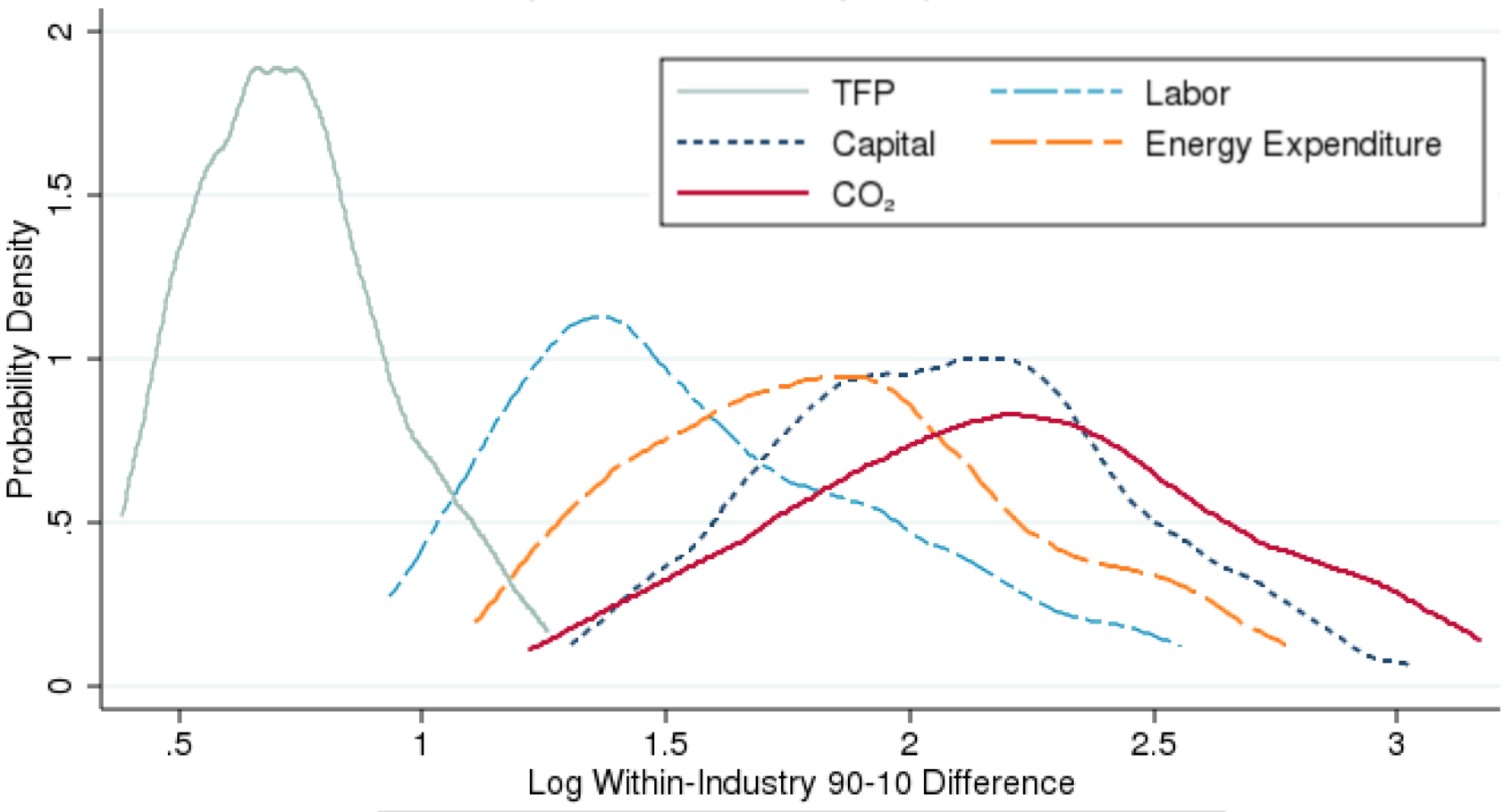

Figure: Within-Industry 90-10 of Productivity Dispersion, Density Across Industries

Results: Productivity Statistics

Table: Productivity Statistics: Value Added Versions

	Direct Energy (1)	CO_2 [CM] (2)	CO_2 [MECS] (3)	Labor (4)	Capital Stock (5)	Materials (6)
	Panel A. Industry-Wide Mean Productivity					
Mean across all plants	3.63	7.89	8.24	3.97	0.48	0.42
SD across all plants	1.07	1.28	1.31	0.81	1.03	1.07
	Panel B. Within-Industry 90-10 Productivity Diff.					
Mean	2.20	2.53	2.47	1.76	2.43	2.33
SD	0.54	0.59	1.28	0.56	0.53	0.76
p90-10	1.39	1.51	3.27	1.43	1.37	1.95
	Panel C. Within-Industry Productivity Standard Dev.					
Mean	0.86	0.99	0.96	0.69	0.95	0.91
SD	0.21	0.23	0.50	0.22	0.21	0.30
p90-10	0.50	0.54	1.28	0.51	0.45	0.63

Results: Social Cost of Carbon Per Dollar of Output (SCC)

Table: Industry-Wide Mean SCC

	SCC Direct (1)	SCC Total (2)	SCC Total (3)	SCC Direct+indirect (4)	SCC Total (5)	SCC Total (6)
Mean	0.019	0.041	0.034	0.044	0.077	0.071
SD	0.048	0.050	0.032	0.062	0.110	0.075
Direct Source	CM	CM	MECS	CM	CM	MECS
Indirect Source		BEA	BEA	CM	CM	CM
Leontief Inverse		X	X		X	X

Results: Social Cost of Carbon Per Dollar of Output (SCC)

Table: Within-Industry 90-10 Difference in SCC, Mean Across Industries

	SCC Direct (1)	SCC Total (2)	SCC Total (3)	SCC Direct+indirect (4)	SCC Total (5)	SCC Total (6)
Mean	0.060	0.060	0.051	0.089	0.142	0.120
SD	0.204	0.204	0.102	0.205	0.221	0.128
p90-10	0.523	0.523	0.261	0.526	0.567	0.329
Direct Source	CM	CM	MECS	CM	CM	MECS
Indirect Source		BEA	BEA	CM	CM	CM
Leontief Inverse		X	X		X	X

Results: Social Cost of Carbon Per Dollar of Output (SCC)

Table: Within-Industry Standard Deviation of Productivity, Mean Across Industries

	SCC Direct (1)	SCC Total (2)	SCC Total (3)	SCC Direct+indirect (4)	SCC Total (5)	SCC Total (6)
Mean	0.023	0.023	0.020	0.035	0.056	0.047
SD	0.080	0.080	0.040	0.080	0.086	0.050
p90-10	0.035	0.035	0.045	0.053	0.073	0.097
Direct Source	CM	CM	MECS	CM	CM	MECS
Indirect Source		BEA	BEA	CM	CM	CM
Leontief Inverse		X	X		X	X

Results: Social Cost of Carbon Per Dollar of Output

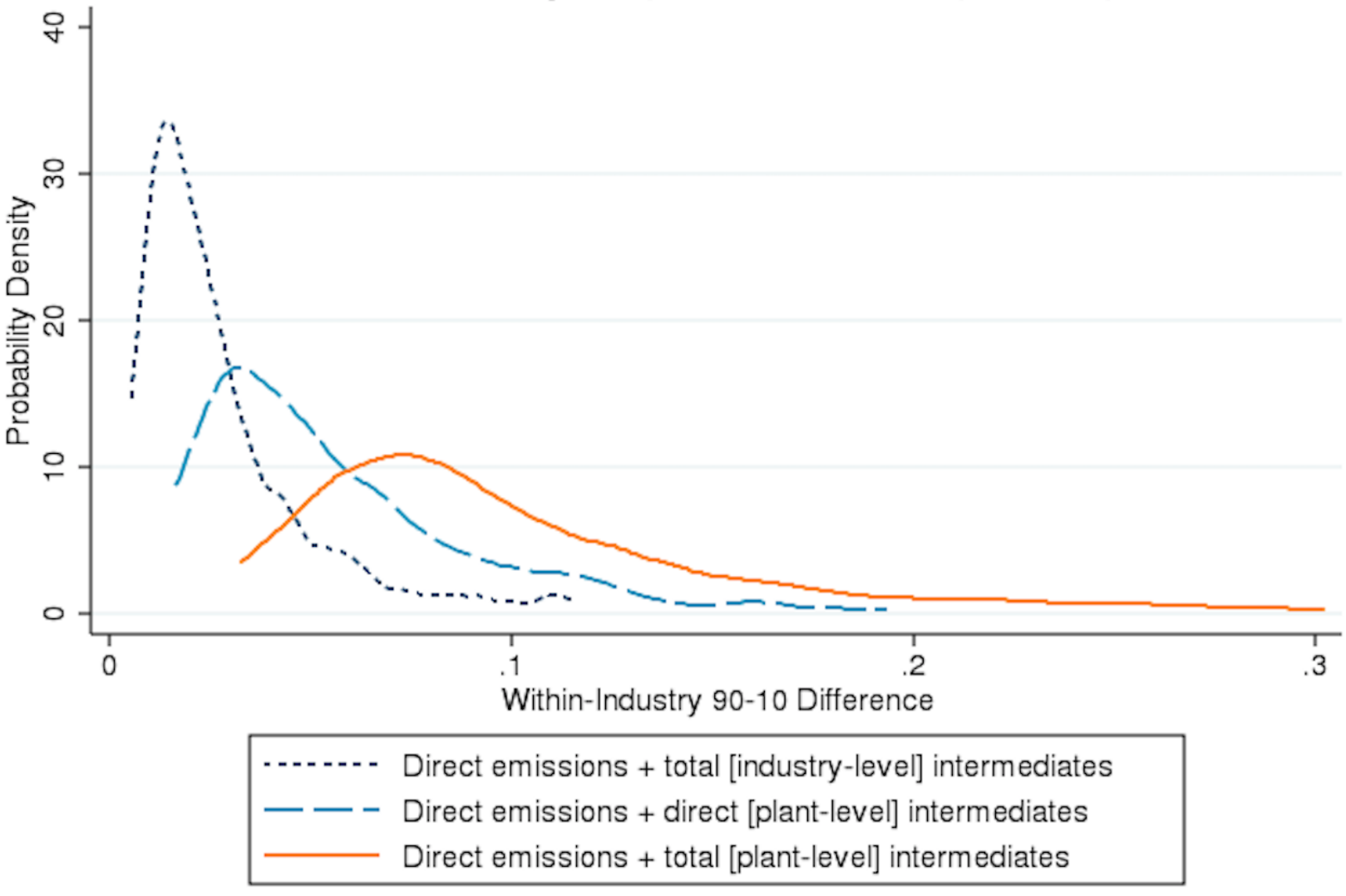

Figure: Within-Industry 90-10 of Productivity Dispersion, Density Across Industries

Results: Social Cost of Carbon Per Dollar of Output

Table: Social Costs of Carbon Per Dollar of Value Added

	SCC Direct (1)	SCC Total (2)	SCC Total (3)	SCC Direct+indirect (4)	SCC Total (5)	SCC Total (6)
	Panel A. Summary Stats, CM					
Mean across all plants	0.06	0.09	0.04	0.23	0.41	0.13
SD across all plants	2.72	2.72	0.31	3.3	4.69	1.01
	Panel B. Within-Industry 90/10 Productivity Diff.					
Mean	0.55	0.55	0.24	1.99	3.76	0.64
SD	4.22	4.22	1.49	12.19	26.54	3.12
p90-10	10.81	10.81	3.82	31.26	68.05	8.00
	Panel C. Within-Industry Productivity Std. Dev.					
Mean	0.21	0.21	0.10	0.78	1.47	0.25
SD	1.65	1.65	0.58	4.76	10.35	1.22
p90-10	0.18	0.18	0.14	0.92	1.71	0.36
Direct Source	CM	CM	MECS	CM	CM	MECS
Indirect Source		BEA	BEA	CM	CM	CM
Leontief Inverse		X	X		X	X

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Conclusions

- **Results**
  - Big heterogeneity in energy, CO_2 productivity
  - Exceeds heterogeneity in TFP, labor productivity
  - Challenge for industry-based carbon tariff
- **May understate heterogeneity**
  - Observe upstream industries, not upstream plants
  - Revenue, not quantity productivity
  - Excludes small plants with imputed data
- **Open questions**
  - How large are welfare consequences for carbon tariffs?
  - Why is energy productivity more dispersed than labor/capital productivity?
  - Implications for heterogeneity in marginal abatement costs?