Costs of Regulation in Partial and General Equilibrium

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Motivation for study

- Analysis of costs at agencies like EPA and DOE is usually done with models that focus on a single or small number of sectors. These models may or may not include a demand response.

- This may produce reasonable estimates for policies or regulations with modest impacts.

- However, for regulations or policies with larger expected impacts, or for assessing cumulative impacts of multiple regulations or policies, this approach has been criticized, e.g. Hazilla and Kopp, JPE, 1990.

Experience at U.S. EPA and DOE

- EPA has used CGE models (in conjunction with sectoral models) to analyze climate legislation, including cap-and-trade programs

- EPA has used CGE models in retrospective and prospective studies of the U.S. Clean Air Act (but not for social costs)

- EPA has used CGE models to estimate GE impacts for sectoral regulations in a limited number of cases (but not for social costs)

- DOE has used a variety of CGE models to analyze a U.S. clean energy standard

Note on types of regulation

- In general, agencies impose environmental regulations based on scientific or other criteria, e.g. reducing emissions to meet a particular air quality or technology standard.

- This is in contrast to an approach that chooses the "optimal" level of abatement by equating marginal benefits and marginal costs. (In some cases, federal agencies are statutorily prohibited from weighing benefits and costs.)

Examples

- An environmental regulation may require the use of a particular technology to reduce emissions. Emissions are reduced, but now more inputs may be required to produce the same amount of output in the regulated sector.

- An electricity policy may require greater use of low carbon energy sources in order to reduce fossil fuel use and emissions. However, use of other inputs may increase for the same amount of electricity generation.

- The same framework can also capture benefits, such as increased worker productivity, etc.

Social cost

- In benefit-cost analysis, we are usually interested in estimating the "social cost" of a policy or regulation.

- "Social cost represents the total burden that a regulation will impose on the economy. It is defined as the sum of all opportunity costs incurred as a result of a regulation where an opportunity cost is the value lost to society of any goods and services that will not be produced and consumed as a result of a regulation." (U.S. EPA, *Guidelines for Preparing Economic Analyses*.)

Measuring social cost

- Economywide (GE) measures:
  - Δ in GDP
  - Equivalent variation (EV), compensating variation (CV)

- Sectoral (PE) measures:
  - Δ in consumer surplus, sectoral EV, sectoral CV
  - Abatement costs / direct costs

Study design

- Begin with CGE model
- Use data and parameters from CGE model to also create partial equilibrium sectoral models
- Impose the same sectoral regulation or policy in both PE and GE frameworks
- Compare cost and welfare estimates computed in PE and GE
- E.g. Kokoski and Smith, AER, 1987

Regulatory costs (I)

We can represent the imposition of a regulation or policy in a sectoral production function

$$q_i \quad = \quad a_i \cdot f\left(K, L, E, M; \alpha_f, \sigma_i, io_{ji}\right)$$

by changing parameters (a_i, α_f, σ_i, io_{ji}) to reflect the change in technology and ultimately cost, brought about in the regulated sector.

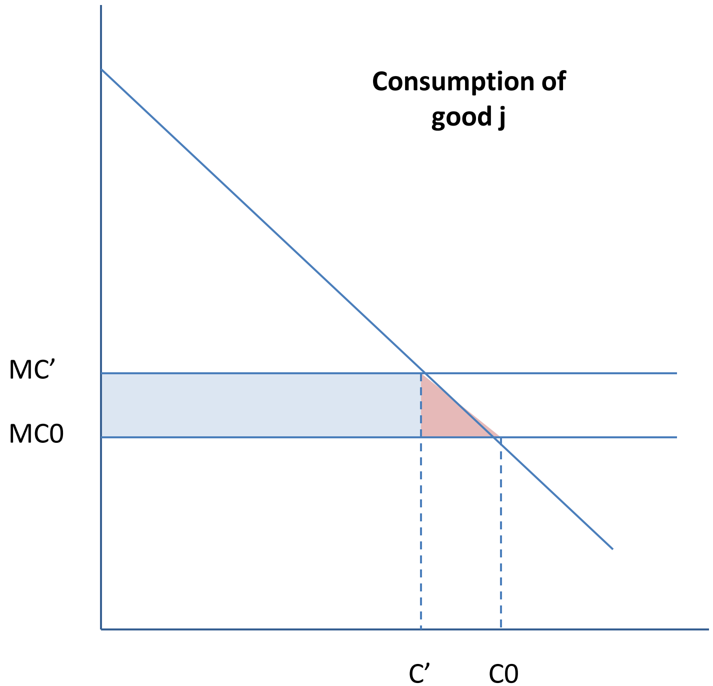
Regulatory costs (II)

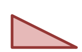
The new parameters result in a change in the cost function. In our simulations we target the change in marginal cost.

$$mc_i^{'} \quad = \quad f\left(w, p; a_i^{'}, \alpha_{fi}^{'}, \sigma_i^{'}, io_{ji}^{'}\right)$$

In our representation, a policy or regulation may alter factor shares, i-o coefficients, etc. and result in an x% change in marginal costs.

PE welfare and abatement costs



PE change in welfare =  + 

PE abatement costs =  + 

Welfare: GE–PE comparison

GE EV for ELES with labor-leisure choice:

$$EV^{GE} = \left(\frac{1}{1-\beta_0}\right) \cdot \left[\prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_i} \cdot \left(\frac{WF0_{lab}}{WF_{lab}}\right)^{\beta_0} \cdot YH - YH0\right]$$

GE EV for ELES without labor-leisure choice:

$$EV^{GE} = \prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_i} \cdot YH - YH0$$

Includes change in income (ΔYH)

PE EV for ELES:

$$EV_i^{PE} = \left(\frac{P0_i}{P_i^{PE}}\right)^{\beta_i} \cdot YH0 - YH0$$

No change in income

Welfare (EV) decomposition

The equivalent variation (EV) measure:

$$EV \;=\; \prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_i} \cdot YH \;-\; YH0$$

can be decomposed into two parts:

$$= \underbrace{\left[\prod_i \left(\frac{P0_i}{P_i}\right)^{\beta_i} \;-\; 1\right] \cdot YH}_{(1)} \;+\; \underbrace{\Delta YH}_{(2)}$$

(1) due to change in economywide prices

(2) due to change in net household income

Abatement/regulatory costs

For our models with CRS, abatement costs in PE are:

$$cost_i^{PE} \quad = \quad \left(mc0_i \quad - \quad mc_i^{PE}\right) \cdot q0_i$$

And in GE:

$$cost_i^{GE} \quad = \quad \left(mc0_i \quad - \quad mc_i^{GE}\right) \cdot q_i$$

U.S. abatement costs, 1991 (mil. $)

Sector	Air	Water	Solid Waste	Total
Utilities and mining	2,210	2,549	1,605	6,364
Construction	466	9,073	715	10,255
Textiles, leather, wood, paper, and products	104	49	277	430
Chemicals and allied products	77	1,015	1,047	2,138
Petroleum refining	94	123	1,354	1,571
Rubber, plastic, stone, clay, and glass products	448	621	49	1,118
Manufacturing products	0	85	849	934
Machinery and transport equipment	89	188	845	1,121
Other industry	0	21	60	81
Services	1,802	2,673	3,714	8,188
Total intermediate inputs	**5,291**	**16,396**	**10,513**	**32,200**
Labor	1,304	3,036	6,737	11,077
Indirect business taxes	0	50	1,560	1,610
Other value added	1,649	1,960	1,176	4,785
Total value added	**2,953**	**5,047**	**9,472**	**17,472**
Total cost	**8,244**	**21,443**	**19,985**	**49,672**

Source: U.S. EPA, 1995.

Models

- 4-sector static CGE model
  - Stylized data set
  - ELES demand system, w/ labor-leisure choice
  - CES production structure

- 29-sector static CGE model
  - Based on GTAP 7 data base
  - ELES demand system, w/ labor-leisure choice
  - Nested CES production structure

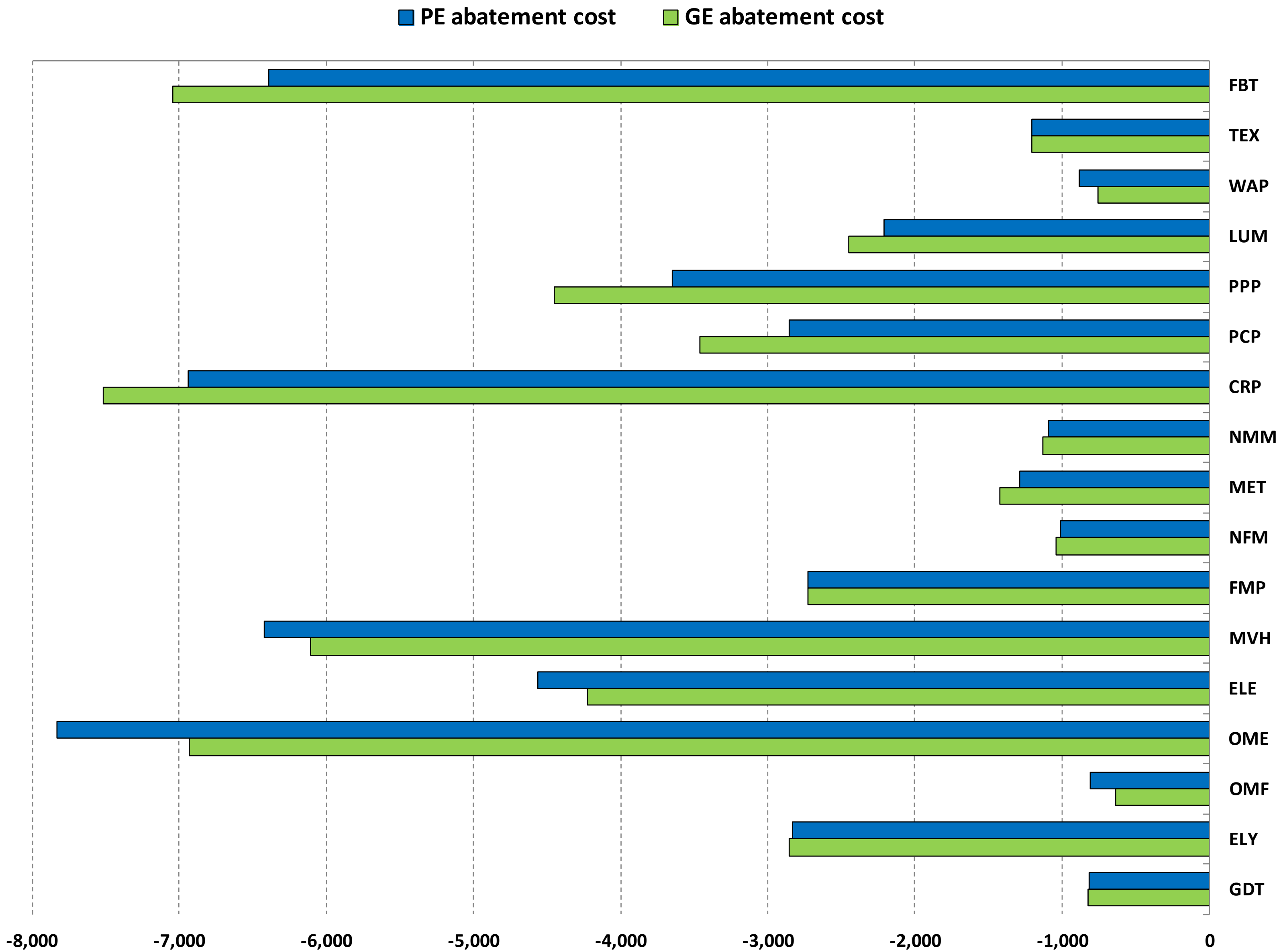
10% increase in marginal cost of electricity

	P	Q	C
AGR	0%	0%	0%
COA	**1%**	**3%**	
OIL	0%	0%	
GAS	0%	0%	
OMN	**1%**	-1%	
FBT	0%	0%	0%
TEX	0%	0%	0%
WAP	0%	0%	0%
LUM	0%	0%	-1%
PPP	0%	0%	-1%
PCP	0%	0%	-1%
CRP	0%	-1%	-1%
NMM	0%	0%	-1%
MET	**1%**	-1%	
NFM	**1%**	-2%	
FMP	0%	0%	-1%
MVH	0%	0%	-1%
ELE	0%	0%	-1%
OME	0%	0%	-1%
OMF	0%	0%	-1%
➡ **ELY**	**11%**	**-5%**	**-4%**
GDT	0%	**1%**	0%
CNS	0%	0%	
TRD	0%	0%	-1%
TRN	0%	0%	0%
CMN	0%	0%	0%
FIN	0%	0%	0%
SER	0%	0%	-1%
DWE	0%	-1%	

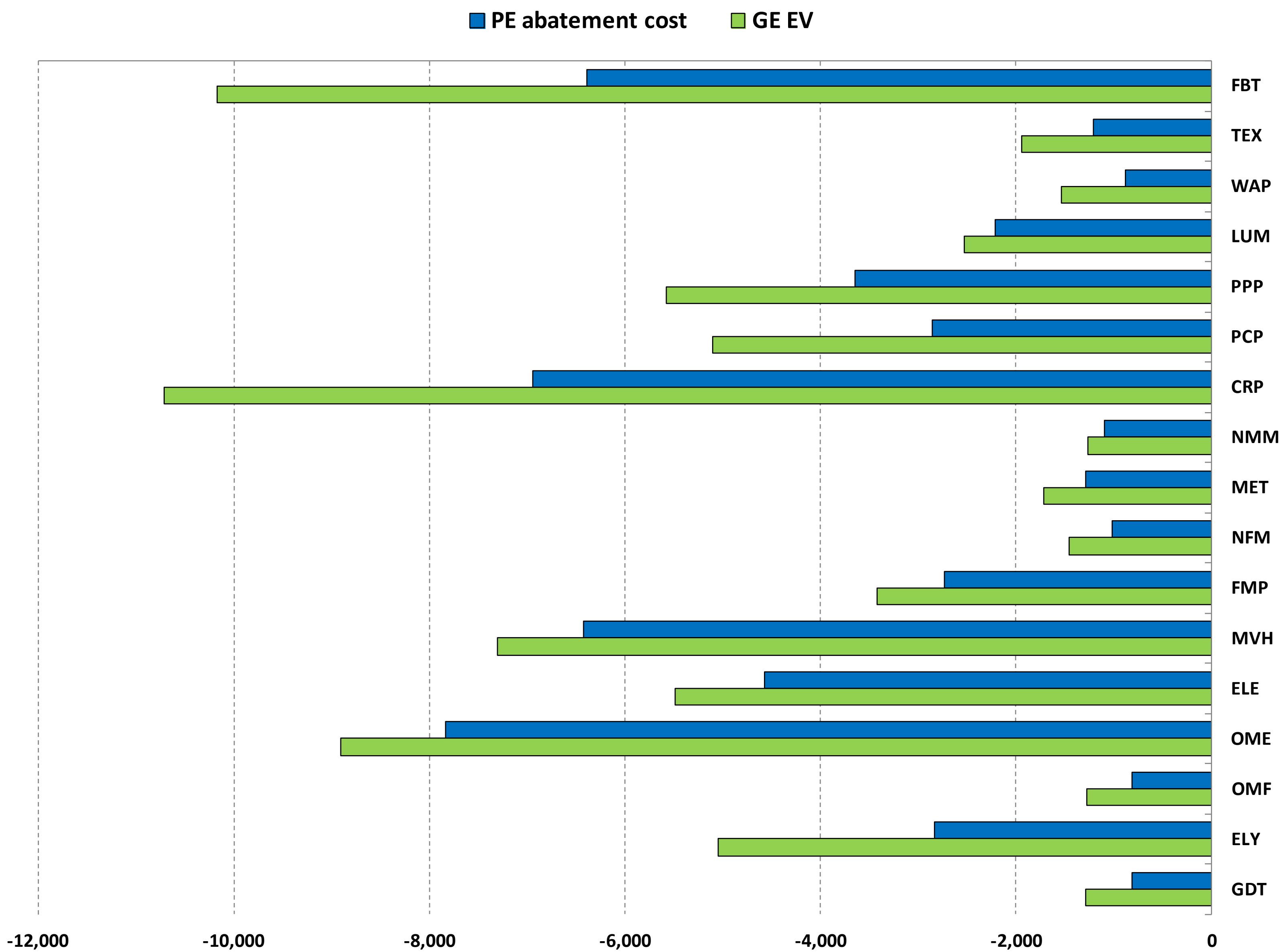
PE abatement cost	-28
GE abatement cost	-29
PE EV	-4
GE EV	-50
Δ GDP	-44

CPI	0.05%
Labor supply	0.03%
Wage rate	-0.43%

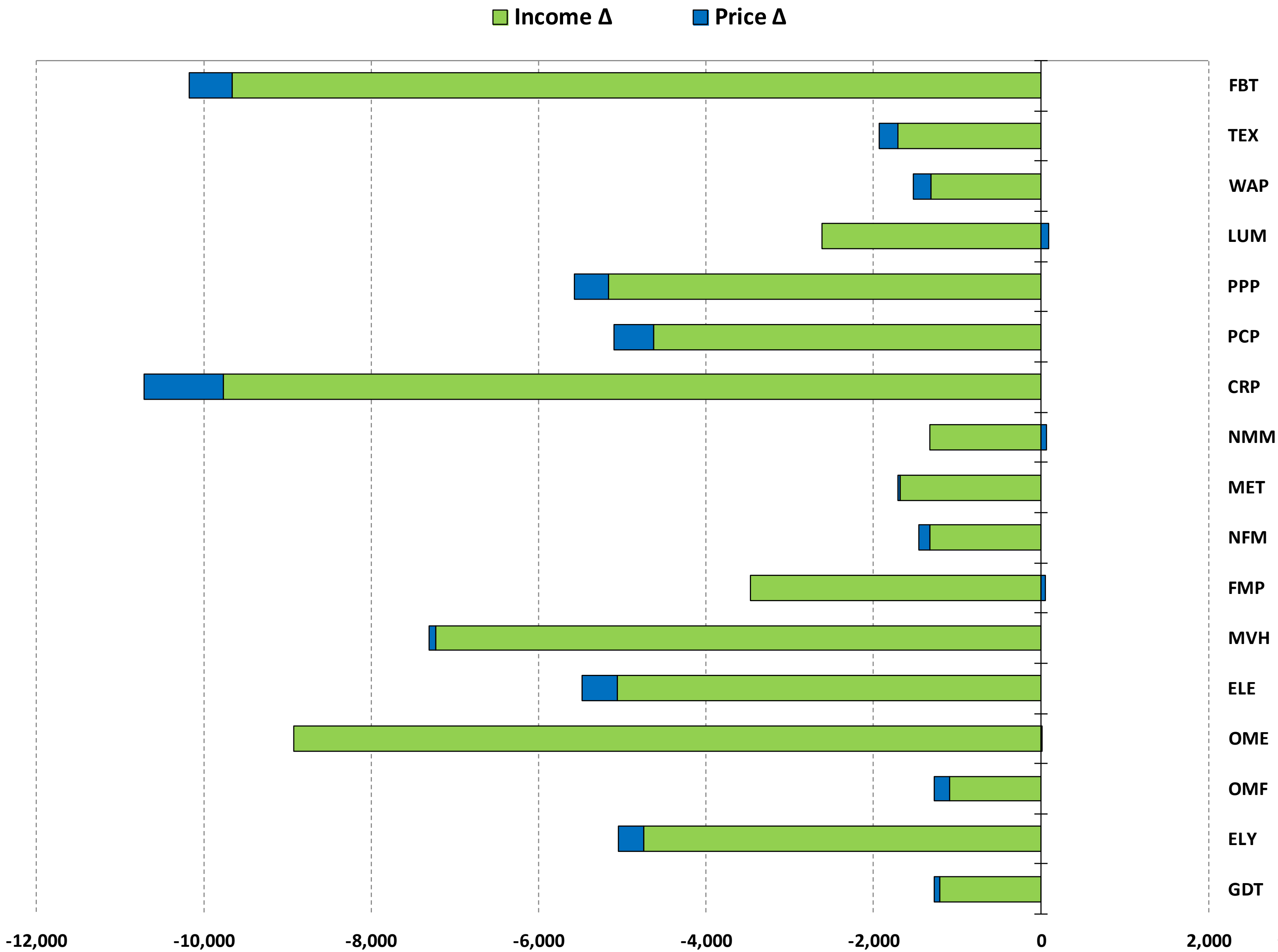
PE and GE abatement costs (10% increase in mc_i)



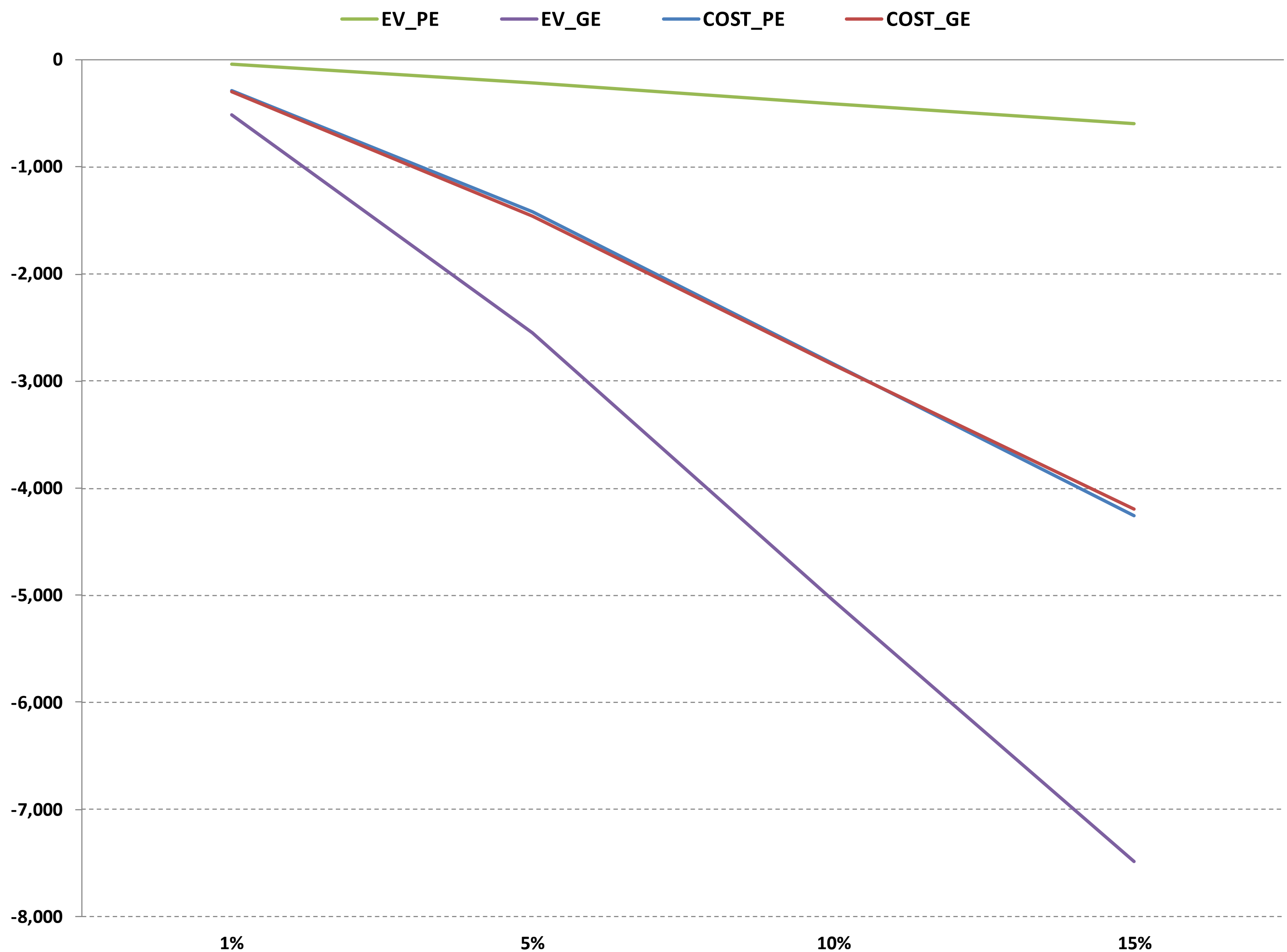
PE abatement costs and GE EV (10% increase in mc_i)



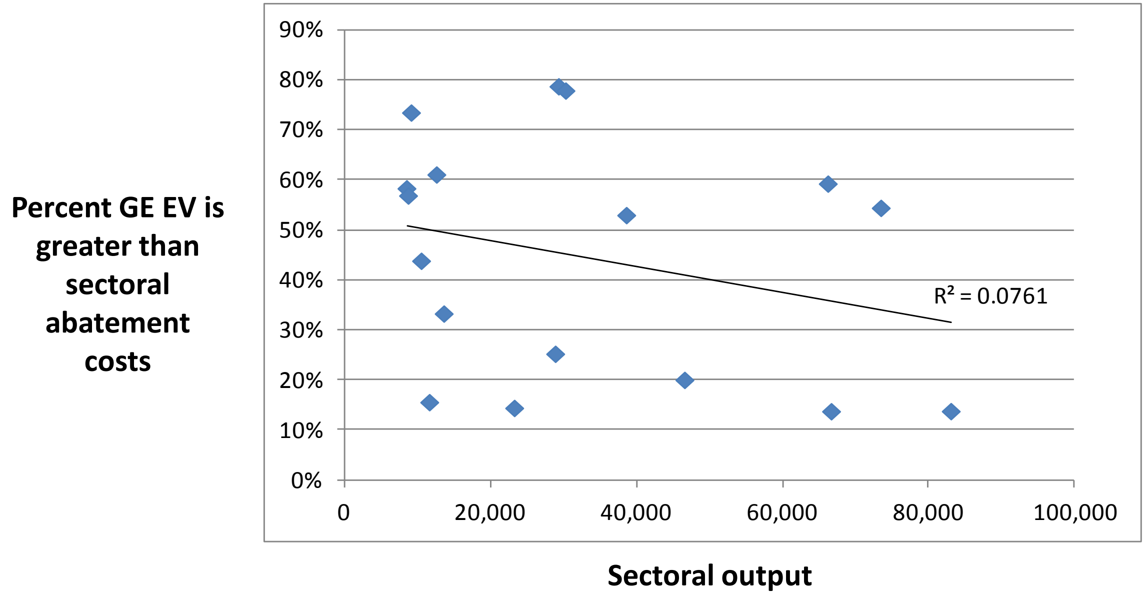
Decomposition of GE EV (10% increase in mc_i)

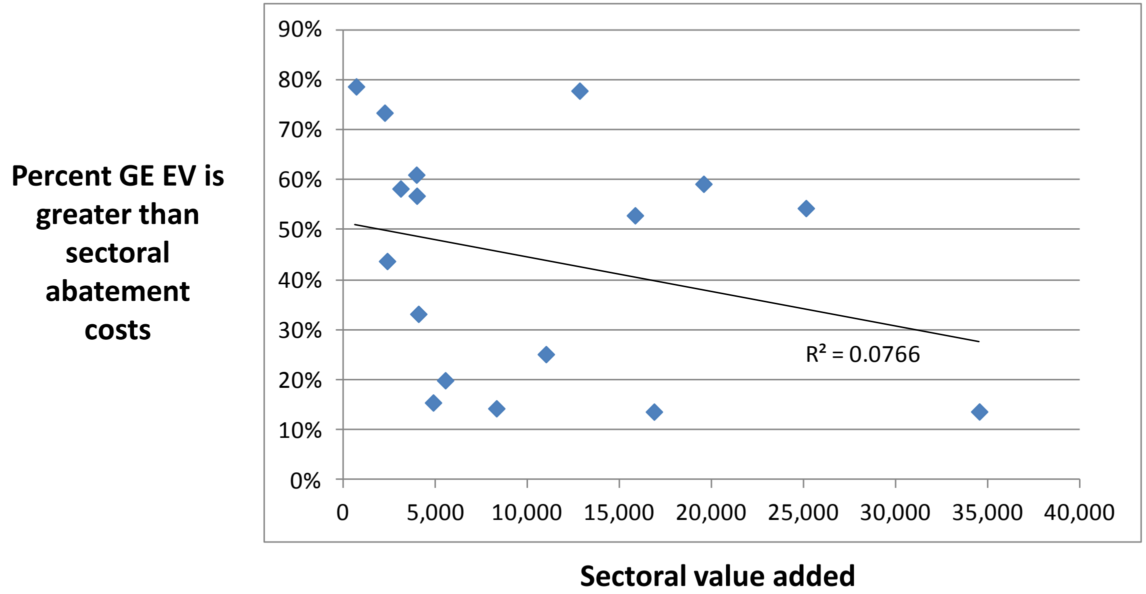


Effects of change in marginal cost of electricity



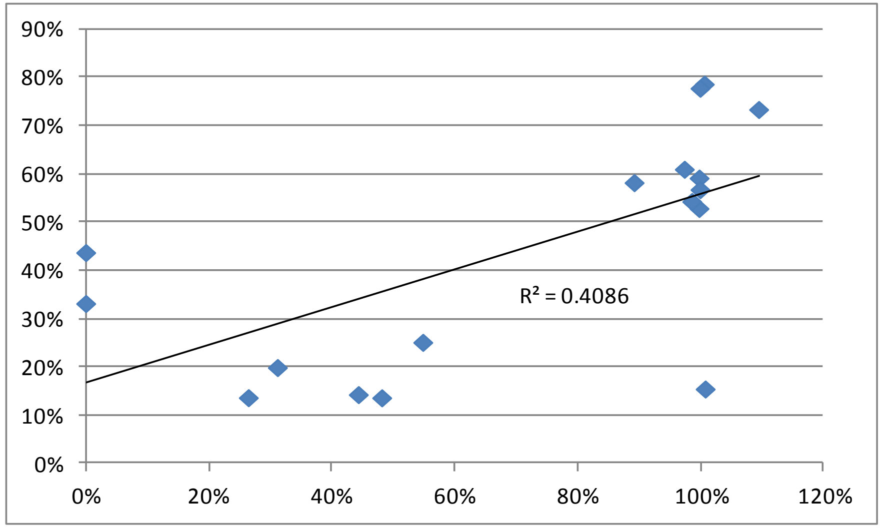
Determinants of PE-GE cost differential (I)





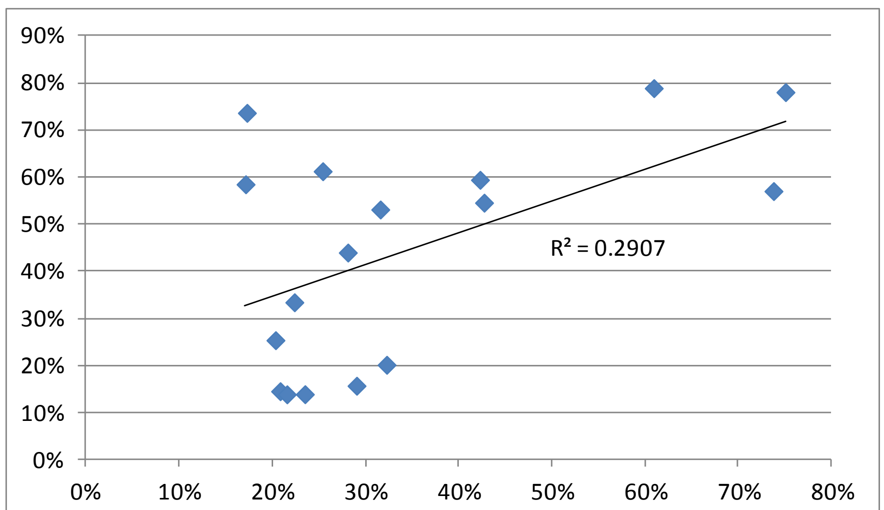
Determinants of PE-GE cost differential (II)

Percent GE EV is greater than sectoral abatement costs



Consumption share in final demand

Percent GE EV is greater than sectoral abatement costs



Capital share in value added

Caveats and preliminary conclusions

- Our work currently assumes a particular set of functional forms and parameters
- For the set of 17 GTAP manufacturing sectors in our CGE model, GE EV is greater than PE abatement costs by 14-79%, with a weighted average of 40%
- For an individual sector, multiple characteristics account for differences in PE and GE estimates of costs
- Sectoral characteristics we have identified that are associated with an increase in the difference between PE and GE costs include a larger share of consumption in final demand and a higher capital share in value added

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