ASM-GIFI Linked Data: Carbon Tax and Productivity Lessons from Canadian Manufacturing[1]

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UNIVERSITY OF CALGARY

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Initially ...

"The Effect of Climate Policy on Performance of Manufacturing Plants"
$\Rightarrow$ Investigate the "competitiveness" impact of BC carbon tax

Annual Survey of Manufactures (ASM)

- Plant-level data on manufacturing activity variables
  - Total shipments of goods of own manufacture (Output)
  - Total employment (production & non-production)
  - Exports (int'l & intra-provincial)
  - Labor productivity
  - Intermediate input expenditures (materials and energy)
  - ... many others

Now ...

Focusing on total factor productivity

GIFI from T2

But ...

ASM does not have data on capital

T2 (Corporate Income Tax Return)

General Index of Financial Information (GIFI)

- Firm-level administrative data (e.g., financial statement)
  - Capital (book value total tangible assets)
  - Taxable income (net income)

But ...

ASM is plant-level while GIFI is firm-level

ASM-GIFI linked microdata

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Linking procedures

1. ASM and GIFI are linked using a business number (BN)
   - 87% of the plants in data is actually a firm
   - but the rest of 13% is a large firm owning multiple plants, and their output shares are large – CANNOT ignore these plants
2. Allocate data down to plants within a firm by its manufacturing size

ASM-GIFI linked data

- 77,000 plants
- 67,000 firms
- Periods: 2004 – 2012
- All 10 provinces and 3 territories
- 86 sub-industries (4-digit NAICS) in manufacturing sector

Research Question

Q: How does a climate policy affect productivity (TFP) of manufacturing plants?

$\Rightarrow$ A revenue-neutral carbon tax in British Columbia, Canada

My Contributions

- First to study the effect of a revenue-neutral carbon tax on productivity using plant-level data
  - Intensive margin adjustments
  - Extensive margin adjustments (entry and exit)
  - Reallocation
- First to isolate the revenue-recycling effect from the overall effect of the carbon tax
  - ASM: energy cost share $\Rightarrow$ direct effect
  - GIFI: taxable net income $\Rightarrow$ indirect effect

Overview of BC carbon tax

- **Surprise implementation** – Announced on February 19th, 2008, and then implemented on July 1st, 2008
- **Most broad-based tax** – it taxes the uses of **all** fossil fuel, and no industries are exempted from the tax initially.
- **High** tax rate – started at \$10/t CO_2e, then increased annually by \$5 until 2012 (\$30). It increased to \$35 in April, 2018, will increase annually by \$5 until 2021 (\$50).
- **Revenue-neutral** — tax revenues are returned to citizens of BC in the form of reduction of other taxes, such as personal and **corporate income taxes**.

Empirical strategy

Exploit three sources of variations

- BC vs. ROC
- Pre-policy (2004-2007) vs. Post-policy (2008-2012)
- Plant-level carbon tax exposure intensity
  - More energy intensive plants are likely to bear higher costs
  - More profitable plants are likely to benefit from the reduction of CIT rate

Productivity Equation

$$\ln TFP_{ijpt} = \beta_1(EI_i \times CTax_{pt}) + \beta_2(TI_i \times (1 - CIT_{pt})) + \Gamma + \epsilon_{ijpt}$$

TFP_{ijpt} = TFP for plant i in industry j in province p at time t

$CTax_{pt}$ = Carbon tax variable, i.e., 0 if $t < 2007$, 10 if $t = 2008$, ...

EI_i = Pre-policy average plant-level energy intensity level

TI_i = Pre-policy average plant-level taxable income

CIT_{pt} = Corporate income tax for province p at time t

Γ = Fixed-effects, e.g., industry $\times$ time

$\beta_1 \Rightarrow$ Direct carbon tax effect

$\beta_2 \Rightarrow$ Indirect CIT effect

Propensity-score weighting (PSW)

To ensure the similarity between BC and ROC plants
(i.e, common trends),

I redistribute the control plants based on the propensity score (PS)

- Estimate PS ($p(X)$) for both BC and ROC plants
- Using $p(X)$, I calculate weights for ROC plants, $\frac{p(X)}{1-p(X)}$
- Estimate the estimation equation using these weights

I estimate PS using the pre-policy plant characteristics: output, labor, wage, capital, intermediates, **taxable income**, TFP, **energy expenditure by fuel types**, int'l and intra-provincial exports, R&D, industry ID, age, multi-plant firm ID, and etc ...

Preview of Results

	(1)	(2)	(3)	(4)	(5)	(6)
CTax	–	–	–			
	***	***	***			
EI x CTax				–	–	–
				*	*	*
TI x (1-CIT)				+	+	+
				*		
2 digit x yr	X			X		
3 digit x yr		X			X	
4 digit x yr			X			X
N	243358	243358	243358	242744	242744	242744
R^2	0.69	0.7	0.7	0.69	0.7	0.7
P-value				0.05	0.15	0.18

Note: All specifications include plant FE and provincial GDP as a control. Standard errors clustered by province $\times$ industry are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Summing up

Q: How did British Columbia's imposition of a carbon tax affect the plant-level manufacturing productivity?

- Carbon tax negatively affect productivity of manufacturing plants
- The reduction of CIT does alleviate the direct negative effect of the carbon tax, but it may not enough and may need to cut the rates more

I conclude that the implementation of carbon tax in BC had significantly negative but small effect on productivity of the manufacturing plants.

Available to download the paper from my website soon

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Thank you