Energy prices and manufacturing plant competitiveness
Empirical evidence from Canada

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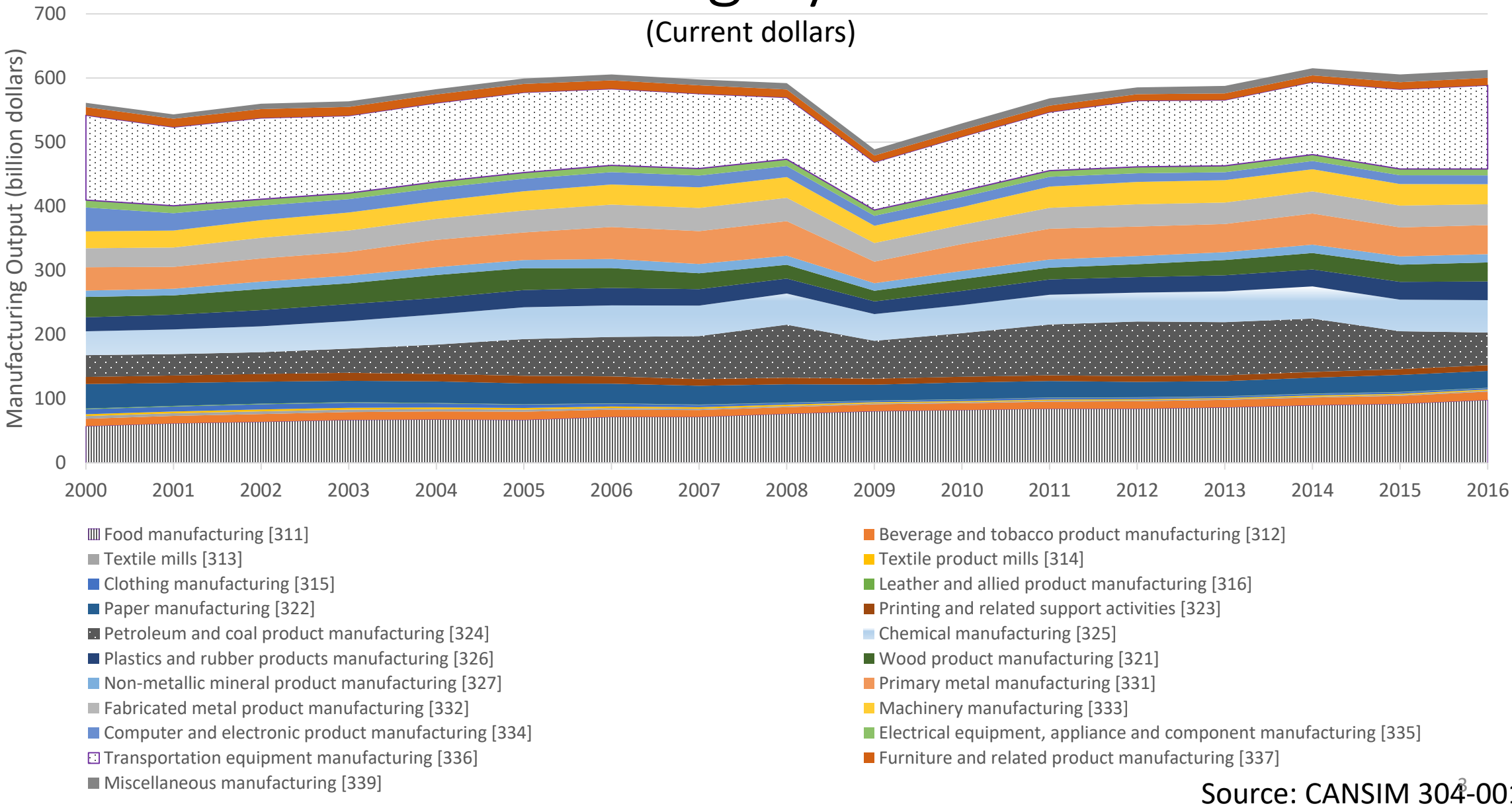
March 1-2, 2018

Background

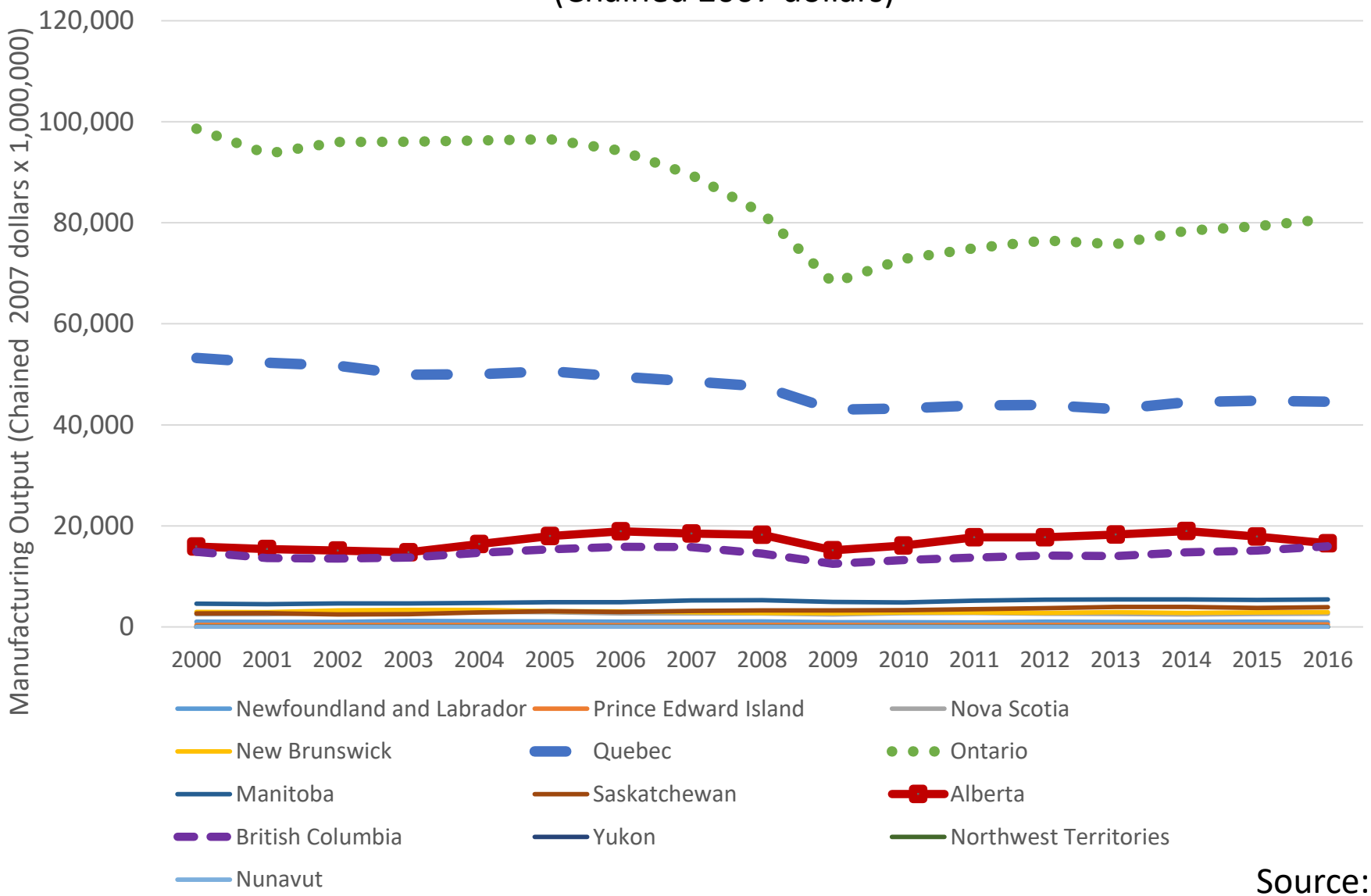
- The introduction of unilateral carbon pricing raises concerns about "competitiveness" and "leakage"
  - The potential exists for some economic activity – especially in energy-intensive and trade-exposed (EITE) sectors – to shift to unregulated regions
- Because of the economic and political importance of the EITE industries, there is a clear interest in estimating the magnitudes involved
  - Several Canadian provinces have implemented cap and trade or carbon taxes; all are required to adopt a carbon price by January 2019.
  - In the US, some states are moving ahead, but the federal government is reducing environmental regulations.
- Evidence on potential competitiveness impacts in Canada is more important than ever. To date, empirical analysis is limited

Manufacturing by NAICS Code



Source: CANSIM 304-0014

Manufacturing by Province



Source: CANSIM 379-0030

Related literature

- Several papers uses historical data on carbon taxes in British Columbia since 2008 to conduct ex post analysis of employment impacts in EITE industries
- Since all combustion sources are covered by the BC program, there is no natural within-province control group; thus all studies use other provinces as a control.
- Four studies, using different data sets and methods, find conflicting results for the impact of BC's carbon tax on employment.
- *Yamazaki (2017a) uses aggregate employment data by sector; compares employment before/after 2008; BC vs other provinces; across different energy intensive sectors.*
    - *Results: Shift in employment from EITE to other sectors with net job gain*

Literature, continued (1)

- *Yamazaki (2017b) uses manufacturing plant level data; also considers before/after 2008; control is matched plants out-of-province.*
  - *Results: reduced production line employment (but not non-production workers) in manufacturing sector*
- *Yip (2017) uses monthly labor force survey rather than plant-level data; also considers before/after 2008; control is matched plants out-of-province*
  - *Results: Increase in unemployment rates for less educated workers*
- *Azevedo et al. (2017) focuses on omitted variables in studies by Yamazaki and Yip; uses synthetic firm level control method*
  - *Results: BC carbon tax had little measurable impact on total employment; even in EITE sectors employment impacts too small to be accurately measured*

Literature cont'd (2)

- Several US papers use energy prices as a proxy for carbon prices:
  - Deschenes (2011) finds that a 1% increase in electricity prices reduces employment by 0.10 to 0.16%. (*state-level data*)
  - Kahn and Mansur (2013) that electricity prices drive location decisions of energy-intensive plants. (*county-level data*)
  - Aldy and Pizer (2015) find that output of the most energy intensive industries in the US declines by 0.4% when energy prices increase by 1%. (*state-level data*)
  - Gray et al. (2016) find that a $10/t CO2 carbon price in California would reduce output of most energy-intensive plants by 4-6 percent. (*plant-level data*)
  - Fowlie et al. (2016) find that a 10% increase in energy price in California would reduce output of energy intensive plants by 4-10 percent. (*plant-level data*)

Approach in this study

- We are interested in how the introduction of carbon pricing in Canada is likely to affect manufacturing plant competiveness
- We use plant-level data and focus on how changes in energy prices affect plant outcomes
- We use historical energy price shocks to provide insight into the effect of carbon prices on plant outcomes
- Model is similar in spirit to Gray et al. (2016)

Empirical approach

- Plants compete with one another to sell output into regional product markets
- A plant's production or employment depends on the energy prices it faces as well as the energy prices its competitors face
- We expect a change in relative energy prices to have larger effects on energy-intensive plants

$$\ln(y) = \beta_1 \mathrm{s} * \ln(p) + \beta_2 s * \ln(p_R)$$

  - y = output, employment, exports
  - s = energy cost share
  - p = price of energy for home plant
  - p_R= price of energy for foreign plant
  - β_1 = Output/empl/export elasticity with respect to energy price
  - β_2 = Output/empl/export elasticity with respect to energy price of competing plants

Empirical specification – Additional considerations

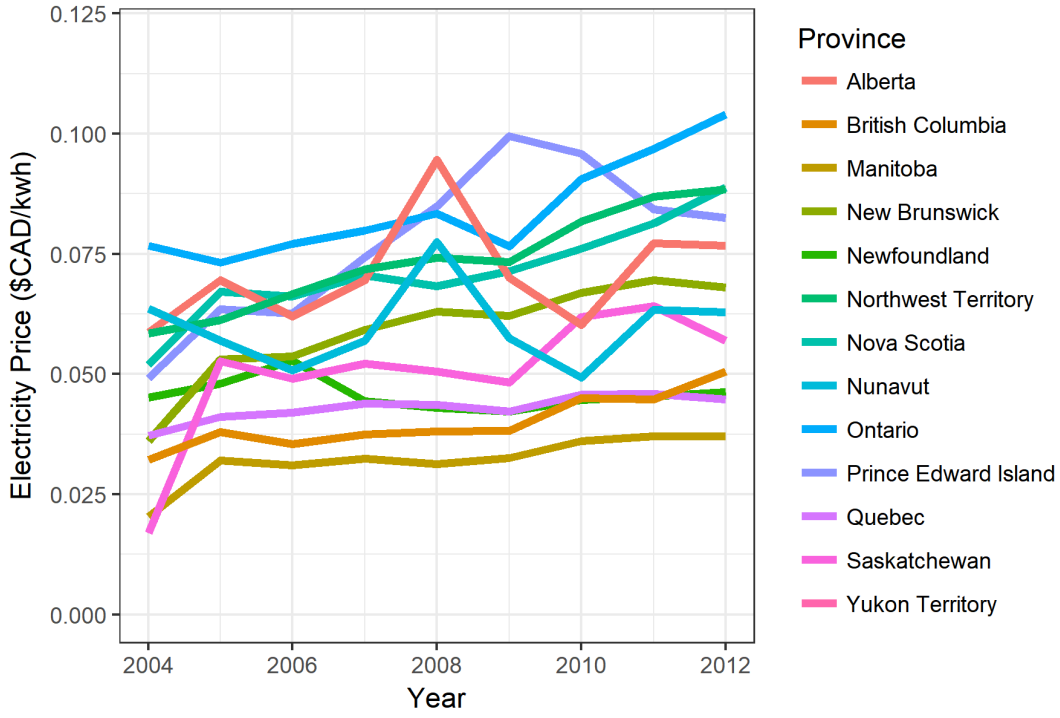
- Despite some guidance from theory about what variables should be important, there remains significant flexibility in specification for which little guidance is available:
- Contemporaneous or lagged energy prices?
  - Main estimation focuses on contemporaneous effects. We also look at one-year lags. Relatively short timeframe of data precludes looking at longer lags.
- Functional form (logs/levels/relative domestic/foreign)?
  - We try a number of specifications, but focus on the ones in which energy prices are in logs and additive.
- Weighting of observations?
  - Try both with and without weights.
- Outlying observations?
  - Use established routine (BACON) to remove outlying observations.
- Control variables and fixed effects?
  - Main specification uses 3-digit NAICS-by-year fixed effects as well as plant fixed effects (we also try with 5-digit by year fixed effects)
  - Include domestic wage rate and index of domestic demand as control variables.
  - Also try interacting energy prices/cost shares with trade intensity.

Data

- Confidential plant-level data from Statistics Canada Centre for Data and Economic Analysis (CDER)
  - Main data source is the Annual Survey of Manufacturers
  - Contains data on plant energy expenditures, employment, shipments, exports, etc.
  - Repeated observations of plants over time (panel data)
  - Roughly 270,000 plant-year observations from 55,000 plants over 9 years (2004-2012).
- Problems with the data
  - We have data on energy *expenditures*, but not data on energy consumption in physical units, and no data on plant-specific prices.
  - Data is survey-derived rather than administrative.

Variation in domestic energy prices

- We do not observe plant-level prices.
- We identify the effect of energy prices on competitiveness using within-province changes in energy prices.
- We focus on electricity, because different market regimes and generation decisions have led to divergent prices in Canada over the past decade. We use these for identification.



Foreign energy prices

- We calculate exposure to foreign energy prices by estimating trade-weighted energy prices unique to each sector/province
  - The majority of manufacturing trade in Canada is to the US.
  - We use the volume of trade between each province-state in each year by 6-digit NAICS sector to weight US energy prices.
  - This gives us a measure of the exposure of each plant to differential US-state prices.
  - We capture non-US trade in a more aggregate manner.
  - While the analysis continues, our preliminarily results do not find a significant impact of foreign prices on domestic output.

Preliminary results

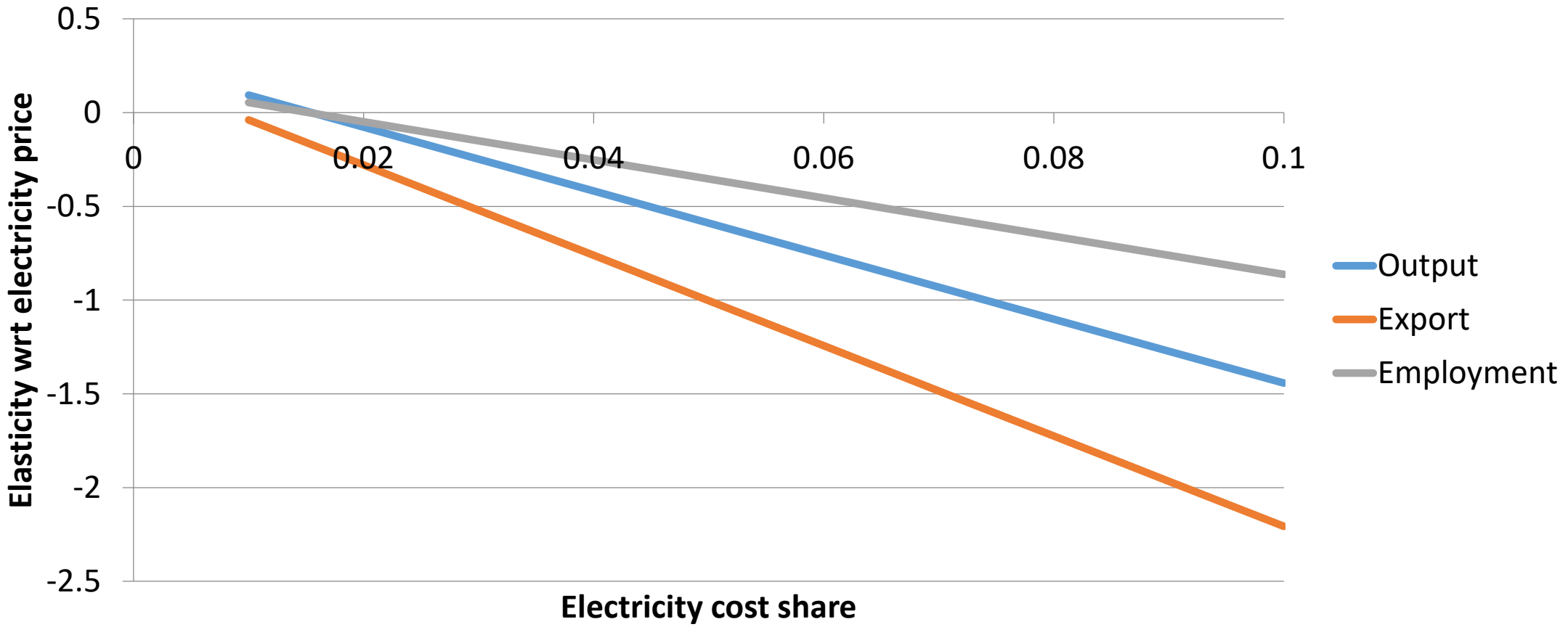
Selected results for log(output)

	(1)	(2)
Log(Electricity price)	0.264	
	(0.0289)	
Log(Electricity price) * electricity cost share	-17.01	
	(2.076)	
Lag Log(electricity price)		0.258
		(0.0325)
Lag Log(electricity price) * electricity cost share		-14.48
		(2.195)
Observations	258,253	258,253
R-squared	0.927	0.935

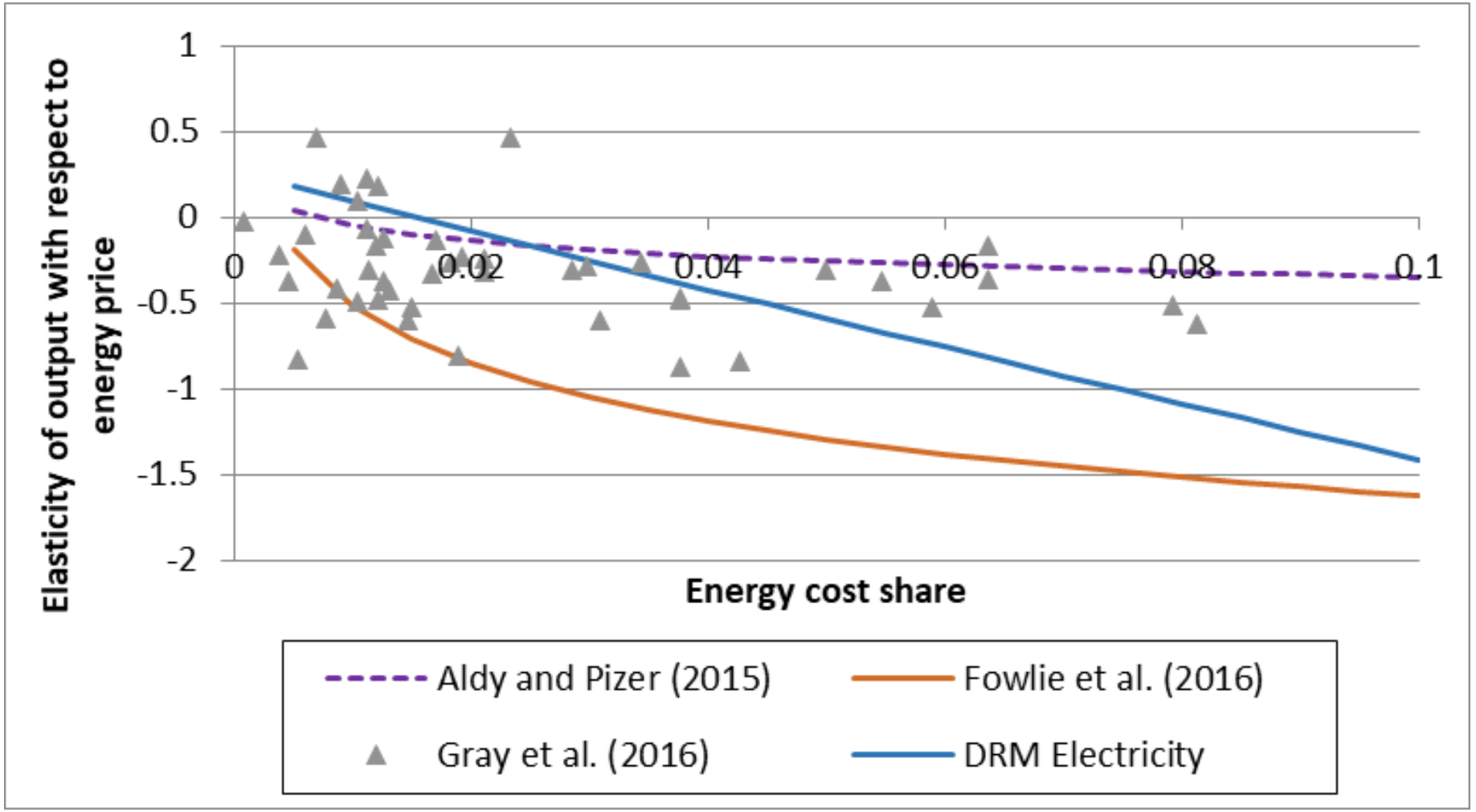
Preliminary results

	Log(output)	Log(exports)	Log(employment)
Log(Electricity price)	0.264 (0.0289)	0.202 (0.169)	0.155 (0.0269)
Log(Electricity price) * electricity cost share	-17.01 (2.076)	-24.09 (8.705)	-10.18 (1.503)
Observations	258,253	187,557	256,904
R-squared	0.926	0.580	0.916

Competiveness and electricity price



Comparison with existing literature



Conclusions and next steps

- Our preliminary results suggest that the most energy-intensive Canadian plants experience a decline in competitiveness when energy prices are high. While not necessarily statistically significant, these declines appear to be slightly smaller than estimated for US plants.
- Our next steps in the project are to:
  - Experiment more with foreign energy prices to understand whether domestic plants are affected by foreign policies
  - Explore the impacts of changes in other (non-electricity) energy prices
  - Simulate the impact of a carbon pricing scheme
  - Compare the magnitude of our results to industry compensation schemes that accompany carbon prices

Future research challenges

- As noted, we hope to simulate alternative compensation schemes that may accompany carbon prices
- Various modeling studies have examined border and consumption taxes, e.g., Bohringer et al (2017). To our knowledge no empirical studies have been developed.
- Another important topic is the potential gains in non-energy intensive sectors.
  - Single BC study (Yamazaki 2017a) lends support to ‘job shift’ hypothesis
  - Data sets for nonmanufacturing sector generally limited but as programs expand in California, Canada and elsewhere, progress should be possible