The Burden of Carbon Taxes: Borne by Workers or Owners?

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Abstract

This paper measures the incidence of a carbon tax on workers and firm owners. To do so, I estimate the changes in total payroll and profits after taxes of the same firms, relative to the total burden, measured as the fall in value added. I study the manufacturing sector under British Columbia's 2008 carbon tax, using balance-sheet data linked to information on fossil fuel expenditure. I use a triple-difference design that compares fossil-fuel-intensive industries to less fuel-intensive industries within British Columbia, and the same difference in other provinces, before and after the reform. At the average fossil-fuel-intensive firm, revenue falls, and lower spending on fossil fuels and other inputs offsets most of this decline. The remaining burden falls mainly on workers. Total payroll falls while profits after taxes do not change, and the difference between the two is statistically significant. Among single-province firms, the burden on workers is larger and statistically significant in smaller and more capital-intensive firms, which have fewer ways to adjust. Owners, whose profit margins were already thin before the reform, bear little of the burden.

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1 Introduction

Climate change imposes large social costs through its effects on health, mortality, and labor productivity (Carleton et al., 2022; Graff Zivin & Neidell, 2014; Schlenker & Walker, 2016). In response, national and subnational governments have implemented 43 carbon taxes worldwide (World Bank, 2025). Although carbon taxes are designed to reduce emissions, they impose a burden, and who bears it determines the distributional effects of their costs. When demand is more elastic than supply, taxed firms cannot pass the tax through higher prices, and they bear most of the burden. Within firms, the incidence is then shifted to workers through lower earnings or lost jobs, and to owners through lower profits. Existing estimates of the split between workers and owners rest on theoretical models with assumed elasticities (Fullerton & Heutel, 2007; Goulder et al., 2019; Rausch et al., 2011). Therefore, empirical evidence on who bears the burden when the cost falls on producers is essential for assessing the equity of carbon taxes and for informing the ongoing political debate about who pays for them.[1]

This paper measures how the burden of a carbon tax is divided between workers and firm owners. It requires three conditions that are rarely met together. First, a large share of the burden must stay within firms. That means a tax without exemptions, levied on firms that have little room to pass it on to prices, such as trade-exposed firms. Also, firms must not be able to move production out of the taxed region right away because it would let them avoid the tax. Second, the data must link firms' exposure to the tax with the outcomes of their workers and owners. Records that combine fuel use, total payroll, and profits for the same firms are scarce. Third, identification needs variation in exposure to the tax. A national carbon price, or a tax on sectors with similar fuel use, leaves no control group to compare against and to account for shocks that occur at the same time as the tax.

Manufacturing firms subject to British Columbia's (BC) 2008 carbon tax meet all three conditions. First, manufacturing is widely exposed to trade. Its goods account for 63% of world merchandise exports (World Trade Organization, 2023), and Canadian manufacturing was no exception in 2007. Its exports accounted for 46% of its output, and imports supplied about half of the manufactured goods used in Canada.[2] On the supply side, manufacturing firms cannot quickly adjust their equipment and workforce. Second, to address the measurement challenge, I link balance sheets with plant-level fossil fuel expenditure. Data that

[1] Carbon pricing has faced backlash in France, Australia, and Canada over concerns about who would end up paying for the tax (Crowley, 2017; Department of Finance Canada, 2025; Douenne & Fabre, 2022; Office of the Parliamentary Budget Officer, 2024).

[2] Trade exposure computed based on 2007 national symmetric input-output tables of Statistics Canada (Statistics Canada, 2007).

combine the two are rare. This linkage lets me measure each industry's exposure to the tax from its fossil fuel expenditure and revenue. It also lets me follow the outcomes of the same firms, their workers, and their owners over 2002–2014.[3] Finally, the BC carbon tax was levied only on fossil fuel purchases within the province, which left producers in other provinces untaxed. Manufacturing industries also differ widely in how much fossil fuel they use.[4] Together, these features create variation in exposure to the tax across both provinces and industries.

The incidence of a carbon tax on firms depends on the elasticities of supply and demand in the output market. When the carbon tax is implemented at the subnational level and firms are exposed to trade, the residual domestic demand they face is elastic (Fowlie et al., 2016). The burden stays on firms when this elastic demand is combined with an inelastic supply. Output is expected to fall because firms can hardly replace fossil fuels with other inputs in the short run (Hawkins-Pierot & Wagner, 2025). The burden on the firm, the fall in its value added, is then expected to exceed the tax it pays on its reduced fossil fuel use. Within firms, how the burden is split depends on the supply elasticities of labor and capital. In the short run, workers are imperfectly mobile (Suárez Serrato & Zidar, 2016). Installed capital also adjusts only gradually (Auerbach, 2006). Therefore, both factors can bear part of the burden. When firms are exposed to trade, competition keeps rents, the profits above the normal return to capital, low. It means that their profits are close to the return owners require to keep their capital in the firm. As a result, owners can protect this return by investing less, while workers cannot easily move to other jobs. In this case, the burden may shift to workers. The split of the burden is ultimately an empirical question.

I exploit the variation in exposure across provinces and industries with a triple-difference design. I compare fossil-fuel-intensive industries to less fuel-intensive industries within BC, and compare the same difference in control provinces, before and after the reform. This design allows me to control for industry shocks common to all provinces, such as the uneven effects of the 2008–2009 recession across industries, and province-wide shocks, such as changes in provincial tax rates that affect all firms. The remaining identifying variation comes from the introduction of the tax in BC in 2008. It increased the marginal cost of production more for fossil-fuel-intensive firms than for other firms in the province. The identifying assumption is that, in the absence of the tax, the gap between high and low fossil-fuel-intensive firms would have evolved similarly in BC and in other provinces.

[3] Fossil fuel expenditure is available from 2004 to 2012.

[4] In US manufacturing, for example, energy costs average about 2% of revenue but exceed 20% in industries such as cement and lime (Ganapati et al., 2020). A similar pattern is also observable in the Canadian manufacturing sector pre-reform in the data used for this paper.

The results are consistent with the burden of the tax staying within firms and growing with the fall in output. At the average fossil-fuel-intensive BC firm, revenue falls by 5.7% of its 2007 revenue. Firms respond by using less of every input. The value of intermediate inputs as a whole falls by 4.3% of 2007 revenue, significant at the 1% level. Fossil fuel use, which represented about 3% of the value of intermediate inputs before the tax, falls by 19.2%. This decrease in intermediate inputs offsets most of the fall in revenue. The remaining burden, represented by the fall in value added, falls on the firms' factors.

I find that the burden falls on workers rather than owners. Total payroll falls by 1.4% of 2007 revenue, about 5.4% of pre-reform payroll, and employment by 4.2%. Both declines are statistically significant. Profits after taxes, measured as a share of each firm's 2007 revenue, do not change significantly. The fall in payroll is significantly larger than the change in profits. In point estimates, the fall in payroll is about as large as the fall in value added, so workers bear nearly all of the burden. This result is expected, since profit margins in manufacturing were thin before the reform. With low rents, owners respond by investing less rather than accepting a lower return. Tangible assets also decline, consistent with owners investing less. Survival and entry rates are on average unaffected, so the results are not driven by firm exit.

The burden on workers is larger in firms that cannot easily adjust to the tax. The first dimension is whether a firm has plants in one province or in several. Multi-province firms can shift production from BC to their plants in untaxed provinces, a form of within-firm leakage (Curtis et al., 2026).[5] Their revenue falls by about as much as that of single-province firms, although, given the small sample, the estimate is imprecise. Lower spending on intermediate inputs offsets most of this decline. Neither their payroll nor their profits change significantly. Plant-level data suggest that they shift part of their production out of BC. Single-province firms, in contrast, cannot easily move production. Their revenue falls by 5.6% of 2007 revenue, a statistically significant decline. Lower spending on fossil fuels and intermediate inputs does not fully offset this loss. This burden falls mainly on workers. The difference in payroll change between the two groups, however, is not statistically significant.

Within single-province firms, the burden on workers is larger in small firms and in more capital-intensive firms. These firm characteristics limit how quickly a firm can adjust. Small firms have less cash and less access to credit to absorb the cost (Chodorow-Reich et al.,

[5]Multi-province firms are 11% of fossil-fuel-intensive BC firms but account for 78% of their revenue. This pattern is not specific to BC manufacturing. In Canada, firms operating in several provinces were 2.3% of employer firms but held 43.4% of business-sector employment in 2011 (Rollin, 2014). In US manufacturing in 2022, firms with more than one establishment were 8.6% of firms but accounted for 70.3% of employment and 84.9% of sales (U.S. Census Bureau, 2025).

2022). In capital-intensive firms, energy use is embodied in installed equipment and adjusts slowly (Atkeson & Kehoe, 1999; Pindyck & Rotemberg, 1983). In these firms, revenue falls by 8.6% to 9.4% of 2007 revenue. Intermediate inputs fall by 5.2% to 5.4% of 2007 revenue, which does not fully offset the fall in revenue. This burden is shifted mainly to workers. Total payroll falls by 3.1% to 3.8% of 2007 revenue, about 10% to 13% of pre-reform payroll. Payroll thus falls by proportionally more than revenue, so the share of revenue paid to workers declines. Profits after taxes do not change significantly. In large and less capital-intensive firms, by contrast, neither total payroll nor profits change significantly. The differences in payroll between groups are statistically significant. Less fuel-efficient firms, which may be locked into the technology they adopted at entry (Hawkins-Pierot & Wagner, 2025), do not show a larger burden on workers than more fuel-efficient firms.

Worker- and owner-level estimates show no significant income loss. These estimates describe the average worker and owner rather than the average firm. In fossil-fuel-intensive industries, a few large firms employ many of the workers. I use matched employer-employee records and owner-level dividend income from corporate tax schedules. Worker-level estimates show no significant earnings loss, consistent with the small payroll response of large firms. The worker-level results therefore suggest that the tax does not cause a large decline in workers' earnings for the fossil-fuel-intensive industries as a whole. Along the same lines, owner-level results show no significant change in owners' total income or dividend income, consistent with the absence of a profit response at the average firm.

My results suggest that, for a subnational carbon tax, the output effect shapes the size of the burden, while low rents shape its split. The average firm in fossil-fuel-intensive industries experiences a significant contraction in revenue. Lower spending on intermediate inputs, including fossil fuels, offsets most of this decline. The remaining fall in value added goes mainly to workers rather than owners. The difference between the effects on total payroll and on profits after taxes is statistically significant. The burden on workers is also larger and statistically significant in firms that are more constrained by limited access to credit or by their installed capital. The difference with less constrained firms is also significant.

This paper contributes to three strands of literature. First, it contributes to the literature on the incidence of environmental regulation by measuring the burden on both workers and owners for the same firms. Fullerton and Heutel (2007) show in an analytical general equilibrium (GE) model that the split depends on the elasticities of substitution between inputs and on the output effect of the tax. Computable GE models analyze changes in wages and returns to capital in an economy fully covered by the tax (Goulder et al., 2019; Rausch et al., 2011). Most empirical studies, in contrast, measure the incidence directly, but only

one side at a time. Studies of price pass-through measure how the burden is split between consumers and producers (Fowlie et al., 2016; Ganapati et al., 2020). Analyses of worker incidence document earnings and job losses in regulated industries, including under the BC carbon tax (Curtis, 2018; Karlsson, 2026; Walker, 2013; Yip, 2018). At the aggregate level, Känzig (2026) combines both sides for households, as consumers and as workers, and finds carbon pricing in the EU more regressive than previous estimates show. Still, the available results do not speak about the burden split within firms. Empirically measuring the losses of workers and owners for the same firms, relative to the same total burden, helps measure the equity of the tax in practice. For BC manufacturing firms, I find that the burden falls on workers rather than owners.

Second, it contributes to the public finance literature on the factor incidence of taxes by measuring the incidence of a tax designed to change behavior. This empirical literature studies the incidence of taxes levied directly on labor, output, or profits. For payroll taxes, Saez et al. (2019) find that rent sharing spreads the gains to all workers in the firm, not only the targeted ones. Also, Lobel (2024) provides evidence that consumers bear most of the tax because firms have market power. For value-added taxes, Benzarti and Carloni (2019) find that firms barely lowered prices after a tax cut, so owners captured most of the gain. For corporate income taxes, workers bear between a third and a half of the burden, mainly through bargaining and rent sharing over profits (Arulampalam et al., 2012; Duan & Moon, in press; Fuest et al., 2018; Kennedy et al., in press; Suárez Serrato & Zidar, 2016). These studies measure the burden relative to the mechanical tax cost, which approximates it when the tax is small and behavioral responses are second order (Weyl & Fabinger, 2013). A carbon tax, in contrast, falls on a third input, fossil fuels, and is designed to reduce their use. In BC, the tax reached about a quarter of the price of natural gas, and taxed firms competed with untaxed producers. As a result, behavioral responses can be large, and the incidence depends on how fossil fuels substitute for other inputs and on the output effect of the tax (Fullerton & Heutel, 2007). The evidence from other taxes does not carry over, so I measure the burden directly as the realized fall in value added.

Third, it contributes to the literature on the firm-level effects of carbon pricing by showing that revenue falls in fossil-fuel-intensive firms, and that the burden on workers is larger in firms that cannot easily adjust. This literature mostly finds small average effects on output and employment. Martin et al. (2014) find that a carbon tax in the UK reduced energy intensity with no significant effect on employment or revenue. Colmer et al. (2025) show that the EU Emissions Trading System cut emissions with no effect on economic activity. Hawkins-Pierot et al. (2026) reach a similar conclusion for provincial carbon pricing in Canada. For the BC carbon tax, Ahmadi et al. (2022) estimate that emissions fell while

output rose. The difference with my results is explained because they measure exposure with a continuous emission intensity across all plants, while I compare the most exposed with the rest. Yamazaki (2022) finds a fall in productivity that revenue recycling partly offsets. Aggregate employment did not fall (Azevedo et al., 2023; Yamazaki, 2017), although Azevedo et al. (2023) document losses in large emission-intensive firms. In contrast with these effects, Känzig (2026) uses high-frequency variation in EU carbon prices and finds significant declines in output and employment at the aggregate level. My firm-level results point in the same direction. Revenue falls in fossil-fuel-intensive BC firms, so the burden includes value added lost through lower output, not only the tax paid. Balance sheet data cover firms of all sizes, so I compare firms that differ in how easily they can adjust to the tax. With suggestive evidence that multi-province firms move revenue out of BC, I also add to the few studies of carbon leakage by multi-plant firms (Curtis et al., 2026).

The rest of the paper is organized as follows. Section 2 describes the BC carbon tax, and Section 3 develops the conceptual framework. Section 4 describes the data. Section 5 presents the empirical strategy. Section 6 reports the main results. Section 7 examines how the burden varies across firms. Section 8 presents robustness checks, and Section 9 concludes.

2 Institutional Background

In February 2008, the government of British Columbia announced a carbon tax on the purchase and use of fossil fuels (Ministry of Finance, 2008). The tax took effect on July 1, 2008, only five months later. It was the first broad-based carbon tax in North America and covered firms in every industry, regardless of their size or other characteristics.[6] The government levied the tax on fossil fuel purchases because greenhouse gas (GHG) emissions come directly from fuel combustion. As a result, the tax reached approximately 70 percent of the province's GHG emissions (Murray & Rivers, 2015).[7] These features make the tax well suited to studying its incidence. The short interval between the announcement and implementation likely limited firms' ability to adjust in advance. There were also fewer concerns about lobbying or selection into the tax given the broad coverage. In addition, levying the tax on fossil fuel purchases, which made it simple to administer, makes exposure to the tax easy to measure.

Another characteristic is that, from the year of implementation, firms knew that the tax

[6] In 2012, the government provided carbon tax relief to protect the competitiveness of the agricultural sector, and in 2015 the government of British Columbia introduced the Cement Low Carbon Fuel Program, which offers subsidies to cement producers that exceed emission intensity targets (Thivierge, 2020).

[7] Appendix A describes the fuels and emissions the tax did not cover.

would be permanent and would rise on a fixed schedule. The rate began at $10 per tonne of CO_2-equivalent[8] and rose by $5 per tonne each year until it reached $30 per tonne in 2012 (Ministry of Finance, 2008). The schedule was designed to give firms strong incentives and enough time to make long-term investments, such as in cleaner technologies. Each fossil fuel emits a different amount of CO_2 per unit of energy. As a result, the same $30/tonne rate translated into a different carbon price by fuel. At $30/tonne, the tax added approximately $2.85/GJ to coal, $2.51/GJ to heavy fuel oil, $2.00/GJ to light fuel oil and diesel, $1.99/GJ to gasoline, $1.81/GJ to propane, and $1.48/GJ to natural gas, reflecting each fuel's CO_2 intensity (Ministry of Finance, 2021).

As a share of the fuel price, however, the tax varied much more across fuels. By 2014, it represented about 41% of the price of coal and 19% of the price of natural gas, up from 7% and 5% in 2008. For gasoline, diesel, light fuel oil, and propane, it stayed below 8% of the price throughout (Appendix Table A2). These shares assume that fuel suppliers pass the full tax on to the price firms pay. The assumption holds for natural gas. Regulated monopoly utilities distribute natural gas in BC and add the carbon tax directly to customers' bills, so pass-through to natural gas prices was complete. Pass-through to gasoline prices, in contrast, was incomplete in the short run (Gittens, 2019). Therefore, the share of the tax in the gasoline price that firms paid may be lower than reported above. Natural gas therefore faced a large tax relative to its price, even though it carried the smallest tax per unit of energy.[9] Its price at the time was low compared with gasoline and diesel, whose prices included federal and provincial fuel taxes as well as refining and distribution margins. The carbon tax was not designed based on market prices. Instead, it was a fixed rate per tonne of CO_2 that was calculated through the emission factor of each fuel (Ministry of Finance, 2021).

The tax was designed to be revenue neutral (Ministry of Finance, 2008). To return its revenue, the government cut the general and small business corporate income tax rates by about 2 percentage points each. It also cut personal income taxes for low- and middle-income households and introduced a small transfer for low-income families. These changes were the same for all firms and households in BC, regardless of the fossil fuel intensity of their industry, so the triple difference absorbs them.[10] The one exception is that the corporate income tax

[8] CO_2-equivalent is a measure of the greenhouse effect created by all GHG emissions, adjusting non-CO_2 gases to a CO_2-equivalent basis (Ministry of Finance, 2008).

[9] Natural gas prices also fell sharply between 2008 and 2012, as shale gas production expanded supply across North America (Hausman & Kellogg, 2015). In BC, the natural gas price fell from $9.7/GJ in 2008 to $5.6/GJ in 2012. As the tax rose and the price fell, the tax grew from 5% of the natural gas price in 2008 to 26% in 2012. The price then partly recovered, to $7.9/GJ in 2014, and the tax share fell to 19% (Appendix Table A2).

[10] Appendix A describes these tax changes in detail.

cut may have favored capital-intensive industries, which I discuss in Section 8.

In 2007, the manufacturing sector was highly exposed to trade. Exports accounted for 46% of Canadian manufacturing output, and imports supplied about half of the manufactured goods used in Canada.[11] Natural gas was the main fossil fuel that manufacturing firms used. It supplied about half of the fossil fuel energy consumed by Canadian manufacturing (Statistics Canada, 2025b), which makes the large tax relative to the price of natural gas especially relevant for this sector.[12,13] Also, manufacturing was the primary source of BC's emissions from stationary combustion (Appendix Table A1), which makes it relevant from an environmental perspective.

3 Conceptual Framework

How the burden of a carbon tax is shifted to workers and firm owners can be decomposed into three steps. The first is whether firms can pass the tax on to prices, which depends on how elastic demand is relative to supply. The second is how large the burden on firms is, which depends on how easily they can replace fossil fuels with other inputs. The third is how this burden is split between workers and owners, which depends on how mobile each factor is and on whether firms earn rents. Section 3.1 addresses the first two steps, Section 3.2 the third, and Section 3.3 explains how incidence is measured.

3.1 Incidence on Consumers and Producers

In a Pigouvian tax setting, the share of the tax burden that goes to consumers depends on how much output prices rise for each dollar of extra cost. This in turn depends on the elasticity of demand relative to supply (Fullerton & Metcalf, 2002; Gruber, 2007). One case is when taxed goods are traded between taxed and untaxed jurisdictions, which makes the residual domestic demand faced by taxed producers highly elastic (Fowlie et al., 2016). On the supply side, short-run frictions in adjusting production, such as immobile capital and labor, make supply less elastic (Fullerton & Metcalf, 2002). This Pigouvian benchmark coincides with a carbon tax set equal to the marginal external damage of emissions.

Panel (a) of Figure 1 shows the case when supply is more elastic than demand. This

[11] Trade exposure computed based on 2007 national symmetric input-output tables of Statistics Canada (Statistics Canada, 2007).

[12] This share excludes electricity, steam, wood, and spent pulping liquor from the base.

[13] In US manufacturing, natural gas supplies about 75 percent of the energy from primary fuels, excluding electricity (Ganapati et al., 2020).

occurs under full geographic coverage of the carbon tax. S is the aggregate private marginal cost of production, and S' is S plus the tax τ. In this case, buyers cannot avoid the tax by switching suppliers because all competing producers face it. Therefore, the relevant demand curve is the relatively inelastic domestic demand. Most of the cost shock τ passes into the price (ρ, the consumer burden) instead of being absorbed by factor income ($\tau - \rho$, the producer burden). There is also a small output contraction, as shown in Panel (a). In both panels, the blue rectangle shows the part of the tax cost paid by consumers, and the orange rectangle shows the part paid by producers. The light orange area shows the burden that comes from the value added lost through the output contraction.

Panel (b) shows the case where demand is more elastic than supply. This occurs when the carbon tax is levied by one jurisdiction on traded goods, making the residual domestic demand curve nearly flat at the prevailing (untaxed) price. If taxed firms want to raise their price above this level, buyers will switch to untaxed producers. In this scenario, the price barely moves (ρ small), and output falls (Q_0 to Q_1) as production moves to untaxed producers. This shift is also known as carbon leakage. As a result, nearly the entire cost shock $\tau - \rho$ is absorbed by factor income instead of being passed forward. Because the firm cannot pass this cost on to consumers, it falls instead on the firm. Beyond the tax paid, the burden on the firm grows by the light orange area, which comes from the output contraction. Together, the orange rectangle and the light orange area make up the total burden on the firm, the fall in its value added.

The size of the output contraction in Figure 1 depends on how easily producers can replace fossil fuels with other inputs, conditional on the demand elasticity. To avoid paying the full tax, producers can use less fuel, so the supply curve would shift up by less than τ and the fall in output from Q_0 to Q_1 would be smaller. When it is difficult to substitute away from fossil fuels, the gap between Q_0 and Q_1 would be larger. The latter is the most common case, given that evidence shows that the short-run elasticity of substitution between energy and other inputs is low (Hassler et al., 2021; Hawkins-Pierot & Wagner, 2025).

3.2 Incidence on Workers and Owners

The burden on producers, the tax bill plus the losses from the output contraction in Figure 1, falls on the factors of production of the taxed firms. The tax lowers the price producers keep per unit of output, which lowers the demand for both labor and capital. In the case of limited substitution, no input demand increases to replace fossil fuels. The result is that the burden is split between workers, through lower payroll, and owners, through a lower return to capital. The split depends on the supply elasticities of labor and capital, as

shown in Figure 2. The burden falls more on the factor whose supply is less elastic (Fullerton & Metcalf, 2002).

Panel (a) of Figure 2 shows the labor market. Workers cannot move to other jobs without cost. Walker (2013) shows that workers in regulated sectors face large earnings losses when they are reallocated. The public finance literature also finds that workers are imperfectly mobile (Suárez Serrato & Zidar, 2016). Short-run labor supply to the taxed firms is therefore inelastic. The contraction in labor demand lowers both earnings ($w_0 - w_1$) and employment ($L_0 - L_1$).

In Panel (b), installed capital cannot relocate in the short run, but part of it adjusts gradually as it depreciates and is not replaced (Auerbach, 2006). The short-run supply (S_K) slopes upward rather than being vertical. Also, when rents, which are the profits above the normal return to capital, are small, the capital supply can be more elastic than labor supply. For example, if profits after taxes are close to the return owners require to keep their capital in the firm, even a small decline in the return will lead to lower investment from owners. Capital supply, however, would not be completely elastic, because selling capital is costly (Ramey & Shapiro, 2001). The return falls from r_0 to r_1 and capital from K_0 to K_1. This loss is borne by the owners of existing capital.

Together, theory predicts that, in the short run, the burden is shared between workers and owners. In this case, competition from untaxed producers can limit rents, which shifts the burden to workers through lower earnings and employment. The analysis is partial equilibrium. It focuses on the incidence split between the workers and owners of the taxed firms, and does not measure effects on other sectors or on fuel suppliers.[14] This study compares more exposed with less exposed firms, which means that it removes the effects common to all firms, such as changes in aggregate demand (Känzig, 2026).

3.3 Factor Incidence Identity

Studies of factor incidence usually measure the burden relative to the mechanical tax cost, the tax rate times the pre-reform tax base (Benzarti & Carloni, 2019). For a small tax, this cost approximates the total burden, because behavioral responses affect it only at second order (Weyl & Fabinger, 2013). When the tax causes large behavioral responses, the mechanical cost no longer approximates the burden. A carbon tax is designed to reduce fossil fuel use. The behavioral effect is larger when it is difficult to replace fossil fuels with other inputs and taxed firms compete with untaxed producers. These two channels make

[14] I assume that fuel suppliers pass the full carbon tax on to the price firms pay.

firms lose output. Hence, I measure the burden directly as the fall in value added and treat the tax paid as one of its components.

I start from the definition of value added, revenue minus intermediate inputs, which is paid out as payroll, profits after taxes, and other payments,

$$\underbrace{VA}_{\text{value added}} = \underbrace{R}_{\text{revenue}} - \underbrace{M}_{\text{intermediate inputs}} = \text{Payroll} + \pi + \text{Other}, \tag{1}$$

where π is profits after taxes and Other includes the remaining payments out of value added, such as depreciation, interest, and taxes on profits.[15] Intermediate inputs include fossil fuels at the price the firm pays, including the carbon tax,

$$M = M^N + \sum_j (p_j + \tau_j) F_j, \tag{2}$$

where M^N is spending on all other inputs, such as materials, electricity, and services, F_j is the quantity of fuel j, p_j is its pre-tax price, and τ_j is the carbon tax per unit.

I difference equation (1) between the pre-reform and post-reform periods, denoted by the subscripts 0 and 1, and divide by pre-reform revenue R_0 (Harasztosi & Lindner, 2019). When output prices do not change, consumers bear none of the tax (Section 3.1), and the burden on producers is the fall in value added,

$$B \equiv -\frac{\Delta VA}{R_0} = \underbrace{-\frac{\Delta \text{Payroll}}{R_0}}_{\text{workers}} \underbrace{-\frac{\Delta \pi}{R_0}}_{\text{owners}} \underbrace{-\frac{\Delta \text{Other}}{R_0}}_{\text{other}}. \tag{3}$$

I measure the burden on workers as the fall in total payroll and the burden on owners as the fall in profits after taxes. Total payroll falls when firms employ fewer workers or pay them less. Therefore, the burden on workers includes job losses as well as lower earnings. Profits after taxes are the income that goes to owners. They are paid out as dividends or kept as retained earnings. Each group's share of the burden is its loss divided by the fall in value added, both relative to pre-reform revenue,

$$s_W = \frac{-\Delta \text{Payroll}/R_0}{B}, \qquad s_\pi = \frac{-\Delta \pi / R_0}{B}, \qquad s_O = \frac{-\Delta \text{Other}/R_0}{B}, \qquad s_W + s_\pi + s_O = 1. \tag{4}$$

Another option to analyze which group bears more of the burden, without using it as a share

[15] I measure value added as revenue minus intermediate inputs, the standard definition in national accounts. Using the same administrative data, Dostie et al. (2023) measure value added as the sum of payroll and net income before taxes.

of the value added, is to compare the loss of workers, $-\Delta\text{Payroll}/R_0$, with the loss of owners, $-\Delta\pi/R_0$.

The size of the burden follows from writing the change in value added as $\Delta R - \Delta M$ and using equation (2). With the prices of fuel and other inputs unchanged and no tax before the reform,

$$B \;=\; \underbrace{\frac{\sum_j \tau_j F_{j,1}}{R_0}}_{\text{tax paid}} \;+\; \underbrace{\frac{-\Delta R \;+\; \sum_j p_j\,\Delta F_j \;+\; \Delta M^N}{R_0}}_{\text{output contraction}}. \tag{5}$$

The first term is the tax the firm pays on the fuel it still uses after the reform, the orange rectangle in Panel (b) of Figure 1. The second term is the value added lost because output falls, the light orange area. It equals the revenue lost net of the savings on fuel ($\Delta F_j < 0$) and on other inputs ($\Delta M^N < 0$). Assuming that input prices do not change, suppliers of intermediate inputs bear none of the burden and lower spending on inputs can be considered a saving for the firm. Firms that cut fuel use lower the tax they pay. However, firms lose output if they can neither pass the tax on to prices nor replace fossil fuels with other inputs. The burden then rises beyond the tax paid (orange rectangle plus the light orange area, in Figure 1).[16]

The tax paid can be written as the mechanical tax cost adjusted for the change in fuel use, $\sum_j \tau_j F_{j,1} = \sum_j \tau_j F_{j,0}\,(1 + \Delta F_j/F_{j,0})$. When fuel use falls by the same proportion for all fuels, the tax paid is the mechanical cost scaled by the change in fuel use. The burden then exceeds the tax paid when the output contraction is positive, that is, when the revenue lost is larger than the savings on fuel and other inputs.

The framework in Sections 3.1 and 3.2 predicts the size of each term. When demand is elastic and firms cannot easily replace fossil fuels, the output contraction is large and the burden exceeds the tax paid. When rents are small, owners respond by investing less rather than accepting a lower return, and the loss of workers accounts for most of the burden.

4 Data and Empirical Setting

4.1 Data

The primary data source is the Canadian Employer-Employee Dynamics Database (CEEDD), which covers the universe of firms and workers in Canada. I use it for the

[16] I do not observe output prices. If taxed firms raised their prices, consumers would bear part of the tax, and output would fall by more than revenue. The split between workers and owners in equation (3) does not depend on whether output prices changed, because payroll and profits are observed directly.

manufacturing sector at three levels of observation, the firm, the worker, and the owner, over 2002–2014. At the firm-year level, the CEEDD includes balance-sheet information from the National Accounts Longitudinal Microdata File (NALMF). From these balance sheets I use revenue, total payroll, employment, tangible assets, intermediate inputs, profits after taxes, whether the firm pays dividends, and the province in which the firm files taxes, which generally coincides with its headquarters. For multi-province firms, these balance-sheet variables cover the whole firm, including plants outside BC. I do not observe output prices or physical output, so revenue combines changes in prices and quantities. Employment is the average number of employees reported in T4 records. Capital is approximated by the book value of tangible assets net of depreciation.[17]

The CEEDD also links firms to individual tax records. At the worker-year level, T1 personal tax forms are merged at the job level with T4 employee tax records. From these records I observe each worker's annual earnings at the main job.[18] At the owner-year level, I use Schedule 50 of the T2 corporate tax return (T2S50). It reports the identity of every owner holding at least 10% of the common or preferred shares of a private firm, and the share each owner holds. I combine these ownership shares with each firm's dividends to compute the dividend income each owner receives from each firm. Owners' labor earnings and total income come from their personal tax records.

Fossil fuel expenditure is not observed in firms' balance-sheet data, which is a challenge for distinguishing high- from low-emission-intensive industries using the CEEDD alone. I therefore merge the balance-sheet data with the Annual Survey of Manufactures and Logging (ASML). The ASML is an annual plant-level survey that Statistics Canada has conducted since 1998 (Statistics Canada, 2025a). Until 2012, it was close to a census and included financial data for a large share of manufacturing plants in Canada. It also reports annual expenditure by fuel type (natural gas, light and heavy fuel oil, coal, propane, electricity, gasoline, and diesel) at the plant level. Firm-level financial information had not previously been linked with fossil fuel expenditure for the manufacturing sector in Canada. This link is key because it lets me observe payroll and profits after taxes for the same firms and their exposure to the carbon tax.

I use external prices for each fuel at the province-year level from 2005 to 2012 (Canada Energy Regulator, 2023b) to recover fuel quantities from the ASML. For coal and propane, only national annual prices are available, which I take from Teck Resources' financial reports

[17] I compute depreciated tangible assets in each year based on the accumulated depreciation reported in firms' balance sheets and their total tangible assets.

[18] Hourly wages are not available. The available measure is each worker's annual labor earnings at a given firm.

and the Canadian Gas Association, respectively (Canadian Gas Association, 2023; Teck Resources Limited, 2023). To recover quantities, I divide fuel expenditure by the price of each fuel per gigajoule (GJ). I also compute CO_2 emissions by multiplying the quantity in GJ of each fuel by its conversion factor from the U.S. Energy Information Administration (2023). This makes it possible to construct fossil fuel expenditures, quantities, and emissions at both the firm and the plant level.

4.2 Treatment Definition

I measure exposure to the tax at the industry level rather than the firm level, following Curtis (2018). A firm's own fuel intensity reflects its choices and characteristics, which may also affect its outcomes and respond to the tax. An industry measure computed before the reform does not depend on any single firm's response. It also allows me to assign treatment to firms without fossil fuel data in the ASML. Firms within an industry still differ in fuel intensity, so the estimates measure the average effect on firms in highly exposed industries.

To construct this industry measure, I use plant-level information from the ASML for plants in BC. First, I add up each plant's expenditure on gasoline, diesel, heavy fuel oil, light fuel oil, propane, coal, and natural gas, and divide this total by the plant's revenue. Then, I average this share across plants within each 4-digit NAICS industry over the pre-reform years 2006 and 2007. This share measures how much an industry spends on fossil fuels to generate one dollar of revenue, so industries with the largest shares should be the most affected by the carbon tax.

To check this prediction, I split industries into quartiles of the share, from the lowest (Q1) to the highest (Q4). I then compute raw means of fossil fuel expenditure and quantities by quartile, relative to 2007 (Figure 3). I repeat this exercise for the other provinces, which did not implement the tax, using the same quartile definitions as in BC. In the other provinces, fossil fuel expenditure falls by a similar magnitude in all quartiles after 2008, consistent with the fall in natural gas prices (Panel A), and quantities drop and then recover (Panel B). In BC, by contrast, the top quartile shows a differential drop relative to the other quartiles in both expenditure and quantities (Panels A and B).

I therefore define treated, or fossil-fuel-intensive, industries as those in the top quartile (Q4) of this fossil fuel expenditure share. Control, or less fuel-intensive, industries are those in Q1 to Q3. Table 1 lists the resulting 21 treated 4-digit NAICS industries, ordered from highest to lowest fuel intensity. The expenditure-to-revenue ratio ranges from approximately 10% for the top industry to approximately 1% for the marginal industry at the bottom of the

top quartile. The list of treated industries is similar when I compute the share using plants in all of Canada.[19] It is also similar to the top quartile of fuel intensity in US manufacturing, measured as the cost of purchased fuels over the value of shipments in 2007 (U.S. Census Bureau, 2008). Most differences arise among industries near the bottom of the US top quartile (Table B1).

4.3 Descriptive Statistics

Table 2 reports pre-reform (2007) means and standard deviations by treatment status and province. Panel A uses the balance sheets in the CEEDD. In 2007, the sample includes 880 treated and 4,775 control firms in BC, and 4,400 treated and 31,060 control firms in other provinces. Treated firms are larger than control firms in employment and revenue, both within BC and within other provinces. This is expected, because the most fuel-intensive industries, such as metals, chemicals, and pulp and paper, tend to have large, capital-intensive firms. Firms in BC are smaller on average than their counterparts elsewhere in Canada, regardless of treatment status. For treated BC firms, total payroll is about 26.5% of revenue and profits after taxes are about 1.5% of revenue. These shares are similar for treated firms in other provinces (24.7% and 1.3%) and for control firms in BC (30.1% and 1.9%). Profit margins are therefore thin for the manufacturing firms in the sample. Only about a quarter of firms paid dividends in 2007.

Panel B uses the ASML-linked subsample. As expected from the treatment definition, treated firms spend far more on fossil fuels than control firms, in absolute terms and per dollar of revenue. For treated firms, fossil fuel expenditure is about 1.8% of revenue in BC, compared with 0.4% for control firms. Fossil fuel quantity per dollar of revenue is three times higher for treated firms in both BC and other provinces (0.003 versus 0.001), so the classification captures differences in fuel intensity and not only in scale. Natural gas is the largest component of fossil fuel expenditure, at more than 70 percent for manufacturing firms in all groups, including 74.6% for treated firms in BC. The denominator of this share excludes electricity, since almost all of BC's electricity comes from hydroelectric generation, which the carbon tax does not affect.[20] Gasoline and diesel together account for less than 5% of fossil fuel expenditure for treated firms in BC and in other provinces.

Following Curtis et al. (2026), I classify firms by whether they operate plants in a single

[19] The main exception is primary aluminum production (NAICS 3313). Aluminum smelting is energy intensive, but smelters in BC run almost entirely on hydroelectricity, so their fossil fuel expenditure is a small share of revenue. In the United States, aluminum ranks seventh in fuel intensity (Appendix B).

[20] In 2007, 92.2% of BC's electricity generation came from hydroelectric sources (Canada Energy Regulator, 2023a).

province or in multiple provinces. I use the CEEDD multi-province indicator as the base measure for this classification and supplement it with plant locations from the ASML. Firms with ASML plants in more than one province that are not flagged as multi-province in the CEEDD are reclassified as multi-province.[21] Single-province firms have all their operations in one province. Treatment for multi-province firms is assigned by the province of tax filing, typically the headquarters province.[22] Treated firms are more likely to operate in several provinces than control firms, both in BC (11.3% versus 6.5%) and in other provinces (16.0% versus 9.1%). The ASML information covers 2004–2012, and I aggregate the plant-level data within each firm. The merged data cover approximately 60% of the firms in the CEEDD sample. This coverage is balanced across the four groups (60–65%), so the ASML-linked subsample is not differentially selected by treatment status or province.

I use revenue, intermediate inputs, total payroll, and profits after taxes, each divided by the firm's own 2007 revenue, and value added, revenue minus intermediate inputs. Total payroll captures both the number of workers and their earnings, so this variable measures the full labor cost borne by the firm. In the case of profits after taxes, a log transformation would drop around 25 percent of firms in the pre-reform period given the negative values. Therefore, this variable is also divided by 2007 revenue. Tangible assets, also measured in dollars, are normalized in the same way. I use the log of employment, a physical quantity, and an indicator for whether the firm pays positive dividends. All CEEDD variables are winsorized at the 5th and 95th percentiles of their distribution, by year and by single- versus multi-province group. This follows Statistics Canada's requirements for disclosing results and limits the influence of outliers. Value added and total payroll minus profits after taxes are computed from the winsorized components, so that the terms of equation (1) add up in the estimation sample.

4.4 The Framework for Fossil-Fuel-Intensive Firms in BC

Several features of fossil-fuel-intensive firms in BC place them in the case of Panel (b) of Figure 1. First, the carbon tax applied only to purchases of fossil fuels in BC. Second, BC producers were exposed to trade. Before the tax, imports supplied about a third of the domestic use of the products of fossil-fuel-intensive industries in Canada.[23] Several

[21] I also require that at least one ASML-reported plant operate in the firm's headquarters (tax-filing) location.

[22] An alternative would assign treatment by the share of a firm's plants or employment in BC. This is not feasible, because the ASML does not cover all the plants of many multi-province firms, and restricting the sample to fully covered firms would further reduce the small multi-province sample.

[23] Import penetration is the share of domestic use of each industry's products met by imports. Domestic use is output plus imports, minus exports. I compute it from the Canadian National Symmetric Input–

sectors, such as textiles and resin and synthetic products, imported more than half of their domestic use (Table C1). This feature makes output price pass-through implausible. Import penetration rose by about 8% on average after 2008 relative to 2007, although it was already rising before (Figure C1). In BC, imports from abroad supplied about a third of the use of these products in 2007, and this share rose after 2008 (Appendix C).

BC producers also faced competition from firms in other provinces that did not implement a carbon tax during the study period. Interprovincial trade flows are available only for broad product groups. In these data, other provinces supplied about a third of BC's use of the products of fossil-fuel-intensive industries in 2007, and this share did not rise after the tax (Appendix C). Leakage to other provinces can violate the stable unit treatment value assumption (SUTVA), which I discuss and test in Section 8. On the supply side, fossil-fuel-intensive industries are more capital-intensive than other manufacturing industries (Table 2). Installed capital is difficult to adjust in the short run, which makes supply less elastic. Trade exposure and installed capital that adjusts slowly make it likely that demand was more elastic than supply for fossil-fuel-intensive industries.

On the tax side, fuel suppliers passed the full carbon tax on to the price firms pay. This is consistent with natural gas, the largest component of fossil fuel expenditure for fossil-fuel-intensive firms. As mentioned in Section 2, regulated utilities add the tax directly to customers' bills, and the tax represents an important increase in the price of natural gas. As mentioned in Section 3.1, the literature points to low substitution between fossil fuels and other inputs, so an output contraction is expected for fossil-fuel-intensive firms. What remains is how the total burden is split between workers and owners in fossil-fuel-intensive firms. Theory predicts that the burden may be shared between workers and owners. However, these firms had low rents before the reform. Their profits after taxes were only about 1.5% of revenue (Table 2), so owners are likely to respond to the tax by investing less rather than accepting a lower return. The literature and the setting of fossil-fuel-intensive firms in BC therefore suggest that workers bear a larger share of the burden than owners.

Output Tables at the L61 level for 2002–2013 (Statistics Canada, 2007).

5 Empirical Strategy

The main estimating equation is a triple-difference event study at the firm level:

$$\begin{aligned} Y_{jt} \;=\; & \sum_{\tau=2002}^{2014} \beta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_j \cdot BC_j \\ & + \sum_{\tau=2002}^{2014} \theta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_j \;+\; \sum_{\tau=2002}^{2014} \gamma_\tau \, \mathbb{1}(t=\tau) \cdot BC_j \;+\; \alpha_j \;+\; \delta_t \;+\; u_{jt} \end{aligned} \tag{6}$$

where Y_{jt} is the outcome for firm j in year t. $Treated_j$ indicates a firm in a top-quartile fossil-fuel-intensity industry. BC_j indicates a firm that files its taxes in BC, which is usually where its headquarters are located. α_j is a firm fixed effect and δ_t is a year fixed effect. The coefficient of interest, β_τ, measures how the gap between fossil-fuel-intensive and less fuel-intensive firms in BC changes relative to the reference year 2007 ($\beta_{2007} = 0$), net of the change in the same gap in other provinces. Standard errors are clustered at the firm level.

This design controls for four possible confounders. First, the year fixed effect δ_t absorbs common shocks to all firms each year. Second, the $\gamma_\tau \cdot BC_j$ terms absorb province-level shocks that impact all industries in BC, such as changes in provincial tax rates. Third, the $\theta_\tau \cdot Treated_j$ terms absorb industry-level shocks that have an effect on treated sectors nationwide, such as global commodity price movements. Fourth, the firm fixed effect α_j absorbs permanent differences across firms in size, productivity, and location. The identifying variation comes from the introduction of the tax in BC in 2008. It raised the marginal cost of production more for fossil-fuel-intensive firms than for other firms in the province. The identifying assumption is that, in the absence of the carbon tax, the gap between fossil-fuel-intensive and less fuel-intensive firms would have evolved in the same way in BC and in other provinces.

Throughout the paper, the reported effect for each outcome is the average of the post-2008 event-study coefficients from equation (6),

$$\bar{\beta} \;=\; \frac{1}{2014 - 2008 + 1} \sum_{\tau=2008}^{2014} \beta_\tau, \tag{7}$$

computed as a linear combination of the post-2008 coefficients, with standard errors that account for the full covariance structure of the underlying β_τ estimates.[24]

[24] I compute this linear combination with the Stata command lincom. I average the year-specific coefficients instead of estimating a single post-reform coefficient. The effect of the tax changes over time as the rate rises from $10 to $30 per tonne, and a single coefficient would then weight the years in ways I do not

The main outcomes at the firm level are revenue, intermediate inputs, value added, total payroll (worker incidence), and profits after taxes (owner incidence), the terms of the identity in equation (1). I divide each outcome in year t by the firm's own 2007 revenue, $Y_{jt}/Rev_{j,2007}$. This normalization keeps firm-years with negative profits, gives a stable base, and expresses each coefficient as a change relative to pre-reform revenue. Also, the coefficients add up across the terms of equation (3). I also estimate equation (6) for total payroll minus profits after taxes, which tests directly whether workers lose more than owners. The coefficient on each outcome estimates the corresponding term of equation (3), so the shares in equation (4) are ratios of the estimated coefficients, for example $s_W = \hat{\beta}_{\text{Payroll}}/\hat{\beta}_{VA}$. Supporting outcomes are log employment, tangible assets divided by 2007 revenue, log fossil fuel quantity and expenditure, and log CO_2 emissions. Worker-level outcomes are estimated using an analogous equation with individual fixed effects and standard errors clustered at the firm and worker level. Owner-level outcomes are estimated in the same way with owner fixed effects and standard errors clustered at the firm and owner level.

6 Main Results

This section first examines the size of the burden of the carbon tax (Section 6.1). It then estimates how this burden is split between workers and owners (Section 6.2).[25]

6.1 The Size of the Burden

This subsection examines the size of the burden and where it comes from. The burden is the fall in value added in equation (3), the change in revenue minus the change in intermediate inputs. The fall in revenue pushes the burden up, while lower spending on fossil fuels and other inputs reduces it.

6.1.1 Revenue

The carbon tax reduces the revenue of fossil-fuel-intensive BC firms by an average of 5.7% of their 2007 revenue after 2008, significant at the 1% level (Panel (a) of Figure 4). Pre-reform coefficients are close to zero, supporting the parallel trends assumption. Revenue falls by 2.4% in 2008, the first year of the tax, and remains about 5 to 8% lower from 2009

choose, some of them possibly negative (de Chaisemartin & D'Haultfœuille, 2020). Averaging gives each post-reform year the same weight of 1/7.

[25] Appendix D reports the event studies separately for BC and the other provinces.

onward. This pattern is consistent with the output effect dominating input substitution, as predicted in Section 3.2. Survival and entry rates are on average unaffected, so the results are not driven by firm exit (Appendix E). If prices do not change, as assumed for firms that compete with untaxed producers, the fall in revenue maps into a fall in output of the same magnitude.[26] If firms instead passed part of the tax on to higher prices, output would fall by more than revenue, so the revenue decline is a lower bound for the output contraction. The burden therefore includes the value added lost through this output contraction, as shown in Panel (b) of Figure 1.

This revenue decline differs from Ahmadi et al. (2022) but is in line with Karlsson (2026). For the BC carbon tax, Ahmadi et al. (2022) find that plant output rose, partly because of the corporate income tax cut (discussed in Section 8). Like this paper, they compare more and less exposed producers in BC and in other provinces. However, they measure exposure with a continuous emission intensity across all plants rather than a group of fossil-fuel-intensive firms.[27] This matters because the response is concentrated among the most fuel-intensive firms (Figure 3). A linear effect across the whole distribution of emission intensity averages this large decline with small, or even positive, responses among less exposed plants (Callaway et al., 2024). It can turn the average effect on output positive. Comparing the top quartile with the rest isolates the firms where the response occurs.

Karlsson (2026) finds a 5.7% decline in revenue for Swedish manufacturing firms after a reform that removed their carbon tax refunds and raised their effective carbon tax by about 66 euros per tonne of CO_2. This study also estimates an average effect across a broad set of producers. The larger tax increase in Sweden, compared with $30 CAD in BC, may explain why it still finds a similar decline. This contraction also parallels Känzig (2026), who finds that the effects of carbon pricing on output and employment are much larger than the direct effect of higher energy prices. In his setting the larger effect comes from lower aggregate demand, while here it comes from the loss of output to untaxed producers.

Colmer et al. (2025) find no detectable effect on output or employment for French manufacturing firms regulated by the EU Emissions Trading System. Instead, regulated firms invested in cleaner production processes, and the authors find no evidence of carbon leakage. During their study period, permits were allocated for free, permit prices were low, and

[26] As mentioned in Section 4.1, I do not observe output prices, so this mapping relies on the assumption that prices do not change.

[27] In Ahmadi et al. (2022), the average pre-policy emission intensity across Canadian manufacturing subsectors is 0.087 tonnes of CO_2 per $1,000 of output, against 0.092 to 0.529 for the five most emission-intensive 3-digit subsectors. Fourteen of the twenty-one treated industries in this paper (Table 1) belong to the six 3-digit subsectors they list as the most emission-intensive in Canada or BC, and none belong to the subsectors they list as the least emission-intensive.

competitors in other EU countries faced the same carbon price. BC firms, in contrast, paid the tax on all their fuel purchases and competed with untaxed producers abroad. In BC, the tangible assets of fossil-fuel-intensive firms fall, consistent with less investment rather than new clean capital.

6.1.2 Intermediate Inputs

Firms also spend less on intermediate inputs. Spending on intermediate inputs falls by an average of 4.3% of 2007 revenue after 2008, significant at the 1% level (Panel (b) of Figure 4). Before the reform, intermediate inputs were 59% of revenue, so this decline equals about 7% of pre-reform spending on inputs.[28] The decline starts in 2008, with a fall of 2.1%, and deepens to about 6% in 2013 and 2014. Intermediate inputs include materials, electricity, services, and fossil fuels at the price firms pay, including the tax.

Treated BC firms respond to the tax by purchasing less fuel. Their fossil fuel quantities fall by 19.2% on average after the reform, a decline significant at the 1% level (Panel (a) of Appendix Figure F1).[29] Before 2008, the coefficients show no differential trend. The response starts in the first year of the tax, with an 11% drop in 2008, and deepens to between 20 and 23% over 2009–2012, the last year with fuel price data. In equation (5), this decline enters as the fuel term ΔF. When firms buy less fuel, they reduce the tax paid and that part of the burden that their workers and owners must absorb. However, fossil fuels were about 3% of intermediate inputs before the reform (Table 2), which means that lower fuel spending accounts for only a small part of the decline in intermediate inputs.[30] The largest share of the decline must come from other inputs, such as materials and services, which fall together with output.

The appendix reports three related outcomes. Fossil fuel expenditure and CO_2 emissions fall by 18.4% and 20.5% (Panels (b) and (c) of Appendix Figure F1). Because expenditure and quantities fall by similar magnitudes, the decline in fuel use is not a consequence of fuel price movements.[31] Electricity use falls by 16.5% (Panel (d) of Appendix Figure F1), so firms did not replace fossil fuels with electricity, and the decline reflects lower production.

Value added, revenue minus intermediate inputs, falls by an average of 1.4% of 2007

[28] I express the effects as a percentage of the pre-reform level by dividing each coefficient by the pre-reform mean of the outcome divided by 2007 revenue. Table 3 reports these means together with the average post-2008 effects.

[29] These estimates use the ASML-linked subsample, the firms for which fossil fuel expenditure is available. Fuel quantities are recovered from this expenditure using external fuel prices (Section 4.1).

[30] Using only ASML data, fossil fuels were 4.5% of production materials and 5.6% of raw materials for treated BC firms in 2007.

[31] Fuel expenditure shows a small positive and significant coefficient in 2006 that quantities do not share.

revenue, about 3.4% of its pre-reform level (Panel (c) of Figure 4). This fall is the total burden of the tax in equation (3). The estimate is not statistically significant. Its 95% confidence interval ranges from a fall of 3.4% to a rise of 0.6% of 2007 revenue.

6.2 Factor Incidence

Total payroll of fossil-fuel-intensive BC firms falls by an average of 1.44% of 2007 revenue after 2008, significant at the 5% level (Panel (a) of Figure 5). Before the reform, total payroll was 26.5% of revenue, so this decline equals about 5.4% of pre-reform payroll. The coefficients before the reform are close to zero. Payroll does not change in 2008, falls by 1.1 to 1.7% of 2007 revenue in 2009 and 2010, and remains 1.4 to 2.2% lower from 2011 onward. Employment falls by 4.2% (Panel (a) of Appendix Figure G1).

Profits after taxes, divided by each firm's 2007 revenue, change by an average of 0.01% of 2007 revenue after 2008, an effect that is not statistically significant (Panel (b) of Figure 5). The coefficients before the reform are close to zero, and after the reform they stay between −0.4 and 0.3 percentage points, with none significant. At the same time, tangible assets of fossil-fuel-intensive BC firms fall by an average of 1.25% of 2007 revenue, significant at the 5% level, about 5.4% of their pre-reform level (Panel (b) of Appendix Figure G1). This is consistent with owners investing less when profits after taxes are close to the return they require (Section 3.2).

Workers therefore lose significantly more than owners. Total payroll minus profits after taxes falls by 1.45% of 2007 revenue, significant at the 5% level (Panel (c) of Figure 5).[32] The fall in payroll is about as large as the point estimate of the fall in value added in Section 6.1, while profits barely change. The point estimates therefore imply a worker share in equation (4) close to one and an owner share close to zero. Value added is less precisely estimated than payroll, so these shares are imprecise. The difference between payroll and profits after taxes, however, is statistically significant. Before the reform, profits after taxes were only about 1.5% of revenue, consistent with the low rents discussed in Section 3.2.

This result differs from calibrated GE models of carbon pricing. In Rausch et al. (2011), the after-tax return to capital falls slightly more than wages in percentage terms, so each dollar of capital income loses more than each dollar of labor income. Their carbon price covers the whole US economy, so capital cannot avoid the tax by moving. The BC tax, in contrast, covers a single province, where firms compete with untaxed producers and earn low

[32] Payroll is a much larger share of revenue than profits, so workers would lose more in dollars even if both lost the same share of their income. The relevant result is that profits do not fall significantly. It means that owners do not absorb the cost through lower profits.

rents. As a result, the burden falls mainly on workers (Section 3.2). Usually, model-based estimates assume a tax that covers the whole economy, so it is necessary to have direct estimates to know who bears the burden of carbon taxes as they are actually implemented.

7 Heterogeneity across Firms

This section analyzes in which types of fossil-fuel-intensive firms the burden of the carbon tax falls on workers. The average effects in Section 6 combine firms that differ in how easily they can adjust to the tax. As discussed in Section 3, firms compete with untaxed producers and cannot pass the tax on to prices. They also earn low rents, so owners respond by investing less instead of accepting a lower return. In addition, firms that cannot adjust in other ways are likely to pass the burden to workers. I study four dimensions that capture how easily a firm can adjust. The first is whether a firm operates plants in one province or in several, which determines whether it can move production to untaxed provinces. Within single-province firms, smaller firms face tighter credit constraints (Chodorow-Reich et al., 2022), capital-intensive firms have more fixed capital that is hard to change (Atkeson & Kehoe, 1999; Pindyck & Rotemberg, 1983), and less fuel-efficient firms may be locked into their technology (Hawkins-Pierot & Wagner, 2025).

Where the burden falls also matters for the aggregate incidence of the tax. Firms differ greatly in size. Among treated BC firms, multi-province firms are 11% of firms (Table 2) but account for 78% of revenue and 72% of total payroll in 2007. Therefore, the effect on the average firm does not necessarily represent the incidence on all fossil-fuel-intensive manufacturing firms in BC.

7.1 Single- versus Multi-Province Firms

Multi-province firms are the largest firms in the sample, and they face a margin of adjustment that single-province firms do not. They own plants in provinces that did not price carbon during the study period, so they can shift production from BC to these plants without cutting output. Curtis et al. (2026) document this channel for multi-plant firms facing environmental regulation in the United States. This is a within-firm form of the carbon leakage described in Section 3.1, operating across provincial rather than international borders. I estimate the differences between multi-province and single-province firms by interacting equation (6) with a multi-province indicator.

The output decline is similar in the two groups. The revenue of single-province firms

falls by 5.6% of 2007 revenue, significant at the 1% level, and the point estimate for multi-province firms, a decline of 5.9%, is as large but imprecisely estimated (Table 4). Spending on intermediate inputs falls by 4.1% of 2007 revenue in single-province firms, significant at the 1% level, and by 5.1% in multi-province firms, which is not significant. Value added, the total burden, falls by 1.5% of 2007 revenue in single-province firms and by 0.9% in multi-province firms, and neither decline is statistically significant. Both groups cut their fossil fuel use, by 16.3% in single-province firms and 28.8% in multi-province firms, although the difference is not statistically significant.

The burden on workers is larger in single-province firms, although the difference with multi-province firms is not statistically significant.[33] Their total payroll falls by 1.7% of 2007 revenue, about 6.1% of pre-reform payroll, significant at the 5% level (Table 4). Employment falls by 5.2%, significant at the 5% level (Appendix Table G1). Their profits after taxes, in contrast, do not change significantly. Total payroll minus profits after taxes falls by 1.8% of 2007 revenue, significant at the 5% level. The fall in payroll is about as large as the point estimate of the fall in value added, so the point estimates imply a worker share in equation (4) close to one and an owner share close to zero. Before the reform, these profits were only 1.5% of revenue. Their tangible assets fall by 1.7% of 2007 revenue, about 7.3% of their pre-reform level, significant at the 5% level (Appendix Table G1), consistent with lower investment.

In multi-province firms, neither payroll nor profits change significantly, so the burden on their workers and owners is not measurable. The point estimates suggest that lower spending on intermediate inputs offsets most of the fall in revenue, so value added changes little, although these estimates are imprecise. Plant-level data also suggest that these firms move part of their production out of BC (Appendix I), so lower payroll at their BC plants may be offset by higher payroll at their plants in other provinces. Owners of these firms adjust their payouts instead. Their probability of paying dividends falls by 20 percentage points (Appendix Table J1). Lower payouts do not by themselves reduce owners' income, because retained earnings stay in the firm. Rather, they suggest that these firms finance their adjustment, such as new investment, from retained earnings.

Plant-level data provide suggestive evidence that multi-province firms move production out of BC. Among multi-province firms with plants in BC and in other provinces, the BC share of firm revenue falls by 4.7 percentage points and the BC share of fossil fuel expenditure by 4.9 percentage points, from about 55% in 2007, both significant at the 10% level

[33]The multi-province sample is small. Among the 880 fossil-fuel-intensive BC firms in 2007, only about 100 operate in several provinces (Table 2), so their estimates are imprecise.

(Appendix I). Multi-province firms are also larger and may face fewer financial constraints, so their size and their ability to move production cannot be fully separated.[34]

To summarize, the burden on workers is statistically significant in single-province firms, while in multi-province firms neither payroll nor profits change significantly. The differences between the two groups are not statistically significant. The plant-level evidence suggests that multi-province firms can move production out of BC, a margin of adjustment that single-province firms lack.

7.2 Heterogeneity within Single-Province Firms

This section excludes multi-province firms, which are structurally different, as shown in Section 7.1. With thin profit margins and the competition of untaxed producers, single-province firms that face further constraints may bear a larger burden, which falls on their workers. The following subsections estimate heterogeneous effects among fossil-fuel-intensive single-province firms by size, capital intensity, and fuel efficiency.

7.2.1 Firm Size

The first constraint is access to credit. Small firms face tighter credit constraints than large firms (Chodorow-Reich et al., 2022), so they have less room to absorb the cost while they adjust. I split single-province firms by pre-reform revenue, below or above the median within their industry, to examine whether the burden differs by firm size.

Point estimates of the output contraction are larger in small firms, although the difference is not statistically significant. Their revenue falls by 8.6% of 2007 revenue, significant at the 1% level, while the revenue of large firms falls by 3.2% and the decline is not significant. Spending on intermediate inputs falls by 5.4% of 2007 revenue in small firms and by 3.1% in large firms, significant at the 1% and 10% levels. Value added falls by 3.2% of 2007 revenue in small firms, significant at the 10% level, and does not change in large firms. Fossil fuel use falls by 14.6% in small firms, a decline that is not significant, and by 16.8% in large firms, significant at the 1% level.

Workers in small firms bear a larger burden, and the difference in total payroll with large firms is significant at the 10% level. Their total payroll falls by 3.1% of 2007 revenue, about 9.9% of pre-reform payroll, significant at the 1% level (Table 5). Payroll thus falls by proportionally more than revenue, which falls by 8.6%, so the share of revenue paid to

[34] A direct comparison between multi-province firms and large single-province firms is not feasible, because multi-province firms are on average about 15 times larger.

workers declines. Employment falls by 8.7%, significant at the 5% level (Appendix Table G1). Their profits after taxes, in contrast, do not change significantly. Total payroll minus profits after taxes falls by 3.3% of 2007 revenue, significant at the 5% level. The fall in payroll is about as large as the fall in value added, so the worker share in equation (4) is close to one and the owner share is close to zero. Before the reform, these firms had almost no profit margin, 0.04% of revenue. Their tangible assets fall by 3.0% of 2007 revenue, about 11.4% of their pre-reform level, significant at the 1% level, and the difference with large firms is significant at the 10% level. This is consistent with owners investing less.

In large firms, total payroll falls by 0.5% of 2007 revenue and employment by 2.5%, and neither decline is significant. Their value added barely changes, falling by 0.1% of 2007 revenue. The fall in spending on intermediate inputs, 3.1% of 2007 revenue, is almost equal to the fall in revenue, 3.2%. Point estimates of the declines in revenue, payroll, and employment are smaller than in small firms. It is possibly because large firms can draw on credit during downturns, which softens the effect of the tax (Chodorow-Reich et al., 2022). Their profits after taxes do not change significantly either, even though their pre-reform profit margin was higher, at 2.8% of revenue. Because the worker-level sample is dominated by large firms, these results also explain why incumbent workers show no significant earnings loss (Appendix K). Likewise, owner-level estimates show no significant change in owners' total income or dividend income (Appendix L).

In short, small firms bear a larger burden than large firms, and this burden falls on their workers. The differences between the two groups in total payroll and in total payroll minus profits after taxes are significant at the 10% level. This result is consistent with small firms being more cash- and credit-constrained, which limits their ability to absorb the cost while they adjust.

7.2.2 Capital Intensity

A second constraint comes from installed capital. Firms that are capital intensive cannot easily change how they produce. This is because the energy use of fixed capital responds slowly to energy prices (Atkeson & Kehoe, 1999; Pindyck & Rotemberg, 1983). In order to analyze whether the burden depends on capital intensity, I divide single-province firms at the median of pre-reform tangible assets relative to revenue.[35]

The output contraction is larger in more capital-intensive firms, and the difference is

[35] Among treated BC firms, firm size is not correlated with capital intensity or fuel efficiency. Each of the four combinations of small or large and more or less capital-intensive firms accounts for about a quarter of these firms, and the same holds for fuel efficiency. Then, the splits capture different firms.

significant at the 10% level. Their revenue contracts by 9.4% of 2007 revenue, significant at the 1% level, compared with a 1.7% decline in less capital-intensive firms that is not significant. Spending on intermediate inputs falls by 5.2% of 2007 revenue in more capital-intensive firms, significant at the 1% level, and by 2.5% in less capital-intensive firms, which is not significant. Value added falls by 4.2% of 2007 revenue in more capital-intensive firms, significant at the 5% level. The difference with less capital-intensive firms is significant at the 5% level. Fossil fuel use falls by about 16% in both groups.

Workers in more capital-intensive firms bear a larger burden. In these firms, total payroll declines by 3.8% of 2007 revenue, about 12.9% of pre-reform payroll, significant at the 1% level (Table 6). The difference with less capital-intensive firms is significant at the 1% level. Payroll thus falls by proportionally more than revenue, which falls by 9.4%, so the share of revenue paid to workers declines. Capital-intensive firms also employ fewer workers. Employment drops by 9.4%, significant at the 1% level (Appendix Table G1). Owners, by contrast, see no significant change in profits after taxes. Total payroll minus profits after taxes falls by 3.9% of 2007 revenue, significant at the 1% level. Before the reform, these firms had no profit margin, −0.1% of revenue. Their tangible assets fall by 2.4% of 2007 revenue, about 6.1% of their pre-reform level, significant at the 5% level. This decline is consistent with the adjustment of capital described in Section 3.2. Firms may not replace capital as it depreciates, and owners with no profit margin may sell part of it rather than accept a lower return.

Less capital-intensive firms show only small changes. Their total payroll moves by 0.5% of 2007 revenue and employment by −0.7%, neither of them significant. Their value added rises by 0.8% of 2007 revenue, an effect that is not significant. The fall in spending on intermediate inputs, 2.5% of 2007 revenue, is slightly larger than the fall in revenue, 1.7%. Profits after taxes do not change significantly either, from a pre-reform margin of 3.1% of revenue.

Taken together, more capital-intensive firms bear a larger burden than less capital-intensive firms, and this burden falls on their workers. The differences between the two groups in revenue, value added, and total payroll are statistically significant. This pattern is consistent with energy use embodied in installed capital that adjusts slowly to the tax.

7.2.3 Fossil Fuel Efficiency

A third constraint comes from technology. Manufacturing plants keep the energy intensity of the technology they adopt at entry throughout their lives (Hawkins-Pierot & Wagner, 2025). As a result, firms that use more fuel per dollar of revenue may be locked into their

production methods and slow to reduce fuel use. To examine whether the burden depends on fuel efficiency, I divide single-province firms at the median of pre-reform fossil fuel quantity relative to revenue. Because this measure needs fuel quantities, the comparison is restricted to the ASML-linked subsample.

The output contraction is similar in the two groups. Revenue falls by 5.9% of 2007 revenue in less fuel-efficient firms and 6.4% in more fuel-efficient firms, significant at the 10% and 5% levels. The difference is not statistically significant. Spending on intermediate inputs falls by 3.8% and 6.1% of 2007 revenue, and value added by 2.1% and 0.3%, with no significant differences between the groups. Fossil fuel use falls by 22.7% in less fuel-efficient firms, significant at the 1% level. It falls by 8.1% in more fuel-efficient firms, which is not significant.

Total payroll falls by similar amounts in less and more fuel-efficient firms. In less fuel-efficient firms, it falls by 1.7% of 2007 revenue, about 6.0% of pre-reform payroll, significant at the 10% level (Table 7). Less fuel-efficient firms also employ fewer workers. Employment falls by 8.3%, significant at the 5% level (Appendix Table G1). Their profits after taxes do not change significantly, and total payroll minus profits after taxes falls by 1.8% of 2007 revenue, significant at the 10% level. Before the reform, these firms had a profit margin of only 0.4% of revenue. In more fuel-efficient firms, total payroll falls by 1.4% of 2007 revenue and employment by 2.9%, and neither decline is significant. Their profits after taxes do not change significantly either, from a pre-reform profit margin of 5.3% of revenue.

In sum, the effects of the carbon tax do not differ significantly between less and more fuel-efficient firms. None of the differences between the two groups in revenue, intermediate inputs, value added, total payroll, or profits after taxes is statistically significant. Less fuel-efficient firms cut their fuel use by more, but the burden on their workers is not larger than in more fuel-efficient firms.

8 Robustness

The main threat to the design is a spillover from treated BC firms to the control group, which would violate SUTVA. Because BC firms compete with untaxed producers, buyers who switch away from BC may buy from control firms in other provinces. Their output would then rise, and the estimated decline in BC would overstate the effect of the tax. Interprovincial trade data suggest that this spillover is limited. After the tax, the share of BC's use of these products bought from other provinces did not rise, while the share bought abroad did (Appendix Figure C2). Even so, I test the robustness of the results to

this spillover. Alberta and Quebec were two of BC's largest interprovincial trading partners in 2007 for the products of fossil-fuel-intensive industries (Statistics Canada, 2022), so they are the provinces most exposed to this spillover. The results are robust to excluding both provinces from the control group (Table 8). This exclusion also addresses a second concern, because Alberta and Quebec introduced their own, much smaller, carbon pricing policies in 2007 (Appendix M.1).

Spillovers can also run through input-output links. If the assumption of limited pass-through does not hold, control industries that buy inputs from fossil-fuel-intensive industries would face higher input prices. Control industries that sell to them would also lose demand as treated firms contract. Using the 2007 national symmetric input-output tables (Statistics Canada, 2007), I identify the control industries whose purchases from, or sales to, fossil-fuel-intensive industries exceed 10% of their total purchases or output. Most of these industries are linked through their purchases, because fossil-fuel-intensive industries are mainly upstream suppliers of inputs. The more likely channel is therefore prices. The results are robust to excluding all of these industries (Table 8 and Appendix Table M1). This stability is consistent with the assumption that competition from untaxed producers keeps fossil-fuel-intensive BC firms from passing the tax on to prices.

The triple difference compares the change in BC with the change in other provinces. The individual differences in differences (DD) show that part of the estimated decline comes from the growth of fossil-fuel-intensive industries in other provinces (Appendix Figure D1). However, the least fossil-fuel-intensive industry in the top quartile, Other food manufacturing (NAICS 3119), contributes to this growth. When I exclude this industry, the estimates become slightly larger (Table 8), and the decline within BC becomes clearer. For example, the DD in BC shows that the revenue of fossil-fuel-intensive firms falls by 3.9% of 2007 revenue, significant at the 5% level. This decline is larger than the 1.4% decline that is not significant when all industries are included (Appendix Table D1).

Another possible confounder is that BC cut its corporate income tax when it introduced the carbon tax, as discussed in Section 2. This cut may have affected some industries more than others. Specifically, firms deduct the cost of new capital only gradually through depreciation allowances. As a result, a lower corporate income tax reduces the cost of capital (Hall & Jorgenson, 1967). This is relevant for capital-intensive firms, as Ahmadi et al. (2022) argue. In my sample, treated firms are more capital-intensive than control firms. In 2007, tangible assets were 23.2% of revenue for treated BC firms and 17.7% for control BC firms, and the gap is similar in other provinces (Table 2). If the tax cut reduces the cost of capital for treated industries, the triple difference does not remove this effect. The estimated declines

in revenue and capital would then be smaller than the effect of the carbon tax alone. The estimates in this paper are therefore conservative.

Other concurrent policies and shocks happened around the introduction of the carbon tax. However, they are unlikely to bias the estimates, mainly because the triple difference removes changes that are common to all industries within a province or to the same industry across provinces. For example, in BC, the Harmonized Sales Tax (HST) replaced the provincial sales tax in 2010. Also, some regional motor fuel taxes rose during the same period. Nonetheless, these changes applied to all industries in the province. At the federal level, faster capital cost allowances for clean energy equipment applied to firms in every province. Similarly, province-wide and industry-wide shocks, such as the 2008–2009 recession, are absorbed in the triple difference design. Appendix M discusses them in detail.

9 Conclusion

In this paper, I provide new evidence on how the burden of a carbon tax is divided between workers and firm owners. Because a carbon tax is designed to change behavior, I measure the burden directly as the fall in value added rather than as the mechanical tax cost. At the average fossil-fuel-intensive firm in British Columbia, revenue falls by 5.7% of 2007 revenue. However, lower spending on fossil fuels and other inputs offsets most of this decline. The remaining burden falls mainly on workers. Total payroll falls by 1.4% of 2007 revenue, about 5.4% of pre-reform payroll. In contrast, profits after taxes do not change significantly. The difference between the two is statistically significant.

The results are consistent with the theoretical prediction for a subnational carbon tax. Firms that compete with untaxed producers can hardly pass the tax on to prices. In the short run, it is difficult to replace fossil fuels with other inputs. Therefore, production contracts and the burden grows with the fall in output. Also in the short run, neither workers nor firm owners can fully avoid this burden. Workers are not completely mobile and selling capital is costly. Owners, however, have few rents, with profits after taxes of only about 1.5% of revenue before the reform. They respond by investing less rather than accepting a lower return. It is consistent with the fall in tangible assets. As a result, workers bear a larger share of the burden than owners.

The burden on workers is larger in firms that cannot easily adjust. Among single-province firms, total payroll falls by about 10% to 13% of pre-reform payroll in small and more capital-intensive firms. The differences with large and less capital-intensive firms are statistically significant. In multi-province firms, neither payroll nor profits change significantly, and plant-

level data suggest that these firms shift part of their production out of BC. The differences with single-province firms, however, are not statistically significant. Less fuel-efficient firms do not show a larger burden on workers than more fuel-efficient firms either.

These results suggest that the decline in earnings for the sector as a whole is likely smaller than at the average firm. This is because a few large firms employ many of the workers in these industries. Thus, the burden falls on workers in firms with few ways to adjust.

The results presented in this paper are relevant for the instruments that governments use to protect the competitiveness of firms exposed to carbon pricing. Some policies, such as free permit allocation under cap-and-trade schemes and output-based pricing systems, usually target relief at the sector level. They use trade exposure or emissions intensity as indicators. Nonetheless, the results suggest that the burden varies within fossil-fuel-intensive industries. Among firms in the same industries, workers in small and capital-intensive firms bear more of the cost than workers in large or less capital-intensive firms. The policy recommendation points to including size-based criteria, which governments have implemented before, showing that they are feasible.[36] In this way, combining firm size with sector characteristics could direct support to the firms whose workers bear the burden.

[36]Canada's federal carbon rebate for small businesses returned fuel charge proceeds to firms with up to 499 employees (Department of Finance Canada, 2024).

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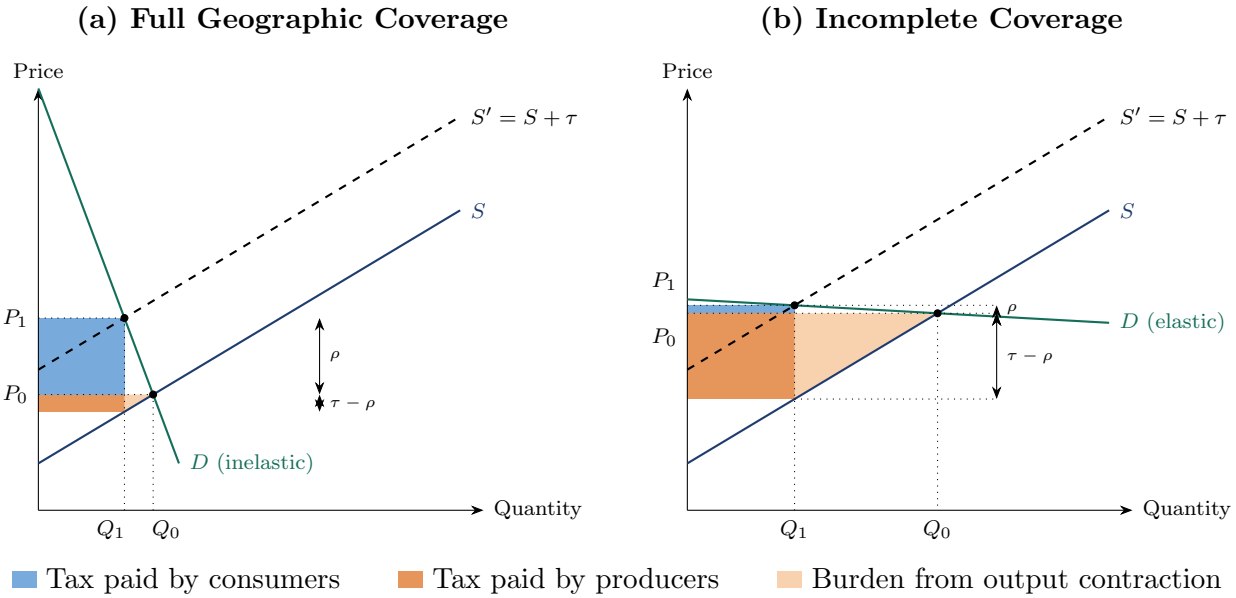
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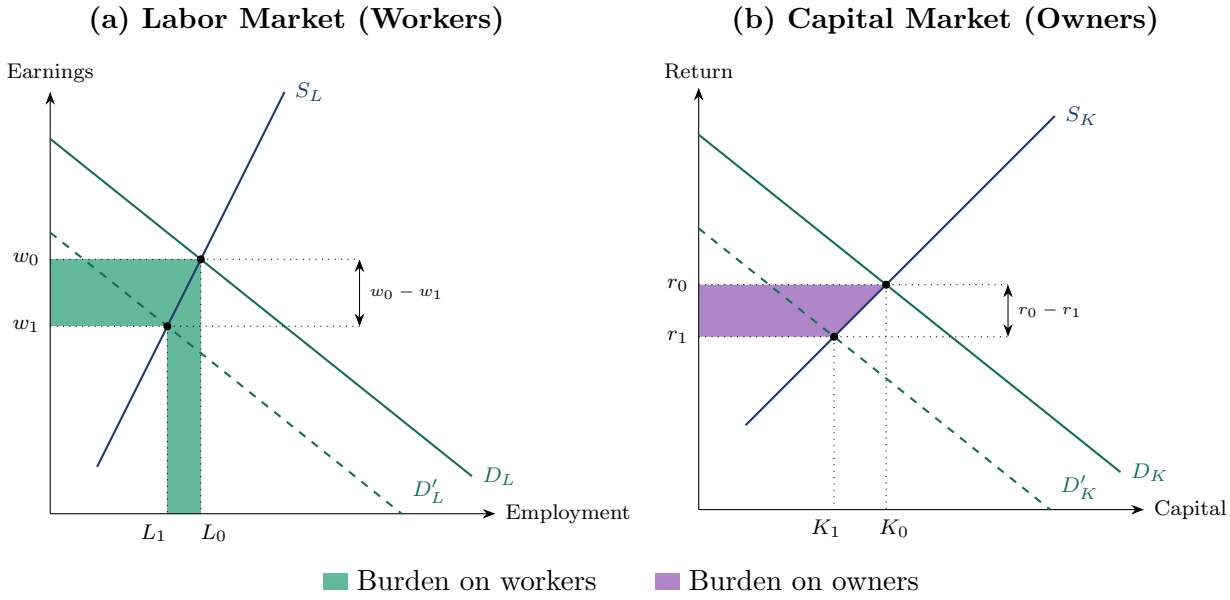
Figures

Figure 1: Incidence under Full vs. Incomplete Geographic Coverage



Note: Both panels apply the same carbon tax τ, set equal to the marginal external damage of carbon emissions, which shifts supply from S to S'. Here τ is the increase in marginal cost holding fuel use per unit of output fixed. The blue region shows the consumer burden (ρ, the price increase), and the orange region shows the producer burden ($\tau - \rho$). The light orange triangle shows the additional burden on producers from the output contraction, the value added lost on the units no longer produced ($Q_0 - Q_1$). In Panel (a), with full geographic coverage, demand is the relatively inelastic aggregate market demand curve, so ρ is large and the orange region is small. In Panel (b), with incomplete coverage, taxed producers face a nearly perfectly elastic residual demand curve set by untaxed producers, so ρ is small, $Q_0 - Q_1$ is large, and producers bear nearly the entire tax. The elastic residual demand under incomplete coverage follows Fowlie et al. (2016).

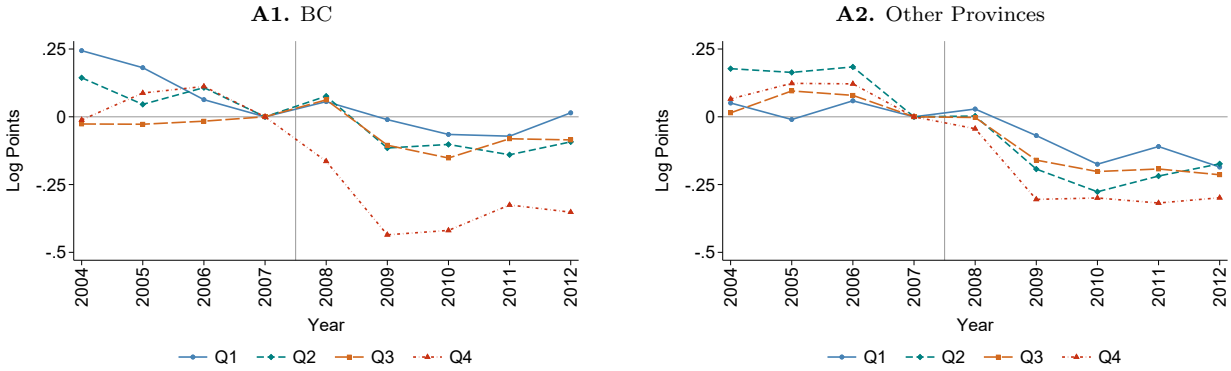
Figure 2: Incidence on Workers and Owners



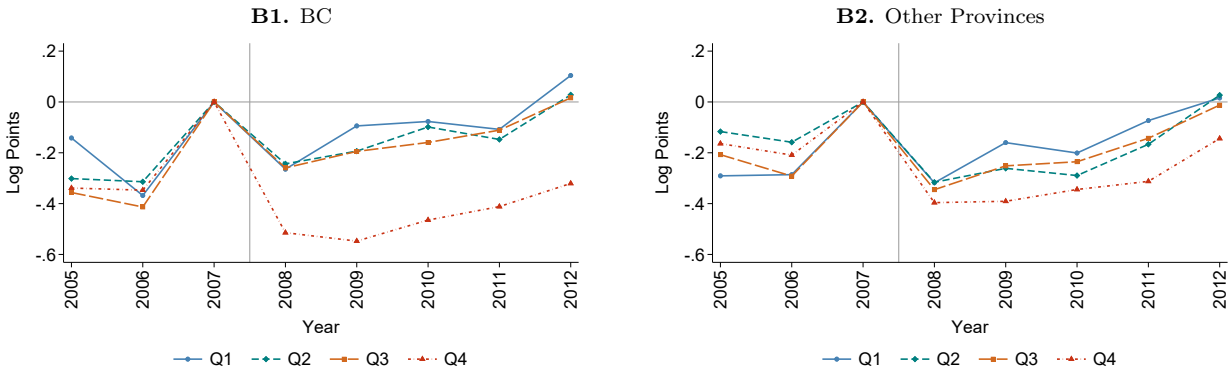
Note: Both panels apply the burden on producers from Figure 1. The tax lowers the price producers keep per unit of output. It shifts the derived demand for labor and capital from D to D'. This shift includes both the tax paid on the remaining output and the loss from production contraction. Given the limited substitution between inputs, neither demand curve shifts outward. The teal region shows the burden on workers (the fall in payroll). The purple region shows the burden on owners (the fall in the return to capital). In Panel (a), workers cannot move to other jobs without cost. As a result, short-run labor supply is inelastic and both earnings ($w_0 - w_1$) and employment ($L_0 - L_1$) fall. In Panel (b), installed capital adjusts only gradually (Auerbach, 2006). Short-run supply (S_K) slopes upward. It is drawn more elastic than labor supply because, with small rents, owners respond to a lower return by investing less. The return falls from r_0 to r_1 and capital from K_0 to K_1. This loss is borne by the owners of existing capital.

Figure 3: Raw Means by Quartile of Industry Fossil Fuel Expenditure Relative to Revenue

Panel A. Log Fuel Expenditure

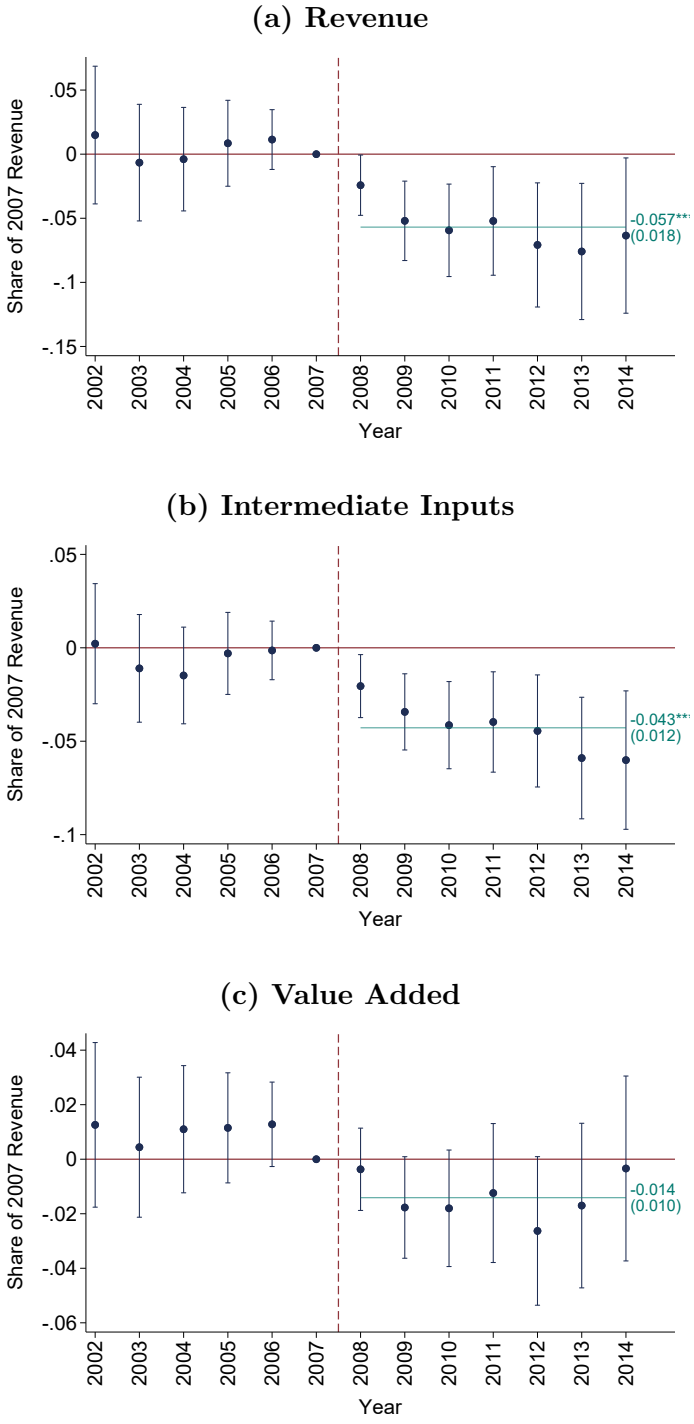


Panel B. Log Fuel Quantities



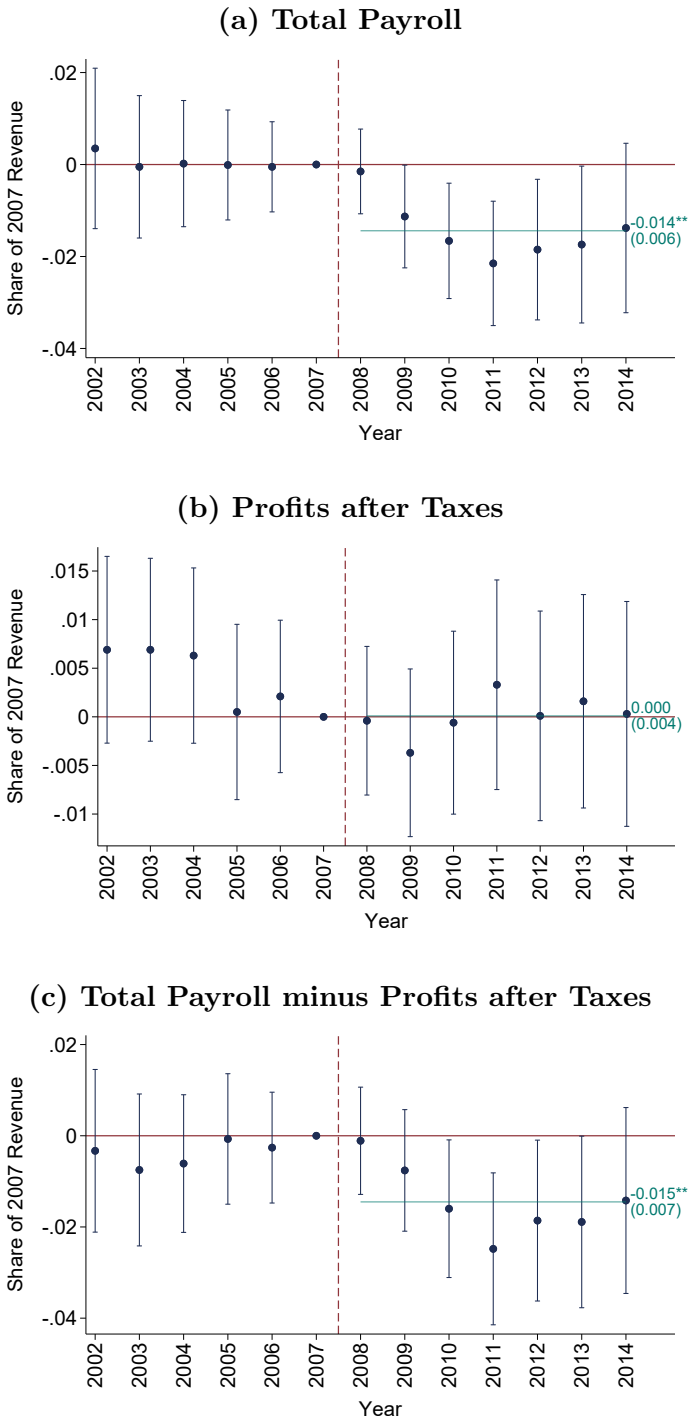
Note: Industries are ranked by their pre-reform (2006–2007) fossil fuel expenditure (gasoline, diesel, heavy and light fuel oil, propane, coal, and natural gas) divided by revenue, averaged across plants within each 4-digit NAICS industry, and split into quartiles, with Q4 the highest share. Q4 is the treated group. Each line shows the log deviation from the 2007 mean for one quartile. The vertical line marks the introduction of the carbon tax in 2008, and the horizontal line marks the 2007 reference level. Data from the ASML linked to the CEEDD, manufacturing firms (NAICS 31–33), BC and other Canadian provinces, 2004–2012. Fuel quantities are constructed from fossil fuel expenditure and province-year fuel prices from the Canada Energy Regulator (2023b), with national prices for coal and propane (Canadian Gas Association, 2023; Teck Resources Limited, 2023).

Figure 4: Revenue, Intermediate Inputs, and Value Added Event Study



Note: Coefficients are from equation (6), which includes firm fixed effects and clusters standard errors at the firm level. Point estimates and 95% confidence intervals are shown in blue. The green line and label show the average of the post-2008 coefficients. Each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs. All panels use the full sample for 2002–2014.

Figure 5: Total Payroll and Profits after Taxes Event Study



Note: Panels show the event-study estimates from equation (6) for total payroll, profits after taxes, and their difference, each divided by the firm's 2007 revenue. Each coefficient is the effect for fossil-fuel-intensive BC firms in that year, relative to 2007, the reference year ($\beta_{2007} = 0$). Vertical bars show 95% confidence intervals, with standard errors clustered at the firm level. The green line and label show the average of the post-2008 coefficients.

Tables

Table 1: Treated Industries in the Top Quartile of Fossil Fuel Expenditure Intensity

Rank	NAICS	Industry
1	3274	Lime and gypsum product manufacturing
2	3221	Pulp, paper and paperboard mills
3	3251	Basic chemical manufacturing
4	3311	Iron and steel mills and ferro-alloy manufacturing
5	3253	Pesticide, fertilizer and other agricultural chemical manufacturing
6	3271	Clay product and refractory manufacturing
7	3272	Glass and glass product manufacturing
8	3314	Non-ferrous metal (except aluminum) production and processing
9	3279	Other non-metallic mineral product manufacturing
10	3273	Cement and concrete product manufacturing
11	3133	Textile and fabric finishing and fabric coating
12	3241	Petroleum and coal product manufacturing
13	3212	Veneer, plywood and engineered wood product manufacturing
14	3112	Grain and oilseed milling
15	3114	Fruit and vegetable preserving and specialty food manufacturing
16	3315	Foundries
17	3328	Coating, engraving, cold and heat treating and allied activities
18	3211	Sawmills and wood preservation
19	3252	Resin, synthetic rubber, and artificial and synthetic fibres and filaments mfg.
20	3111	Animal food manufacturing
21	3119	Other food manufacturing

Note: Industries ranked by pre-reform (2006–2007) average fossil fuel expenditure as a share of revenue, computed at the 4-digit NAICS level from ASML. Among these treated industries, the share ranges from about 10% of revenue for the highest-ranked industry to about 1% for the lowest-ranked.

Table 2: Descriptive Statistics by Treatment Status and Province

	BC		Other Provinces	
	Control	Treated	Control	Treated
Panel A: Firm Characteristics (CEEDD)				
Employment	16.8	31.7	27.3	39.3
	(44.3)	(105.1)	(82.8)	(113.4)
Revenue ('000 CAD)	3,084.2	9,136.5	6,260.4	12,764.1
	(11,288.9)	(37,410.9)	(26,887.0)	(45,156.5)
Intermediate Inputs (% of Revenue)	54.9	58.6	55.4	60.7
	(18.9)	(19.8)	(19.0)	(19.3)
Value Added (% of Revenue)	45.1	41.4	44.6	39.3
	(18.9)	(19.8)	(19.0)	(19.3)
Total Payroll (% of Revenue)	30.1	26.5	28.9	24.7
	(15.3)	(15.4)	(14.8)	(14.8)
Profits After Taxes (% of Revenue)	1.9	1.5	1.6	1.3
	(10.5)	(10.7)	(9.9)	(10.2)
Tangible Assets (% of Revenue)	17.7	23.2	19.1	25.0
	(22.2)	(25.1)	(21.7)	(24.2)
Firms Paying Dividends (%)	25.9	26.0	31.2	29.9
	(43.8)	(43.9)	(46.3)	(45.8)
Multi-province Firms (%)	6.5	11.3	9.1	16.0
	(24.6)	(31.7)	(28.7)	(36.7)
In ASML Sample (%)	60.5	63.0	59.6	65.3
	(48.9)	(48.3)	(49.1)	(47.6)
Observations	4,775	880	31,060	4,400
Panel B: Fossil Fuel Use (ASML-linked subsample)				
Fossil Fuel Quantity ('000 GJ)	3.1	102.2	11.2	130.8
	(34.9)	(789.7)	(170.6)	(1,053.9)
Fossil Fuel Expenditure ('000 CAD)	20.0	725.9	78.0	1,012.3
	(201.3)	(5,749.6)	(1,143.5)	(8,389.9)
CO_2 Emissions (Tonnes)	157	5,630	583	7,433
	(1,752)	(42,780)	(8,908)	(59,537)
Fossil Fuel Expenditure (% of Revenue)	0.4	1.8	0.4	2.0
	(0.4)	(1.5)	(0.5)	(1.8)
Fossil Fuel Expenditure (% of Intermediate Inputs)	0.8	3.3	0.8	3.3
	(1.0)	(3.0)	(1.1)	(3.5)
Natural Gas (% of Fossil Fuel Expenditure)	75.0	74.6	74.2	70.6
	(21.2)	(26.3)	(24.6)	(32.3)
Fuel Efficiency (Qty./Rev.)	0.001	0.003	0.001	0.003
	(0.001)	(0.003)	(0.001)	(0.003)

Note: The pre-reform (2007) sample means, with standard deviations in parentheses. "Control" and "Treated" refer to industries below and in the top quartile of fossil fuel expenditure intensity (Section 4.2). Panel A observation counts are for the full CEEDD sample. Panel B uses the ASML-linked subsample. In Panel A, variables in percent of revenue are firm-level means of each variable divided by the firm's revenue, computed from components winsorized at the 5th and 95th percentiles by year and by single- versus multi-province group. Value added is revenue minus intermediate inputs. In Panel B, shares are firm-level means of ratios. Fossil fuel expenditure combines ASML fuel spending with CEEDD revenue and intermediate inputs. Dollar variables are in thousands of Canadian dollars. Fossil fuel quantities are in thousands of GJ. CO_2 emissions are in tonnes. Employment is average firm headcount. Fuel efficiency is fossil fuel quantity divided by revenue.

Table 3: Average Post-2008 Effects on Revenue, Inputs, and Factor Income

	(1) Revenue	(2) Interm. Inputs	(3) Value Added	(4) Total Payroll	(5) Profits After Tax	(6) Payroll − Profits
Treated BC firms	-0.0569***	-0.0428***	-0.0141	-0.0144**	0.0001	-0.0145**
	(0.0184)	(0.0116)	(0.0103)	(0.0060)	(0.0041)	(0.0068)
Observations	448,785	448,785	448,785	448,785	448,785	448,785
Adj. R^2	0.340	0.503	0.465	0.609	0.370	0.605
Mean	1.000	0.586	0.414	0.265	0.015	0.251

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. In Columns (1)–(6), each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs, and Column (6) is total payroll minus profits after taxes. Each component is winsorized before these differences are taken, and all six outcomes use the same sample, so Column (3) equals Column (1) minus Column (2). "Mean" reports the pre-reform (2007) mean of the outcome for treated BC firms, as a share of 2007 revenue. Figure 4 and Figure 5 report the underlying event studies. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 4: Average Post-2008 Effects, Single- vs. Multi-Province Firms

	(1) Revenue	(2) Interm. Inputs	(3) Value Added	(4) Total Payroll	(5) Profits After Tax	(6) Payroll − Profits
Single	-0.0561***	-0.0410***	-0.0152	-0.0169**	0.0006	-0.0175**
	(0.0200)	(0.0122)	(0.0113)	(0.0067)	(0.0044)	(0.0074)
Multi	-0.0591	-0.0505	-0.0086	-0.0020	-0.0042	0.0022
	(0.0480)	(0.0385)	(0.0239)	(0.0110)	(0.0101)	(0.0144)
Difference	0.0029	0.0095	-0.0066	-0.0149	0.0048	-0.0197
	(0.0520)	(0.0403)	(0.0264)	(0.0129)	(0.0110)	(0.0162)
Observations	448,785	448,785	448,785	448,785	448,785	448,785
Adj. R^2	0.340	0.504	0.465	0.609	0.370	0.605
Mean, Single	1.000	0.574	0.426	0.275	0.015	0.260
Mean, Multi	1.000	0.683	0.317	0.191	0.017	0.174

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. In Columns (1)–(6), each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs, and Column (6) is total payroll minus profits after taxes. Each component is winsorized before these differences are taken, and all six outcomes use the same sample, so Column (3) equals Column (1) minus Column (2). "Difference" is Single minus Multi. "Mean" rows report the pre-reform (2007) mean of the outcome, as a share of 2007 revenue. Sample pools single- and multi-province firms. Figure H1 in Appendix H reports the underlying event studies, and Appendix Table G1 reports employment and tangible assets. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: Average Post-2008 Effects, Below- vs. Above-Median Revenue

	(1) Revenue	(2) Interm. Inputs	(3) Value Added	(4) Total Payroll	(5) Profits After Tax	(6) Payroll − Profits
Below	-0.0855***	-0.0539***	-0.0316*	-0.0312***	0.0015	-0.0326**
	(0.0311)	(0.0180)	(0.0190)	(0.0118)	(0.0077)	(0.0131)
Above	-0.0317	-0.0307*	-0.0009	-0.0050	-0.0003	-0.0047
	(0.0247)	(0.0158)	(0.0129)	(0.0069)	(0.0047)	(0.0078)
Difference	-0.0538	-0.0231	-0.0307	-0.0262*	0.0017	-0.0279*
	(0.0397)	(0.0240)	(0.0229)	(0.0137)	(0.0090)	(0.0152)
Observations	405,310	405,310	405,310	405,310	405,310	405,310
Adj. R^2	0.359	0.519	0.467	0.605	0.371	0.600
Mean, Below	1.000	0.541	0.459	0.314	0.000	0.313
Mean, Above	1.000	0.605	0.395	0.237	0.028	0.209

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. In Columns (1)–(6), each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs, and Column (6) is total payroll minus profits after taxes. Each component is winsorized before these differences are taken, and all six outcomes use the same sample, so Column (3) equals Column (1) minus Column (2). "Difference" is Below minus Above. "Mean" rows report the pre-reform (2007) mean of the outcome, as a share of 2007 revenue. Sample is single-province firms only, split by pre-reform revenue (below- vs. above-median). Figure H2 in Appendix H reports the underlying event studies, and Appendix Table G1 reports employment and tangible assets. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6: Average Post-2008 Effects, Below- vs. Above-Median Capital Intensity

	(1) Revenue	(2) Interm. Inputs	(3) Value Added	(4) Total Payroll	(5) Profits After Tax	(6) Payroll − Profits
Below	-0.0166	-0.0249	0.0082	0.0046	0.0007	0.0039
	(0.0278)	(0.0174)	(0.0150)	(0.0091)	(0.0055)	(0.0099)
Above	-0.0938***	-0.0519***	-0.0419**	-0.0382***	0.0006	-0.0388***
	(0.0287)	(0.0170)	(0.0167)	(0.0098)	(0.0068)	(0.0110)
Difference	0.0771*	0.0270	0.0501**	0.0428***	0.0001	0.0427***
	(0.0399)	(0.0243)	(0.0224)	(0.0133)	(0.0088)	(0.0148)
Observations	402,240	402,240	402,240	402,240	402,240	402,240
Adj. R^2	0.343	0.509	0.458	0.598	0.370	0.595
Mean, Below	1.000	0.582	0.418	0.255	0.031	0.224
Mean, Above	1.000	0.565	0.435	0.295	-0.001	0.296

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. In Columns (1)–(6), each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs, and Column (6) is total payroll minus profits after taxes. Each component is winsorized before these differences are taken, and all six outcomes use the same sample, so Column (3) equals Column (1) minus Column (2). "Difference" is Below minus Above. "Mean" rows report the pre-reform (2007) mean of the outcome, as a share of 2007 revenue. Sample is single-province firms only, split by pre-reform capital intensity (below- vs. above-median). Figure H3 in Appendix H reports the underlying event studies, and Appendix Table G1 reports employment and tangible assets. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 7: Average Post-2008 Effects, Below- vs. Above-Median Fossil Fuel Physical Intensity

	(1) Revenue	(2) Interm. Inputs	(3) Value Added	(4) Total Payroll	(5) Profits After Tax	(6) Payroll − Profits
Below	-0.0643**	-0.0610***	-0.0033	-0.0138	-0.0053	-0.0085
	(0.0319)	(0.0212)	(0.0168)	(0.0085)	(0.0063)	(0.0100)
Above	-0.0589*	-0.0376*	-0.0213	-0.0173*	0.0009	-0.0182*
	(0.0342)	(0.0208)	(0.0189)	(0.0103)	(0.0069)	(0.0110)
Difference	-0.0055	-0.0235	0.0180	0.0035	-0.0061	0.0097
	(0.0468)	(0.0297)	(0.0253)	(0.0134)	(0.0093)	(0.0149)
Observations	245,300	245,300	245,300	245,300	245,300	245,300
Adj. R^2	0.325	0.487	0.468	0.627	0.383	0.625
Mean, Below	1.000	0.597	0.403	0.219	0.053	0.166
Mean, Above	1.000	0.581	0.419	0.287	0.004	0.284

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. In Columns (1)–(6), each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Value added is revenue minus intermediate inputs, and Column (6) is total payroll minus profits after taxes. Each component is winsorized before these differences are taken, and all six outcomes use the same sample, so Column (3) equals Column (1) minus Column (2). "Difference" is Below minus Above. "Mean" rows report the pre-reform (2007) mean of the outcome, as a share of 2007 revenue. Sample is single-province firms only, split by pre-reform fossil fuel quantity divided by revenue (below- vs. above-median). Figure H4 in Appendix H reports the underlying event studies, and Appendix Table G1 reports employment and tangible assets. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 8: Robustness of the Average Post-2008 Effects

	(1) Revenue	(2) Interm. Inputs	(3) Total Payroll	(4) Profits After Tax	Observations
Baseline	-0.0569***	-0.0428***	-0.0144**	0.0001	448,785
	(0.0184)	(0.0116)	(0.0060)	(0.0041)	
Excluding AB and QC from controls	-0.0517***	-0.0369***	-0.0147**	0.0008	281,935
	(0.0193)	(0.0123)	(0.0062)	(0.0043)	
Excluding IO-linked control industries	-0.0653***	-0.0509***	-0.0173***	0.0018	293,770
	(0.0189)	(0.0119)	(0.0063)	(0.0043)	
Excluding NAICS 3119	-0.0673***	-0.0473***	-0.0177***	-0.0024	443,775
	(0.0190)	(0.0120)	(0.0063)	(0.0043)	

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. Each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. "Baseline" reproduces the main estimates. The second row drops Alberta and Quebec from the control provinces. The third row drops the control industries whose purchases from, or sales to, fossil-fuel-intensive industries exceed 10% of their total purchases or output (Appendix Table M1). The fourth row drops other food manufacturing (NAICS 3119) from the treated industries. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Appendix

A Additional Details on the BC Carbon Tax

The carbon tax applied to the combustion of fossil fuels. When it was introduced, it did not apply to biomass fuels and biofuels, such as firewood, wood waste, ethanol, biodiesel, and bio-heating oil. It also did not apply to process emissions, which arise from chemical reactions in production rather than from fuel combustion, such as those from oil and gas production, aluminum smelting, and cement making.[37] These exclusions explain why the tax reached only about 70 percent of the province's GHG emissions (Murray & Rivers, 2015). Table A1 reports BC's emissions by source in 2007.

The tax was designed to be revenue neutral (Ministry of Finance, 2008). On the business side, the small business corporate income tax (CIT) rate fell from 4.5 percent before the reform to 2.5 percent by the end of 2008, and the general CIT rate fell from 12 percent to 10 percent between 2008 and 2011. These cuts applied to all firms, regardless of the fossil fuel intensity of their industry. Section 8 discusses whether the general rate cut favored capital-intensive industries.

On the household side, the government cut personal income tax rates for the two lowest brackets, which covered incomes below $70,000 per year, by 2 percent in 2008 and by a further 3 percent in 2009. It also introduced a lump-sum transfer of up to $100 for low-income individuals and families. These changes did not differ across high- and low-fossil-fuel-intensive industries, so the triple difference absorbs them, although some studies incorporate such adjustments in industry- and firm-level analyses (Azevedo et al., 2023; Yamazaki, 2017).

Table A2 reports, for each fossil fuel, the carbon tax per GJ, the fuel price, and the tax as a share of the price from 2008 to 2014.

[37] In cement, for example, about 40 percent of GHG emissions come from fuel combustion and were taxed, while the remaining 60 percent are process emissions that were not.

Table A1: Greenhouse Gas Emissions in British Columbia by Source, 2007

	kt CO_2e	Share (%)
Panel A: Stationary Combustion by Sector		
Manufacturing	6,939	29.3
Fossil fuel industries	6,289	26.5
Residential	4,372	18.4
Commercial and institutional	3,326	14.0
Other	2,785	11.7
Total stationary combustion	23,711	100.0
Panel B: Total Emissions by Source		
Stationary combustion	23,711	35.2
Transport	24,888	37.0
Fugitive sources	5,512	8.2
Industrial processes	3,845	5.7
Other	9,353	13.9
Total	67,309	100.0

Note: Emissions in kilotonnes of CO_2-equivalent. Panel A reports shares of total stationary combustion emissions, and Panel B reports shares of total provincial emissions. Source: Ministry of Environment (2007).

Table A2: Carbon Tax, Fuel Prices, and Tax Share by Fossil Fuel in British Columbia, 2008–2014

	2008	2009	2010	2011	2012	2013	2014
Panel A: Carbon Tax (CAD/GJ)							
Coal	0.95	1.42	1.90	2.37	2.85	2.85	2.85
Heavy fuel oil	0.84	1.25	1.67	2.09	2.51	2.51	2.51
Light fuel oil	0.70	1.06	1.33	1.67	2.00	2.00	2.00
Diesel	0.70	1.06	1.33	1.67	2.00	2.00	2.00
Gasoline	0.70	1.05	1.33	1.66	1.99	1.99	1.99
Propane	0.60	0.90	1.20	1.50	1.81	1.81	1.81
Natural gas	0.49	0.74	0.98	1.23	1.48	1.48	1.48
Panel B: Fuel Price (CAD/GJ)							
Coal	13.32	10.69	11.15	14.63	11.01	8.61	6.95
Heavy fuel oil	24.90	21.84	23.89	28.98	30.78	28.68	29.68
Light fuel oil	38.89	28.60	32.74	37.07	38.58	40.16	41.21
Diesel	45.49	34.23	39.17	46.45	47.72	45.68	45.11
Gasoline	45.63	38.92	42.55	48.91	48.98	46.55	44.68
Propane	27.59	22.85	25.08	26.05	25.93	25.44	27.46
Natural gas	9.73	7.65	6.80	6.60	5.61	6.54	7.85
Panel C: Carbon Tax as a Share of the Fuel Price (%)							
Coal	7.1	13.3	17.0	16.2	25.9	33.1	40.9
Heavy fuel oil	3.4	5.7	7.0	7.2	8.1	8.7	8.4
Light fuel oil	1.8	3.7	4.1	4.5	5.2	5.0	4.9
Diesel	1.5	3.1	3.4	3.6	4.2	4.4	4.4
Gasoline	1.5	2.7	3.1	3.4	4.1	4.3	4.5
Propane	2.2	4.0	4.8	5.8	7.0	7.1	6.6
Natural gas	5.1	9.6	14.5	18.6	26.3	22.6	18.8

Note: Panel A reports the carbon tax per GJ at the rate in effect from July 1 of each year, which rose from \$10 per tonne of CO_2-equivalent in 2008 by \$5 per year to \$30 in 2012 and then stayed constant. The tax per GJ follows each fuel's emission factor (Ministry of Finance, 2021). Panel B reports annual fuel prices in British Columbia from Natural Resources Canada. Panel C divides Panel A by Panel B.

B Comparison of Treated Industries with US Evidence

The treatment definition used in this paper, the top quartile of fossil fuel expenditure as a share of revenue at the 4-digit NAICS level, identifies industries that are established as energy-intensive in the literature on US manufacturing. Ganapati et al. (2020) document that energy costs, including feedstock, exceed 20 percent of revenues in alkali and chlorine manufacturing, cement, gasoline refining, and lime manufacturing. Shapiro and Walker (2018) rank US manufacturing sectors by tons of pollution per dollar of production costs. They place basic metals, other non-metallic minerals (which include cement and lime), paper and publishing, and coke and refined petroleum at the top of the distribution. These are the same sectors that are in the top quartile of the Canadian ranking used in this paper.

I also rank US 4-digit NAICS industries by the cost of purchased fuels over the value of shipments in 2007, using public data from the Annual Survey of Manufactures (U.S. Census Bureau, 2008). Thirteen of the seventeen US industries in the top quartile are also in the BC treated list (Table B1). This confirms that the treatment definition captures industries whose high fossil fuel intensity reflects production-technology characteristics, rather than idiosyncrasies of the Canadian data or of the pre-reform period chosen.

The one exception is primary aluminum production (NAICS 3313). In the United States, aluminum smelting is among the most energy-intensive manufacturing activities. It would rank near the top of a fossil-fuel intensity distribution. However, in British Columbia, primary aluminum smelters, mainly Rio Tinto's Kitimat facility, are powered almost entirely by hydroelectric installations (the Kemano generating station). Fossil fuel expenditure at these facilities is therefore very low, which is why the sector does not appear in the top quartile of the BC ranking. This difference shows that the definition of fossil-fuel-intensive industries correctly identifies industries for which the BC carbon tax generates an important burden.

Table B1: US Top Quartile of Fuel Intensity, 2007

Rank	NAICS	Industry	Fuels/Shipments (%)
1	3274	Lime and gypsum product manufacturing	11.7
2	3221	Pulp, paper, and paperboard mills	7.4
3	3271	Clay product and refractory manufacturing	6.6
4	3272	Glass and glass product manufacturing	5.3
5	3251	Basic chemical manufacturing	4.0
6	3212	Veneer, plywood, and engineered wood product mfg.	3.6
7	3313	Alumina and aluminum production and processing†	2.8
8	3112	Grain and oilseed milling	2.7
9	3279	Other nonmetallic mineral product manufacturing	2.6
10	3252	Resin, synthetic rubber, and artificial fibers mfg.	2.4
11	3273	Cement and concrete product manufacturing	2.3
12	3253	Pesticide, fertilizer, and other agricultural chemical mfg.	2.1
13	3241	Petroleum and coal products manufacturing	1.5
14	3118	Bakeries and tortilla manufacturing†	1.3
15	3133	Textile and fabric finishing and fabric coating mills	1.3
16	3113	Sugar and confectionery product manufacturing†	1.2
17	3312	Steel product manufacturing from purchased steel†	1.1

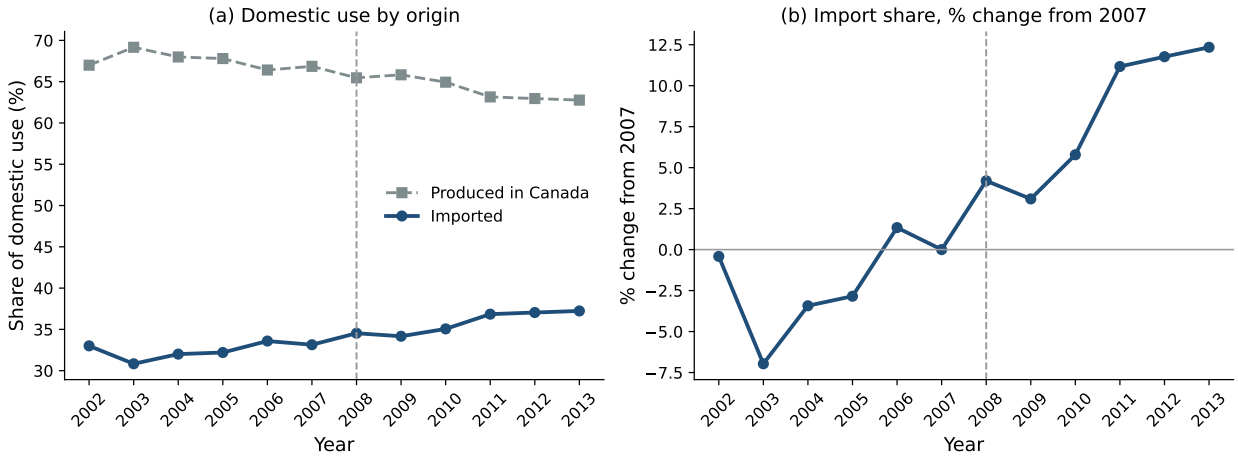
Note: US 4-digit NAICS manufacturing industries in the top quartile of the cost of purchased fuels over the value of shipments in 2007 (17 of 69 industries). †Not in the BC treated list (Table 1). Two BC treated industries fall outside the US top quartile. These are animal food manufacturing (rank 24) and other food manufacturing (rank 37). Six BC treated industries are not reported separately in the US data. Source: US Census Bureau, Annual Survey of Manufactures (U.S. Census Bureau, 2008).

C Trade Exposure of Treated Industries

C.1 Import Penetration in Canada

Figure C1 and Table C1 measure import penetration for the treated industries in Canada, the share of domestic use of each industry's products met by imports. Domestic use is output plus imports, minus international exports and re-exports. Before the tax, imports supplied about a third of the domestic use of these products. The share rose by about 8% on average after 2008 relative to 2007 and by 12% by 2013, although it was already rising after 2003. Control manufacturing industries were also exposed to trade. In these sectors, imports supplied about 61% of the domestic use of their products in 2002–2007. However, this share barely changed after 2008. It increased by about 1% on average relative to 2007. These data cover Canada as a whole and do not separate BC from the other provinces.

Figure C1: Import Penetration of Treated Industries in Canada



Note: Panel (a) shows the shares of the domestic use of the products of treated industries (output plus imports, minus international exports and re-exports) produced in Canada and imported. The two shares add up to 100%. Panel (b) shows the percentage change in the import share relative to 2007. The aggregate sums imports and domestic supply across treated L61 IO sectors. It excludes resin and synthetic products, which the IO tables merge with another sector after 2010. Source: Canadian National Symmetric Input–Output Tables, 2002–2013.

Table C1: Import Penetration of Treated Industries in Canada by IO Sector

IO sector	Treated industries (NAICS)	2002–2007		2008–2013	
		Dom.	Imp.	Dom.	Imp.
Non-metallic mineral products (except cement and concrete)	Lime and gypsum (3274), clay and refractory (3271), glass (3272), other non-metallic mineral products (3279)	51.2	48.8	44.9	55.1
Pulp, paper and paperboard mills	Pulp, paper and paperboard mills (3221)	64.8	35.2	59.0	41.0
Basic chemicals	Basic chemicals (3251)	57.0	43.0	55.4	44.6
Primary metals	Iron and steel mills and ferro-alloys (3311), non-ferrous metals except aluminum (3314), foundries (3315)	54.5	45.5	43.7	56.3
Pesticides, fertilizers and other agricultural chemicals	Pesticides, fertilizers and other agricultural chemicals (3253)	65.4	34.6	57.8	42.2
Cement and concrete products	Cement and concrete products (3273)	96.2	3.8	93.8	6.2
Textile and textile product mills	Textile and fabric finishing and coating (3133)	36.1	63.9	28.6	71.4
Petroleum and coal products	Petroleum and coal products (3241)	85.8	14.2	78.2	21.8
Wood products	Veneer, plywood and engineered wood (3212), sawmills and wood preservation (3211)	85.4	14.6	82.3	17.7
Miscellaneous food	Grain and oilseed milling (3112), other food (3119)	70.6	29.4	69.8	30.2
Fruit and vegetable preserving and specialty food	Fruit and vegetable preserving and specialty food (3114)	68.6	31.4	63.2	36.8
Fabricated metal products	Coating, engraving, cold and heat treating (3328)	57.0	43.0	57.8	42.2
Resin, synthetic rubber, and artificial and synthetic fibres	Resin, synthetic rubber, and artificial and synthetic fibres (3252)	34.2	65.8	26.8	73.2
Animal food	Animal food (3111)	87.5	12.5	86.4	13.6

Note: Average share (%) of the domestic use of each IO sector's products met by domestic production and by imports. Domestic use is output plus imports, minus international exports and re-exports. The IO tables report several treated industries within one L61 sector, so these industries share the sector's values. Sectors are ordered by the highest-ranked treated industry they contain in the BC ranking of fossil fuel expenditure as a share of revenue (Table 1). For resin and synthetics, the IO classification merged this sector after 2010, so the post-2008 average covers 2008–2010 only. Source: Canadian National Symmetric Input–Output Tables (L61 level, 2002–2013).

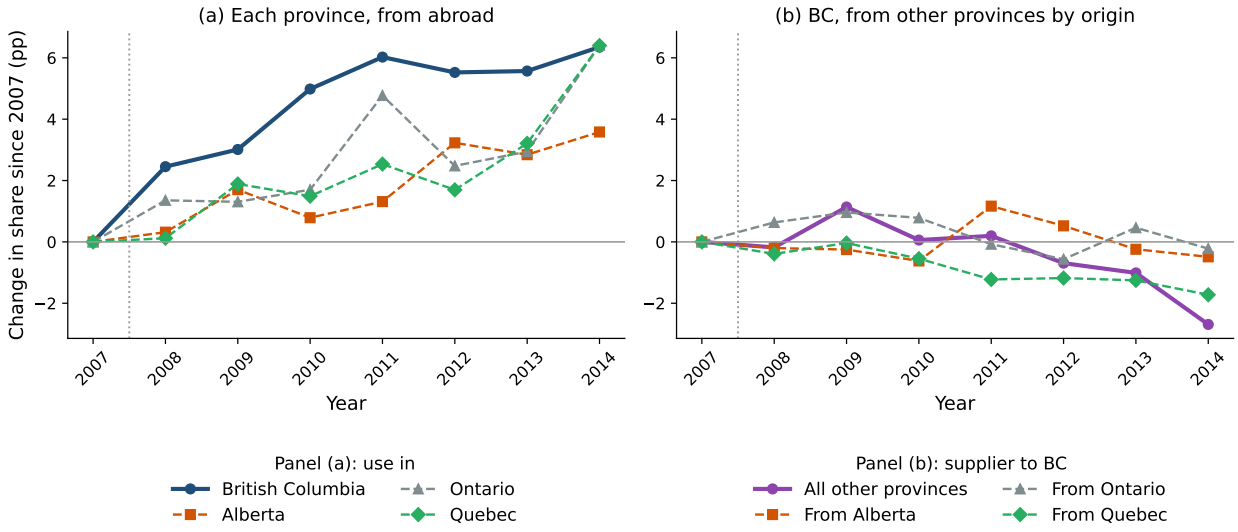
C.2 Trade Flows of British Columbia

Statistics Canada reports interprovincial and international trade flows by province from 2007 onward, for broad product groups (Statistics Canada, 2022). I use the seven groups that contain the treated industries, food, wood products, paper, refined petroleum, chemicals, non-metallic mineral products, and primary metals. These groups are broader than the treated industries, so the results are suggestive.

In 2007, Alberta supplied 47% of BC's purchases of these products from other provinces, Ontario 25%, and Quebec 18%. Other provinces shipped about $10.7 billion of these products to BC, almost twice the $5.6 billion that BC shipped to them.

Figure C2 compares BC with Alberta, Ontario, and Quebec. Between 2007 and 2012, the share of BC's use of these products bought abroad rose from 33% to 39%, about 2 to 4 percentage points more than in the three other provinces (Panel (a)). Panel (b) splits BC's purchases from other provinces by origin. After the tax, neither Alberta, Ontario, nor Quebec gained more than about one percentage point of BC's use, and Quebec lost share. Therefore, it seems that producers in other provinces did not gain market share in BC. On the other hand, the share of BC's use bought abroad rose for manufactured goods in control industries. As a result, competition from foreign producers strengthened during the study period for the whole province.

Figure C2: Change in the Share of Provincial Use Supplied from Outside the Province



Note: Change since 2007, in percentage points, in the share of each province's use of the product groups that contain the treated industries (food, wood products, paper, refined petroleum, chemicals, non-metallic mineral products, and primary metals) supplied by imports from abroad (Panel (a)). Panel (b) shows the share of BC's use supplied by all other provinces and by Alberta, Ontario, and Quebec separately. In 2007, BC bought 33% of its use of these products abroad and 34% from other provinces, including 15% from Alberta, 8% from Ontario, and 6% from Quebec. Values at basic prices in current dollars. Source: Statistics Canada, Table 12-10-0088-01.

D Event Study Figures: BC vs. Other Provinces

This appendix presents event study estimates for equation (6) with the sample split by region (BC vs. Other Provinces). It shows, for each region separately, the response of treated firms relative to control firms in the same region.

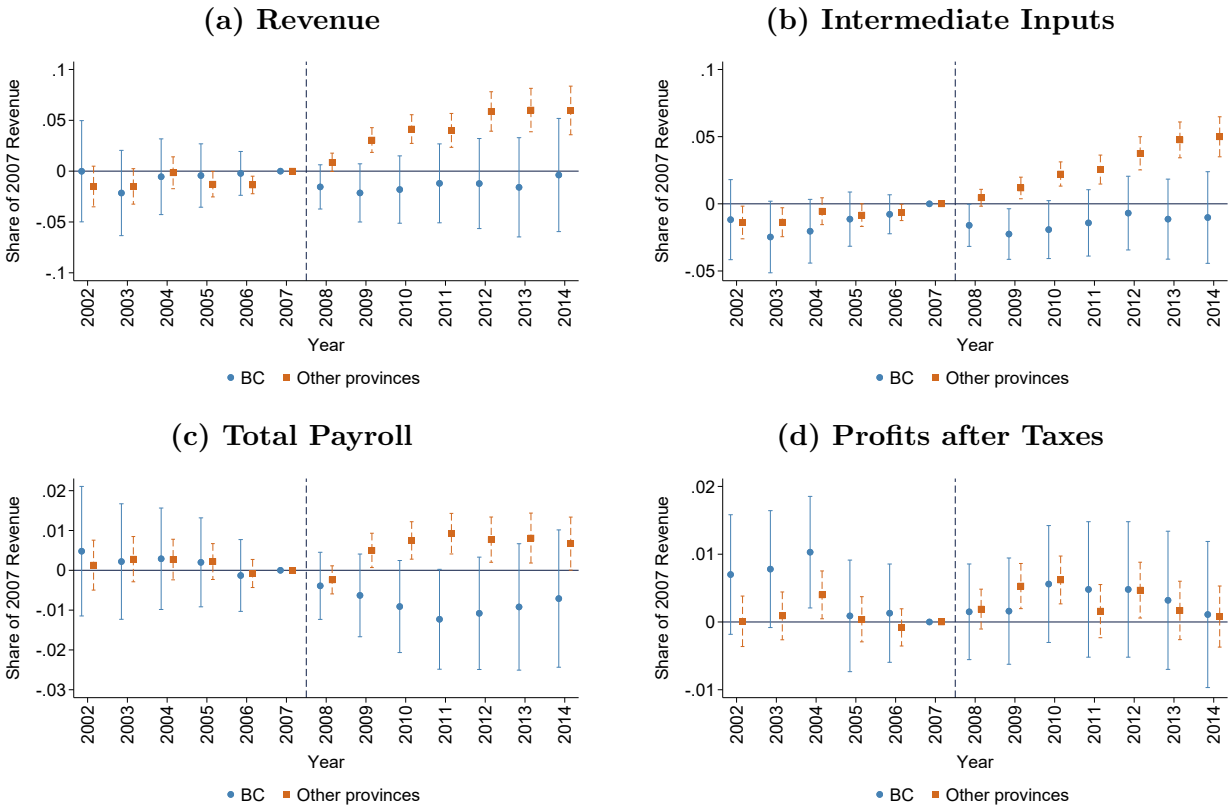
In these region-specific event studies, the negative triple-difference effect could appear to be driven by an increase in the other-provinces diff-in-difference rather than a decline in BC's. This pattern is driven by *Other food manufacturing*, the lowest fuel-intensity industry in the treated group (Table 1). This industry recovers faster than the other treated industries after the 2008 financial crisis, pulling both the BC and other-provinces diff-in-differences upward. Excluding this industry, the negative triple-difference effect is clearly driven by a decline in BC's diff-in-difference specifically (Figure D2 and Table D1). The main results are robust to its exclusion.

Table D1: Difference-in-Differences by Region, with and without Other Food Manufacturing

	(1) Revenue	(2) Interm. Inputs	(3) Total Payroll	(4) Profits After Tax	Observations
Panel A: All Treated Industries					
BC	-0.0141	-0.0143	-0.0084	0.0032	60,410
	(0.0169)	(0.0106)	(0.0056)	(0.0038)	
Other provinces	0.0427***	0.0284***	0.0060***	0.0031**	388,370
	(0.0073)	(0.0046)	(0.0022)	(0.0015)	
Panel B: Excluding Other Food Manufacturing (NAICS 3119)					
BC	-0.0393**	-0.0282**	-0.0155***	0.0010	59,465
	(0.0174)	(0.0110)	(0.0058)	(0.0040)	
Other provinces	0.0280***	0.0190***	0.0022	0.0033**	384,310
	(0.0076)	(0.0048)	(0.0023)	(0.0016)	

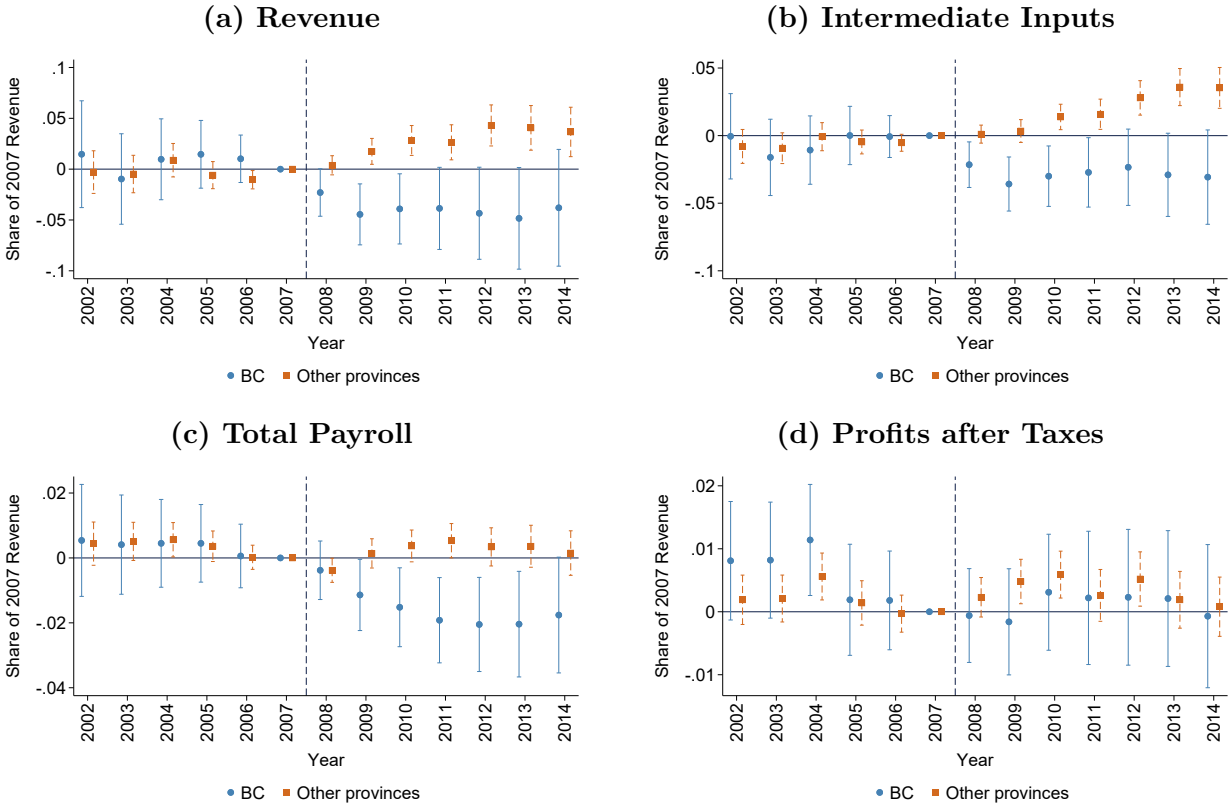
Note: Each row reports the average of the seven post-2008 (2008–2014) coefficients from a difference-in-differences regression estimated separately for BC and for the other provinces, comparing fossil-fuel-intensive with less fuel-intensive firms before and after the reform. Standard errors in parentheses account for the full covariance structure of the underlying estimates. Each outcome is divided by the firm's 2007 revenue, so coefficients are changes as a share of pre-reform revenue. Panel B drops other food manufacturing (NAICS 3119) from the treated industries. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure D1: BC vs. Other Provinces Event Study



Note: Each panel shows the event-study estimates of a difference-in-differences regression estimated separately for BC (circles, solid intervals) and for the other provinces (squares, dashed intervals), comparing fossil-fuel-intensive with less fuel-intensive firms in each year relative to 2007. Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals.

Figure D2: BC vs. Other Provinces Event Study, Excluding Other Food Manufacturing

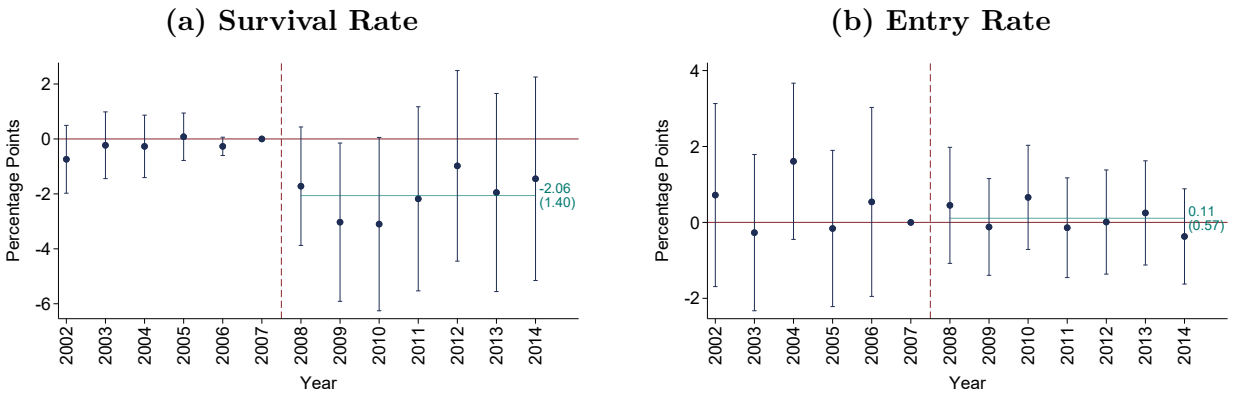


Note: Each panel shows the event-study estimates of a difference-in-differences regression estimated separately for BC (circles, solid intervals) and for the other provinces (squares, dashed intervals), comparing fossil-fuel-intensive with less fuel-intensive firms in each year relative to 2007. Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals. The sample excludes other food manufacturing (NAICS 3119) from the treated industries.

E Extensive Margin: Survival and Entry

This appendix reports event study estimates for the extensive margin (firm survival and firm entry) for the full regression sample. Both outcomes are estimated as linear probability models using the same triple-difference specification as equation (6), so coefficients are in percentage points. These estimates check whether the main results in Section 6 reflect firm exit rather than adjustment within firms. Survival rates fall slightly after 2008, significantly only in 2009 and 2010 (about 3 percentage points), and entry rates do not change (Figure E1). The main results are therefore unlikely to be driven by firm exit.

Figure E1: Extensive Margin: Firm Survival and Entry Rates

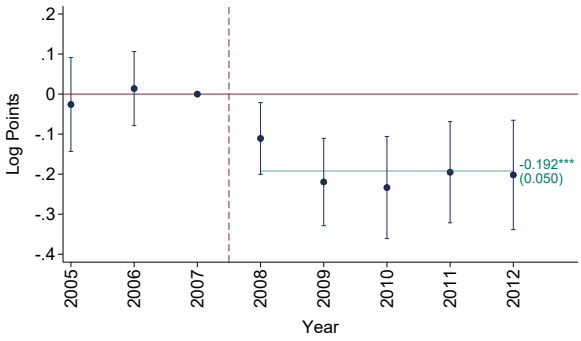


Note: Coefficients are from linear probability models using equation (6), which includes firm fixed effects and clusters standard errors at the firm level. Point estimates and 95% confidence intervals are shown in blue. The green line and label show the average of the post-2008 coefficients. The sample is the full regression sample.

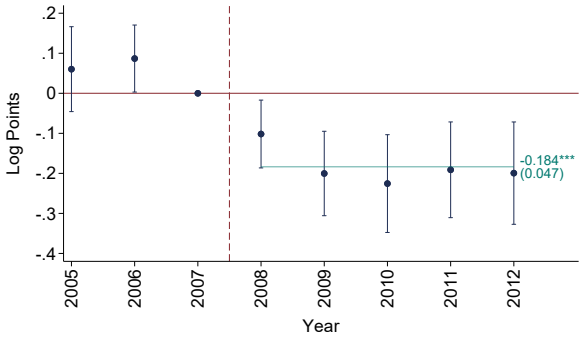
F Fossil Fuel Quantity: Electricity and Fuel Intensity

Figure F1: Fossil Fuel Quantities, Expenditure, CO_2 Emissions, Electricity, and Fuel Intensity

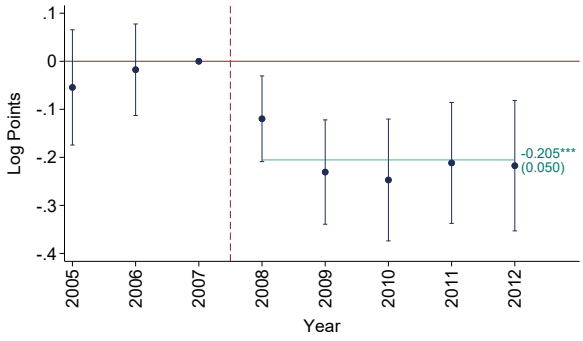
(a) Log Fossil Fuel Quantities



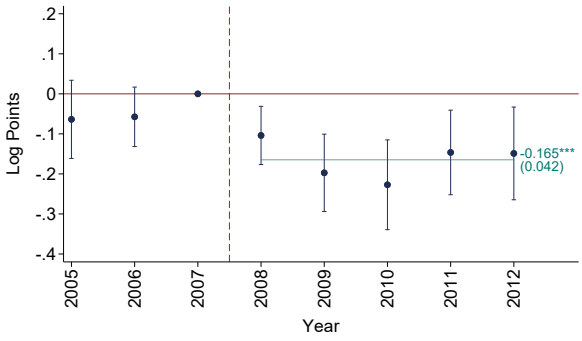
(b) Log Fossil Fuel Expenditure



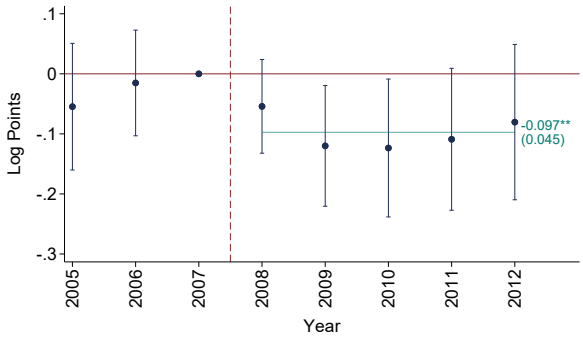
(c) Log CO_2 Emissions



(d) Log Electricity Quantity



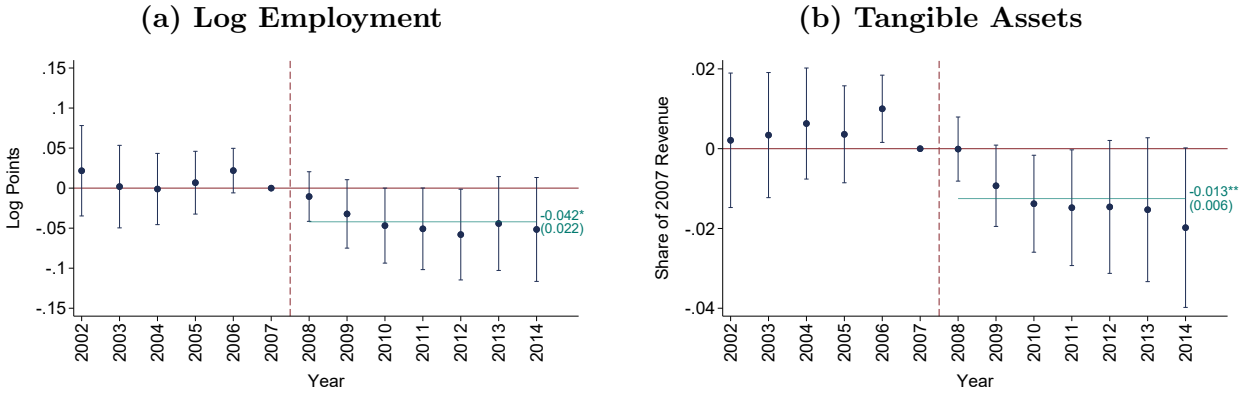
(e) Log Fuel Intensity



Note: Coefficients are from equation (6), which includes firm fixed effects and clusters standard errors at the firm level. Point estimates and 95% confidence intervals are shown in blue. The green line and label show the average of the post-2008 coefficients. Fuel intensity is physical fuel quantity divided by revenue. All outcomes are estimated for 2005–2012, the years for which fuel price and expenditure data are available, and are limited to the ASML-linked subsample (approximately 60% of the regression sample).

G Labor and Capital Inputs

Figure G1: Employment and Tangible Assets Event Study



Note: Panel (a) shows the event-study estimates from equation (6) for log employment, and Panel (b) for tangible assets, measured at book value net of depreciation and divided by the firm's 2007 revenue. Each coefficient is the effect for fossil-fuel-intensive BC firms in that year, relative to 2007, the reference year ($\beta_{2007} = 0$). Vertical bars show 95% confidence intervals, with standard errors clustered at the firm level. The horizontal line across the post-2008 coefficients marks their average.

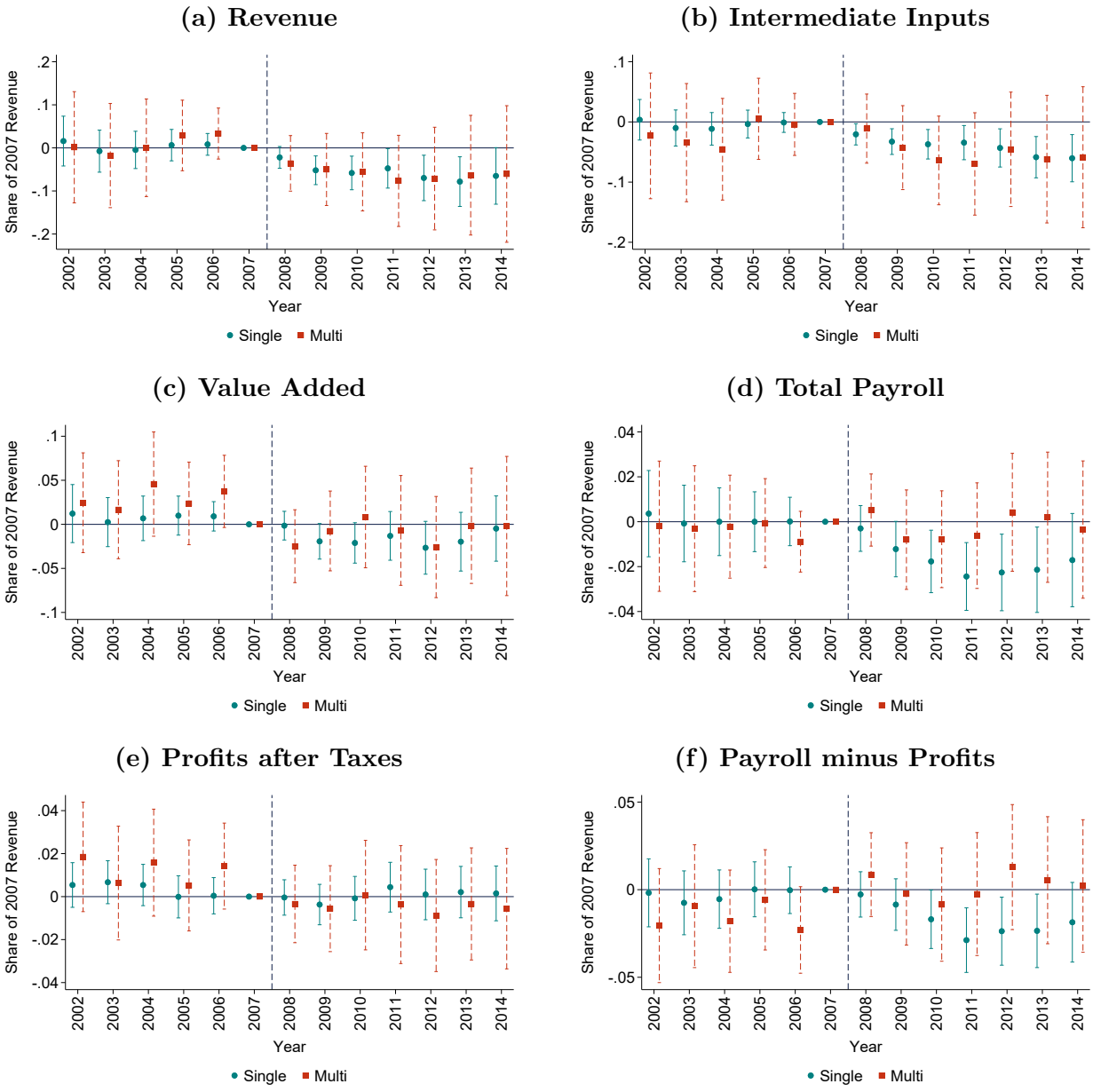
Table G1: Average Post-2008 Effects on Labor and Capital Inputs by Firm Group

	(1) Log Employment	(2) Tang. Assets / Revenue
Panel A: Firm Type		
Single	-0.052**	-0.017**
	(0.023)	(0.007)
Multi	0.033	0.010
	(0.054)	(0.018)
Difference	-0.085	-0.026
	(0.059)	(0.019)
Observations	448785	445815
Panel B: Firm Size		
Below	-0.087**	-0.030***
	(0.037)	(0.011)
Above	-0.025	-0.006
	(0.029)	(0.007)
Difference	-0.061	-0.024*
	(0.047)	(0.014)
Observations	405310	402650
Panel C: Capital Intensity		
Below	-0.007	-0.010
	(0.034)	(0.007)
Above	-0.094***	-0.024**
	(0.032)	(0.011)
Difference	0.087*	0.014
	(0.047)	(0.013)
Observations	402240	401050
Panel D: Fossil Fuel Physical Intensity		
Below	-0.029	-0.022**
	(0.038)	(0.010)
Above	-0.083**	-0.012
	(0.042)	(0.011)
Difference	0.054	-0.010
	(0.057)	(0.015)
Observations	245300	243610

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. Column (2) divides tangible assets by the firm's 2007 revenue. "Difference" is the first group minus the second. Panel A compares single- and multi-province firms. Panels B to D use single-province firms only, split at the median of pre-reform revenue, capital intensity, and fossil fuel physical intensity. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

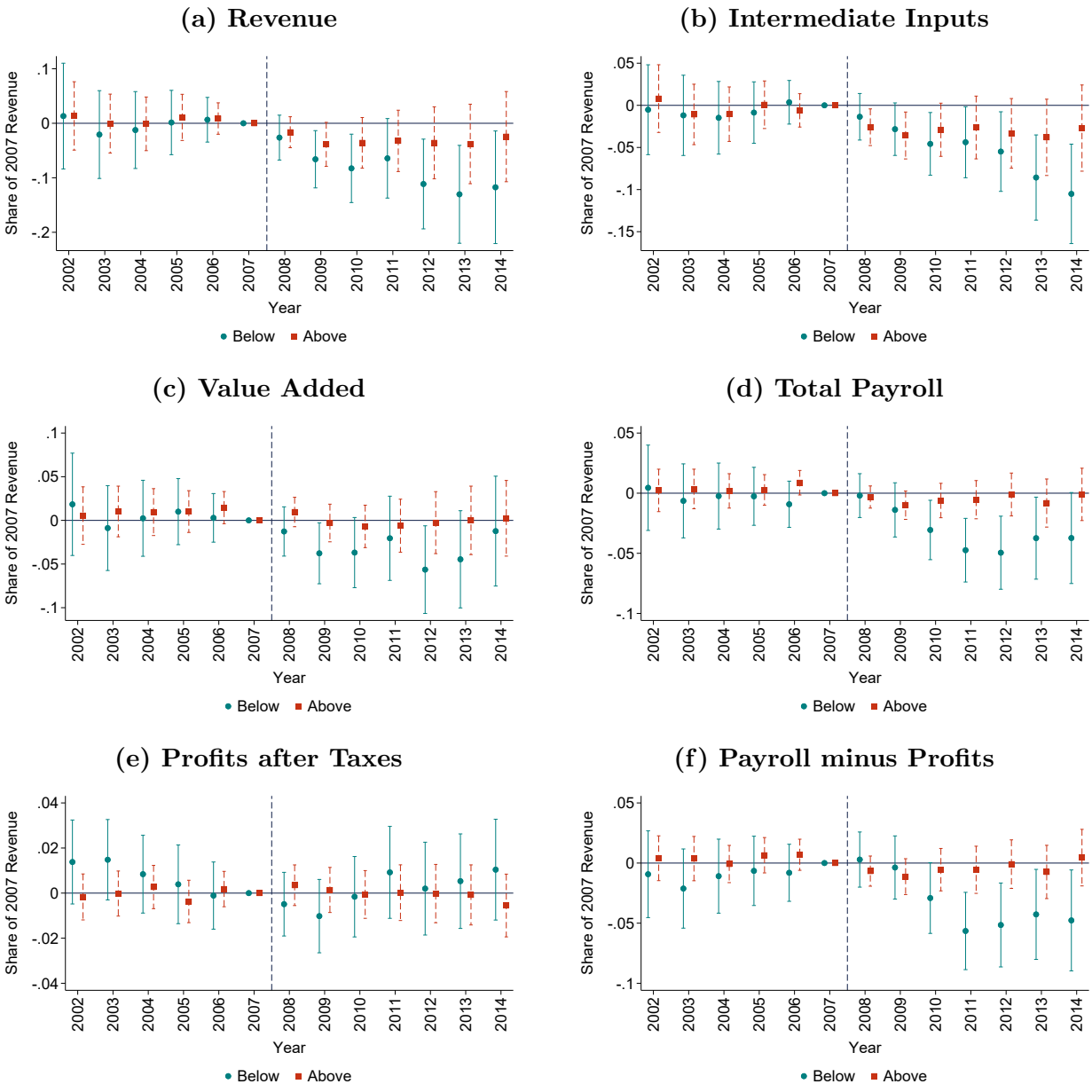
H Event Study Figures: Heterogeneity by Firm Type, Firm Size, and Mechanisms

Figure H1: Event Study by Firm Type, Single- vs. Multi-Province Firms



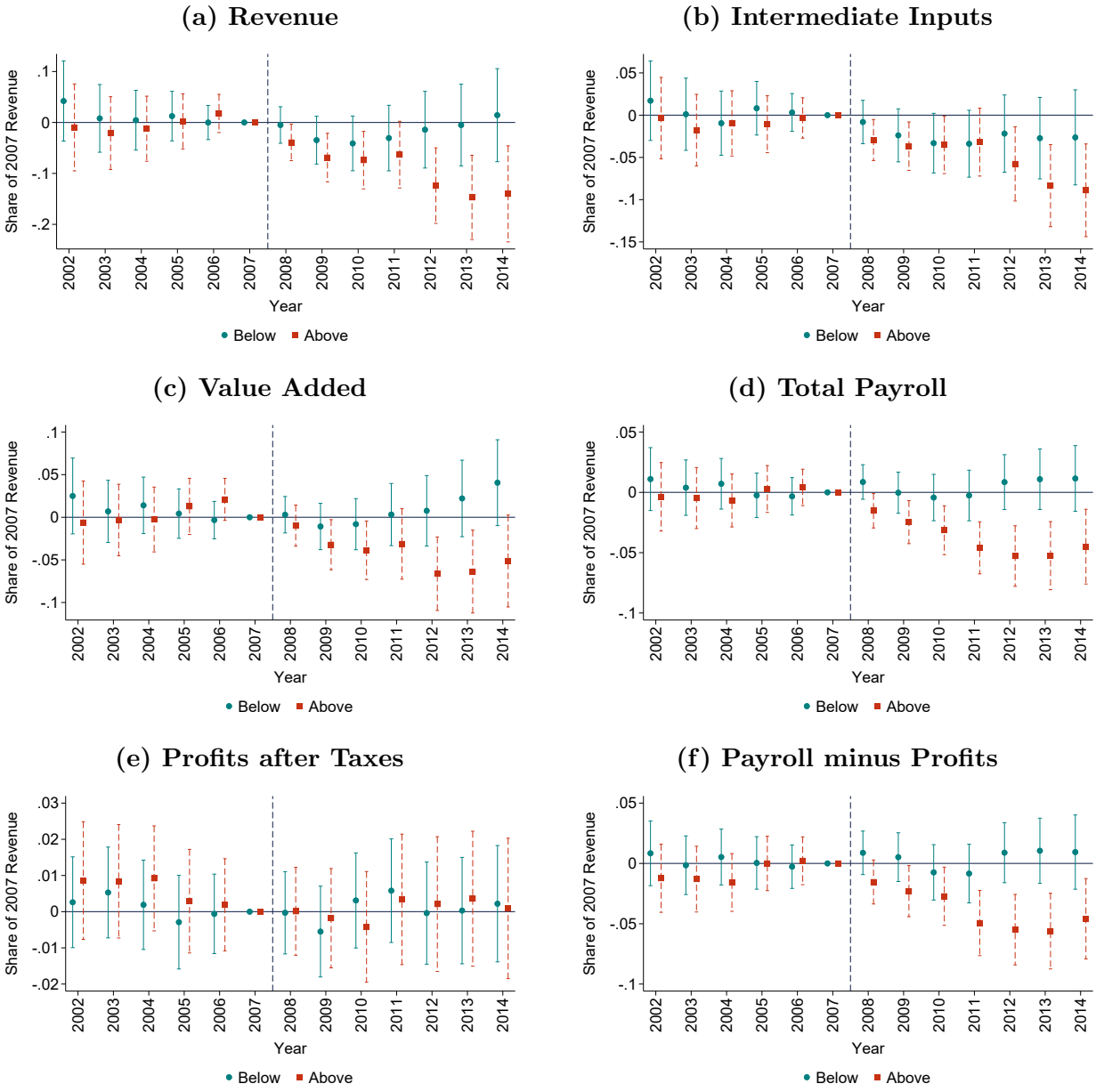
Note: Each panel shows the event-study estimates from equation (6) interacted with the group indicator, for single-province firms (circles, solid intervals) and multi-province firms (squares, dashed intervals). Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals.

Figure H2: Event Study by Firm Size, Below- vs. Above-Median Revenue



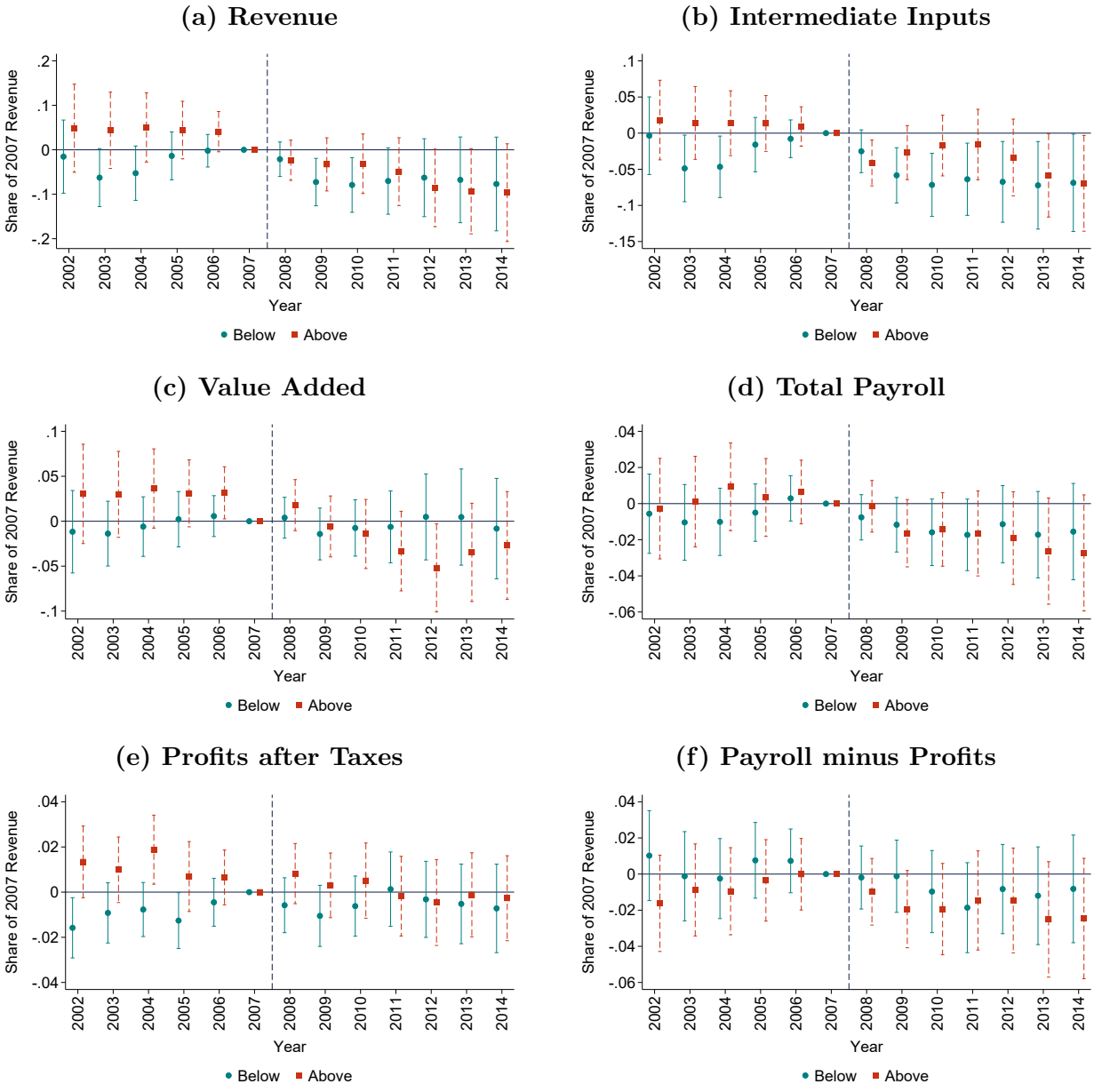
Note: Each panel shows the event-study estimates from equation (6) interacted with the group indicator, for below-median (circles, solid intervals) and above-median (squares, dashed intervals) pre-reform revenue, among single-province firms. Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals.

Figure H3: Event Study by Capital Intensity, Below- vs. Above-Median



Note: Each panel shows the event-study estimates from equation (6) interacted with the group indicator, for below-median (circles, solid intervals) and above-median (squares, dashed intervals) pre-reform capital intensity, among single-province firms. Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals.

Figure H4: Event Study by Fossil Fuel Efficiency, Below- vs. Above-Median Fuel Quantity/Revenue



Note: Each panel shows the event-study estimates from equation (6) interacted with the group indicator, for below-median (circles, solid intervals) and above-median (squares, dashed intervals) pre-reform fossil fuel quantity divided by revenue, among single-province firms. Each outcome is divided by the firm's 2007 revenue. Regressions include firm fixed effects, and standard errors are clustered at the firm level. Vertical bars show 95% confidence intervals.

I Production Shifting in Multi-Province Firms

This appendix examines whether multi-province firms move production out of BC after the carbon tax. The sample includes multi-province firms that in 2007 had at least two plants, at least one of them in BC. The outcome is the BC share of each firm's total revenue, fossil fuel expenditure, CO_2 emissions, and employment, computed from plant-level ASML data. The sample includes 60 treated firms and 65 to 75 control firms. The average BC share of revenue is about 55% in 2007.

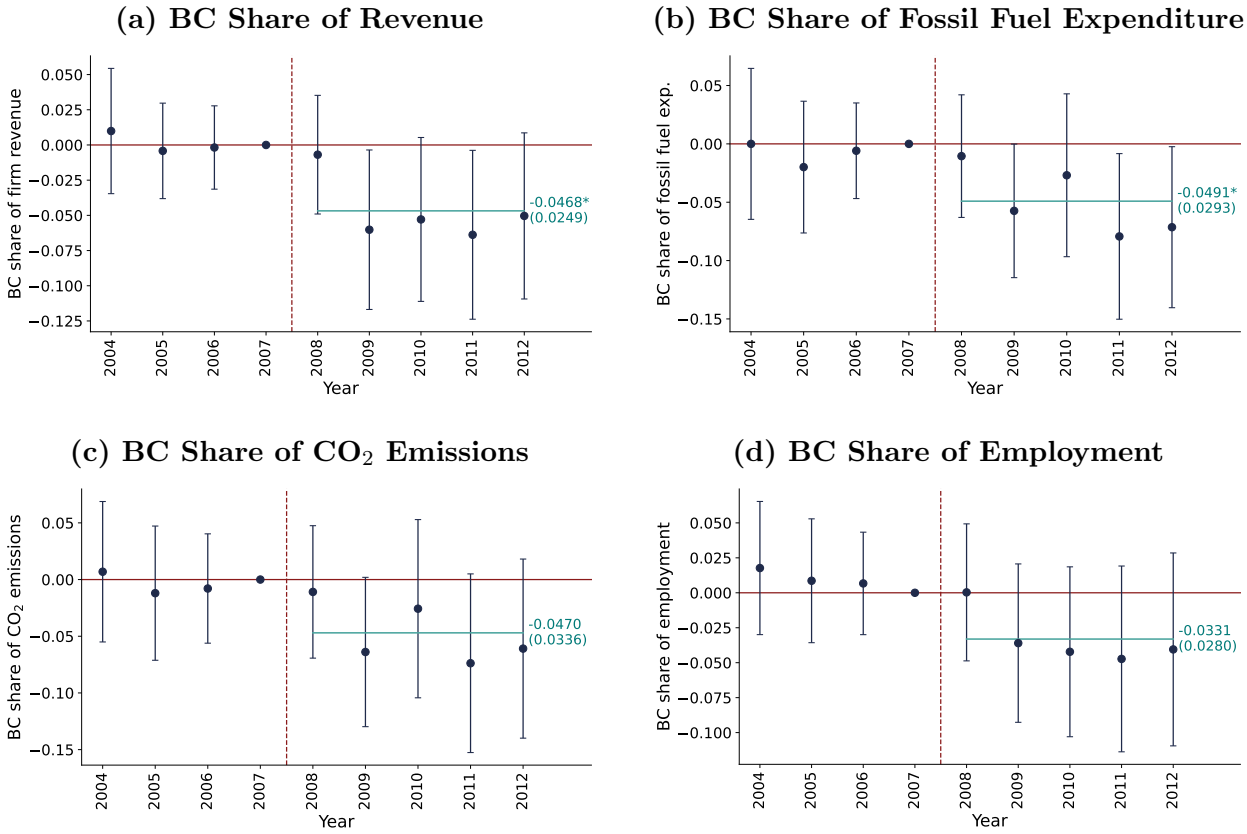
I compare fossil-fuel-intensive firms with less fuel-intensive firms before and after 2008 with a difference-in-differences event study at the firm level:

$$S_{jt} \;=\; \sum_{\tau=2004}^{2012} \beta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_j \;+\; \alpha_j \;+\; \delta_t \;+\; u_{jt}, \tag{8}$$

where S_{jt} is the BC share of firm j's revenue, fossil fuel expenditure, CO_2 emissions, or employment in year t. $Treated_j$ indicates a firm in a top-quartile fossil-fuel-intensity industry, α_j is a firm fixed effect, and δ_t is a year fixed effect. The coefficient β_τ measures how the gap in the BC share between fossil-fuel-intensive and less fuel-intensive firms changes relative to the reference year 2007 ($\beta_{2007} = 0$). Because every firm in the sample has a plant in BC, the comparison is within multi-province firms rather than across provinces. Standard errors are clustered at the firm level. As in equation (7), the reported effect is the average of the post-2008 coefficients, here over 2008–2012, the years with plant-level data.

Figure I1 shows that the BC share of revenue falls by 4.7 percentage points and the BC share of fossil fuel expenditure by 4.9 percentage points after 2008, both significant at the 10% level. The BC shares of CO_2 emissions and employment also fall, by 4.7 and 3.3 percentage points, but these declines are not statistically significant. The small number of firms limits precision, so these results are suggestive evidence that fossil-fuel-intensive multi-province firms move part of their production out of BC.

Figure I1: Production Shifting in Multi-Province Firms



Note: Sample of multi-province firms with at least two plants in 2007, at least one of them in BC. Outcomes are the BC share of each firm's total revenue, fossil fuel expenditure, CO_2 emissions, and employment. The comparison is between fossil-fuel-intensive and less fuel-intensive firms, before and after 2008, with 2007 as the reference year. Point estimates and 95% confidence intervals are shown in blue. The green line and label show the average of the post-2008 coefficients (2008–2012), with its standard error in parentheses. Standard errors are clustered at the firm level. Data from ASML linked to CEEDD.

J Probability of Paying Dividends

This appendix reports the probability that a firm pays any dividend, estimated as a linear probability model. Dividend payouts do not measure owner incidence, because owners can retain profits in the firm, but they show how firms finance their adjustment. Table J1 reports the results. For all fossil-fuel-intensive firms, the probability of paying dividends does not change significantly. By firm type, it falls by 20 percentage points for multi-province firms and does not change for single-province firms.

Table J1: Probability of Paying Dividends

	(1) All Firms	(2) By Firm Type
All	-0.010	
	(0.016)	
Single		0.014
		(0.017)
Multi		-0.201***
		(0.051)
Difference		0.215***
		(0.053)
Observations	448785	448785
Adj. R^2	0.496	0.497
Mean, All	0.24	
Mean, Single		0.25
Mean, Multi		0.37

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (6). Standard errors in parentheses account for the full covariance structure of the underlying estimates. "Difference" is Single minus Multi. "Mean" rows report the pre-reform (2007) sample mean of the outcome, the share of firms that pay dividends. The outcome is an indicator for paying any dividend, estimated as a linear probability model. Column (1) pools single- and multi-province firms, and Column (2) estimates separate effects for each firm type. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

K Worker-Level Evidence

This appendix reports worker-level evidence as supporting evidence for the worker-incidence result in Section 6.2. These estimates use individual worker panels and test whether workers employed at treated BC firms experience changes in earnings and other labor market outcomes.

I estimate a worker-level version of the triple difference on a matched sample. Each worker employed at a fossil-fuel-intensive firm in 2007 is matched to one worker employed at a less fuel-intensive firm, without replacement. Matches are exact on the province of the employer, the province where the worker files taxes, 10-year age group, sex, tenure at the employer (one, two, three, or four or more years before the tax), union status, full-time status, whether the employer is a single- or multi-province firm, and whether earnings at the main job are above the sample median. They are also within calipers on pre-reform log earnings at the main job and its one-year lag (0.15 log points each), and on the employer's log revenue in 2007 (0.5 log points). Matching on pre-reform earnings makes treated and control workers follow similar earnings paths before the tax. I then estimate

$$\begin{aligned} Y_{it} \;=\; & \sum_{\tau=2002}^{2014} \beta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_{j(i)} \cdot BC_{j(i)} \\ & + \sum_{\tau=2002}^{2014} \theta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_{j(i)} \;+\; \sum_{\tau=2002}^{2014} \gamma_\tau \, \mathbb{1}(t=\tau) \cdot BC_{j(i)} \;+\; \alpha_i \;+\; \delta_t \;+\; u_{it}, \end{aligned} \tag{9}$$

where Y_{it} is an outcome for worker i in year t and $j(i)$ is the employer of the worker's main job in 2007. $Treated_{j(i)}$ and $BC_{j(i)}$ are defined as in equation (6) for that employer, α_i is a worker fixed effect, and δ_t is a year fixed effect. Because treatment is assigned by the 2007 employer, workers who leave treated firms remain in the treated group, so the estimates include earnings losses from job loss and reallocation. Standard errors are clustered by worker and by 2007 employer. The sample covers 2002–2014, and the reported effect is the average of the post-2008 coefficients over 2008–2014, as in equation (7).

Table K1 reports the average post-2008 effect on log earnings at the worker's main job. The point estimate is -2.1%, but it is not statistically significant. One likely reason this pooled worker-level estimate is not significant is firm size. Point estimates of the firm-level payroll and employment declines among single-province firms are larger in below-median firms (Table 5). These firms are numerous but individually small. A worker-level sample dominated by employment at larger firms would be expected to show a smaller, less precisely estimated effect.

Table K1: Worker Earnings: Average Post-2008 Effect

	Log Earnings, Main Job
Prov × Treated × After	-0.021
	(0.025)
Observations	3,857,945

Note: Coefficient is the average of the seven post-2008 (2008–2014) event study coefficients from equation (9). Standard error in parentheses accounts for the full covariance structure of the underlying estimates. The outcome is log earnings at the worker's main job. The sample matches each worker at a fossil-fuel-intensive firm in 2007 to one worker at a less fuel-intensive firm. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

L Owner-Level Evidence

This appendix reports owner-level evidence as supporting evidence for the owner-incidence result in Section 6.2. These estimates use individual owner panels and track the income received by the owners of treated BC firms.

Owners are individuals who hold at least 10% of the shares of a private firm, as reported in Schedule 50 of the T2 corporate tax return. Each owner is assigned the treatment and province status of the firms they owned in 2007. Dividend income and labor earnings are summed across the owner's firms. I drop owners who in 2007 held shares in both treated and control firms, or in firms in both BC and other provinces. I estimate an owner-level version of equation (6). Dividend income is zero for many owner-years, because only about a quarter of firms pay dividends in a given year (Section 4.3). A log specification would drop these observations, so I estimate total income, dividend income, and labor earnings by Poisson pseudo-maximum likelihood, which keeps the zeros,

$$E[Y_{it}] \;=\; \exp\Bigg(\sum_{\tau=2002}^{2014} \beta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_i \cdot BC_i \;+\; \sum_{\tau=2002}^{2014} \theta_\tau \, \mathbb{1}(t=\tau) \cdot Treated_i \\ +\; \sum_{\tau=2002}^{2014} \gamma_\tau \, \mathbb{1}(t=\tau) \cdot BC_i \;+\; \alpha_i \;+\; \delta_t \Bigg), \tag{10}$$

where Y_{it} is the income of owner i in year t, $Treated_i$ and BC_i indicate that the owner's firms in 2007 are fossil-fuel-intensive and located in BC, α_i is an owner fixed effect, and δ_t is a year fixed effect. Ownership share is estimated by OLS with the same terms. Standard errors are clustered by owner. The reported effect is the average of the post-2008 coefficients over 2008–2014, as in equation (7).

Table L1 reports the average post-2008 effects. None of the four estimates is statistically significant. The point estimates are -0.9% for total income, 18.1% for dividend income, and -7.2% for labor earnings, and ownership share does not change.

Table L1: Owner Income: Average Post-2008 Effect

	(1) Total Income	(2) Dividend Income	(3) Labor Earnings	(4) Ownership Share
Prov × Treated × After	-0.009	0.181	-0.072	0.000
	(0.050)	(0.118)	(0.049)	(0.020)
Observations	590,150	590,150	590,150	590,150

Note: Coefficients are the average of the seven post-2008 (2008–2014) event study coefficients from equation (10). Standard errors in parentheses account for the full covariance structure of the underlying estimates and are clustered by owner. Columns (1) to (3) are estimated by Poisson pseudo-maximum likelihood and are read as approximate percentage effects. Column (4) is estimated by OLS and is in percentage points. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

M Threats to Identification

M.1 Environmental Policy in Other Provinces

In October 2007, Quebec also implemented a carbon tax. However, it charged $3.5 per tonne of CO_2-equivalent, which implied a modest increase of ¢0.8/l in the gasoline price (Sumner et al., 2011). Subsequently, the carbon tax was replaced by a cap-and-trade system in 2013. Alberta also implemented the Specified Gas Emitters Regulation (SGER) strategy in 2007, which required facilities emitting more than 100,000 tonnes of CO_2 per year to reduce their emissions by 12 percent. As part of the program, there were different compliance options, such as a carbon tax on every tonne of CO_2 that exceeded the target and purchasable emission-performance and offset credits (Dobson & Winter, 2015). My main estimations include both Alberta and Quebec in the control group. Because environmental regulations were implemented in these provinces simultaneously with the carbon tax in British Columbia, firms there could be affected by the regulations and might not be suitable controls for the estimations. As a robustness check, I verify that the results are similar when Alberta and Quebec are excluded from the sample.

M.2 Input-Output Links between Treated and Control Industries

A concern arises if the assumption of limited pass-through does not hold. If treated firms raised their prices, control industries that buy their inputs would face higher costs, which would also violate SUTVA. This appendix describes how I identify the control industries most exposed to this spillover and exclude them from the control group.

Table M1 lists the control industries that are closely linked to fossil-fuel-intensive industries through input-output flows. I build it from the 2007 national symmetric input-output tables of Statistics Canada at the Link-Public level (Statistics Canada, 2007). I use the domestic flows table, which reports, in thousands of dollars, the value of output that each industry sells to every other industry.

The construction follows three steps. First, I match each fossil-fuel-intensive industry to its corresponding industry in the input-output tables. Some input-output industries combine fossil-fuel-intensive and less fuel-intensive NAICS industries. For example, the wood products industry (3210) contains both sawmills (3211), which are fossil-fuel-intensive, and other wood products (3219), which are not. I treat every input-output industry that contains at least one fossil-fuel-intensive industry as fossil-fuel-intensive. Therefore, the shares below are an upper bound on the true links.

Second, I compute two shares for each control manufacturing industry. The first is the purchase share. It is calculated as the value of inputs the control industry buys from fossil-fuel-intensive industries divided by its total intermediate purchases. A high purchase share means the control industry would face higher input costs if fossil-fuel-intensive firms raised prices to pay for the tax. The second is the sales share. It is the value of output the industry sells to fossil-fuel-intensive industries divided by its total output. A high sales share means the industry would lose demand if fossil-fuel-intensive firms contracted.

Third, I exclude from my sample every industry of the control group whose purchase share or sales share exceeds 10%. I map these input-output industries back to their 4-digit NAICS industries to drop the corresponding firms. Thirteen input-output industries meet this criterion. Eleven of them are linked only through their purchases. Two, converted paper products and miscellaneous chemical products, are also linked through their sales. The input-output tables are national, so the shares measure links between industries across Canada and are a proxy for BC.

Table M1: Control Industries Linked to Fossil-Fuel-Intensive Industries

IO code	Industry (NAICS)	Purchase share (%)	Sales share (%)
3222	Converted paper products (3222)	17.1	13.6
3363	Motor vehicle parts (3363)	15.8	0.8
3365	Railroad rolling stock (3365)	15.4	0.1
3362	Motor vehicle bodies and trailers (3362)	15.2	0.7
312A	Soft drinks and ice (3121)	14.4	0.4
3370	Furniture and related products (3371, 3372, 3379)	14.3	0.6
3352	Household appliances (3352)	12.9	0.7
3366	Ships and boats (3366)	11.8	1.5
3330	Machinery (3331–3339)	11.5	1.8
335A	Electrical equipment and components (3351, 3353, 3359)	11.3	2.7
3150	Clothing (3151, 3152, 3159)	11.2	1.7
325A	Miscellaneous chemical products (3255, 3256, 3259)	11.1	10.6
3261	Plastic products (3261)	10.5	5.5

Note: Control manufacturing industries whose purchases from, or sales to, fossil-fuel-intensive industries exceed 10% of their total purchases or output. The purchase share is the value of inputs an industry buys from fossil-fuel-intensive industries divided by its total intermediate purchases. The sales share is the value of output it sells to fossil-fuel-intensive industries divided by its total output. Both shares count every input-output industry that contains at least one fossil-fuel-intensive 4-digit NAICS industry. Source: Statistics Canada, National Symmetric Input-Output Tables, Link-Public level, 2007, domestic flows.

M.3 Other Regulations in British Columbia

In 2010, the Harmonized Sales Tax (HST) was implemented in British Columbia and Ontario. Before the reform, BC had the Goods and Services Tax (GST). It was a value-added tax applied to most goods and services sold in Canada and was charged at 5% of the sale price. It included the motor fuel tax and carbon tax. Additionally, BC had the Provincial Sales Tax (PST), which was 7% on the purchase price of goods and services. The PST did not apply to motor fuels such as gasoline, ethanol, diesel, and biodiesel when used in motor vehicles, but it was charged on intermediate goods. Since July 2010, the HST replaced the GST and PST. The point-of-sale rebate of the HST worked similarly to a PST exemption. For motor fuels, the motor fuel tax and carbon tax were applied plus 5% HST on the sale price, including taxes. For other fuels, the carbon tax was applied on the volume of the fuel plus 12% HST on the fuel price. I argue that the HST implementation did not differentially affect high and low fossil fuel-intensive industries. First, it did not change the fossil fuel charges due to the continuation of PST exemptions. Second, the PST was reduced to zero for all intermediate inputs, including those for both high and low fossil fuel-intensive industries.

On the other hand, the motor fuel tax on clear gasoline and clear diesel is composed of provincial and dedicated taxes. The provincial tax varies by region and its proceeds go to general revenue. The dedicated taxes apply in certain regions of BC. They go to the South Coast British Columbia Transportation Authority (TransLink), the British Columbia Transit Authority, and the British Columbia Transportation Financing Authority (BCTFA). The tax designated for the South Coast BC increased from ¢12/L in 2005 to ¢15/L in 2010 and ¢17/L in 2012, while the BC Transit Authority tax remained at ¢2.50/L from 2003 through 2008. The BCTFA tax remained stable at ¢6.50/L during the observed period of time. Because the changes in the motor fuel tax coincided with the introduction of the carbon tax, they could confound the estimates. However, as mentioned earlier, the carbon tax raised gasoline prices by less than 5% of the total price (Appendix Table A2), and more than 60% of fossil fuel expenditure was on natural gas (Section 4.3). It is therefore unlikely that the estimated effects are driven by the motor fuel tax.

M.4 Other Regulations in Canada

In 2006, the government modified Canada's accelerated capital cost allowance (CCA)[38] to incentivize investment in efficient and renewable energy generation. In particular, class 43.2 was introduced, an amendment that changed the CCA rate for highly efficient fossil fuel and clean energy generation from 30 percent to 50 percent. The new rates applied to equipment acquired after February 22, 2005, and before 2012 (Natural Resources Canada, 2019). The objective of the CCA rate change was to contribute to the reduction of GHG emissions and a more diversified energy supply. Therefore, high fossil fuel-intensive industries probably had more incentives to improve their technology and replace fossil fuels to get financial benefits. However, the possible effects of this policy do not affect the results of my estimations since it was implemented at the national level, and the triple-difference methodology removes the industry-specific shocks experienced by my treatment group during the studied period.

M.5 Compositional Change and Spillover Effects

Once the carbon tax is implemented, some firms could be forced to close due to increased marginal costs. Consequently, the closure of these firms could release capital and labor that may be acquired or hired by control firms, leading to an increase in their production and growth in size. However, the extensive-margin results in Appendix E show that this compositional concern is unlikely to be quantitatively important. Treated BC firms exit the sample by less than 5 percentage points more than their counterparts, and this difference is not statistically significant on average.

[38] Taxpayers can deduct CCA in relation to the capital cost of depreciable property when calculating their taxable income.