# Comparing Provincial Carbon Emission Regulation Policies in Canada: Impacts on Greenhouse Gas Emissions, Production, and Labor Measures

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## ABSTRACT

Carbon emissions regulation policies have been instituted in several regions in the last 35 years to force firms to reduce emissions but have been accused of being ineffective or reducing economic growth. This research utilizes a difference-in-differences (DID) model with two-way fixed effects to explore how carbon taxes, cap-and-trade systems, and baseline and credit systems instituted across 13 Canadian provinces from 2004-2022 impact emissions and economic outcomes (GDP, employment, hours worked, and earnings). Estimates demonstrate that carbon taxes have slight negative effects on GDP and earnings, while cap-and-trade systems have no effects on economic outcomes. Both policies effectively target the highest-emitting economic sectors and the most emission-intensive industries. Cap-and-trade systems are more effective at this than carbon taxes, while also allowing for economic growth in less emission-intensive industries and reducing emissions directly rather than through decreased economic activity.

## POLICY

Carbon policies impose a monetary penalty on carbon emissions, disincentivizing carbon-intensive processes. Since 2007, every Canadian province has instituted a carbon policy. There are three types: carbon taxes are added to the price of fossil fuels based on carbon content; baseline and credit systems (credit systems) add a price on emissions emitted above a "baseline" level; cap-and-trade systems cap total emissions in a jurisdiction and firms who emit less than their allocated/purchased amount can earn credits and trade them.

Credit systems are almost always instituted in conjunction with carbon taxes. In 2019, a federal carbon policy system was implemented that most provinces adopted, a combination of a carbon tax and credit system. Figures 1 and 2 show yearly carbon policy rates by province beginning in 2004.

**Figure 1: Carbon Tax Rates by Province**

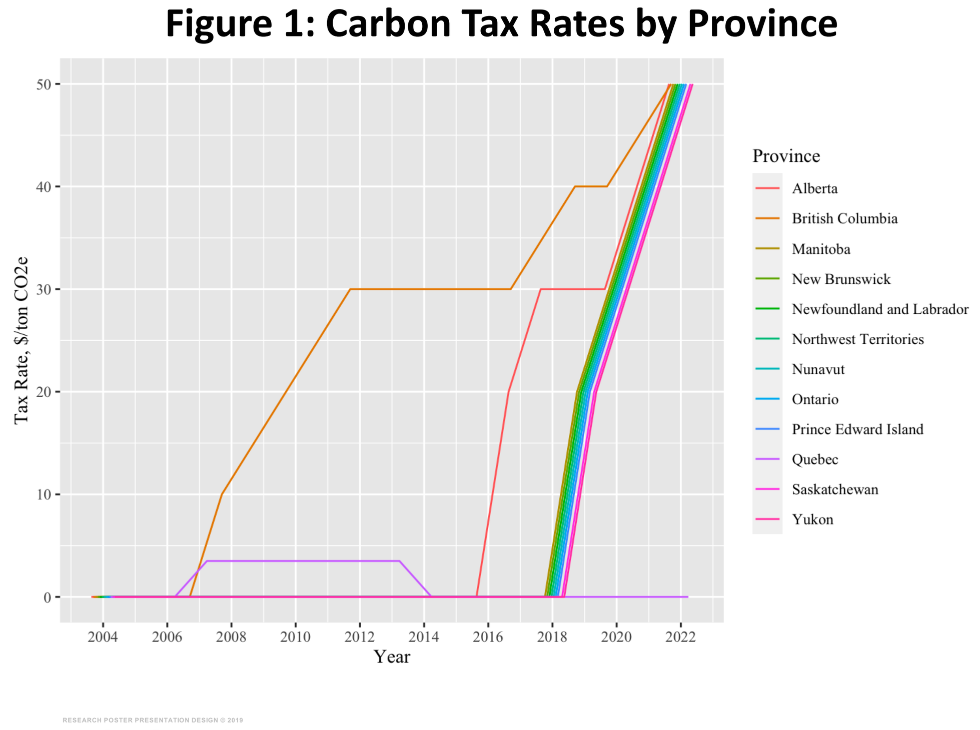
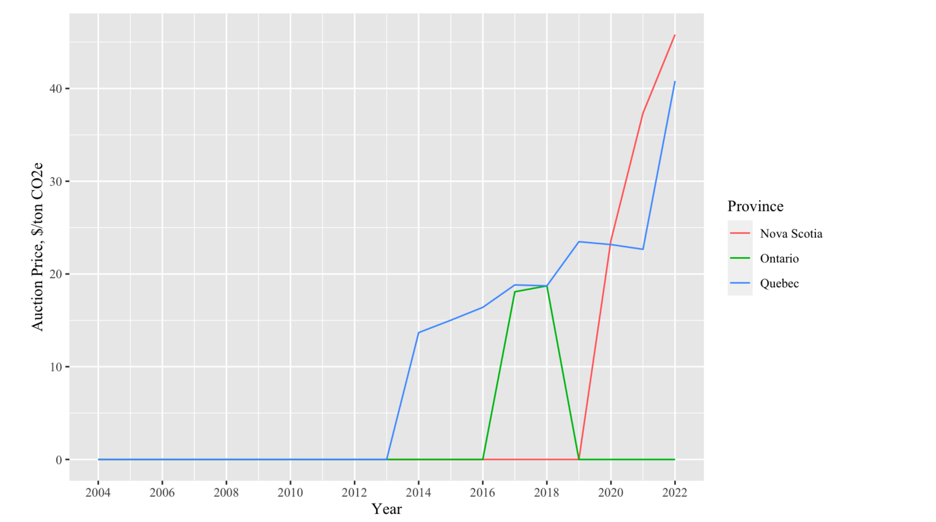



**Figure 2: Cap-and-trade System Auction Prices by Province**




## DATA

Primary data is collected from Statistics Canada. Outcome variables include greenhouse gas (GHG) emissions, GDP in 2012 dollars, number of paid workers jobs, hours worked of paid workers, and earnings for paid work. Industry characteristics include GHG emission intensity, energy intensity, and percent innovations that reduce GHG emissions. Control variables include total and working age population.

The chosen time range is 2004-2022. All data is merged at the province, industry, and year levels, though industry characteristics are only merged by industry and year and control variables by province and year. Industries are classified by NAICS codes.

## THEORETICAL FRAMEWORK

The theoretical framework assumes the economic agents (firms) are profit-maximizing and cost-minimizing, and can adjust levels of labor, capital, and emissions inputs accordingly. Each input also has a corresponding price; carbon policy rates represent the price on emissions.

Carbon policies can cause firms to change input levels through four channels. The *direct cost channel* reduces overall economic activity. The *energy-labor substitution channel* replaces emissions-producing inputs with labor. The *energy-capital substitution channel* replaces emissions-producing inputs with investment into sustainable energy technologies and/or less carbon-intensive inputs. The *redistributive effect* is when the government redistributes carbon policy revenues through tax credits or subsidization of firms using sustainable technologies. The effects of each channel on economic outcomes is displayed in Table 1.

**Table 1: Channels of Reducing Emissions**

| Channel | Emissions | Production | Employment | Innovations |
|---|---|---|---|---|
| Direct cost | ↓ | ↓ | ↓ | — |
| Energy-labor substitution | ↓ | — | ↑ | — |
| Energy-capital substitution | ↓ | — | — | ↑ |
| Redistributive | — | — | — | — |

## EMPIRICAL MODEL

The baseline empirical model is a DID model with two-way fixed effects. This model can compare changes in outcomes before and after policy enactment for many provinces with different enactment times. The baseline model is presented in the following equation:

$$Y_{jpt} = \gamma P_{pt} + \beta Z_{pt} + \sigma_j + \varphi_p + \theta_t + \epsilon_{jpt}$$

$Y_{jpt}$ represents an outcome variable; each outcome is logged. The policy treatment variable $P_{pt}$ indicates presence of a policy (binary) in a province and year. $\gamma$ represents the percent change in the outcome variable caused by presence of a policy. $Z_{pt}$ includes controls (population variables). $\sigma_j$, $\varphi_p$, and $\theta_t$ are industry, province, and time fixed effects, respectively.

The baseline model can be modified to demonstrate the effects of the policies by economic sector. The equation below demonstrates this model, in which is $P_{pt}$ interacted with $S_j$, a categorical variable indicating the sector of an industry. $\gamma_S$ represents the percent change in outcome caused by a carbon policy for sector $S$.

$$Y_{jpt} = \sum_{S=1}^{n_S} \gamma_S (P_{pt} * S_j) + \beta Z_{pt} + \sigma_j + \varphi_p + \theta_t + \epsilon_{jpt}$$

The policy variable can also be interacted with emission intensity and other industry characteristics to show the heterogeneous effects of the policy by industry emission intensity. In the equation below, $M_{j,t-2}$ is a lagged industry condition from two years prior. $\gamma_3$ is the percent change in outcome when a carbon policy is present from a one-unit increase in the lagged industry condition.

$$Y_{jpt} = \gamma_1 P_{pt} + \gamma_2 M_{j,t-2} + \gamma_3 (P_{pt} * M_{j,t-2}) + \beta Z_{pt} + \sigma_j + \varphi_p + \theta_t + \epsilon_{jpt}$$

A mediating model is created from the previous model which can show the direct and indirect effect of the policy on emissions. The indirect effect is emission reductions caused by the policy reducing economic outcomes, rather than directly from the policy itself.

## RESULTS

Table 2 shows $\gamma$ values from the baseline empirical model for each policy simultaneously. All three policies negatively affect emissions, but not significantly. Carbon taxes negatively affect GDP and earnings, but for the most part, none of the policies significantly affect economic outcomes. Since credit systems are usually implemented with carbon taxes, we focus on comparing carbon taxes and cap and trade systems going forward.

**Table 2: Outcome Variables Regressed on Carbon Policies**

| Logged outcome variables: | Emissions | GDP (2012 dollars) | Paid jobs | Hours worked | Earnings |
|---|---|---|---|---|---|
| Carbon tax | -0.047 (0.047) | -0.051* (0.030) | -0.029 (0.024) | -0.032 (0.024) | -0.094*** (0.025) |
| Cap-and-trade system | -0.050 (0.050) | -0.031 (0.039) | -0.007 (0.032) | -0.004 (0.033) | -0.054 (0.033) |
| Credit system | -0.035 (0.058) | 0.030 (0.036) | 0.022 (0.027) | 0.025 (0.028) | 0.059** (0.029) |

*** p<0.01, ** p<0.05, * p<0.1

**Figure 3: Effects of Carbon Policy Presence by Sector**

(a) Carbon tax (b) Cap-and-trade system

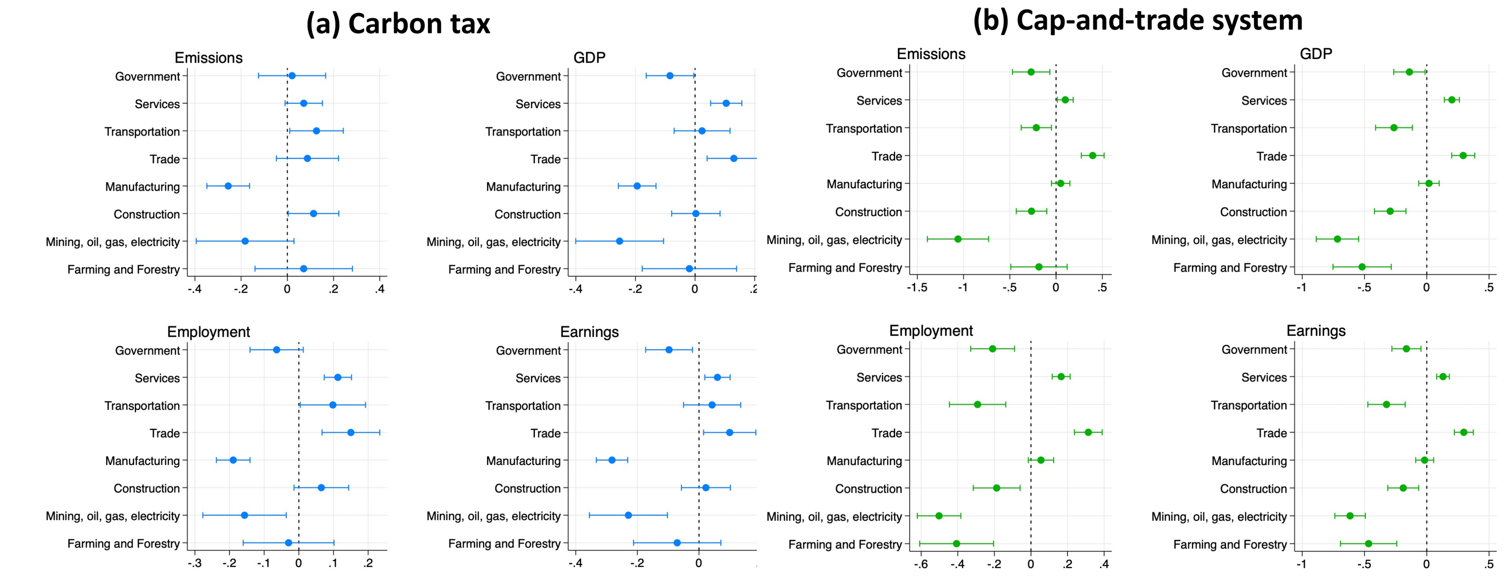



Figure 3 shows the effect of each policy on each sector separately. Sectors that see negative impacts on emissions also see negative impacts on economic outcomes, and vice versa. The carbon tax reduces emissions and economic activity in Manufacturing and Mining, Oil, Gas, and Electricity (highest emitting sectors). Cap-and-trade systems negatively impact outcomes for more sectors. For both policies, Services and Trade (low-emitting and large economic sectors) see positive effects.

**Figure 4: Marginal Effects of Carbon Policy Presence by Emission Intensity**

(a) Carbon tax (b) Cap-and-trade system

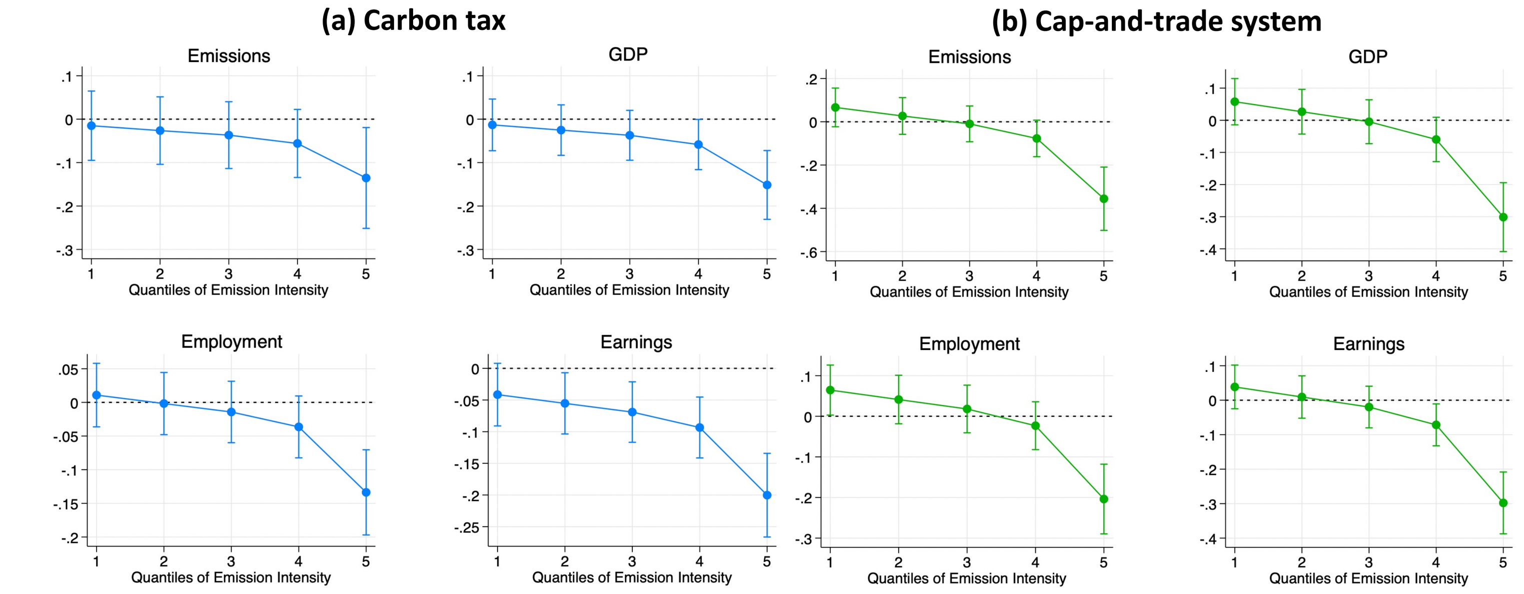



Figure 4 shows the impacts of each policy for various quantiles of emission intensity. For both policies, more emissions-intensive industries experience lower emissions and economic outcomes than less emissions-intensive industries. However, only cap-and-trade systems see economic growth in less emissions-intensive industries (coefficients above zero).

The mediating model (results not displayed) shows that carbon taxes mainly reduce emissions through reduction of economic activity (GDP, jobs, hours worked, earnings). Cap-and-trade systems reduce more emissions directly, not giving up as much in economic activity to achieve the policy goal.

## CONCLUSION

This research finds that carbon policies generally do not hurt the economy, though carbon taxes do negatively impact GDP and earnings. Carbon policies negatively impact overall emissions, though not at significant levels. When comparing carbon taxes with cap-and-trade systems, it is clear cap-and-trade systems are more effective – they do not significantly hurt the overall economy, they are better at targeting emissions in more sectors, they reduce emissions in more emissions-intensive industries while also allowing for economic growth in less emissions-intensive industries, and they reduce more emissions directly rather than through downsizing of economic activity. Cap-and-trade systems are more reliable policies that will allow the economy to thrive and shift away from fossil fuels while limiting pollution.