# The Economic Effects of Carbon Tax Policy in British Columbia

by

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# Abstract

This study examines the impact and underlying mechanisms of carbon tax policy on employment in British Columbia using data for 10 Canadian provinces spanning from 1997 to 2021 and a Difference-in-Difference (DiD) model. Our findings reveal that under reasonable carbon tax rates, the imposition of such taxes stimulates increased investment in clean technology research and development by enterprises, leading to a significant reduction in carbon emissions. However, the influence on economic development appears to be statistically insignificant. Moreover, the rate of adjustment in carbon tax rates plays a pivotal role in achieving sustainable economic growth. As a result, to attain a steady-state economy under carbon emission constraints, policymakers should consider a balanced approach to carbon tax rate adjustments.

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# 1. Introduction

## 1.1 Background

Climate change stands as a paramount global challenge of the 21st century, with overwhelming scientific consensus attributing it to the emissions of greenhouse gases (GHGs) that induce global warming (Maslin, 2021). The concept of greenhouse gas pollution emerges as a classic negative externality, with its social costs often omitted from private emitters' calculations. This omission begets market distortions in the absence of effective policies, resulting in excessive pollution and severely affecting people’s lives.

Therefore, reducing carbon emissions has become a hot topic of close concern for nations and the public. To address this problem, economists advocate for carbon pricing mechanisms, such as carbon taxes and cap-and-trade systems, which have proven effective in reducing emissions. Notably, British Columbia (BC)’s carbon tax has emerged as a global model due to its significant environmental impact.

## 1.2 Research Significance

### 1.2.1 Theoretical Significance

Although the achievements of BC's carbon tax policy in emission reduction are widely recognized, concerns about its potential negative effects have also arisen. Taxation directly leads to a decrease in disposable income for residents, thereby impacting the economy in various ways. These concerns were first raised in Europe half a century ago. However, due to different industrial structures and economic policies in different regions,

economists have not reached a consensus on the economic consequences of carbon taxes. Through elasticity theory and the supply and demand model, this article analyzes the impact pathways of carbon taxes on the labor market, providing theoretical support for the impact of carbon taxes on the labor market. By selecting British Columbia as the research subject and through empirical research, this paper enriches the research findings in this field.

### 1.2.2 Practical Significance

While reducing carbon emissions, we must also ensure that the economy operates normally to achieve sustainable development. If the carbon tax leads to mass unemployment, it will face strong opposition, making it politically difficult to implement. Secondly, the implementation of carbon tax policy will lead to changes in the industrial structure. Understanding how different industry labor markets react to carbon taxes will help predict economic growth and plan future labor market needs, thereby helping policymakers design more effective and socially acceptable policies to minimize the adverse effects of carbon taxes.

## 1.3 Research Methods

Theoretical analysis is based on partial equilibrium theory and the theory of firm behavior decisions using Shephard's Lemma fundamentally analyzing the impact pathways of carbon taxes on the labor markets of different industries. In terms of empirical analysis, this reports uses the Difference-in-Differences method. By comparing the changes in outcomes over time between the treatment group and the control group,

the treatment effect is estimated. This method is particularly suitable for policy effect evaluation, and by adding control variables, it effectively isolates other influencing factors to assess policy impacts.

### 1.4 Report Structure

Using panel data from 10 provinces and 19 industries in Canada, this report analyzes the impact of carbon taxes on the employments of different industries. The report is structured as follows:

The first section is the introduction. It introduces the research background, discusses the significance of the problem, outlines the research methods, and presents the structure of the report. Section 2 is the literature review. It synthesizes existing research related to carbon tax impacts, focusing on labor markets and industrial responses, setting the stage for the empirical investigation. Section 3 presents the theoretical framework for formulating hypotheses about how carbon taxes influence labor demand across different sectors. For example, it hypothesizes that industries with higher carbon intensity may experience greater employment declines due to increased operational costs. Section 4 contains the empirical analysis: applying the Difference-in-Differences method, this section assesses the impact of carbon tax variations on employment across industries. The analysis distinguishes between treated provinces subjected to higher carbon tax rates and control regions with lower rates, controlling for other economic factors.

Finally, Section 5 draws conclusions from both theoretical insights and empirical findings, offering policy recommendations to optimize carbon tax strategies in Canada, focusing on minimizing job losses while achieving environmental objectives.

# 2. Literature Review

Climate change remains one of the most pressing challenges of our time. As global temperatures rise and ecosystems are disrupted, the consequent socioeconomic implications demand meticulous examination. Economists and policymakers have sought to understand these implications to introduce effective policy design. This literature review provides a comprehensive overview of the history of Canada's carbon tax policy, seminal economic theories related to carbon pricing, and empirical research on this important topic.

## 2.1 Carbon Tax Development in Canada

In 2018, the federal government of Canada passed the Greenhouse Gas Pollution Pricing Act (GHGPPA), which establishes a set of minimum national standards for carbon pricing in Canada in order to meet the Paris Agreement's goal of limiting global temperature rise to less than 2°C. In 2019, the GHGPPA initially sets the price of carbon emissions at CAD 20.00 per tonne of carbon dioxide, with plans to gradually increase it by 2025 to CAD 95.00, a federal framework that allows provinces the flexibility to tailor their carbon pricing programs to local circumstances while adhering to a minimum emissions price.

In stark contrast to broader national policies, British Columbia has been at the forefront of carbon tax collection, implementing North America's first comprehensive carbon tax in 2008. Starting at a modest CAD 10.00 per tonne, the carbon tax increased by CAD 5.00 per tonne per year, stabilizing at CAD 30.00 per tonne in 2012. This tax rate was maintained at this rate until 2018. As of April 1, 2023, the tax rate was CAD 65.00 per

tonne, covering approximately 75% of the province's GHG emissions. Notably, B.C.'s carbon tax takes a revenue-neutral approach, mitigating any adverse economic impacts of the tax on the public by redistributing all the proceeds through tax reductions or direct transfers to households and businesses. This strategy has not only fostered public acceptance but has also led to significant environmental successes.

The success achieved in British Columbia has influenced other Canadian provinces and even international carbon pricing policies. For example, Alberta implemented a carbon tax and emissions trading program for large industrial emitters, which was later enhanced to incorporate a broader carbon pricing model (Leach 2012).

These carbon tax policies in Canada and British Columbia have helped reduce per capita carbon emission. In British Columbia, per capita emissions were reduced to 12.5 tons by 2020, 32% below the national average, demonstrating the potential efficacy of well-implemented carbon pricing on emission reductions. However, the overall impacts on economic performance, social welfare, and industrial competitiveness need to be assessed to optimize the policy framework to ensure sustainable economic and environmental health (Murray and Rivers, 2015).

### 2.2 Review of Theoretical Approaches to Carbon Tax Employment Effects

The theoretical origins of environmental regulation can be traced back to the early 20th century with the introduction of the Pigouvian tax by economist Arthur Cecil Pigou. Pigouvian taxes are designed to correct market failures by imposing a tax on economic activities that generate societal costs. Pigou proposed using economic incentives to address environmental pollution, laying the groundwork for later environmental

economic policies. Carbon tax, a typical form of Pigouvian tax, aims to reduce carbon emissions by increasing the cost of fossil fuels, thereby encouraging businesses and consumers to reduce emissions and foster innovation in environmental technologies.

Environmental economics identifies two primary market-based mechanisms for controlling carbon emissions: carbon taxes and tradeable emission permits. Carbon taxes, a price-based tool, directly increase the cost of emissions, aiming to influence the decision making by businesses and consumers and thus reduce emissions. In contrast, carbon emissions trading is a quantity-based tool that seeks the most cost-effective way to reduce emissions by setting an emissions cap and allowing the market to trade emission rights freely. Compared to emissions trading, carbon taxes have lower administrative costs and provide more predictable environmental benefits, making them advantageous in promoting social equity and economic efficiency.

The literature primarily employs three theoretical models to analyze the employment effects of carbon taxes. Berman (2001) used a partial equilibrium model, defining environmental regulation as a "quasi-fixed factor" from a neoclassical microeconomic perspective. Incorporating this factor into the production function and applying Shepard's Lemma, Berman derived the induced demand for labor and thus the impact mechanism of environmental regulation on employment.

Stokey (1998) utilized the Cobb-Douglas production function within the endogenous growth model framework to analyze how environmental pollution intensity as a production cost factor impacts firms' production costs. By maximizing firm profits, Stokey derived the labor demand function and its dependency on regulatory intensity.

Lastly, Copeland and Taylor (2004) considered pollution emissions as a variable production factor, analyzing the impact of regulatory costs as factor prices. Using the Lagrangian function and Shepard's Lemma, they derived the factor demand functions and price elasticity, thereby determining the substitution effects at a given output level and the scale economic effects under profit maximization conditions.

This study derives the labor demand response to carbon tax policy using a partial equilibrium model. Considering the revenue-neutral nature of BC's carbon tax, it incorporates consumers as market participants in the model to better represent the employment effects of carbon tax in BC.

Carbon regulations have surfaced as an influential lever in addressing climate change. As regions worldwide adopt varying intensities and styles of carbon regulations, it becomes indispensable to dissect their economic ramifications. Scholars have extensively employed diverse modeling techniques to chart out these impacts.

The infusion or alteration of carbon regulations in an economy elicits immediate market responses. Parry et al. (2009) navigated the complex landscape of carbon taxes, documenting how, in the short term, industries—especially those that are energy-intensive—adjust. Their findings paint a nuanced picture: while some sectors grapple with immediate challenges owing to escalated operational expenses, others discern growth vistas, notably in the realms of renewable energy and energy efficiency.

However, the carbon regulatory landscape isn't without its challenges. Carbone & Rivers (2017) brought to the fore the phenomenon of "carbon leakage"—a scenario where industries migrate to jurisdictions with relaxed regulations. Such movement could result in a mere reshuffling of emissions globally, coupled with economic strains on regions with rigorous carbon protocols.

Over the long haul, carbon regulations sculpt economic trajectories in profound ways. Aldy & Pizer (2015) steered the discourse towards long-term impacts, particularly on competitiveness and productivity. While certain sectors might wade through challenges, innovation driven by these regulations could stimulate productivity surges in others. Additionally, Chan et al. (2012) posited that structural shifts in economies can usher in "green jobs", potentially counterbalancing job deficits in traditional carbon-heavy sectors.

Yamazaki (2017) deepened this discourse by probing into the intricate dynamics of employment in the wake of carbon regulations. It's evident that transitions could be taxing, especially for regions steeped in carbon-intensive industries.

The economic tapestry of carbon regulations is further complicated when global trade dynamics enter the fray. Fankhauser et al. (2016) unveiled the potential of "border carbon adjustments" to equilibrate disparities among countries with stringent regulations and those lagging. While such adjustments can be efficacious, they are not devoid of potential pitfalls, including spawning trade disagreements.

## 2.3 Review of Empirical Approaches to Analyzing Carbon Tax Employment Effects

In alignment with our chosen theoretical basis of partial equilibrium, the empirical analysis of carbon tax effects on employment is analyzed accordingly. Most empirical studies on Canada's carbon pricing system primarily utilize two methods: Difference-in-Differences (DiD) and Computable General Equilibrium (CGE) models. For instance, Yamazaki (2017) employed the DiD method with firm level data to investigate the impact of a revenue-neutral carbon tax on employment in British Columbia. The study found that although the carbon tax increased costs for carbon-intensive industries, the tax revenue recycling mechanism mitigated its negative impact on employment. Although due to due to data availability, he used national-level data for carbon emission intensity, which may introduce biases. Rivers (2015) analyzed the differential response to the carbon tax across Canadian provinces in the gasoline market using the DiD method. The results indicated that consumers are more sensitive to prominently labeled carbon taxes, which has important implications for designing more effective carbon tax policies. Dissou (2014) used a CGE model to assess the economic impact of Canada’s carbon tax and its effects on different income groups. The study concluded that through well-designed tax revenue recycling mechanisms, carbon taxes can achieve both economic benefits and progressive qualities, reducing adverse impacts on low-income households. CGE models, considering the simultaneous equilibrium of multiple sectors and markets, are generally regarded as capable of providing a comprehensive system simulation of economic changes. However, CGE models also have limitations: they assume the economy is already in general equilibrium, and the accuracy of CGE models is influenced by the researcher's subjective design of economic agents' behavior. Furthermore, when

analyzing the connection between the experimental and control groups, CGE typically treats them as wholes, leading to biases in model settings.

The Difference-in-Differences (DiD) method is a robust econometric approach that estimates the impact of policies by comparing the differences between a treatment group and a control group. Compared to other methods, the DiD method can control for unobserved confounding factors that may affect the groups. This is crucial in policy evaluation, particularly for carbon taxes, as economic and environmental conditions can vary significantly across regions. By examining changes within the same group over time, the DiD mitigates the bias that these unobserved factors might introduce (Wing, Simon, & Bello-Gomez, 2018). Additionally, the DiD estimates are robust to external shocks, allowing researchers to more confidently attribute differences in outcomes to the policy itself rather than to other external factors (Lechner, 2011). The DiD model also includes various variants, such as Triple Differences (Meyer, Viscusi, & Durbin, 1995), and the Synthetic Control Method (Abadie, Diamond, & Hainmueller, 2010), which provide additional robustness checks. The DiD model as an empirical method has become the mainstream research direction. Therefore, this report selects the DiD for the empirical analysis.

# 3. Methodology

## 3.1 Theoretical Framework

In this section, we introduce the channels of a revenue-neutral carbon tax's impact on greenhouse gas emissions, labor and investment.

We assume perfect competitive markets and constant marginal cost, c. Under conditions of market clearance, price equal to marginal cost:

$$P_i = c_i(w, r, x) \tag{1}$$

where, i is the $i^{th}$ industry, *P* is the commodity price, *w* is wage, *r* is interest rate, *x* is energy price. With the market clearing condition, the quantity demanded equals the quantity supplied:

$$Q_i^d = Q_i^s \tag{2}$$

The total cost is:

$$C_i = Q_i^s c_i(w, r, x) \tag{3}$$

By Shephard's Lemma,

$$l_i^d = Q_i^s c_{wi} \tag{4}$$

Where $Q_i^S$ denotes quantity supplied in industry i and $c_{wi}$ denotes the labor force required to produce one unit of product in industry i.

Taking the logarithm on both sides of the equation and then solving for the derivative, we get:

$$\frac{dl_i^d}{l_i^d} = \frac{dQ_i^S}{Q_i^S} + \frac{dc_{wi}}{c_{wi}} \tag{5}$$

Similarly,

$$k_i^d = Q_i^S c_{ri} \tag{6}$$

$$\frac{dk_i^d}{k_i^d} = \frac{dQ_i^S}{Q_i^S} + \frac{dc_{ri}}{c_{ri}} \tag{7}$$

On the demand side,

$$Q_i^d = D_i(P_i, T) \tag{10}$$

Which $T$ is the amount of carbon tax levied, which is same for all industries. Since carbon tax is revenue-neutral, government will give back all the tax they levied to people, which will increase their income. Thus, *T* is treated as an income variable.

Taking the logarithm and total derivative on both sides we have:

$$\frac{dQ_i^d}{Q_i^d} = \frac{1}{D_i}\frac{\partial D_i}{\partial P_i}P_i\frac{dP_i}{P_i} + \frac{1}{D_i}\frac{\partial D_i}{\partial T}T\frac{dT}{T} \tag{11}$$

By rearrange the function, we have:

$$\frac{dQ_i^d}{Q_i^d} = \frac{\varepsilon_i^P dP_i}{P_i} + \frac{\varepsilon_i^T dT}{T} \tag{12}$$

Which $\varepsilon_i^P$ and $\varepsilon_i^T$ is the elasticity of demand with respect to price and income in industry i:

$$\varepsilon_i^P = \frac{P_i}{D_i}\frac{\partial D_i}{\partial P_i} \tag{13}$$

$$\varepsilon_i^T = \frac{T}{D_i}\frac{\partial D_i}{\partial T}$$

Totally differentiating Equation (1) and dividing through by $P_i$ , we have:

$$\frac{dP_i}{P_i} = \frac{wc_{wi}dw}{P_i w} + \frac{rc_{ri}dr}{P_i r} + \frac{xc_{xi}dx}{P_i x}$$

$$\frac{dP_l}{P_l} = \frac{wc_{wi}dw}{P_i w} + \frac{rc_{ri}dr}{P_i r} + \frac{xc_{xi}dx}{P_i x} \tag{14}$$

$c_{wi}$, $c_{ri}$, $c_{xi}$ represent the derivatives of the cost function with respect to labor, capital and carbon costs, respectively.

The change rate of imposed carbon tax amount $T$ depends on the rate of change in energy consumption $e$ and the change rate in the carbon tax rate $t$. Similar to our derivations above

$$\frac{dT}{T} = \frac{dt}{t} + \frac{de}{e} = \frac{dt}{t} + \frac{\varepsilon^e dx}{x} \tag{15}$$

The change rate of energy depends on the demand elasticity of energy and the rate of change of price. So, we introduce $\varepsilon^e$ to represent the demand elasticity of energy. Combining (12) (14) (15), we have:

$$\frac{dQ_i^d}{Q_i^d} = \varepsilon_i^P \left(\frac{wc_{wi}dw}{P_i w} + \frac{rc_{ri}dr}{P_i r} + \frac{xc_{xi}dx}{P_i x}\right) + \varepsilon_i^T \left(\frac{dt}{t} + \frac{\varepsilon^e dx}{x}\right) \tag{16}$$

Since the wage rate *w* and the interest rate *r* are determined by the markets, they are treated as exogenously determined under the assumption of perfect competition. Accordingly, $\frac{dw}{w} = \frac{dr}{r} = 0$. Let $\theta = \frac{xc_{xi}}{P_i}$ be the energy share in cost, combine (9) and (16), we have:

$$\frac{dQ^d}{Q^d} = \varepsilon_i^P \left(\frac{\theta dx}{x}\right) + \varepsilon_i^T \left(\frac{dt}{t} + \frac{\varepsilon^e dx}{x}\right) \tag{17}$$

By taking the total derivatives of both sides of $c_{wi}$ and dividing by $c_{wi}$, we obtain:

$$\frac{dc_{wi}}{c_{wi}} = \frac{c_{wwi}dw}{c_{wi}} + \frac{c_{wri}dr}{c_{wi}} + \frac{c_{wxi}dx}{c_{wi}} \tag{18}$$

Since we assume d*w*=d*r*=0, we have:

$$\frac{dc_{wi}}{c_{wi}} = \frac{c_{wxi}dx}{c_{wi}} = \frac{dx\theta P c_{wxi}}{x c_{wi} c_{xi}} = \frac{\varepsilon^s \theta dx}{x} \tag{19}$$

The amount of labor required to produce a unit of product depends on the price of labor and the price of other factors; an increase in the price of energy make the producer to increase the labor share in production of a unit of product and reduce the energy share, and the share of increased labor depends on the factor elasticity of substitution between labor and energy. Therefore, we define $\varepsilon^s = \frac{Pc_{wxi}}{c_{wi}c_{xi}}$ as the factor elasticity of substitution between labor and energy.

Combining (5), (17), (19), we have:

$$\frac{dl_i^d}{l_i^d} = \varepsilon_i^P \left(\frac{\theta dx}{x}\right) + \varepsilon_i^T \left(\frac{dt}{t} + \frac{\varepsilon^e dx}{x}\right) + \frac{\varepsilon^s \theta dx}{x} \tag{20}$$

Based on the theoretical framework, we can propose the hypothesis that carbon tax will affect employment rates with different industries to be affected differently.

### 3.2 Empirical Model Setting

From our theoretical framework, we can see that different industries respond differently to the carbon tax due to factors such as elasticity, and these factors include those that carry out impacts on all industries, such as income elasticity, and those that are only available to specific industries, such as the elasticity of substitution between energy and labor. Therefore, we can examine the effect of carbon tax on employment for different industries taking into account of the heterogeneity of the industries. To accomplish this, we decided to build a DID model as follows:

$$\ln(labor_{it}) = \beta_0 + \beta_1 treat_i + \beta_2 period_t + \beta_3 (treat_i * period_t) + \beta_{4i} X_i + \beta_{5i} (treat_i * period_t) X_i + e_{it}$$

Based on our theoretical framework, the carbon tax policy affects labor demand through various channels among which, some exhibit heterogeneous effects across specific industries, while others have general impacts on all industries.

Therefore, in our empirical analysis, we decompose the effects of the carbon tax into two categories: one representing the general impact on all industries, and the other reflecting the effects on specific industries. Where i represent industry type, t represent time, X is set of dummy variables, represents various industries classified by NAICS (North American Industry Classification System, clustered by 2-digit NAICS industry), treat is a dummy variable used to distinguish the treatment group and the control group, period is carbon tax policy (before the introduction of the policy, treat = 0, after policy introduced, treat=1), e is the error term. The labor demand is logged to measure the impact in percentage changes.

From the model we can see that the regression equation for a sector in BC before the introduction of the policy, such as agriculture, is:

$$\ln(labor_{BCpreagri}) = \beta_0 + \beta_1 + \beta_{4agri}$$

The regression equation for agriculture in other provinces before the introduction of the policy is:

$$\ln(labor_{otherpreagri}) = \beta_0 + \beta_{4agri}$$

The regression equation for agriculture in BC after the introduction of the policy is:

$$\ln(labor_{BCpostagri}) = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_{4agri} + \beta_{5agri}$$

The regression equation for agriculture in other provinces after the introduction of the policy is:

$$\ln\left(labor_{otherpostagri}\right) = \beta_0 + \beta_2 + \beta_{4agri}$$

The difference in labor growth rates between B.C. and other provinces before the introduction of the policy is:

$$\Delta\left(\ln\left(labor_{preagri}\right)\right) = \beta_1$$

After the policy, the difference is:

$$\Delta\left(\ln\left(labor_{postagri}\right)\right) = \beta_1 + \beta_3 + \beta_{5agri}$$

Then we can know the effect of the policy is:

$$\Delta\left(\ln\left(labor_{agri}\right)\right) = \beta_3 + \beta_{5agri}$$

where $\beta_3$ is the general impact of the carbon tax policy, while $\beta_{5agri}$ is the impact of the carbon tax policy on agriculture, other industries are similar.

# 4. Empirical Analysis

## 4.1 Model Interpretation and Data Summary

In this report, our dependent variable is ln ($labor$) represent by *lnem* in the model. *Treat* is a dummy variable indicating whether the region i has implemented a carbon tax. Specifically, for BC, this variable is assigned a value of 1, and for other regions, it is 0. *Period* is a dummy variable representing the time period, distinguishing between the periods before and after the implementation of the carbon tax. It is assigned a value of 0 before 2008. X is a set of industry dummy variables that control for the impact of different industries in each region. These variables help isolate the industry-specific factors affecting employment, ensuring accuracy of model. However, the employment rate is not only affected by the policy, but there are also several other factors that can affect the employment. If we use the above variables for regression only, it will lead to omitted variable bias. So, we added the growth rate of GDP, CPI, and the growth rate of population as control variables to reduce the omitted variable bias and to isolate the effects of carbon tax policies impact. The final empirical model is as follows:

$$\ln(labor_{it}) = \beta_0 + \beta_1 treat_i + \beta_2 period_t + \beta_3(treat_i * period_t) + \beta_{4i} X_i + \beta_{5i}(treat_i * period_t)X_i + \ln(GDP_{it}) + \ln(CPI_{it}) + \ln(population_{it}) + e_{it}$$

GDP is a comprehensive measure of economic activity within a region. By adding GDP into the model, we control the overall size and economic capacity, which inherently affects employment levels. Higher GDP generally indicates more business activities and potentially higher employment opportunities. We take logarithm of GDP. This

transformation helps in stabilizing variance and interpreting the GDP's impact in percentage terms, which is more intuitive and aligns with economic growth models.

CPI is a direct indicator of the purchasing power of consumers. The change of CPI is similar to inflation rate, which can represent the changes in cost of living and production. CPI could affect the real earning power of individuals and might influence labor market.

Population size is used as a proxy for labor force. The natural logarithm of population is used to model the potential labor supply available for employment, which directly impacts employment rates. Similarly, the logarithmic transformation helps addressing non-linear relationships between population size and employment.

Descriptive statistics of the data are as follows.

Table 4.1: Descriptive Statistics: 1997-2021

| Group | | lnem | GDP (*1000000) | CPI | Population |
|---|---|---|---|---|---|
| Overall | N | 4,750 | 4,750 | 4,750 | 4,750 |
| | Mean | 10.18 | 8,890.98 | 115.5132 | 3,367,246 |
| | Std.Dev | 1.66 | 14,395.63 | 15.79 | 3,966,261 |
| BC pre | N | 209 | 209 | 209 | 209 |
| | Mean | 11.17 | 9353.728 | 100.5 | 4,106,239 |
| | Std.Dev | 0.8096 | 5615.032 | 5.80 | 103,709 |
| BC post | N | 266 | 266 | 266 | 266 |
| | Mean | 11.37 | 12758.28 | 121.8 | 4,767,388 |
| | Std.Dev | 0.83 | 8861.198 | 7.47 | 283,232 |
| Rest of Canada pre- | N | 1881 | 1881 | 1881 | 1881 |
| | Mean | 9.99 | 7498.53 | 100.3 | 3,015,380 |
| | Std.Dev | 1.65 | 13490.57 | 7.47 | 3,842,548 |
| Rest of Canada post- | N | 2394 | 2394 | 2394 | 2394 |
| | Mean | 10.12 | 9514.95 | 128.04 | 3,423,625 |
| | Std.Dev | 1.70 | 15913.93 | 8.96 | 4,386,731 |

The descriptive statistics reveal variations in employment growth rates across different regions and periods. After the implementation of the carbon tax, British Columbia (BC) experienced a slight increase in employment growth rates, suggesting that the carbon tax may have had a positive impact on the local job market. However, the increase in variance indicates that the specific effects are not clear. Therefore, to accurately determine the impact and significance of the carbon tax, it is necessary to conduct further regression analysis using the Difference-in-Differences (DiD) model. This approach will help control for other potential confounding factors, ensuring the accuracy and reliability of the research findings.

### 4.2 Model Selection

In choosing between fixed effects and random effects model, I considered the nature of the data and the assumptions underlying the model and decided to use random effects model. The rationale behind opting for the random effects model stems from the nature of my analysis, which employs a Differences-in-Differences (DiD) framework spanning multiple periods. In this context, the inclusion of dummy variables representing categorical variables is imperative for capturing the effects of the treatment or intervention across different entities. However, due to the fixed effects model performs first order differencing in the process of within-group estimation, variables such as dummy variables, which do not change over time, are omitted. Since the dummy variables cannot be discarded due to their significance in the analysis, the fixed effects model becomes inadequate for my purposes. The final empirical model is set as follows:

$$\ln(labor_{it}) = \beta_0 + \beta_1 treat_i + \beta_2 period_t + \beta_3(treat_i * period_t) + \beta_{4i} X_i + \beta_{5i}(treat_i * period_t) X_i + \ln(GDP_{it}) + \ln(CPI_{it}) + \ln(population_{it}) + e_{ij}$$

### 4.3 Results

All data used are sourced from Statistics Canada. In the analysis, the province of British Columbia is treated as the treatment group, while the control group consists of all Canadian provinces except Quebec. This designation is because Quebec introduced a low-rate, revenue non-neutral carbon tax in 2007 and implemented an Emissions Trading System (ETS) in 2013 and partnered with the state of California to create a joint market the following year, whereas the other provinces did not adopt such policies. This leads to a parallel trend in Quebec with British Columbia.

The empirical results are as follows:

Table 4.2: Estimation Results for Carbon Tax Effect on Employment

| LN(EMPLOYMENT) | COEF | Z | P |
|---|---|---|---|
| TREAT | 0.0379 | 0.76 | 0.446 |
| PERIOD | 0.0105 | 1.38 | 0.167 |
| DID | -0.0186 | -0.39 | 0.700 |
| AGRICULTURE | -0.250*** | -3.68 | 0.000 |
| MINING | 0.320*** | 0.320 | 0.000 |
| UTILITIES | -0.121 | -1.78 | 0.076 |

| | | | |
|---|---|---|---|
| **CONSTRUCTION** | 0.224** | 3.29 | 0.001 |
| **MANUFACTURE** | -0.239*** | -3.52 | 0.000 |
| **WHOLESALE** | -0.0715 | -1.05 | 0.292 |
| **RETAIL** | 0.0283 | 0.42 | 0.677 |
| **TRANSPORTATION** | 0.0520 | 0.77 | 0.444 |
| **CULTURAL** | -0.0145 | -0.21 | 0.831 |
| **FINANCE** | -0.142* | -2.10 | 0.036 |
| **REAL-ESTATE** | -0.135* | -1.98 | 0.047 |
| **TECHNICAL** | 0.170* | 2.50 | 0.012 |
| **WASTE MANAGEMENT** | 0.131 | 1.93 | 0.054 |
| **EDUCATION** | 0.00889 | 0.13 | 0.896 |
| **HEALTH** | 0.131 | 1.93 | 0.054 |
| **ENTERTAINMENT** | 0.0482 | 0.71 | 0.478 |
| **ACCOMMODATION** | 0.122 | 1.80 | 0.072 |
| **OTHER** | 0.0628 | 0.92 | 0.355 |
| **LNGDP** | 0.433*** | 38.05 | 0.000 |
| **LNCPI** | -0.0811** | -3.00 | 0.003 |
| **LNPOPULATION** | 0.567*** | 32.99 | 0.000 |

| | | | |
|---|---|---|---|
| **CONSTANT** | -0.529* | -2.38 | 0.017 |

In Table 4.2, *ln*(*employment*) is the dependent variable, *did* represents the coefficient of *treat*period*, capturing the general effect of carbon tax. The other results in the table are coefficients of the interaction terms *treat*period*X*, which signify the specific effects for the corresponding industries.

From the table, we can see that the logarithm of GDP, CPI and population have a significant impact on employment. The coefficient of *did* is -0.0186 but insignificant, which represent the general impact of the carbon tax policy indicating that the BC carbon tax had no significant general effect on employment.

As for specific effect, we can see significant impacts of policies on agriculture (NAICS-11), mining (NAICS-21), construction (NAICS-23), manufacturing (NAICS-31-33), finance and insurance (NAICS-52), real estate and rental and leasing (NAICS-53), professional, scientific and technical services (NAICS-54).

In this case, the values of the coefficients on the interaction terms of agriculture, manufacturing, finance and real estate and leasing with treat*period are -0.250, -0.239, -0.142 and -0.135 respectively. The coefficient values of the interaction terms for mining, construction and professional, scientific and technical services and administrative are 0.320, 0.224 and 0.170 respectively. This is in line with our expectation that carbon taxes tend to have a negative effect for energy-intensive industries and achieve lower carbon emissions by facilitating the transfer of labor between industries.

However, the introduction of the policy did not negatively impact labor growth rates in the energy-intensive industries such as mining and construction. This is probably because these firms were possibly more responsive to the carbon tax, and therefore they might have increased their investments in clean technologies, and since technological innovations require increased labor to achieve, the overall impact is positive . In fact, as shown in Fig. 4.1 this is exactly what has happened: as labor productivity in both mining and construction in B.C. has continued to rise since 2013, after a brief period of relatively small declines in 2008.


Figure 4.1 Labor Productivity in BC's Mining Industry (Left) and Construction (Right)

### 4.4 Robustness Test

In the empirical process, we exclude data from Quebec since Quebec introduced a carbon tax policy in 2007, but at a very low and non-revenue-neutral rate, and that Quebec introduced an emissions trading system in 2013.

For the robustness test, we will add the Quebec data to the model estimation. We will perform three estimations; first, we set up Quebec as the treatment group. Next, we set Quebec as the control group. Finally, we set Quebec as the treatment group and exclude

BC. The comparison of the significance of the coefficients of the four groups allows us to analyze the robustness of the model. The estimation results are shown in Table 4.3.

Table 4.3: Estimating the Employment Effects of the Carbon Tax for Robustness check

| LN(EMPLOYMENT) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| TREAT | 0.0379 | 0.0240 | 0.0240 | 0.00552 |
| | (0.76) | (0.63) | (0.53) | (0.11) |
| PERIOD | 0.0105 | 0.00715 | 0.00710 | 0.00717 |
| | (1.38) | (1.01) | (1.00) | (0.96) |
| DID | -0.0186 | -0.00660 | -0.00638 | 0.00393 |
| | (-0.39) | (-0.20) | (-0.19) | (0.08) |
| AGRICULTURE | -0.250*** | -0.145** | -0.146** | -0.0418 |
| | (-3.68) | (-3.14) | (-3.14) | (-0.62) |
| MINING | 0.320*** | 0.281*** | 0.281*** | 0.240*** |
| | (4.71) | (6.06) | (6.06) | (3.59) |
| UTILITIES | -0.121 | -0.0612 | -0.0612 | -0.00127 |
| | (-1.78) | (-1.32) | (-1.32) | (-0.02) |
| CONSTRUCTION | 0.224** | 0.182*** | 0.182*** | 0.143* |
| | (3.29) | (3.92) | (3.92) | (2.14) |
| MANUFACTURE | -0.239*** | -0.198*** | -0.198*** | -0.158* |
| | (-3.52) | (-4.26) | (-4.26) | (-2.35) |
| WHOLESALE | -0.0715 | -0.0830 | -0.0830 | -0.0924 |
| | (-1.05) | (-1.79) | (-1.79) | (-1.38) |
| RETAIL | 0.0283 | 0.0325 | 0.0325 | 0.0391 |
| | (0.42) | (0.70) | (0.70) | (0.58) |
| TRANSPORTATION | 0.0520 | -0.0226 | -0.0226 | -0.0965 |
| | (0.77) | (-0.49) | (-0.49) | (-1.44) |
| CULTURAL | -0.0145 | -0.0179 | -0.0179 | -0.0186 |
| | (-0.21) | (-0.39) | (-0.39) | (-0.28) |
| FINANCE | -0.142* | -0.0954* | -0.0954* | -0.0459 |
| | (-2.10) | (-2.06) | (-2.06) | (-0.68) |
| ESTATE | -0.135* | -0.0329 | -0.0328 | 0.0725 |
| | (-1.98) | (-0.71) | (-0.71) | (1.08) |
| TECHNICAL | 0.170* | 0.188*** | 0.188*** | 0.210** |
| | (2.50) | (4.05) | (4.05) | (3.14) |
| WASTEMANAGE | 0.131 | 0.120** | 0.120** | 0.111 |
| | (1.92) | (2.59) | (2.59) | (1.66) |

| | | | | |
|---|---|---|---|---|
| **EDUCATION** | 0.00889<br>(0.13) | 0.0178<br>(0.38) | 0.0178<br>(0.38) | 0.0274<br>(0.41) |
| **HEALTH** | 0.131<br>(1.93) | 0.114*<br>(2.47) | 0.114*<br>(2.47) | 0.0972<br>(1.45) |
| **ENTERTAINMENT** | 0.0482<br>(0.71) | 0.0771<br>(1.66) | 0.0770<br>(1.66) | 0.105<br>(1.56) |
| **ACCOMMODATION** | 0.122<br>(1.80) | 0.106*<br>(2.28) | 0.106*<br>(2.28) | 0.0885<br>(1.32) |
| **OTHER** | 0.0628<br>(0.92) | 0.0279<br>(0.60) | 0.0279<br>(0.60) | -0.00684<br>(-0.10) |
| **LNGDP** | 0.433***<br>(38.05) | 0.441***<br>(41.06) | 0.441***<br>(41.04) | 0.436***<br>(38.92) |
| **LNCPI** | -0.0811**<br>(-3.00) | -0.0709**<br>(-2.82) | -0.0716**<br>(-2.85) | -0.0690**<br>(-2.59) |
| **LNPOPULATION** | 0.567***<br>(32.99) | 0.556***<br>(34.39) | 0.559***<br>(36.49) | 0.563***<br>(33.02) |
| **CONSTANT** | -0.529*<br>(-2.38) | -0.521*<br>(-2.50) | -0.547**<br>(-2.73) | -0.554*<br>(-2.50) |

In Table 4.3, column (1) presents our main results presented in the previous section. Column (2) shows the regression results after including Quebec in the control group. Column (3) depicts the regression outcomes when Quebec is incorporated into the treatment group. Column (4) illustrates the regression analysis performed after excluding British Columbia, with Quebec serving as the treatment group.

The results indicate that if Quebec is added to the treatment group or the control group, the sign of the coefficients remains unchanged, with only a slight decrease in the significance for agriculture. Notably, the coefficient values for agriculture, construction, manufacturing, and real estate & rental leasing significantly decrease after incorporating Quebec into the regression. Agriculture drops from -0.250 to -0.146, mining drops from 0.320 to 0.281, construction from 0.224 to 0.182, manufacturing drops from -0.239 to -

0.198, finance drops from -0.142 to -0.0954, and real estate & rental leasing from -0.135 to -0.0329 and become insignificant. Furthermore, column (4) results show that if we exclude British Columbia from the regression and run it for Quebec and the other provinces, we can see that the outcomes for agriculture and construction become insignificant, while the significance for mining declines. This could be attributed to the limited industry coverage of Quebec's Emissions Trading System (ETS), which only encompasses the electricity, building, transport, and industrial sectors, possibly leading to these results.

# 5. Conclusion

Using the DiD model, this report analyzed provincial employment data and identified the impact of revenue-neutral carbon taxation on the employment in British Columbia. The findings indicate that carbon taxation had no significant general effect on employment in the province. Although the increase in energy prices resulting from the carbon tax had a negative impact on the economy, the positive effects of increased transfer payments may have offset this impact.

As for specific effect for each industry. An analysis of employment across various industries revealed that carbon taxation significantly influenced employment in emission-intensive industries, with a notable decrease in employment rates in some emission-intensive sectors and an increase in employment rates in clean industries, thereby facilitating a structural transformation in employment. The differing effects of carbon taxation across industries can be attributed to variations in price elasticity, income elasticity, and factor substitution elasticity.

Furthermore, the policy was found to promote employment in emission-intensive industries more sensitive to carbon taxation, possibly due to increased investment in clean technology development within these sectors. Trends in labor productivity provide compelling evidence supporting this observation.

In conclusion, this report suggests that the carbon tax policy in British Columbia successfully move labor force from high emission industries to low emission industries while the general employment rate didn't suffer much negative effect. Its design regarding tax rates, coverage, and the utilization of tax revenue could serve as an excellent model for other provinces considering the introduction of carbon taxes.

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