Do Carbon Taxing Policies Foster Investment in Green Energy: Assessing the Impact of British Columbia's 2008 Carbon Tax on Investment in Wind Energy

Krishna Paudel (66658931)
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Terry Moon

Abstract

This paper investigates whether carbon taxing policies stimulate investment in green energy by examining the causal impact of British Columbia's 2008 carbon tax on wind power development. Employing a Difference-in-Differences framework, it compares annual electricity generated by wind turbines in British Columbia, the treatment group, with that in provinces without independent carbon pricing, the control group, over 2000–2018. Using Canada's Wind Turbine Dataset, which reports every commercial wind turbine build in the country, this study estimates both contemporaneous and three-year-lagged policy effects. For the multiple controls model with incorporated provincial fixed effects and the lag structure, this study finds that the carbon tax is associated with a 552 % greater increase in wind-generated electricity in British Columbia relative to control provinces. These results provide robust evidence that well-designed carbon taxes can mobilize private capital toward renewable infrastructure, thereby informing policymakers seeking to accelerate the energy transition.

Introduction

Throughout the past several decades, the issue of climate change has unfolded as one of the main concerns facing humanity. Global temperatures have steadily risen since the industrial revolution, with environmental disasters like severe floods and wildfires becoming more frequent and potent around the world (IPCC, 2021). Furthermore, these trends are only projected to worsen under our current emissions trajectory. In response, regional governments around the world have implemented various forms of carbon pricing policies to mitigate the impact of climate change. These policies have two main purposes, the first being to incentivize companies to lower their CO2 emissions by increasing the cost of polluting. For example, carbon taxes force companies to pay for the externalities they create in their production process and hence shift market behaviour by making fossil fuel-based energy more expensive relative to renewable energy (Beugin, 2018). The second purpose is to stimulate investment in these renewable energy sources as companies want to minimize long-term costs, and the most effective way to do that is by shifting their production processes to the cheaper, greener alternatives (He, 2023).

There are already various research papers and news articles which empirically verify, or at least fail to disprove, that carbon pricing policies fulfil their first purpose. For example, Siweya (2021) found empirical evidence that CO2 emissions drop substantially after the imposition of carbon taxes and Pedersen & Elgie (2015) found that carbon pricing policies help internalize the cost of climate change because the funds from the tax are used to assist the regions and communities most heavily impacted by climate change, and to finance renewable energy and low-carbon technology deployment. Contrastingly, there is substantially less literature covering the impact of carbon pricing policies on renewable energy investment, especially using a causal empirical methodology to determine whether they are effective in incentivizing energy transition to greener power sources.

Economic theory suggests that implementing carbon pricing policies increases the cost of production for industries, most of which primarily use fossil-fuel-based energy sources. As such, in order to reduce their costs in the long run, these taxes incentivize producers to increase investments in alternative power sources like solar, hydro, and wind energy (Pedersen & Elgie, 2015). Therefore, economic theory predicts that carbon taxes increase investment in renewable energy sources, and this paper will seek to empirically test this theory. More specifically, it will look at the context of carbon pricing policies in Canada, and utilize the Difference-in-Differences methodology, which is good at isolating causal relationships, to estimate the impact of British Columbia's 2008 Carbon Tax on investment levels in wind energy. The purpose of this study is to inform policy makers on utilizing carbon pricing policies as a method to incentivize transitioning to clean energy. As such, the following will go over the previous literature in this topic area and highlight my specific contribution to the field, overview my study's institutional setting, empirical strategy, and data sources, and finally explain my results and its interpretations.

Literature Review & Contribution

Initially, there are various research papers that investigate a similar economic question. For example, Yin et al. (2023) investigate the relationship between carbon taxes and renewable energy consumption using a panel regression model across 39 economies from 1991 to 2019. Their study finds that carbon taxes impede renewable energy consumption in the short run but promote it in the long run, with stronger effects observed in advanced economies. Other authors utilize more complex mathematical models to study these relations, like He (2023) who examined the effect of both environmental taxes and green energy transition subsidies on renewable energy investment in China, specifically using a multistage optimization model, and found that such "green" policies significantly enhance renewable energy investment.

Similarly, Zhao et al. (2019) use the real options theory to assess the effects of carbon taxes and tradable permits on wind power investments in China, and find that carbon taxes above 30 yuon/ton, as well as stricter quotas on trading permits, are necessary to stimulate investments in the wind power sector. Finally, using a more intuitive empirical approach, as well as the same institutional setting as this paper, Matterne et al, (2024) utilize the difference-in-differences (DiD) approach to analyze the causal impact of

British Columbia's 2008 carbon tax on innovation in Canada. The study reveals that the tax shifted innovation from product-based to process-based, significantly contributing to emissions reductions, emphasizing the role of innovation as a mediator between carbon taxes and environmental outcomes.

Evidently, there is a significant gap in the literature in terms of studying the impact of carbon pricing policies specifically on renewable energy investment levels. As such, this paper's contribution will be to fill this gap by empirically determining whether such policies are effective in stirring green energy investment. Specifically, I will focus on the Canadian context, where, prior to 2018, provincial governments independently decided whether to adopt environmental protection policies and in 2008, British Columbia implemented a carbon tax while most other provinces did not, creating a natural setting for a DiD analysis. Although, there are various studies who utilize a DiD approach to study the impact of BC's 2008 Carbon Tax on economic factors like GDP, emissions, and inflation; none of them look specifically at the tax's impact on investment in renewable energy sources. Furthermore, previous literature does investigate this question in different settings, however, none specifically utilize the DiD approach which is great at estimating causal relationships. As such, this paper will use the DiD model to isolate the causal impact of BC's 2008 Carbon Tax on wind power investments.

Institutional Setting

In 2018, the Canadian Federal government implemented the widely controversial Carbon Tax under the Greenhouse Gas Pollution Pricing Act, which placed a price of CO_2 emissions starting at $20 per tonne, and increasing annually to reach $50 per tonne by 2022 (Canadian Climate Institute, 2025). Before 2018 however, provinces had autonomy over carbon pricing policies, and until 2018 in Canada, there were only four provinces with any significant, independently adopted environmental policies. The first of these provinces was Alberta, which introduced the Specified Gas Emitters Regulation (SGER) in 2007, requiring large industrial emitters to reduce their emissions by 12% per year, or pay $15/tonne (Brightspot Climate, 2023). There was also Quebec which established a relatively small carbon levy of 0.8 cents/litre on gasoline and $8/tonne on coal in 2007, as well as a more extensive cap-and-trade system for large industrial emitters starting in 2013 (Brightspot Climate, 2023). Ontario also briefly adopted a cap-and-trade system in 2017, but it was scrapped only a year later with the change in provincial government in 2018 (Brightspot Climate, 2023).

Most importantly, in 2008, British Columbia implemented a Carbon Tax which put a price of emissions starting at $10/tonne of CO_2, increasing by $5/year until it reached $30/tonne in 2012, where it remained until 2018 (Brightspot Climate, 2023). All the other provinces did not have any notable carbon pricing policies until they adopted the nationwide carbon tax in 2018. Furthermore, this carbon tax in BC was also the most substantive carbon pricing policy out of all provinces as it effected more than 75% of the provincial greenhouse emissions across all industries (Matterne et al, 2024). As such, it will serve as an effective treatment group in our DiD analysis, and allow us to estimate the policy's total impact.

Data Sources:

One important limitation I ran into during data collection was that investment datasets did not categorize renewable energy as a separate category of investments until around 2012. As such, I used an alternative variable that is highly correlated with renewable energy investments, as my dependent variable. This new variable, electricity generation, is categorized by sources, and the logic is that if investments in wind, solar, and hydroelectric sources increased, then we should see a subsequent increase in electricity generated by these sources because the only way to increase how much electricity is generated in total by these sources is to either improve pre-existing structures, or to build new ones, both of which require investments. As such, because of the near perfect correlation between investment levels and electricity generated levels, I will use the latter as my dependent variable. Furthermore, another limitation was that solar power datasets only included large solar farm projects, which are not a representative sample of total investment in solar power because solar panels are also used on a smaller scale by companies and households. Lastly, because not all provinces have the geographical requirements for hydroelectric power, it also means that conceptually, I cannot include hydroelectric power in my research as it will cause bias.

As such, this narrows my research question as now, this paper will investigate how BC's carbon tax impacted the electricity generated by wind power, as wind power has no such conceptual or data limitations.

The dataset I will be using for my dependent variable is the Canada Wind Turbine Dataset, which has a record of every single commercial wind turbine ever established in Canada, categorized by provinces and year of establishment. This dataset also reports each turbine's Total Rated Capacity, which is the maximum amount of electricity a turbine can produce in an hour, measured in mWh's. Using the formula:

$$Electricity\ Generated\ (gWh) = \left(\frac{\text{Total Rated Capacity} \times 24 \times 365 \times 0.3\ \text{(Capacity Factor)}}{1{,}000{,}000}\right)$$

I will transform Total Rated Capacity into total electricity generated per year by wind power in each province. Note that capacity factor, which is a variable that determines the generation capacity of wind turbines, is usually around 0.3, and is not something that can be altered by producers as it is determined by turbine design, location, weather, etc (Windurance, 2025). Secondly, to extend my DiD model, I will also add some control variables to measure how electricity generation, or investment in renewable energy, varies by certain economic factors, such as Real Gross Domestic Product Per Capita (RGDPPC) in 2017 chained dollars, which is a measure for average welfare or income, unemployment rate, which is an important indicator of concurrent economic conditions, and corporate tax rate, which play an important role in investment as higher taxes may deter investments. The data for all of these are collected from Statistics Canada. Overall, I have data on electricity generated by wind power, RGDPPC, unemployment rate, and corporate tax rate, for all 10 Canadian provinces, from 2000-2018, and Figure 1 below provides a visualization of these variables in my dataset.

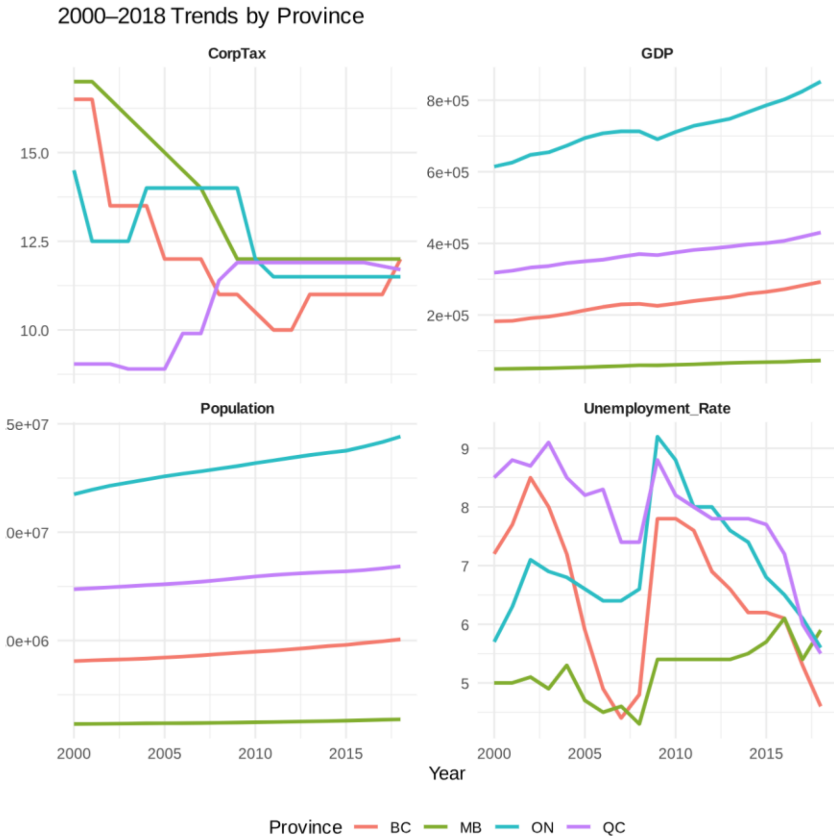

Figure 1: Data Visualization

Empirical Strategy and Hypothesis:

This paper will utilize the DiD method, using BC as the treatment group, and two sets of control groups. For the first set, I will use only Manitoba as the control, and for the second, I will use all the provinces in Canada that did not have any carbon pricing policies before 2018 as my control. This means Alberta and Quebec will not be included as they both had carbon pricing policies, as previously noted. Furthermore, Ontario will also be omitted because it briefly had a cap-and-trade program in 2017, which means it will be partially treated and cause downward bias, and because Ontario violates the parallel pre-trends assumption. The parallel pre-trends assumption in a DiD analysis requires that before the policy implementation, both the control and treatment group follow the same trajectory for the dependent variable. If this assumption does not hold, it will cause bias in the coefficients estimated by the regression model. In this case, Ontario violates the assumption because the first wind turbine in the province was established in the late 1990's, but BC did not install its first turbine until 2009. This means that electricity generation will not follow the same trajectory for the two provinces before the policy, and as such, using Ontario in the control group will violate the pre-trends assumption and cause significant bias in the results.

For the other set, I chose to use Manitoba as the only control group for two main reasons. First, although it still slightly violates the pre-trends assumption since Manitoba installed its first wind turbines in 2005, four years before BC, it is one of the three provinces that comes closest to satisfying the assumption. The second and more important reason is that Manitoba's distribution of economic variables, such as RGDPPC, population growth rate, unemployment rate, and corporate tax rate, is closer to BC than the other two provinces, as shown by Table 1 below. Lastly, Manitoba is also a very representative province in all the control group provinces, which makes it a good control to compare individually.

Canadian Provinces Summary Statistics

	BC	MB	NB	NL	NS	PEI	SK
GDP	234,971.100	60,523.440	33,998.170	31,488.610	40,349.330	5,939.830	69,220.500
	(31,314)	(7,435.550)	(1,506.180)	(2,747.360)	(2,164.390)	(532.720)	(8,383.440)
Population	4,488,585.000	1,233,114.000	754,839.600	521,862.900	941,958.500	142,223.200	1,058,510.000
	(308,328.600)	(64,963.310)	(7,961.320)	(6,929.560)	(8,218.200)	(4,985.810)	(61,268.110)
Unemployment Rate	6.470	5.220	9.530	14.400	8.820	11.080	5.180
	(1.300)	(0.480)	(0.890)	(1.450)	(0.580)	(0.640)	(0.740)
Corporate Tax	11.810	13.420	12.750	14.170	16.000	16.000	13.530
	(1.600)	(1.840)	(1.520)	(0.380)	(0.000)	(0.000)	(2.280)
GDP Growth (%)	2.670	2.210	1.160	2.120	1.310	1.810	2.030
	(1.700)	(0.990)	(1.470)	(5.840)	(1.220)	(1.630)	(3.060)
Population Growth (%)	1.240	0.940	0.160	0.020	0.190	0.680	0.800
	(0.380)	(0.410)	(0.280)	(0.530)	(0.440)	(0.770)	(0.790)
GDP per Capita Growth (%)	1.420	1.270	0.990	2.110	1.110	1.130	1.230
	(1.760)	(1.100)	(1.570)	(6.060)	(1.140)	(1.660)	(3.000)

Table 1: Summary Statistics – (mean values reported, standard deviation reported underneath in brackets)

Lastly, for each set of control groups, I will run a standard DiD regression, as well as another with an implemented time-lag to account for the fact that I am using electricity generated by wind power and not wind energy investment itself. The logic is that although these two variables will be highly correlated, it might take time for investments in wind energy to manifest as increased electricity output by wind turbines. This time lag will be set to 3 years because generally, that is how long it takes to build a commercial wind turbine (Windurance, 2025). Finally, I will also run another regression using both time-lag and controls to isolate their effects. Note that for the models including multiple control groups, I will also implement province fixed effects to account for the time-invariant differences between the provinces which would otherwise cause higher omitted variable bias. The following shows my regression equation:

$$\log\left(\text{ElectricityGenerated}_{it}\right) = \beta_0 + \beta_1 \text{Treatment}_i + \beta_2 \text{Post}_t + \beta_3 (\text{Treatment}_i \times \text{Post}_t)$$

$$+\beta_4 \log(\text{GDPPC}_{it}) + \beta_5 \text{CorpTax}_{it} + \varepsilon_{it}$$

Here, treatment will be a dummy variable that has value 1 for BC, and 0 for other provinces. The post variable will be a similar 1 or 0 dummy for either 2008, the policy implementation and announcement year, or 2011 with the 3-year time lag. Finally, I hypothesize that the coefficients on the interaction term should be large, positive, and statistically significant for all models, with the coefficient size increasing once we implement the lag, indicating that the policy does in-fact increase investment in wind power, and perhaps more so in the long run, which is consistent with Yin et al. (2019)'s findings.

Results:

Initially, the results for the models with only Manitoba as the control group indicate that BC's 2008 Carbon Tax substantially increased wind power consumption, and hence, wind energy investments. First, looking at the parallel trends in Figure 2, we can see that after the policy implementation in 2008, BC's wind energy consumption increased significantly more than Manitoba's. It is important to note however, that due to the violation of the parallel pre-trends assumption in the figure, there will be some downward bias in my regression estimates as we see that before the policy implementation, the control group was already rising relative to the treatment group. Furthermore, we see that when we implement the time lag, the pre-trends assumption hold more closely, and gap between the BC and Manitoba's wind energy investments becomes more clear.

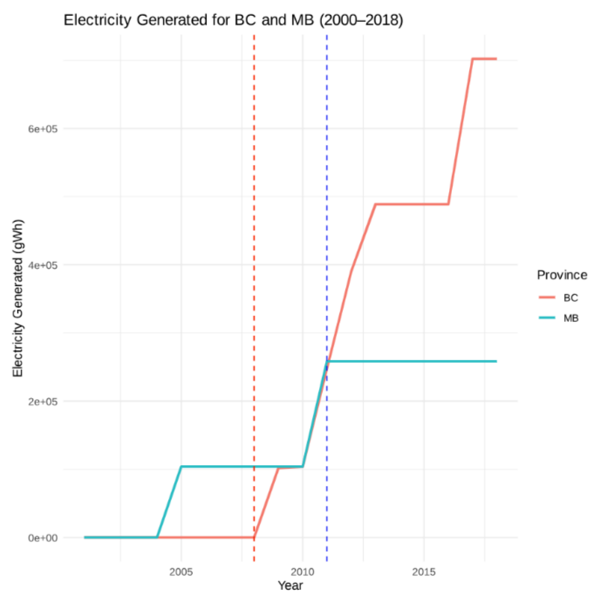

Figure 2: Manitoba Control

Regression Results

	Dependent variable:		
	Electricity_Generated		
	(1)	(2)	(3)
Treatment	-4.951**	-4.623**	-8.820***
	(1.850)	(1.827)	(1.667)
Post	7.263***	5.531***	-0.091
	(1.673)	(1.938)	(2.058)
GDPPC			10.564
			(18.590)
CorpTax			-1.713**
			(0.630)
Treatment:Post	4.345*	5.237*	6.949***
	(2.367)	(2.741)	(2.133)
Constant	4.951***	6.931***	64.316
	(1.308)	(1.292)	(50.472)
Observations	36	36	36
R^2	0.689	0.567	0.761
Adjusted R^2	0.660	0.526	0.721
Residual Std. Error	3.461 (df = 32)	4.085 (df = 32)	3.135 (df = 30)
F Statistic	23.639*** (df = 3; 32)	13.956*** (df = 3; 32)	19.092*** (df = 5; 30)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 2: Manitoba Control Regressions

Table 2 show three DiD regressions: standard, with time-lag, with time-lag and controls, respectively. For the first model, we see that the Treatment regressor is significant at the 5% level, and indicates that electricity generated by wind turbines was, on average, 495% lower in BC than MB, before the policy implementation. Additionally, the Post regressor is significant at the 1% level, and indicates that electricity generated by wind turbines increased by 726% in both BC and MB, after the policy implementation year. Finally, and most importantly, we see that the interaction term, which measures the causal effect of the policy, is significant at the 10% level, and indicates that electricity generated by wind turbines increased 435% more in BC than MB, after the policy implementation. We see that after we implement the time lag, these estimates become larger, but their significance level stays the same. Finally, in the third model with both time-lags and control variables, we see that our coefficients become larger and more significant, and although the coefficient on GDPPC is not significant, we see that the coefficient on Corporate Tax is significant and negative, which also makes sense because as taxes increases, investment in wind energy should go down.

Below, Figure 3 and Table 3 show even stronger and more significant results when we use multiple provinces as controls instead of just Manitoba. Initially, Figure 3 is very important because it shows that the parallel trends assumption is violated for many of the control provinces. However, these pre-2008 values of the electricity generated by wind turbines are relatively low for these provinces, and we also see that if we implement the time lag, this issue decreases significantly because by 2011, BC catches up to the other provinces by following a similar upward trend in electricity generated values. Most significantly, we see in Figure 3 that after both the policy implementation year, and the three year time lag, the gap between BC's and the other provinces' wind energy consumption, grows significantly. This result is substantiated by the regression results in Table 3, and looking at the second model which includes the time lag, we see that the coefficient on the interaction term is significant at the 1% level, and indicates that electricity generated by wind turbines increased 552% more in BC than the other provinces, after the policy implementation. Like the previous results, we see that the coefficient sizes increase once we implement the time lag, and that all the coefficients are more significant than when we just used Manitoba as a control. Lastly, once we implement the controls, we see that GDPPC absorbs a significant portion of the effects, with the estimate suggesting that a 1% increase in GDPPC results in 26% increase in electricity generated by wind power, and the treatment effect becoming a little lower, but still very large and significant.

Collectively, these results demonstrate very strong evidence that BC's 2008 Carbon Tax increased wind energy consumption, indicating a strong, positive, and causal relationship between carbon tax policies and investment in wind power, and thus supporting the thesis of the previously mentioned economic theory. These results are also consistent with the literature review as many other researchers also found that carbon pricing policies increase investment levels in renewable energy. One important limitation to note however, is that my regression models can still suffer from omitted variable bias, because there might be other factors that are driving the increase in wind power investments, such as climate change sentiments or availability of provincial subsidies, or some other factors. As such, future papers investigating this topic should also try to take those factors into account.

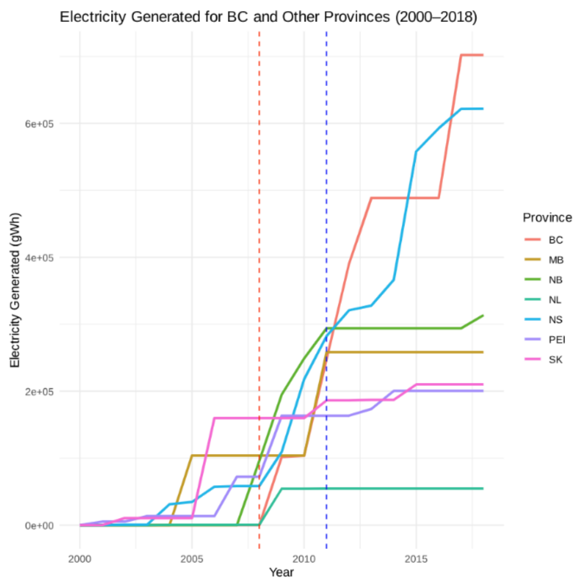

Figure 3: Multiple Controls

Regression Results

	Dependent variable:		
	Electricity_Generated		
	(1)	(2)	(3)
Treatment	-6.214^{***}	-5.842^{***}	-0.506
	(1.318)	(1.441)	(1.808)
Post	6.953^{***}	5.459^{***}	2.258^{***}
	(0.574)	(0.706)	(0.736)
GDPPC			26.705^{***}
			(5.250)
CorpTax			-0.633^{***}
			(0.222)
Treatment:Post	4.655^{***}	5.519^{***}	4.556^{***}
	(1.519)	(1.868)	(1.564)
Constant	6.214^{***}	7.941^{***}	91.137^{***}
	(0.770)	(0.904)	(13.550)
Province Fixed Effects	Yes	Yes	Yes
Observations	133	133	133
R^2	0.666	0.496	0.657
Adjusted R^2	0.645	0.463	0.629
Residual Std. Error	3.027 (df = 124)	3.721 (df = 124)	3.095 (df = 122)
F Statistic	30.975^{***} (df = 8; 124)	15.245^{***} (df = 8; 124)	23.353^{***} (df = 10; 122)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 3: Multiple Controls Regression Models

Policy Implication and Conclusion

In conclusion, this paper investigated the impact of BC's 2008 Carbon Tax on investment levels in wind power energy. This study sought to determine whether carbon pricing policies really stirred investment in renewable energy sectors, as hypothesized by economic theory. Within the context of Canada, this study utilized the DiD approach, with its particular strength in determining causal relationships, using BC as the treatment group and two configurations of control groups: Manitoba alone, and then all provinces that did not adopt carbon pricing policies. Furthermore, utilizing a three-year time lag to account for the time between investment decision and observable increases in electricity output, this study ran multiple regressions, and all indicated that the policy did have a strong and significant effect on increasing wind energy consumption, and hence, investment in wind energy. More specifically, the most robust regression model, which used multiple controls, province fixed effects, and time lags, found that the carbon tax was associated with an approximately 552% greater increase in wind generated electricity in British Columbia than in comparable provinces. However, interpretation of these results still warrants caution, as some control provinces exhibited divergent trends before 2008, potentially undermining the parallel pre-trends assumption, and omitted variable bias cannot be entirely ruled out.

From a policy perspective these results imply that a well designed carbon pricing policy can effectively mobilize private capital toward renewable energy infrastructure. By raising the cost of fossil fuel-based generation relative to greener alternative, the carbon tax provides a clear market signal that encourages firms to increase investment in renewable energy sources, as evidenced by the marked uplift in wind power capacity in BC. For policy makers around the world, these results suggest that an effective measure to mitigate climate change is to establish carbon pricing policies in order to stimulate investment in greener energy sources, and reinvest the revenues into renewable energy research and infrastructure to ensure an equitable transition away from CO2 emitting energy sources, to greener alternatives.

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