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Assessing the Economic Cost of California's Cap and Trade Program Through a Difference-in-Difference Analysis

Introduction

Cap and trade is often posited as the end-all-be-all be all solution to Climate Change as it makes a very compelling argument from an introductory economics perspective. The argument for cap and trade is built on the normative assumption that addressing global warming through the reduction of greenhouse gas emissions is in the best interest of society. Cap and trade is enticing in that it is theoretically able to address the issue of greenhouse gas emissions at an economically efficient cost. The idea is simply to internalize the externalities of greenhouse gas (GHG) emissions by creating a market for pollution as a good. These so-called pollution tokens or permits, theoretically, are able to set the total GHG emissions rate and allow market forces to determine the most economically efficient way to meet this goal. Another theoretical benefit of cap and trade as a tool is the concept of the independence property. This posits that the initial allocation of carbon emission permits has no impact on the market's choices to reduce emissions. Meredith Fowlie and Jeffrey M. Perloff's 2013 paper DISTRIBUTING POLLUTION RIGHTS IN CAP-AND-TRADE PROGRAMS argues that this theoretical benefit of cap and trade programs held in Southern California's RECLAIM program. In a similar vein, can we argue that Cap and Trade programs are economically efficient? Does the market mechanism reduce pollution with the most efficiency and at the lowest economic cost? This paper looks to answer the positive question, what is the economic cost in terms of wage and employment of California's 2013 cap and trade program? This analysis is broken down into two parts. First, I performed a difference in difference model of the regression of low carbon emitting industries against high carbon emitting industries. To do this, I collected data from California's Air Resources Board. This gave me a collection of all Greenhouse Gas Emissions measured in CO2 equivalents by year and industry sector. I will discuss this in more detail later but we would not have been able to analyze the impact of the program on low and high-emission industries data using a DID model because this would fail to meet the parallel trends assumption. Because of this, I incorporated the data from the Quarterly Census of Employment and Wages (QCEW). This employment and wage data serves as an estimate for the GDP of industries in California by year. By matching California's air resources and QCEW data, I was able to show how the cap and trade program impacted the wages and employment levels of California's employees based on their employment in low and high emission emissions industries. This may allow me to conclude how efficient the program was in reducing emissions. The result of this analysis was a negative wage and employment effect of the policy. The standard error of these predictions was so large that attempting to draw any conclusions from this analysis was not justified.

Institutional Background

In 2013, California implemented a comprehensive cap-and-trade program as part of its broader strategy to combat climate change and reduce greenhouse gas emissions. This initiative is a key component of California's strategy to incentivize businesses to lower their carbon footprints. The law was passed on October 20, 2011, by the California Air Resources Board (CARB). Like any other cap and trade system, the state sets a limit on total greenhouse gas emissions and issues emissions allowances that add up to that cap. From there, companies are allowed to buy and sell these allowances in an open market. This market-based approach allows companies that can reduce emissions at a low cost to sell their extra allowances to companies that find it economically prohibitive to exceed their allotted emissions. This policy was not without its critics. Some argued that it could lead to higher energy prices and unfairly burden lower-income communities. This program is also not unique or uniquely applicable to California. Because GHG emissions are global, this is a system that would benefit from implementation across the world. Many cap and trade systems have already been implemented in many other parts of the world to try and regulate many types of public goods. California's cap and trade itself is linked to the Canadian province of Quebec’s cap-and-trade system through the Western Climate Initiative. The program's market-based nature has been studied extensively to understand its impact on reducing emissions, economic growth, and its role in encouraging technological innovation in the energy sector.

Linking Literature

Many papers have been written attempting to examine similar questions based on the examination of cap and trade policy. Lawrence H. Goulder in their Journal of Economic Perspectives article, "Markets for Pollution Allowances: What Are the (New) Lessons?" (Goulder 2013), discusses the nuanced effects of cap and trade laws. This highlights the complexity of cap and trade beyond what a simple economic model could suggest. Their findings are specifically important to question the assumption of the economic efficiency of cap and trade programs. Another paper "Who Loses under Cap-and-Trade Programs?" (Curtis 2018) delves into labor market effects of the NOx Budget Trading Program (NBP) program that ran from 2003 to 2008. This program was found to reduce ozone precursor emissions in 19 states in the eastern United States at a much lower economic cost to command and control policies. If the outcome of this program is similar to that of California's program, we can be hopeful that my analysis will show a positive or small negative impact to wages and employment over the period. Another relevant study titled "Employment and Output Leakage under California's Cap-and-Trade Program" by Wayne Gray, Joshua Linn, and Richard D. Morgenstern (2016) looks at the impact of California's cap-and-trade program on the state's manufacturing industries. Using data at the plant-level, the paper models the effect of historical energy prices on output, employment, and profitability. The study finds that the program could lead to short-term output and employment losses in certain industries. Although this paper is more limited in scope, it shows very clearly that for manufacturing industries, cap and trade is economically harmful in the short run. Because manufacturing is in my data considered a high emission industry, this paper should shed light on the findings I should expect from high emission industries as a whole.

Data Description

Using only data from California's air resources board, I was able to use a dataset of CO2 equivalent emissions by year and Industry Classification. From there, I sorted Industry Classification by their emissions. A preliminary look at the data showed me that much of the data had observations with 0 emissions or emissions data that was unreasonably high. Looking deeper into the data this seemed to be because the top polluting industry, transportation, was polluting at a much higher rate than the next highest polluting industry. Because transportation was not covered under the 2013 iteration of the cap and trade bill, this should not be counted in the model. Because of this, I decided to windsor the data. This means that I removed the bottom and top 5% of all observations. Even though a hand selection of the problematic data points may have been more effective, this method allowed me to proceed with my analysis without the influence of data reporting errors or outliers. I then assigned high polluting industries as the treatment group and low polluting industries as the control group. High polluting industries were defined specifically as those whose industries were in the top 10% of emissions and low polluting industries were those in the bottom 10% of emissions. Because this analysis is focused on how emissions the California's cap and trade bill changed industry emissions, I generated a "post" variable. All observations after the introduction of the bill in January 2013 are in the post period and all observations before this are in the pre period. It is important to note that these industries were selected into their treatment categories based on their emissions levels in the pre period. This allows us to examine the change in behavior of the low and high polluting industries after the introduction of the program. Let's look at a graph that shows us the difference in the mean emissions of high and low polluting industries by year:

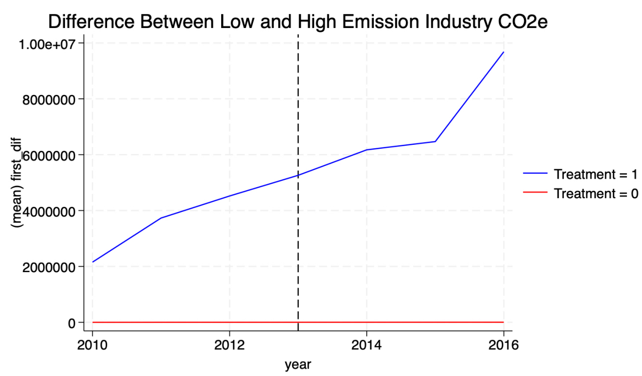


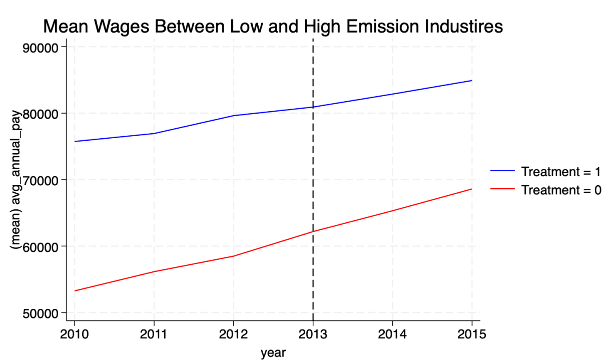
Figure 1: Difference Between the mean CO2 equivalent emissions of Low and High polluting industries by year
Note the dotted black line represents the start date of the program

Immediately we see why a DID analysis would pass the parallel trends assumption with this data. This also makes sense from an economic perspective as low emission industries would be expected to have low variability in their emissions. This means that most variability observed in the treatment group would not be parallel to that of the control.

Thankfully, the California Air Resources Board uses comprehensively categorized industry names. This allows us to match the industry classifications well with the QCEW data.

This process of matching industries into a set of titles agreeable to both datasets was imperfect. The ramifications of this will be discussed further in the paper. Note that certain industries like “Not Specified”, “National Security” were removed from the dataset for not being categorized or for being industries specifically not subject to emissions regulation. Another industry from the QCEW titled “Health care and social assistance” was removed for not being sufficiently similar to an industry classification in California's emissions database. After combining both datasets, I used the treatment and period variables defined with California's emissions database and the annual average employment and wage data from the QCEW to create a new DID analysis. I chose to look at wage and employment because these are strongly correlated with GDP and are variables that impact the daily lives of California’s citizens. They capture much of the economic impact that policy decisions have.

Results



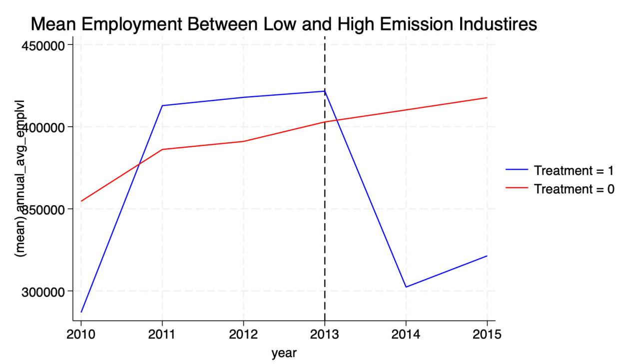


Figure 2: Mean yearly wages paid to employees in high vs low polluting industries.
Figure 3: Total employment in high vs low polluting industries.

As you can see in *figure 2*, the parallel trends assumption is much stronger in this case. The effect of the policy is also noticeable. After 2013, the wages of low polluting industries seem to be unaffected as wages continue to increase at the same rate. The rate of the increase in wages in the treatment group seems to decrease slightly. The parallel trends assumption is more convincing in this analysis because wages are tied strongly to the performance of an overall economy or sector. Over a given period of time in the pre period, one would expect the wages of low and high polluting industries to grow or shrink at similar rates.

Figure 3 represents the Total employment in high and low polluting industries over the time frame of our analysis. This graph seems to tell a similar story. We can see that the rate of employment in both industries matches to an acceptable degree. The year 2010 is concerning but this may be due to the natural variability of employment and or the flaws in the model. The graph also seems to argue that employment was much more dramatically impacted by the policy than wages. Because this analysis looks at both wages and employment, I have two regressions of interest:

$$y_{st} = a + 1B_1(treatment_s) + 1B_2(post_t) + 1B_3(interaction)_{st} + e_{st}$$

- y_{st} **:** The average yearly wage of employees or the employment level in Industry *s* and year *t.*
- $(treatment_s)$ **:** Dummy variable which equals 1 if an Industry *s* in California is in the top 10% of CO2e. The dummy variable equals 0 if Industry *s* in California is in the first Quantile of CO2e in period 1.
    - This corresponds to the pre-existing differences between the treatment and control groups.
- $(post_t)$ **:** Dummy variable equal to 1 if year *t* is after the implementation of California Cap and Trade program (2013-2015) or 0 if the year *t* is before the policy (2011-2013).
    - This represents the trend in CO2e emissions over time that is unrelated to the policy.
- $interaction_{st}$ **:** Dummy variable equal to the multiplication of previous variables. This takes a value of 1 when Industry *s* is treated and year *t* is after the implementation of the policy.
    - This is the DID estimator. The slope coefficient of this term in the regression can be interpreted as how the cap and trade policy changed wages or employment in California between the top and bottom polluting industries.

Running these regression on the data, results in these parameters:

		avg_annual_pay	annual_avg_emplvl
_cons	B0	55965.65	377260.3
	SE(B0)	14738.29	150444
	95% CI	(26129.53, 85801.76)	(72702.26, 681818.3)
treatment	B1	21468.53	-4751.033
	SE(B1)	17438.59	178007.8
	95% CI	(-13834.04, 56771.1)	(-365109, 355606.9)
post	B2	9399.386	32994.65
	SE(B2)	20843.1	212760

	95% CI	(-32795.26, 51594.03)	(-397715.5, 463704.8)
interaction	B3	**-3934.51**	**-57057.01**
	SE(B3)	24661.88	251741
	95% CI	(-53859.88, 45990.86)	(-566680.1, 452566.1)

The DID estimate for wages estimates the effect of the cap and trade program to be an average decrease of 3934.5$ dollars in yearly wage. This is a substantial number considering that the mean yearly wage of all employees in the QCEW is 54,985.21$ (median is 52,026$). Attributing a decrease of ~7.15% in wages from a single climate policy initiative would be a massive finding. Fortunately, the p-value for this estimate was 0.874, far above our statistical significance level of 0.05. We can also see that the 95% confidence interval for the DID estimate is from -53859.88$ to 45990.86$ in yearly wage. This means that at the 95% confidence level, we cannot argue that the effect of this policy is different from zero. Similarly, the DID for employment estimates that the cap and trade program reduced the employment of high emission industries by 57057 workers. The p-value of this estimate was 0.822, also above our significance level. Once again, the 95% confidence interval captured zero by a large margin. Because of the large standard errors computed by the regression, we cannot come to any conclusion on the direction or magnitude of the impact of California's 2013 cap and trade program.

Conclusion

The results are not able to relate to any literature because they are fully inconclusive. Because of this the analysis is not effective in the measurement of the economic cost of California's cap and trade programs. This is likely due to imperfections in the matching process of industry categories from California Air Resources Board to the QCEW. Some categories were too vague or had to be questionably joined under other categories. The problem with imperfect classification is that it would blur the relationship between treatment and wage or treatment and employment. Because my analysis is inconclusive to the economic cost of cap and trade, I can only recommend a policy of more effective data collection and classification. This could allow future economic analysis to find more clearly the real policy effect. This could be done through a more standardized industry classification among federal and state agencies. Standardization in general could be beneficial to cap and trade. As I mentioned before, California's cap and trade system is linked to Candas. This has massive benefits to the liquidity and efficiency of both markets. If standardization of rules and data collection were to be put in place, it could lead to a more efficient cap and trade program. Better data could by itself equip policy makers and politicians to manage the normative questions of society's best interest more effectively, leading to better policy outcomes. An incredibly important question of future study is the standardized measurement of the efficiency of a climate change program and the factors that affect this. If policy makers could directly compare the estimated efficiency of a given program with its political viability or international relations impact, that could lead to an overall improvement in the way that we are currently attempting to address climate change and an improvement in the daily lives of the citizens of the world.

Citations

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