IS CAP-AND-TRADE CAUSING MORE GREENHOUSE GAS EMISSIONS IN DISADVANTAGED COMMUNITIES?

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There is mounting concern that market-based climate change policies, such as cap-and-trade, may be causing disproportionately more greenhouse gas emissions near disadvantaged communities.[1–5] As a consequence, the future of existing and proposed cap-and-trade policies around the world are being questioned on environmental justice grounds. Using facility-level greenhouse gas emissions data, this paper examines whether California's cap-and-trade program, the second largest in the world, has led to relatively more emissions in disadvantaged communities. I do not find evidence that cap-and-trade has caused emission trends to differ across disadvantaged and non-disadvantaged communities since the program's inception. If anything, data suggests that emissions have dropped more in disadvantaged communities during this period, though this difference is not statistically significant.

Socially and economically disadvantaged individuals tend to experience more harm from environmental conditions.[6] Climate change is no exception. Recent studies on climate change impacts project considerable social and economic inequality under anthropogenic climate change, both across[7,8] and within[9,10] countries. However, much less is known about how policies that mitigate climate change may themselves affect inequality. Because greenhouse gases (GHG) spread evenly around the planet and do not directly yield localized effects, the primary environmental justice concern is not about local GHG emissions per se. Rather, GHG emissions are often co-produced alongside local pollutants, such as particulates, carbon monoxide, and nitrogen oxides. Climate policies may lead to greater environmental inequality if they induce more GHG emissions near disadvantaged communities.

In light of this, environmental justice concerns are now at the center of many climate policy debates. Recent efforts to introduce a carbon tax in the State of Washington failed in part due to environmental justice critiques.[ii] Similar debates are occurring about the European Union Emissions Trade System, the continent's flagship climate policy.[iii] No where is this issue more hotly contested than in California, where the future of the state's pioneering cap-and-trade program is being questioned on equity grounds.[iv] In particular, critics argue that the flexibility of using permit markets to meet regulatory

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[ii]http://grist.org/election-2016/washington-carbon-tax-732/

[iii]https://www.tni.org/files/download/scrap_the_ets18feb.pdf

[iv]http://www.latimes.com/politics/la-pol-ca-offsets-environmental-justice-20170313-story.html

requirements may allow polluting facilities near disadvantaged communities to increase GHG emissions.

Can cap-and-trade cause more GHG emissions in disadvantaged communities? Conceptually, there is no obvious answer. When functioning correctly, market-based incentives employed by cap-and-trade directs greater emissions reduction from cheaper, dirtier polluting facilities in the state. If such facilities tend to be located near disadvantaged communities, then these communities should experience a larger decline in emissions under cap-and-trade than under non-market-based climate policies. Indeed, existing studies of another California cap-and-trade program for NOx pollution have found that lower income households are either not affected[11] or may actually benefit from emissions trading.[12] On the other hand, if lower cost facilities are not located near disadvantaged communities, then cap-and-trade may increase emissions from these facilities compared to a non-market based regulation.[v]

This paper examines whether California's cap-and-trade program has caused relatively more GHG emissions in disadvantaged communities compared to other communities. To do this, I gather facility-level on-site GHG emissions data for all cap-and-trade regulated facilities in California since the start of the cap-and-trade program. I then compare average emission trends in zip codes that contain a "disadvantaged communities" as defined by the California Environmental Protection Agency, against zip codes that do not contain such communities (see Methods for data details).

Average emission for these two groups of zip codes are plotted in the top panel of Figure 1. Throughout 2012-2015, average on-site emissions (in annual megatons of CO_2 equivalent) produced in zip codes with disadvantaged communities are consistently higher than average emissions in zip codes that do not contain disadvantaged communities. This is in line with an existing study showing that disadvantaged communities tend to be located near a greater number of GHG emitting facilities and near the largest GHG emitting facilities.[13]

The evidence in the top panel of Figure 1, however, does not support the argument that cap-and-trade has led to relatively more GHG emissions near disadvantaged communities. That key question is fundamentally about whether cap-and-trade has caused the gap in nearby emissions between disadvantaged and other communities to converge. To test that claim, I calculate the change in average emissions for each group relative to 2012 levels, the year just before the start of the cap-and-trade program, and examine whether disadvantaged and non-disadvantaged communities have experienced different emission trends. A greater drop in emissions for disadvantaged communities compared to other communities would suggest that cap-and-trade has caused emission differences to narrow across the two groups.

[v] Additionally, it is possible that the distribution of more free permits to polluters near disadvantaged communities increases pollution over a longer period by subsidizing those polluters to stay in business.

These trends are shown in the middle panel of Figure 1. By and large, the annual change in emissions across disadvantaged and non-disadvantaged communities look similar. Over the 2012-2015 period, it appears that emissions in disadvantaged communities have declined slightly more than that of other communities. The same picture emerges when one examines percentage changes in emissions instead of level changes (Figure A.1).

Next, I turn to a more sophisticated regression analysis using panel data at the zip code level. This "differences-in-differences" approach has three notable advantages over the plot of average trends shown in the middle panel of Figure 1. First, one can control for time-invariant confounding factors at the zip code level that determine local emissions. Second, because population size varies across California zip codes, the average change in GHG emissions across zip codes may not correspond to the average change experienced by a disadvantaged individual. This can be addressed in a regression setting by weighting zip code level observations by the zip code population prior to cap-and-trade. Third, a regression approach allows for the estimation of uncertainty in the differential trends between disadvantaged and non-disadvantaged zip codes.

The bottom panel of Figure 1 shows point estimates and associated uncertainty from the difference-in-difference regression analysis (see Methods for more details). Each point estimate shows the average difference in emissions between disadvantaged and non-disadvantaged zip codes for the 2013-2015 period relative to the difference before the start of the cap-and-trade program in 2012. Two features are worth noting. First, for none of the years is the difference in emission trends between disadvantaged and non-disadvantaged zip codes statistically significant. Second, judging from the noisy point estimates alone, it appears that emissions produced in disadvantaged zip codes have fallen more than that from non-disadvantaged zip codes. These results are replicated in greater detail in Table 1. Similar results are found when examining alternative definitions for a disadvantaged community commonly found in the environmental justice literature. In particular, as shown in Table 2, I do not detect statistically different emission trends across zip codes with different median household income or minority share in the population.

The middle and bottom panels of Figure 1 show that emissions have similarly declined for disadvantaged and non-disadvantaged community since the start of the cap-and-trade program. This does not mean, however, that individual communities have not experienced increases in recent emissions. To see which areas of California have seen emission increases, Figure 2 shows a map of all California zip codes. Orange areas indicate zip codes that contain both disadvantaged communities and greenhouse gas emitting facilities. Blue areas indicate other communities that contain emitting facilities. Darker shaded colors indicate zip codes which have experienced rising emissions during 2012-2015. Lighter shaded colors pick out zip codes with falling emissions over the same period. There are zip codes with and without disadvantaged communities that have experienced rising and falling emissions since the start of cap-and-trade.

Pollution tends to hurt disadvantaged communities the most. As such, existing environmental policies should be carefully evaluated on environmental justice grounds. Using recent facility-level emissions data, I do not find statistical evidence that California's cap-and-trade program has led to more greenhouse gas emissions in disadvantaged communities. If anything, the evidence suggests that disadvantaged communities may have experienced on average a greater decline in emissions since the start of the cap-and-trade program than other communities. This finding, however, does not obviate the need for additional policies that more directly address environmental justice concerns associated with local pollution. Such policies should exist in tandem with California's existing cap-and-trade policy.

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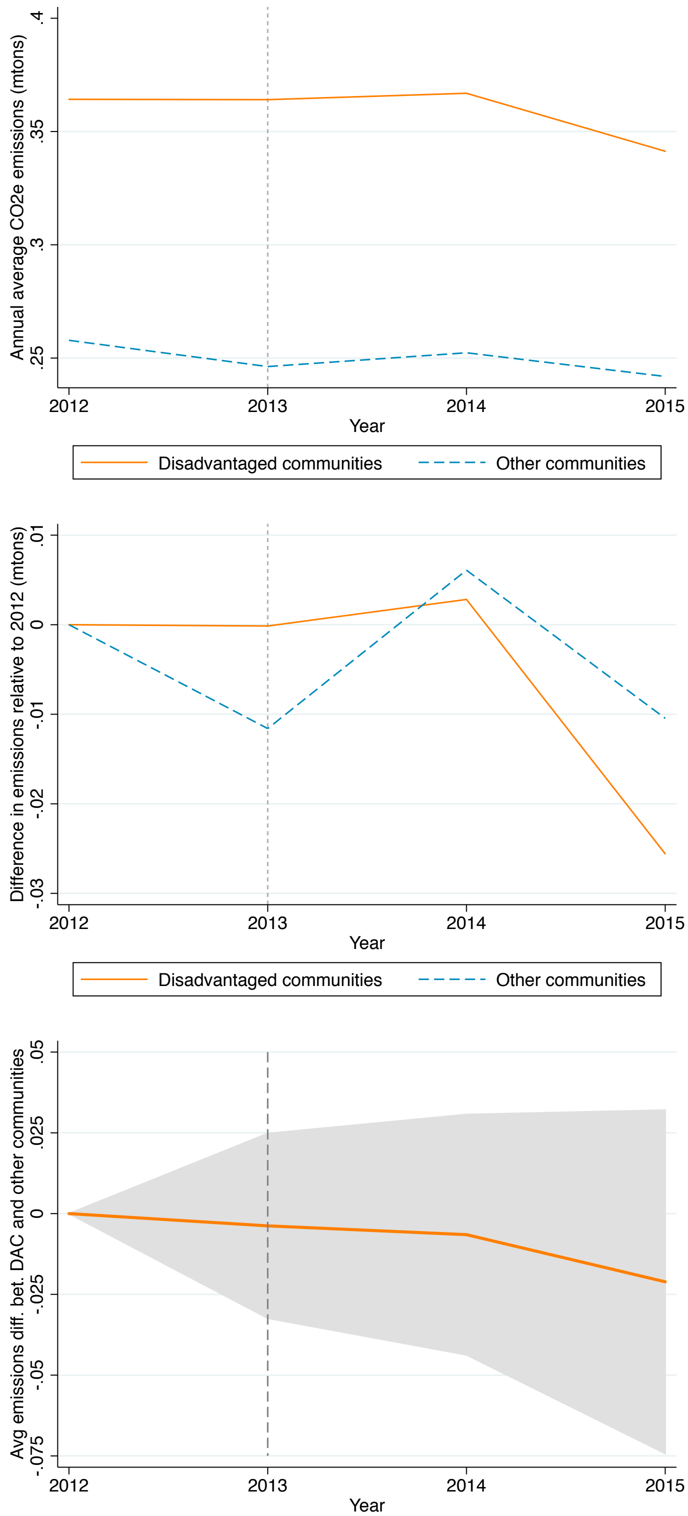
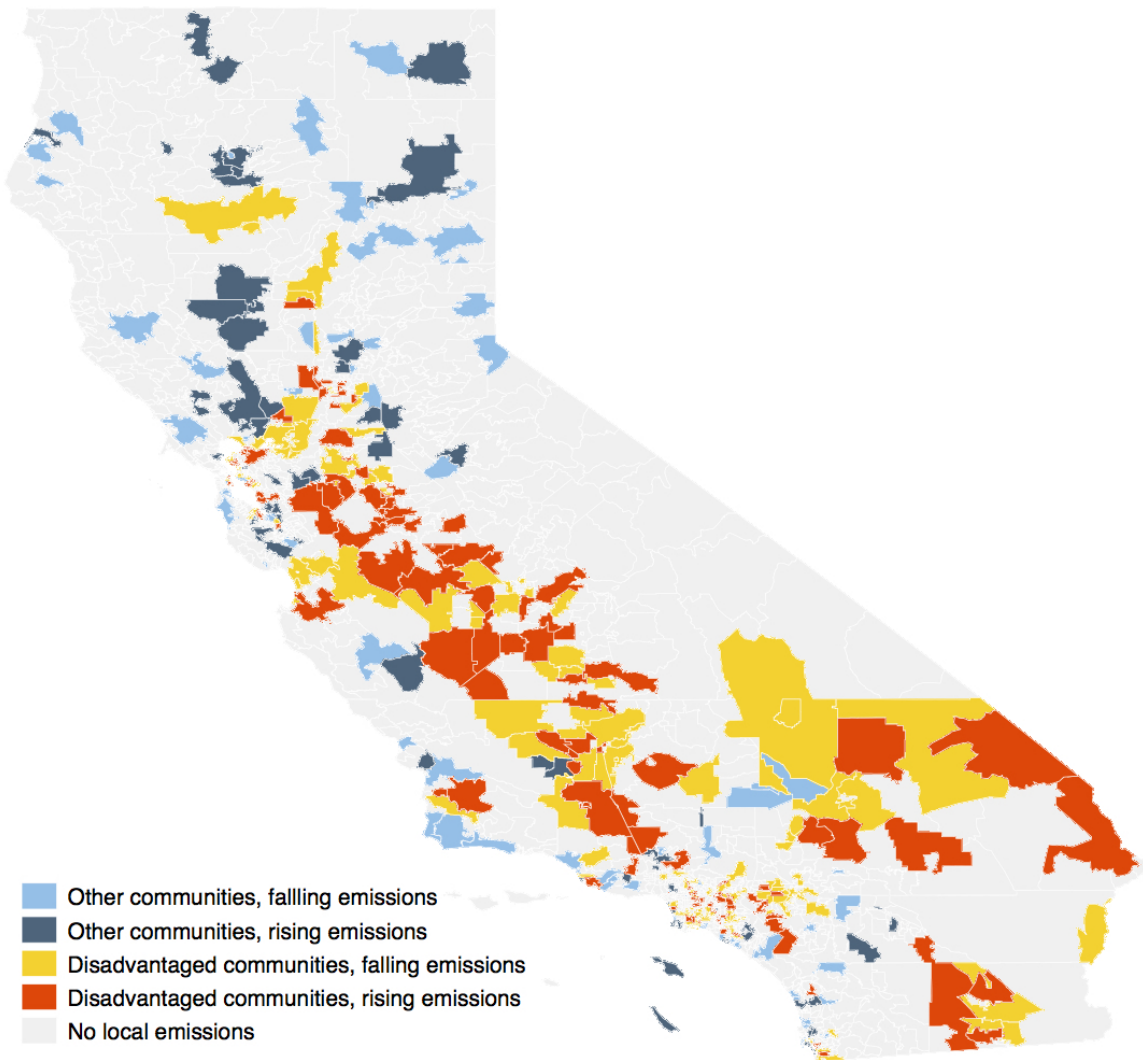
Figure 1: Emission trends for disadvantaged and other communities (2012-2015)



Notes: Top panel shows average annual on-site GHG emissions produced in zip codes that contain (orange, solid line) and do not contain (blue, dashed line) a disadvantaged community over 2012-2015. Middle panel shows change in average emissions since 2012. Bottom panel shows the average difference in emissions between disadvantaged and not disadvantaged zip codes for years 2013-2015 relative to the 2012 difference. Estimates based on a panel data regression (see Methods for details). 90% confidence intervals in gray. Vertical dashed gray line shows start of cap-and-trade policy.

Figure 2: Map of zipcodes by direction of emission change



NOTES: Map shows California zip codes broken down by whether it contains a disadvantaged community and whether emissions produced in that zip code have risen or fallen during 2012-2015.

Methods

A Data

Emissions 2012-2015[vi] facility-level on-site GHG emissions data under Californias Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) obtained from the Air Resources Board.[vii] California's cap-and-trade market began in 2013. The emissions variable corresponds most closely to emissions produced at the facility.[viii] This data is aggregated to the zip code level.

"Disadvantaged community" definition I use the legal definition of a "disadvantaged community" following California Senate Bill 535. This is the definition used for distributing cap-and-trade auction revenue funds to disadvantaged communities. Specifically, I follow the California Environmental Protection agency (CalEPA) and Air Resources Board (ARB) definition of a zip code as being disadvantaged if it contains all or part of a "Disadvantaged Community Census Tracts" (DACs) with a CalEnviroScreen score in the top 25th percentile.[ix]

Other zip code demographics Average 2008-2012 zip code population, median household income, and Black and Hispanic share of population obtained from the U.S. Census Bureau.[x]

Zip code shapefiles Zip code shapefiles obtained from ESRI.[xi]

B Statistical analysis

The bottom panel of Figure 1 shows difference-in-difference estimates using a panel dataset at the zip code level. Specifically, for emissions in zip code i and year t, I estimate:

$$E_{it} = \sum_{\tau=2013}^{2015} \beta_\tau [DAC_i \times \mathbf{1}(t=\tau)] + c_i + \gamma_t + \epsilon_{it} \quad (1)$$

where DAC_i is an indicator variable which equals one when zip code i is disadvantaged. c_i is a full vector of zip code fixed effects which controls for time-invariant unobserved determinants at the zip code

[vi] MRR data is available since 2008. However, 2008-2010 and 2011-2015 data are not consistently reported and thus cannot be directed compared. Furthermore, in 2011 there were potential issues with potential double-counting of emissions from natural gas distribution. As a consequence, I restrict our sample period to 2012-2015.

[vii] Available here: `https://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm`

[viii] This is also known as "Scope 1" emissions. Specifically, I take the sum of GHG emissions (from both biogenic and non-biogenic sources) from all on-site combustion. I exclude "Scope 2" emissions associated with purchased electricity and emissions contained in the fuel sold by fuel suppliers.

[ix] Available here: `https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/535investments.htm`

[x] I use pre-cap-and-trade population to reduce endogeneity concerns. Purchased from zipcode.com

[xi] Available here: `https://www.arcgis.com/home/item.html?id=8d2012a2016e484dafaac0451f9aea24`

level. γ_t is a full vector of year fixed effects which controls for common annual shocks to all zip codes. The error term, ϵ_{it}, is clustered at the county level to allow for arbitrary forms of heteroskedasticity and serial correlation within a county. The parameters of interest are β_τ which capture the average difference in emissions between disadvantaged and not disadvantaged zip codes for years 2013-2015 relative to the difference in 2012.

Table 1 shows estimates of β_τ for 2013-2015. Column 1 shows unweighted results. Coefficients decline over the sample period. However, this decline is not monotonic, nor is it statistically significant. Column 3 shows results weighted by zip code population.[xii] These coefficients decline monotonically over 2013-2015 compared to 2012 suggesting that disadvantaged individuals have consistently experienced a larger decline in GHG emissions since 2012. They are again not statistically significant. The coefficients β_τ and its 90% confidence interval is shown in the bottom panel of Figure 1. The results in column 2, which estimates the unweighted model for the subset of counties with 2008-2012 population, indicate that the difference in results across columns 1 and 3 is not driven by zip code sample.

The CalEPA/ARB definition of a "disadvantaged community" combines a number of demographic characteristics. Table 2 examines differential emission trends using alternative categories that are common in the environmental justice literature. Column 1 replicates the main result in column 3 of Table 1. Column 2 examines whether emission trends differ by median household income prior to the start of the cap-and-trade program and finds no statistically significant difference. Column 3 examines differential emission trends by the minority share of the population, defined as the sum of the Black and Hispanic share of the population. I detect that zip codes with a greater minority share also experienced a larger decline in emissions. However, this result isn't statistically significant for all years of the sample.

Finally, the middle panel of Figure 1 plots the change in average emission trends for disadvantaged and non-disadvantaged zip codes since 2012. Figure A.1 shows the same plot but for percentage differences in average emissions since 2012 and is highly similar to the middle panel of Figure 1.

[xii] Note that because I do not observe the population share of a zip code that is disadvantaged, our implicit assumption is that the disadvantaged population share is uniform across zip codes.

C Additional Figures and Tables

Table 1: Difference-in-difference results: disadvantaged communities

Outcome is GHG emissions (mtons)			
	(1)	(2)	(3)
DAC X [year=2013]	0.008	0.008	-0.006
	(0.007)	(0.007)	(0.015)
DAC X [year=2014]	0.009	0.013	-0.008
	(0.011)	(0.011)	(0.021)
DAC X [year=2015]	-0.011	-0.005	-0.023
	(0.017)	(0.017)	(0.030)
Observations	1,553	1,442	1,442
Population weights?	No	No	Yes

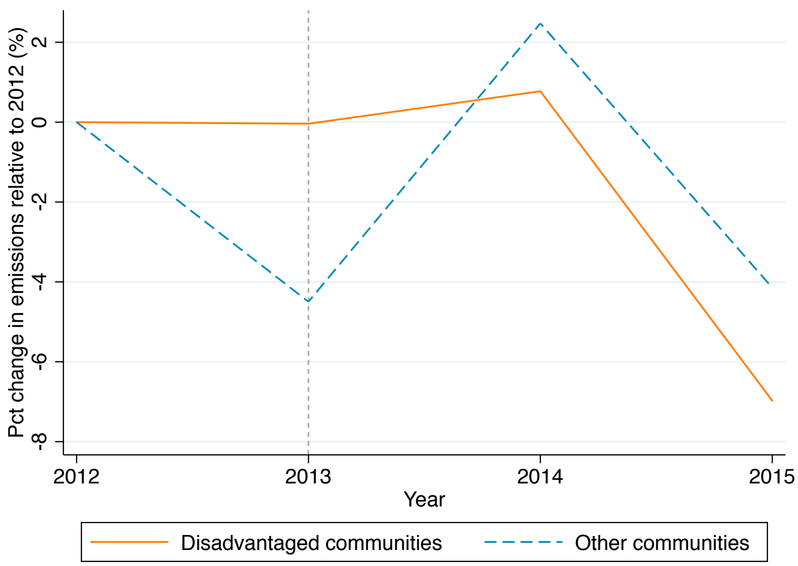
NOTES: Estimates of β_τ from equation (1). All models include zip code fixed effects and year fixed effects. Column 1 shows unweighted results. Column 2 restricts sample to zip codes with population data from the U.S. Census Bureau. Column 3 shows population weighted results. Standard errors clustered at zip code level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2: Difference-in-difference regression: other EJ categories

Outcome is GHG emissions (mtons)			
	(1)	(2)	(3)
DAC X [year=2013]	-0.006		
	(0.015)		
DAC X [year=2014]	-0.008		
	(0.021)		
DAC X [year=2015]	-0.023		
	(0.030)		
income X [year=2013]		-0.000	
		(0.000)	
income X [year=2014]		0.000	
		(0.000)	
income X [year=2015]		0.000	
		(0.000)	
% minority X [year=2013]			-0.005
			(0.030)
% minority X [year=2014]			-0.058*
			(0.032)
% minority X [year=2015]			-0.059
			(0.041)
Observations	1,442	1,442	1,442
Population weights?	Yes	Yes	Yes

NOTES: Estimates of β_τ from equation (1). All models include zip code fixed effects and year fixed effects. Column 1 replicates the disadvantaged community result in column 3 of Table 1. Column 2 examines differential trends by median household income averaged over 2008-2012. Column 3 examines differential trends by minority share of the population averaged over 2008-2012. Standard errors clustered at zip code level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure A.1: Average pct change in emissions for disadvantaged and other communities (2012-2015)



Notes: Shows the percentage change in average on-site GHG emissions produced in zip codes that contain (orange, solid line) and do not contain (blue, dashed line) a disadvantaged community since 2012.