Is cap-and-trade causing more greenhouse gas emissions in disadvantaged communities?

Kyle C. Meng*

Abstract

There is mounting concern that market-based climate change policies may be causing disproportionately more greenhouse gas emissions near disadvantaged communities. This paper uses facility-level reported greenhouse gas emissions data to examine the environmental justice consequences of California's cap-and-trade policy, the second largest such program in the world. I do not find that this policy has led to relatively more greenhouse gas emissions in disadvantaged communities. If anything, evidence suggests that emissions have fallen more in disadvantaged communities since the start of the program, though this difference is not statistically significant.

Key words: climate change policy, cap-and-trade, environmental justice, California

*Bren School of Environmental Science and Management and Department of Economics, University of California, Santa Barbara, and NBER (email: kmeng@bren.ucsb.edu). I thank Irena Asmundson, Severin Borenstein, Jim Bushnell, Chris Costello, and Meredith Fowlie for helpful comments. All errors are my own.

1 Introduction

Socially and economically disadvantaged individuals tend to experience more harm from environmental conditions (Mohai, Pellow and Roberts, 2009). Climate change is no exception. Recent studies on climate change impacts project considerable social and economic inequality under anthropogenic climate change, both across (Dell, Jones and Olken, 2012; Burke, Hsiang and Miguel, 2015) and within (Burgess et al., 2013; Houser et al., 2015) 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 (Solomon and Lee, 2000; Kaswan, 2008; Stavins, 2008; Ringquist, 2011; Boyce and Pastor, 2013)

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 U.S. State of Washington failed in part due to environmental justice critiques.[1] Similar debates are occurring about the European Union Emissions Trade System, the continent's flagship climate policy.[2] No where has this issue been more hotly contested than in California, where the future of the state's pioneering cap-and-trade program has recently been questioned on equity grounds.[3] In particular, critics argued that the flexibility of using permit markets to meet regulatory requirements may allow polluting facilities near disadvantaged communities to increase GHG emissions.

Can cap-and-trade cause more GHG emissions in disadvantaged communities? Con-

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

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

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

ceptually, 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 (Fowlie, Holland and Mansur, 2012) or may actually benefit from emissions trading (Grainger and Ruangmas, 2016). 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.[4]

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 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.

I do not find statistical evidence that California's cap-and-trade program has led to more GHG emissions in disadvantaged communities. Statistically noisy point estimates suggest that disadvantaged communities have experienced a greater decline in GHG emissions since the start of the program in 2013.

The remainder of the paper is organized as follows. Section 2 introduces data sources and my statistical approach. Section 3 presents results. Section 4 concludes the paper.

2 Data and methods

This section details all data sources and my main statistical approach.

[4] 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.

2.1 Data sources

Emissions I obtain facility-level GHG emissions data collected under Californias Regulation for the Mandatory Reporting of Greenhouse Gas Emissions (MRR) from the Air Resources Board.[5] This data covers the 2012-2015 period.[6] In order to calculate a greenhouse gas emissions variable that corresponds most closely to emissions produced at the facility, I take the sum of GHG emissions (from biogenic and non-biogenic sources) resulting from on-site combustion.[7] Emissions data is then aggregated to the zip code level.

Zip code definition of a "disadvantaged community" I use the legal definition of a "disadvantaged community" following California Senate Bill 535.[8] 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.[9]

Other zip code demographics I obtain average 2008-2012 zip code population, median household income, and Black and Hispanic share of population from the U.S. Census Bureau.[10]

Zip code shapefiles I use zip code shapefiles available from Environmental Systems Research Institute.[11]

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

[6] 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.

[7] This is also known as "Scope 1" emissions. I exclude "Scope 2" emissions associated with purchased electricity and emissions contained in the fuel sold by fuel suppliers.

[8] This is the definition used for distributing cap-and-trade auction revenue funds to disadvantaged communities.

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

[10] Purchased from zipcode.com

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

2.2 Statistical method

My primary statistical method is a difference-in-difference estimator. Specifically, for emissions in zip code i and year t, E_{it}, 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 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 each 2013-2015 year, relative to the difference in 2012.

3 Results

3.1 Average emission trends

I begin by first plotting average greenhouse gas emission trends for disadvantaged and non-disadvantaged zip codes to provide a visual preview of the data. The top panel of Figure 1 shows average emissions for these two groups of zip codes. 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 a prior study showing that disadvantaged communities tend to be located near a greater number of GHG emitting facilities and near the largest GHG emitting facilities Cushing et al. (2016).

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.

These trends are shown in the bottom 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.

3.2 Difference-in-difference estimates

Next, I turn to a regression analysis using panel data at the zip code level. The differences-in-differences approach introduced in Section 2.2 has three notable advantages over the plot of average trends shown in the bottom 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.

Figure 2 presents point estimates and associated uncertainty from the difference-in-difference regression model. 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 regression results are presented in greater detail in Table 1. Column 1 shows results from a model that does not include population weights. 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 and corresponds to what is plotted in Figure 2.[12] 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. Column 2 presents a model without population weights for the subset of counties with 2008-2012 population and shows that the difference in results across columns 1 and 3 is not driven by the 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 before the cap-and-trade program. I detect that zip codes with a greater minority share also experienced a larger decline in emissions. However, this result is not statistically significant for all post 2013 years.

[12]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.

3.3 Heterogeneity across zipcodes

Figure 2 and Table 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 3 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.

4 Conclusion

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.

References

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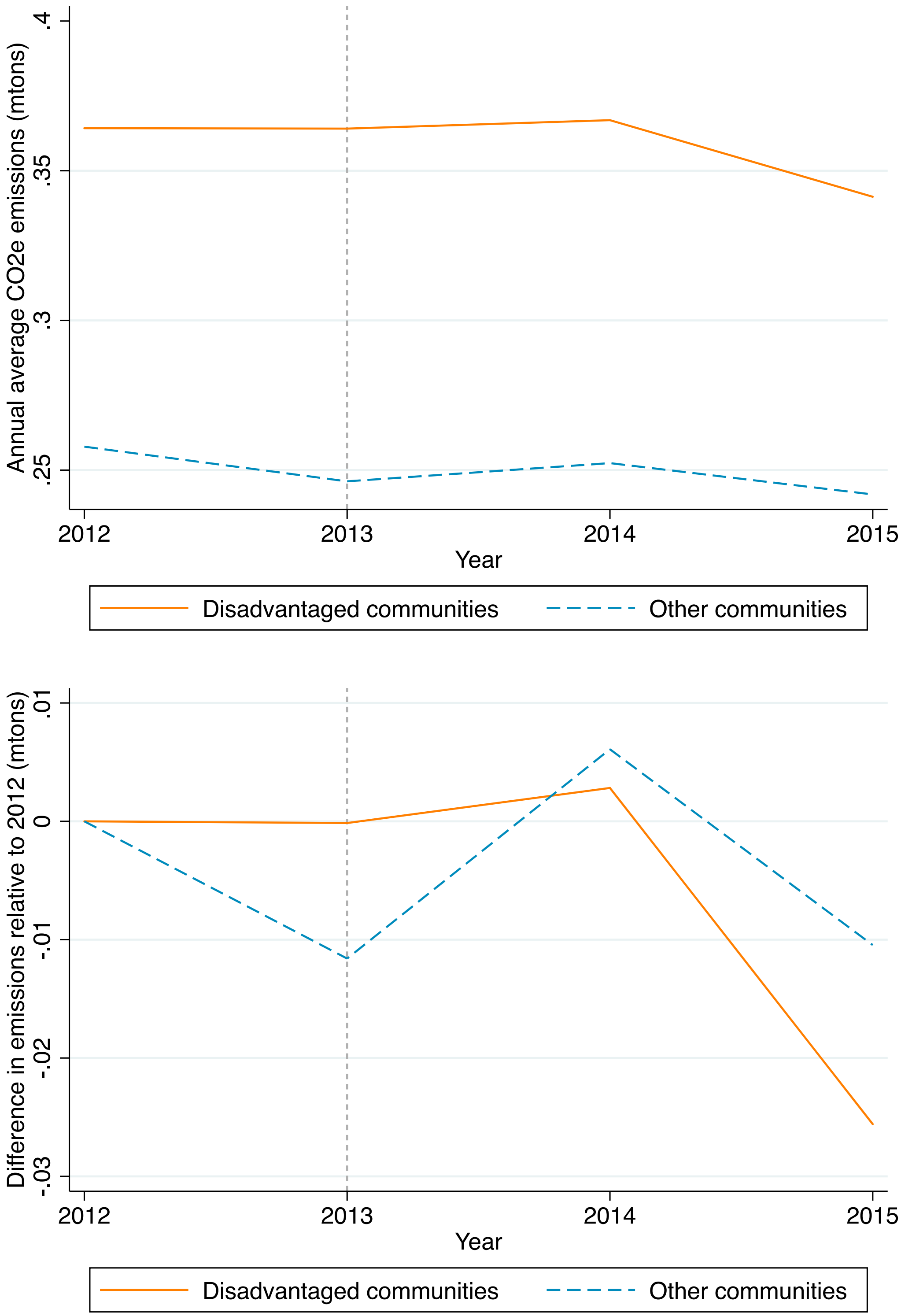
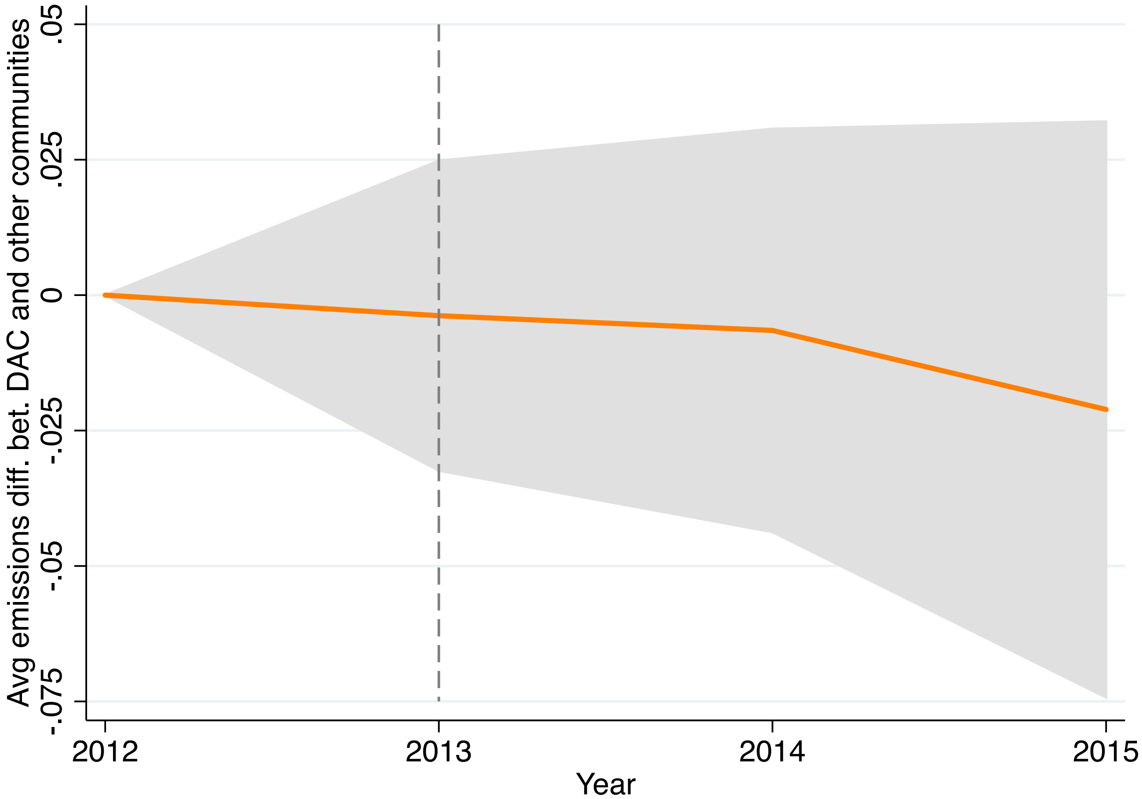
Figures

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



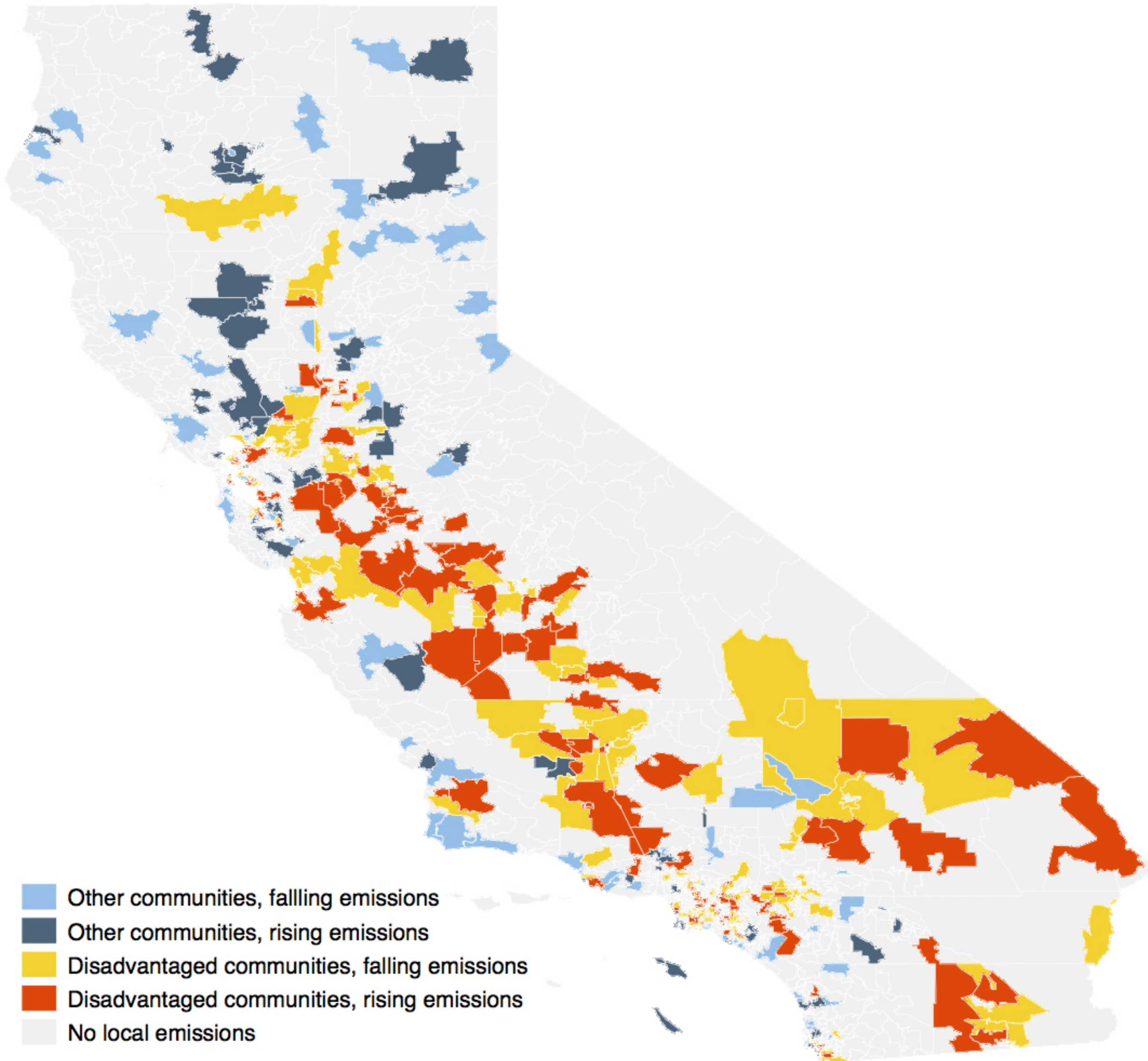
NOTES: Top panel shows average annual on-site GHG emissions produced in zip codes that contain (orange, solid line) and do not contain (blue, dashed line) a disadvantaged community over 2012-2015. Bottom panel shows change in average emissions since 2012.

Figure 2: Difference-in-difference estimate (2012-2015)



Notes: 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 difference-in-difference panel data regression (see Section 2.2 for details). 90% confidence intervals in gray. Vertical dashed gray line shows start of cap-and-trade policy.

Figure 3: 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.

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.