Online Appendix

Incentivizing the Green Vote?
The Role of California's Cap-and-Trade Investments on Electoral Outcome

Esha M. Vaze

1 Proof of IV Exogeneity

This section provides a short proof to show that the instrument is exogenous.

Proof. Consider $Z_{i,t}$, the instrument that is uncorrelated with the error term in the structural equation for the outcome variable. We state this assumption as:

$$\mathbb{E}[\varepsilon_{i,t} \mid Z_{i,t}] = 0$$

This implies that the instrument is as-good-as-randomly assigned, conditional on covariates.

Let $Y_{i,t}$ be the outcome (proportion of votes cast in favor of a green ballot measure) in county i at time t, and let the estimated equation be:

$$Y_{i,t} = \beta_0 + \beta_1 F_{i,t} + \varepsilon_{i,t}$$

Where $F_{i,t}$ is the endogenous treatment variable (Log cumulative GGRF funding received by county i until time t), $Z_{i,t}$ is the instrument defined as proportion of treated census tracts above the RD threshold, and $\varepsilon_{i,t}$ is the error term.

This paper's design requires:

$$\mathbb{E}[\varepsilon_{i,t} \mid Z_{i,t}] = \mathbb{E}[\varepsilon_{i,t}] \quad \text{or} \quad \text{Cov}(Z_{i,t}, \varepsilon_{i,t}) = 0$$

Now we define the CES score for census tract j in county i at time t as $p_{i,j,t}$, and a deterministic cut-off score c such that:

$$T_{i,j,t} = \mathbf{1}\{p_{i,j,t} \in (c, c+h]\}$$
$$C_{i,j,t} = \mathbf{1}\{p_{i,j,t} \in [c-h, c]\}$$

For any chosen bandwidth (here, $h = 3.86$), under standard sharp RD assumptions (continuity and no manipulation of $p_{i,j,t}$ at cutoff c), we have:

$$\mathbb{E}[\varepsilon_{i,j,t} \mid T_{i,j,t} = 1] = \mathbb{E}[\varepsilon_{i,j,t} \mid C_{i,j,t} = 1]$$

This implies exogeneity at the census tract level: assignment to treatment around the cutoff is independent of unobserved determinants of the outcome.

We now define the instrument:

$$Z_{i,t} = \frac{\sum_{j=1}^{k_{i,t}} T_{i,j,t}}{\sum_{j=1}^{k_{i,t}} T_{i,j,t} + \sum_{j=1}^{N-k_{i,t}} C_{i,j,t}}$$

Which is the proportion of tracts in the RD bandwidth that are treated, at the county-year level.

Let $\varepsilon_{i,j,t}$ be the residual component of the outcome at the tract level, and assume county-level outcomes are aggregated from census tract-level outcomes. Then,

$$\varepsilon_{i,t} = \frac{1}{N_i} \sum_{j=1}^{N_i} \varepsilon_{i,j,t}$$

From census tract-level exogeneity, we get:

$$\mathbb{E}[\varepsilon_{i,j,t} \mid T_{i,j,t}] = \mathbb{E}[\varepsilon_{i,j,t}]$$

Using the law of iterated expectations and linearity of expectations:

$$\mathbb{E}[\varepsilon_{i,t} \mid Z_{i,t}] = \frac{1}{N_i} \sum_{j=1}^{N_i} \mathbb{E}[\varepsilon_{i,j,t} \mid Z_{i,t}] = \mathbb{E}[\varepsilon_{i,t}]$$

Then $Z_{i,t}$ is a function of $T_{i,j,t}$, and $T_{i,j,t}$ is independent of $\varepsilon_{i,j,t}$ by design.

Thus the instrument satisfies:

$$\text{Cov}(Z_{i,t}, \varepsilon_{i,t}) = 0$$

□

2 Voter Turnout

In an attempt to explain the counterintuitive results in the main paper, an additional outcome we look at is voter turnout: if receiving targeted funding doesn't increase the share of votes in favor of an environmental proposition, does it also lead to a reduction in voter turnout?

The hypothesized causal chain is as follows: an increased number of disadvantaged people in a county leads to higher GGRF funding. Then higher funding, instead of galvanizing people to vote in favor of the environment ends up reducing their desire to vote pro-environment (perhaps because of policy fatigue, a perception that the policy is ineffective, or that the policy and funding efforts are so useful that they no longer feel compelled to participate in the public debate to protect the environment).

Testing the last link of this chain explicitly is hard. Section 3 looks at some survey data from the state of California, specifically concerning public attitudes towards the Cap-and-Trade program, but there is no data that measures how the *recipients* of GGRF funds feel about the policy after its implementation. As a first pass, (and perhaps a proxy for policy fatigue) this paper uses Secretary of State voter outcome data to test if higher funding over time has reduced the share of eligible voters who show up to the polling booths when environmental issues are up for vote. I run the same 2SLS framework as used in the main paper on voter turnout data from 2016, 2018 and 2022 (all years that include pro-environmental ballot measures), and find a significant negative effect that persists across all years and is robust to the inclusion of race as a control. These results are reported in 1.

Much like actual voting outcomes on the ballot, voter turnout is driven by a host of factors: as a very blase example, global shocks like COVID-19 reduced average household income (a factor used to calculate the census tract level CES score) and also reduced total voter turnout. In fact, voter turnout in the United States has been declining for over a decade now, much before the inception of the GGRF program. What makes these results interesting despite these concerns is that the calculated CES score is a weighted measure of 19 indicators, and the claim of instrument exogeneity persists because of the nature of this score calculation and its sharp regression discontinuity design. Furthermore, both scoring iterations used in this paper (2.0 and 3.0) were calculated pre-COVID.

A plausible chain that can explain the results we see is as follows: level of income and education is negatively correlated with pollution and disease burden → census tracts with low education and income have higher CES score → a county with lots of census tracts with high CES scores has a higher calculated value of the instrument, which leads to higher predicted GGRF funding → leads to lower voter turnout, because people who are poor and less educated have a demonstrated pre-trend of low voter turnout rates. A survey report from CalMatters (2020) and Votebeat found racial gaps in turnout during the 2020 general election, and Californian Latinos especially lagged behind. The same survey found that in areas with large communities of color, only about 70% of registered voters cast a ballot. In contrast, in primarily white areas, 87% of voters did. This conforms with the income-and-race driven voting pattern in the United States, where rich white voters are the most likely group to cast ballots in both gubernatorial and federal elections, potentially helping

us interpret the results we see where higher GGRF funding leads to lower voter turnout rates.

PPIC survey analysis shows that Latinos, (California has the largest population of eligible Latino voters in the country) make up 35% of the voting-age population but only 22% of the state's likely voters. Since areas with higher populations of Latinos are more likely to be poor and less educated, this chain could be suggestive evidence for turnout being driven by demographics instead of funding, and help explain why higher GGRF funding implies lower voter turnout through the years.

3 PPIC Statewide Surveys: Californians and the Environment

A reasonable question that one might ask is "*Do people even know about the Cap-and-Trade program*?"[1] – if the level of program salience is low, then the results of this paper have little credibility. Indeed, a "first-stage" for this paper would be measuring if (a) Californians know what the Cap-and-Trade program is, (b) If they support it, and (c) If they are aware of/support the targeted program fund allocation into disadvantaged communities. Fortunately, this data exists in the form of a survey conducted by the Public Policy Institute of California in July every year, titled "Californians and the Environment" which measures the residents' attitudes on a host of environmental issues. In the years 2014, 2016-2021 and 2023, the survey contained questions (a), (b) and (c) about the Cap-and-Trade program. Each survey uses a representative sample of ∼1750 Californians from all 58 counties, and reports weighted results. This paper uses raw survey results for each year from 2014 to 2023, and parses out the unweighted data to test if survey trends correspond with the results we find in the main paper.[2]

First, I look at outcomes from 2014, to check for baseline program support. The main paper looks at a 2SLS specification to verify that the instrument does not predict pre-program environmental outcomes. In this section, I look at survey data to check if baseline awareness and support for the program rises over time as it is rolled out and more people receive funding. Figure 2 shows categorical survey responses for three questions from 2014:

1. How much, if anything, have you heard about the state government policy called "cap-and-trade" that sets limits on carbon dioxide emissions? Have you heard a lot, a little, or nothing at all?

2. In the system called "cap-and-trade," the California state government issues permits limiting the amount of greenhouse gases companies can put out. Companies that do not use all their permits can sell them to other companies. The idea is that many

[1] And many have.

[2] All results that use PPIC surveys are reported in the Appendix for two main reasons: First, it would be both disingenuous and misleading to borrow the survey weighting system for this paper's main analysis (since the survey is representative, some counties used for the analysis only have one respondent reported). Second, the author is largely skeptical of survey evidence, and as such it is reported in the appendix only to help point this paper into suggestive mechanisms that might explain the main results.

companies will find ways to put out less greenhouse gases, because that will be cheaper than buying permits. Do you favor or oppose the cap-and-trade system?

3. The governor and legislature recently agreed on a plan for how to spend the revenues generated by California's cap-and-trade program. The plan includes spending 25 percent of the revenues on high speed rail, 35 percent on affordable housing and other mass transit projects, and the rest on projects related to natural resources, energy efficiency, and transportation. In general, do you favor or oppose this spending plan?

Pre-program data shows that program awareness is at 55 percent, favor is ~ 45 percent and the proposed spending plan is favored by a little over half of the total respondents. The baseline trend before the program shows that even before they receive funding, Californians are aware of the cap-and-trade and its targeted investment objectives. In Figure 3 I restrict the data to non-white (excluding Asians) respondents to check for racial heterogeneity: non-white responders are less aware of the Cap-and-Trade program, favor it roughly as much as the total sample does, but show much larger support for the disadvantaged group specific spending plans. So ex-ante, there exists support for the program, in both the full sample and the restricted non-white sample of respondents.

Figure 4 shows a post-program time trend of the first two questions above, and:

- How important to you is it that some of the cap-and-trade revenues are spent on projects to improve environmental conditions in lower-income and disadvantaged communities—very important, somewhat important, or not too important?

There is no clear trend that jumps out from these responses – awareness and importance of targeted funding fluctuate over the years, but support for the cap-and-trade is shows an increase over time. [3] For awareness, if we combine "a little" and "a lot", then the awareness is, overall increasing over time. If the same positive response grouping is done for targeted spending support, then we get a somewhat noisy and weak upward trend over the years. This effectively confirms (to the extent that a representative survey of the state can) that Californians are aware of the Cap-and-Trade program, and its investment objectives. This lends some credibility to the arguments made in the main paper, because it provides support for program salience and serves as a proof of concept. Californians are aware, and so the hypothesized channel of GGRF funding having the capacity to influence behavior remains intact.

Once again, to check is there is racial heterogeneity in the raw survey data, I plot the time-trends for all survey responses for the non-white respondents only. Awareness grows over time, but the share of unaware people is on average higher than the full sample. Support for the program is steadily rising, while support trend for targeted funding is noisy when we look at the raw numbers, it is rising weakly over time as a proportion of total responses. The difference in total sample trends and race sub-sample trends is further evidence that there is racial heterogeneity in how Californians perceive the cap-and-trade program specifically, and possibly extends to other environmental ballot measures as well.

[3] Note that the year 2016 did not feature the option to code responses as "not important at all", and thus does not appear in the time-trend bar for that year.

As this section previously mentions, a representative survey implies that many counties have few respondents on record. To check for some county-level raw pre-trends, I restrict the survey sample to counties with more than fifty observations, to eyeball if there is significant difference in county-level responses to the Cap-and-Trade program before its full GGRF roll-out.[4] This is an attempt to check for a county-level "environmental voting trend" that could have influenced the main paper's results. The plots show that there is consistent *support* for both the program and its spending plan in the pre-period, even though awareness is slightly lower when compared to the full sample. There is little descriptive evidence for county specific trends. I then restrict the sample to non-white respondents: awareness (on average) is lower in each county, support mimics the full sample, and support for targeted spending is also higher on average.

For reference, in 2015 at the start of the program, the calculated instrument values (proportion of "treated" census tracts) were as follows for each of the counties in Figure 7:[5]

County	**Instrument**
Alameda	0.4444444
Contra Costa	0.1666667
Los Angeles	0.5
Orange	0.625
Riverside	0.5
Sacramento	0.5833333
San Bernardino	0.6428571
Santa Clara	0.5454546
San Diego	0.3

Table 1: Instrument values for selected California counties

[4]For curiosity's sake

[5]This table serves to illustrate that the counties graphed are a good sample for approximating the existence of a negative pre-trend, which doesn't seem to exist.

Turnout	OLS		2SLS	
Log(Cumulative Funding)	-0.00516	0.00122	-0.0523***	-0.0796*
	(0.00381)	(0.00500)	(0.0187)	(0.0442)
Proportion Non-white		-0.143***		0.373
		(0.0502)		(0.289)
Constant	0.666	0.607	1.478	1.816
Observations	268	267	268	267
Standard errors clustered at the county level.				

(a) Voter Turnout 2016

Turnout	OLS		2SLS	
Log(Cumulative Funding)	-0.00640	0.00200	-0.0592***	-0.0873*
	(0.00457)	(0.00646)	(0.0201)	(0.0463)
Proportion Non-white		-0.188***		0.382
		(0.0671)		(0.297)
Constant	0.606	0.528	1.516	1.865
Observations	268	267	268	267
Standard errors clustered at the county level.				

(b) Voter Turnout 2018

Turnout	OLS		2SLS	
Log(Cumulative Funding)	-0.00842**	-0.000114	-0.0569***	-0.0812*
	(0.00368)	(0.00427)	(0.0204)	(0.0474)
Proportion Non-white		-0.185***		0.334
		(0.0529)		(0.303)
Constant	0.563	0.485	1.398	1.699
Observations	268	267	268	267
Standard errors clustered at the county level.				

(c) Voter Turnout 2022

Figure 1: Voter Turnout

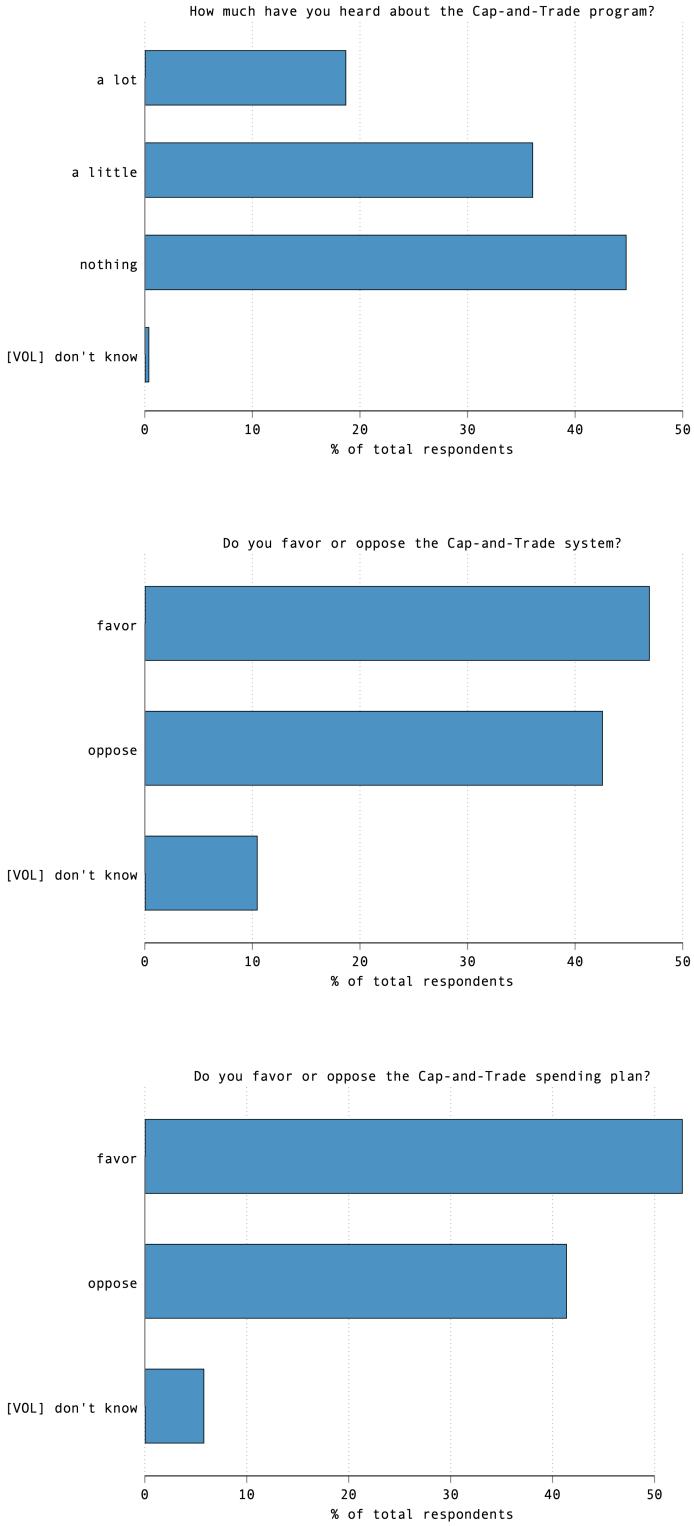

Figure 2: Cap-and-Trade: 2014 Pre-Trends

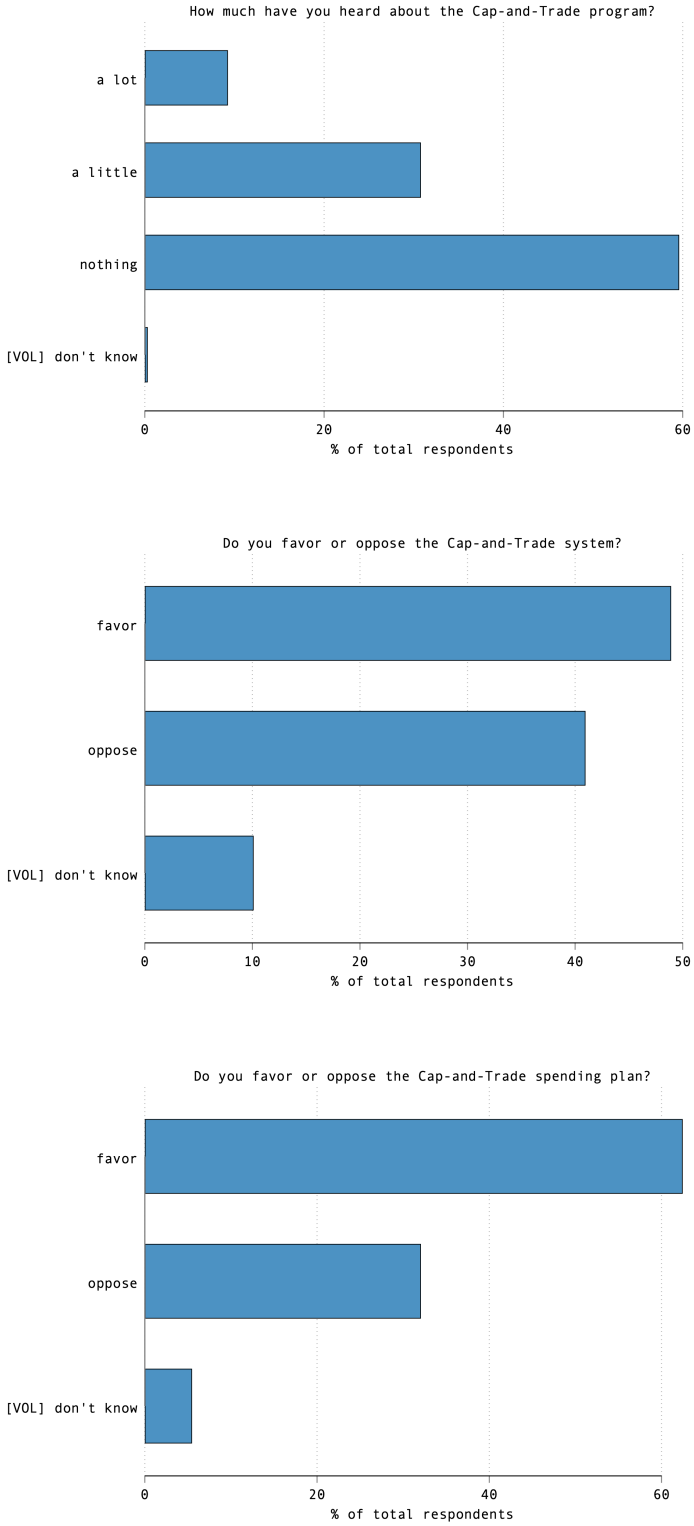

Figure 3: Cap-and-Trade: 2014 Pre-Trends for Non-White Respondents

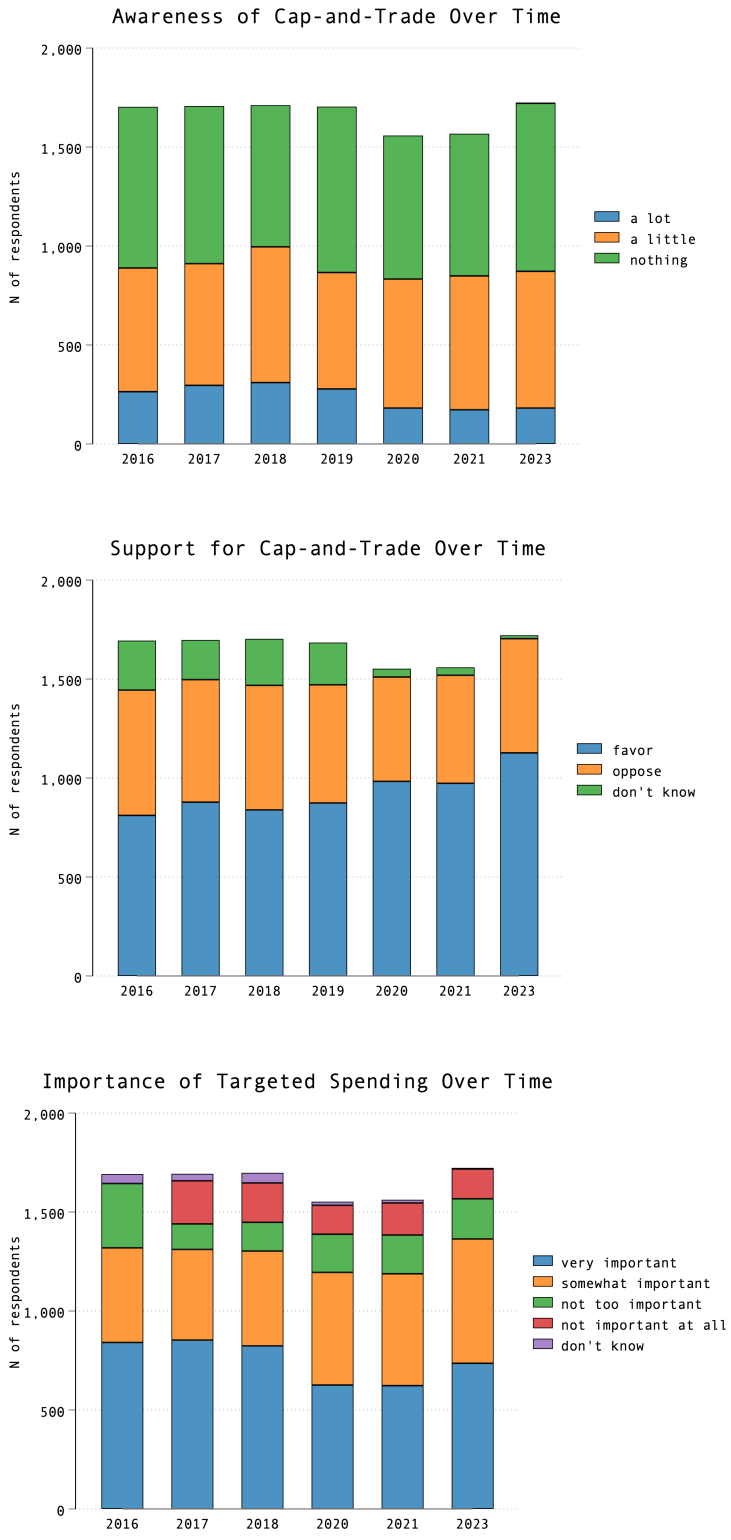

Figure 4: Cap-and-Trade: Time-trends

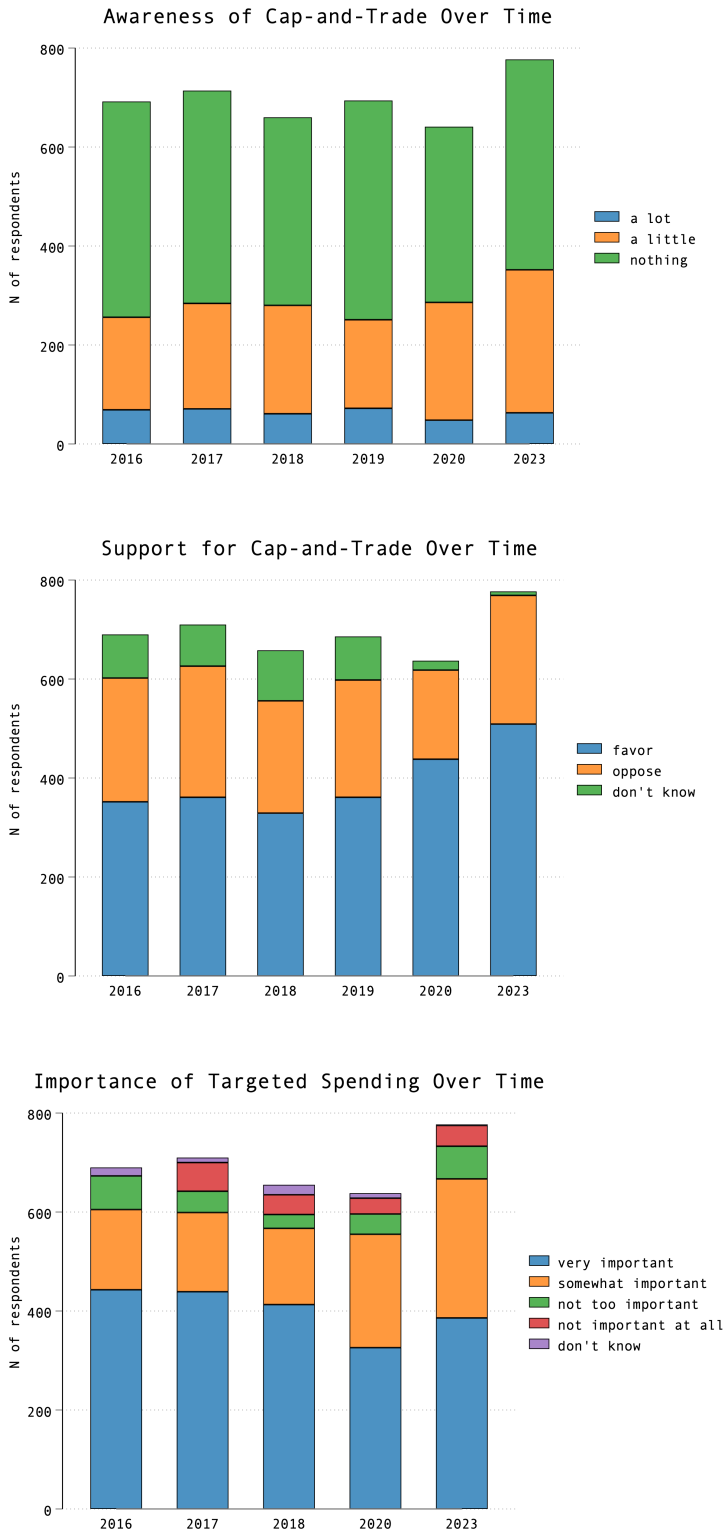

Figure 5: Cap-and-Trade: Time-trends for Non-White respondents

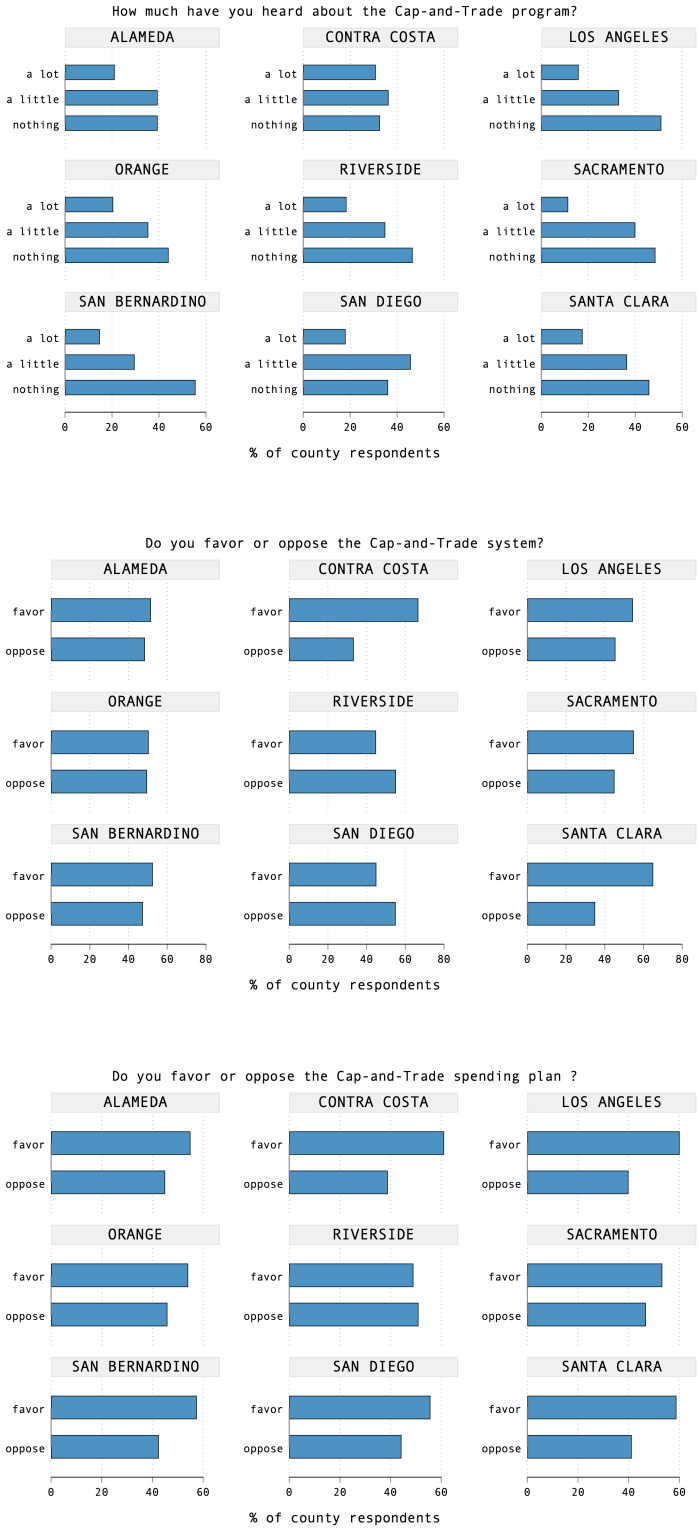

Figure 6: County-level responses (2014)

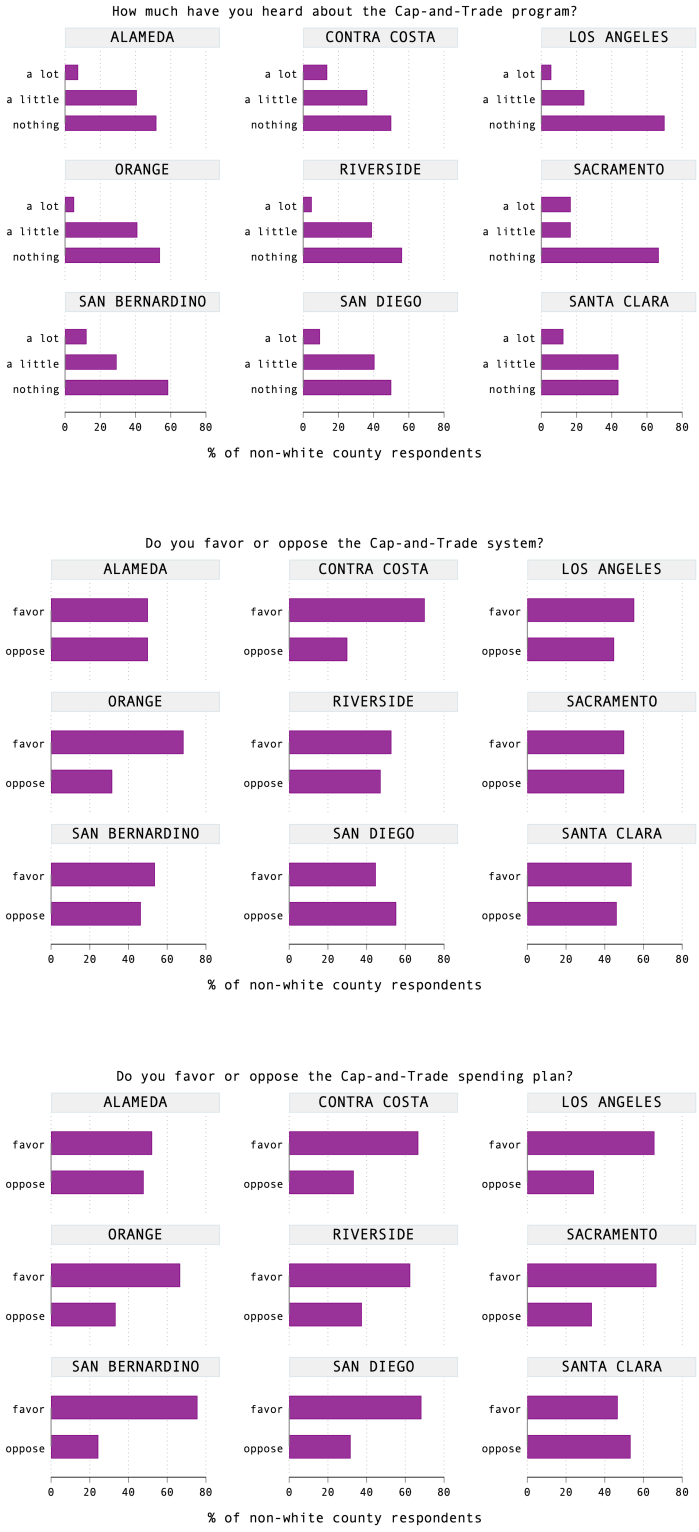

Figure 7: County-level responses, Non-White respondents only (2014)