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A County-level Analysis of California Cap-and-Trade Auctions and the Corresponding Investments in Emissions Reduction Projects

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Abstract

Over the past several decades, climate change has become an increasingly important topic of conversation. Government agencies across the globe have developed different methods to mitigate greenhouse gas (GHG) emissions, as well as the effect GHG emissions have on the environment. In the state of California, a Cap-and-Trade emissions trading system was put in place in hopes of reducing GHG emissions in California. Within this emissions trading system, the California Air Resources Board holds quarterly carbon allowance auctions, allowing entities under regulation of the Cap-and-Trade program to purchase carbon allowances in order to satisfy emissions requirements. Through these auctions, billions of dollars of revenue have been generated and appropriated to greenhouse gas emissions reductions projects aimed at further reducing California's carbon footprint. This paper investigates county-level economic, social, and political factors that play a role in the appropriation of these funds in comparison to the total auction revenue generated. The findings of this paper show that the investments allocated to projects in specific counties peak during senate election years. Additionally, democratic counties receive significantly higher amounts of investment, in proportion to the total auction revenue that they generate, than non-democratic counties. These findings imply that a political bias may exist within this system of the allocation of Greenhouse Gas Reduction Fund (GGRF) investments to emissions reductions projects in particular counties.

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1. Introduction

In 2006, the state of California passed the Global Warming Solutions Act, which established California's Cap-and-Trade program in an effort to reduce greenhouse gas (GHG) emissions (Schmalensee & Stavins, 2017). The program was officially introduced and implemented in 2012 by the California Air Resources Board (CARB), who oversees and regulates the program. The program covers over 450 different entities that are responsible for about 80 percent of the state's greenhouse gas emissions (CARB, 2015). In 2014, California linked its Cap-and-Trade program with Quebec's, creating a joint jurisdiction in which entities covered by either program can use allowances that are issued by one of the jurisdictions (CARB 2017).

The program covers entities that emit at least 25,000 metric tons of carbon dioxide equivalent (MT CO2e) each year, and each of those covered entities is required to report their annual emissions data to CARB (Berkeley Law, 2019). CARB collects annual emissions data on the entities that are covered by the program, compares those emissions levels to 1990 emissions levels, and uses that information to set a *cap* on statewide emissions. The *cap* is set based on emissions reductions targets, and a specified number of allowances are issued in accordance with the *cap*. If a covered entity creates greenhouse gas emissions, they are required to obtain allowances that are equal to that level of emissions (Berkeley Law, 2019). Each allowance is equal to one metric ton of carbon dioxide equivalent emissions (MT CO2e). Therefore, for each metric ton of carbon dioxide equivalent that is emitted, an entity must possess an allowance. The overall *cap* declines annually, which in turn, decreases the total number of available allowances under the *cap*

(Berkeley Law, 2019). In theory, statewide greenhouse gas emissions should decrease as the overall emissions *cap* decreases.

Carbon allowances are tradeable permits that allow the holder or owner to emit one metric ton of carbon dioxide equivalent greenhouse gas. Covered entities can obtain allowances through free allocation, which is designated by CARB, or by purchasing allowances at quarterly-held auctions. CARB has set allowance budgets up until 2050. The 2030 *cap* has been set at 200.5 million metric tons of CO2 equivalent (MMTCO2e), which corresponds to an annual decline of approximately 13.5 MMTCO2e each year from 2021 to 2030 (Wang et al, 2022). The number of allowances that are freely distributed also varies by sector. In 2022, The Electrical Distribution Utilities sector accounted for about 50% of freely allocated allowances, followed by Natural Gas Suppliers (26%), and Industrial (23%) (Wang et al, 2022).

Another way for entities to obtain allowances is by purchasing them at the quarterly auctions held by CARB. There are two types of auctions: current and advance. Current auctions are held four times a year. At each current auction, a quarter of the year's total allowances are sold, as well as any allowances that were not sold in previous auctions. Advance auctions occur at the same time as current auctions. However, the allowances sold during advance auctions are eligible three years into the future (Wang et al, 2022). For example, an advance auction held in 2023 would sell allowances that could be used in 2026.

CARB has implemented several mechanisms to ensure allowance prices are optimized. Firstly, a percentage of the annual allowances available under the cap are set aside into an Allowance Price Containment Reserve. When a quarterly auction yields an allowance settlement price that is greater than or equal to 60% of the lower tier reserve price, CARB will offer a reserve sale auction in which entities can purchase allowances at either of the two reserve tier prices. Additionally, if there is a situation in which an entity does not possess the equivalent number of allowances needed to offset their emissions, and all of the Reserve allowances have been sold, then CARB offers a price ceiling sale in which entities can purchase the required number of allowances they need to offset their emissions at a specified price. Both price ceiling prices and reserve prices increase by 5% annually plus inflation (CARB, *Cost Containment Information*).

Another way for regulated entities to cover their emissions obligations is through carbon offsets. CARB issues offset credits for projects that reduce emissions or sequester greenhouse gases as long as they align with CARB's Compliance Offset Protocols. Essentially, a carbon offset can be awarded for each metric ton of carbon dioxide equivalent that is reduced or sequestered through the funding or implementation of emission reduction projects. These awarded offsets can be used to satisfy a small portion of an entity's overall emissions compliance obligation. However, there are specified limits for how much of an entity's overall compliance obligation can be met using offsets. For emissions from 2021-2025, 4 percent of an entity's overall obligation can be met with offset credits. From 2026-2030, 6 percent of an entity's overall obligation can be met through offsets (CARB, *Compliance Offset Program*).

The funds that are generated from the Cap-and-Trade allowance auctions are distributed into the Greenhouse Gas Reduction Fund (GGRF). These funds are invested into a portfolio of programs called the California Climate Investments (CCI), which appropriates these funds to administering agencies who develop and implement projects aimed at reducing greenhouse gas emissions within the state of California (CARB 2021). As of May 2022, California Climate Investments estimates a cumulative total of 11.4 billion dollars invested into greenhouse gas emissions reductions projects, with nearly $5.4 billion of those funds benefitting priority populations and an estimated reduction of 78.6 million metric tons of carbon dioxide equivalent (CCI, 2022).

A major focal point of CARB's appropriation process, as well as the cooperating administering agencies, is to appropriate GGRF funds to projects that maximize benefits to disadvantaged communities whenever possible. A disadvantaged community refers to the areas in California that are subject to significant pollution burdens. The state collects data on California communities using CalEnviroScreen, which is an analytical tool created by the California Environmental Protection Agency (CalEPA). CalEnviroScreen combines multiple forms of census-tract information into a scoring system, which determines whether or not a community is to be considered "disadvantaged". The census-tract information that is taken into account includes data concerning things like poverty, population, unemployment rates, air and water pollution, high incidence of disease, high concentration of hazardous wastes, etc. Essentially, CalEnviroScreen measures a community's vulnerability in terms of pollution based on a set of economic, health, and socioeconomic factors (CPUC, 2019).

Lastly, a covered entity who has a surplus of allowances can trade those allowances with other entities who are regulated by CARB and the California Cap-and-Trade program. They can also bank their excess allowances for future use. However, the number of allowances each entity can bank for future use is subject to regulation based off the annual allowance budget for the year the allowance originally belonged to, also known as the "*vintage*" year (Wang et al, 2022).

This paper focuses on analyzing the revenue generated during Cap-and-Trade allowance auctions, as well as the portion of auction revenue that is appropriated by CARB to administering agencies who use the funds to implement GHG emissions reduction projects in California. In particular, this paper investigates the trends of allowance auction revenue and the associated GGRF funds that are allocated to emissions reductions projects in California counties. As greenhouse gas emissions have become a topic of focus in today's political and economic climate, government agencies and corporations have attempted to investigate the most efficient ways to reduce GHG emissions and mitigate climate change. However, the findings of this paper suggest that other factors play a role in determining the allocation of GGRF investments to emissions reduction projects, which could result these projects being implemented in ways that are less beneficial and effective in reducing the state of California's carbon footprint.

Section 2 of this paper summarizes prior literature pertaining to the California Cap-and-Trade emissions trading system. Most of the previous literature focuses on the overall effectiveness of the program with less emphasis on auction revenue and GGRF fund implementation. Section 3 describes the data used in this analysis and provides definitions for each significant variable. This section also displays and describes summary statistics for auction revenue and GGRF funding, as well as funds that directly benefit disadvantaged communities. Section 4 includes a detailed description of the regression methodology used to generate results. Section 5 shows the results from the initial regression analysis and addresses implications of the findings. Section 6 introduces an extension of the empirical analysis and explains the results. Section 7 summarizes the findings of this paper and details a discussion of further possibilities of research and implications for policymakers based on the results of this analysis.

2. Literature Review

As climate change becomes an increasingly hot-topic in today's political, economic, and social sphere, so too does the study of greenhouse gas emissions in order to explore different methods of mitigating the negative impact of GHG emissions on the environment. As a result, many state agencies have worked to establish programs aimed at neutralizing these emissions. In California, the California Air Resources Board established California's Cap-and-Trade program in an attempt to reduce emissions. CARB collects and analyzes emissions-based data pertaining to the specific businesses and entities that are under regulation by the Cap-and-Trade program. This data includes general information on offsets allocation, auction results, use of auction proceeds, market data, and GHG emissions reporting. Although CARB monitors these factors regularly, this information fails to provide proper analysis showing that the California Cap-and-Trade program is effective in reducing emissions in California. Moreover, although CARB tracks the results of allowance auctions and the use of the auction proceeds, there has been no in-depth analysis pertaining to the effectiveness of using auction proceeds funds to further reduce CO2 equivalent emissions through investing in emissions reductions projects (CARB, 2022).

In June of 2022, Alex Wang, Daniel Carpenter-Gold, Siyi Shen, and Andria So conducted an evaluation analysis of California's two major emissions trading systems (ETS): the Regional Clean Air Incentives Market (RECLAIM) program and the California

Cap-and-Trade program. Their evaluation analysis included an assessment of the efficacy of the California Cap-and-Trade program, which highlights the overall concerns and criticisms that appear within the program. The biggest critique of the program, according to Wang et al, is the lack of definitive evidence that California's cap-and-trade program has played a significant role in reducing statewide emissions in comparison to other climate policies, such as California's renewable portfolio standard, which are thought to have had a substantial impact on emissions reductions. Another aspect of the California Cap-and-Trade program that this assessment analyzes is the use of allowance auction revenue. Wang et al indicate that these auctions have generated $19.2 billion into the Greenhouse Gas Reduction Fund (GGRF) as of March 2022 (Wang et al, 2022). A substantial portion of these funds, according to the California Air Resources Board and the California Climate Investments portfolio, are supposed to be directly invested into projects that benefit "low-income" or "disadvantaged" communities. However, a 2017 study that examined the implementation of these funds in Orange County, California showed that a majority of the funds were invested in projects that generally benefitted non-disadvantaged communities (Serrano, 2017). This study also points out that the criteria needed to be met for a community to be considered a "low-income" or "disadvantaged" community is relatively broad and, by definition, could include households that earn over twice the state's median income (Wang et al, 2022).

Other studies have attempted to assess the overall economic efficiency of the Cap-and-Trade program. One of these studies, conducted by Raphael Yolson Louis in May of 2022, contained three different analyses to determine the economic efficiency of the program as well as the program's effectiveness in meeting GHG emissions goals in the state of California. In his analysis, Louis found that California's Cap-and-Trade program promotes environmental efficiency and effectiveness. Furthermore, Louis shows that the main drivers of GHG emissions reductions in California can mainly be attributed to other state policies that complement the goals of the Cap-and-Trade program. Overall, Louis' analysis supported his hypothesis that the California Cap-and-Trade program is moderately effective in reducing and mitigating GHG emissions in California, but it is not the main driver of reduced emissions (Louis, 2022). However, Louis fails to provide quantitative findings and evidence that support this hypothesis fully. Additionally, no analysis is conducted that provides evidence showing that the proceeds received from the Cap-and-Trade auctions have been effectively used and allocated in order to further reduce emissions in California.

As described earlier, Kimberly Serrano, the coordinator of Community Resilience Projects at the University of California Irvine, conducted a study on the GGRF investments trends in Orange County, California. The study used data released by the California Air Resources Board to analyze the funding of emissions reductions projects for six southern California Counties, focusing mainly on "disadvantaged" communities in Orange County. Under SB 535 (2012), disadvantaged communities are defined as "census tracts disproportionately burdened by multiple sources of pollution with population characteristics that make them more sensitive to these pollution burdens" (Serrano, 2017). This is determined through CalEnviroScreen, which is a mapping tool that helps identify these disadvantaged communities throughout the state of California. However, in 2017, a new version of CalEviroScreen was released, which modified the qualifications for a community to be considered disadvantaged. This resulted in many communities that had previously been considered to be "disadvantaged" not meeting the new criteria under the modified qualifications. Serrano also indicated that the majority of the implemented projects in disadvantaged communities came from multi-regional projects, meaning that the projects are aimed at benefitting multiple regions rather than single communities. Therefore, although it was stated that 62% of the funds implemented in Orange County in 2016 were used within disadvantaged communities, this number was heavily skewed since most of those projects did not provide direct benefits to those communities. Serrano estimated that only about 8.5% of the funds implemented in Orange County were directly linked to households in disadvantaged communities (Serrano, 2017). Serrano's analysis of the efficacy of the implementation of proceeds in Orange County raises important questions and concerns pertaining to the proper allocation of these funds by the California Air Resources Board and the California Climate Investments Portfolio. With that said, this study only proposes further research questions, given that it does not provide definitive evidence or clarification on whether the allocation of these funds is socially and economically inefficient as a whole.

Similar to Raphael Yolson Louis' analysis, Richard Schmalensee and Robert N. Stavins presented an overview of the design and performance of the major emissions trading systems that have been implemented over the past several decades. They found that well designed cap-and-trade systems are very effective in meeting emissions goals and emissions reductions cost-effectively. Within their analysis, they discuss the strengths and weaknesses of California's Cap-and-Trade program. However, since the program has only been in existence since 2013, Schmalensee and Stavins stated that it was too early to properly assess how effective the program has been in reducing emissions. Therefore, similarly to Louis' analysis, Schmalensee and Stavins fail to provide meaningful evidence that the California Cap-and-Trade program has been effective in reducing GHG emissions and mitigating climate change in the state of California. Moreover, they fail to analyze the effectiveness and social equity pertaining to the allocation of the funds collected from market auctions that are used to introduce new emissions reduction programs in California (Schmalensee and Stavins, 2017).

Much of the previous literature pertaining to California's Cap-and-Trade system focuses on evaluating the overall structure and efficiency of the program. However, very little analysis has been done that specifically assesses the efficiency of the allocation of allowance auction proceeds. Kimberley Serrano raised important questions asking whether or not the distribution of these funds has been efficient and ethical as it pertains to allocating these funds to disadvantaged communities. This paper builds on the prior literature by providing statistical evidence that there are political factors that play a role in the allocation of these funds, which could lead to these funds not being appropriated in a way that most effectively and efficiently reduces carbon emissions throughout the state of California.

3. Data Collection and Summary Statistics

3.1: Data Summary & Variable Definitions

The data I have collected comes directly from The California Air Resources Board (CARB), the regulating body of California's Cap-and-Trade program, and California Climate Investments (CCI), the portfolio that appropriates auction proceeds to greenhouse gas emissions reductions projects. Each entity covered by the California Cap-and-Trade program is required to report annual greenhouse gas emissions data through CARB's

Mandatory GHG Reporting Program (CARB, *Mandatory Greenhouse Gas Emissions Reporting)*. CARB maintains an annual statewide emissions inventory categorized by ARB ID, facility, emission type, total emissions in metric tons of carbon dioxide equivalents, industry sector, and city. Additionally, CARB collects data pertaining to the use of auction proceeds in a detailed dataset containing all data collected for California Climate Investments projects. This data set includes detailed information concerning the appropriation of the Greenhouse Gas Reduction Funds (GGRF) from 2015-2022 (California Climate Investments, August 2022).

This paper combines the GHG emissions data from CARB with the portfolio investments data from California Climate Investments at the county level in which the projects were implemented in. However, each individual project can be implemented in multiple counties, making it impossible to differentiate how much of the funding went to a particular county. This results in inconsistencies between the two datasets, unless an assumption is made pertaining to the allocation of funds within projects. I assume that the allocation of funds for projects that affect multiple counties can be estimated based on population size of the counties in which a particular project is implemented in. Thus, in order for each individual observation to be attributed to a single county, I pro-rated the dollar amount of funds by population for data points that were implemented in several counties. Hence, I was able to distribute the total funds attributed to a project with multiple counties into several datapoints containing pro-rated funds for single counties based on population size. By pro-rating this data, I am able to estimate how much project funding each individual county received.

Similarly, each project can be implemented in multiple senate districts, and there can be multiple senate districts within a single county. Therefore, in order to compare the project investments based on partisan control by county, I assume that the partisan control in a specific county coincides with the political party associated with the elected senate district official of the senate district that contains the majority of the population of a given county. This assumption allows for each project to coincide with a political party, based on the elected senate district official within that year.

Lastly, in order to properly analyze the social, economic, and political influence on the appropriation of auction proceeds funds, my dependent variable would need to include the total auction revenue that was generated by each individual county. However, CARB does not have auction data that shows the total revenue based on each county. Thus, I make the assumption that the amount of auction dollars generated from each county coincides with a particular county's greenhouse gas emissions levels. For example, if Los Angeles County is responsible for 60% of total emissions in a given year, then 60% of the auction revenue in that year can be attributed to Los Angeles County, given that entities under regulation of the Cap-and-Trade are required to obtain allowances based on their emission levels. In theory, the counties that produce the most greenhouse gas emissions should be the counties that are most active in purchasing auction allowances in order to satisfy their emissions requirements.

With these assumptions in place, the main variables I include in my analysis are as follows:

Table 1: Variable Definitions

Base Variable	Definition
Report Year	Fiscal year in which Cap-and-Trade auction funds were appropriated to a project in a given county.
County	Name of the California county in which funded projects are implemented.
Total Auction Revenue	Total dollar amount of allowance auction revenue generated by a county in a given year.
Total GGRF Investment	Total dollar amount of Greenhouse Gas Reduction Funds appropriated to projects in a given county and year.
Disadvantaged Community Investment	Total dollar amount of implemented GGRF funds that benefit disadvantaged communities in a given county and year.
Senate Election Year	Indicator variable that takes on the value of 1 if the report year is a senate election year for a given county.
Mismatch Party	Indicator variable that takes on the value of 1 if the senate district political party in a county does not match the political party in control of the state of California
Covid Year	Indicator variable that takes on the value of 1 if the report year occurs after the onset of the COVID-19 pandemic.

3.2 Summary Statistics

Table 2: Summary Statistics from CARB Data

Variable	**Mean**	**Median**	**Std dev.**	**Skew**	**Count**
Total Auction Revenue ($mm)	45.10	2.95	136.00	4.65	401
Total Investment ($mm)	18.60	3.92	67.00	10.44	401
Disadvantaged Investment ($mm)	6.25	0.11	18.00	5.79	401
Average Project Life (years)	13.20	9.15	53.39	19.37	401

*Data obtained from CARB

Table 2 contains summary statistics from the Auction Proceeds data obtained from the California Air Resources Board (CARB). The average annual auction revenue by county is approximately $45.1 million, with a standard deviation of 136 million. The average GGRF investment appropriated to a given county is approximately $18.6 million, with a standard deviation of 67 million. The average GGRF investment appropriated to a given county that benefitted disadvantaged communities is around $6.25 million. The average project life is around 13.2 years with a standard deviation of 53.39.

Table 3: Average Total Revenue, Total Investment, and Total Disadvantaged Community Investment by County Senate District Party in Millions of Dollars

Political Party	Total Revenue *($mm)*	Total Investment *($mm)*	Disadvantaged Investment *($mm)*	Frequency
Democratic	72.26	17.58	8.97	188
Mix	46.79	94.91	18.80	34
Republican	16.18	5.22	1.01	179
Total	45.07	18.62	6.25	401

*Data obtained from CARB

Table 3 shows the average total revenue generated by counties and the corresponding investments based on the political party control of a county in millions of dollars. The political party of a county is determined by the political party of the elected senate district official in the senate district that contains the majority of the population of a county. If the political affiliation of a county is approximately evenly split between parties based on senate districts, they are assumed to be mixed. The average total auction revenue generated by a county is significantly higher in counties in which elected senate district officials are democratic. More specifically, average total revenue generated by democratic counties is nearly $27 million higher than in republican counties.

Table 3 also displays the average total GGRF investments that are allocated to democratic and republican counties. The average investment made in democratic counties is around $12 million higher than in republican counties, with mixed counties receiving the most investment dollars of approximately $95 million. Additionally, the GGRF investments that directly benefitted disadvantaged communities are about $8 million higher in democratic counties compared to republican counties, with mixed counties receiving more than double the amount of investment dollars than democratic counties.

Table 4: Average Total Revenue, Total Investment, and Total Disadvantaged Community Investment During Senate Election Years in Millions of Dollars

Senate Election Year	Total Revenue *($mm)*	Total Investment *($mm)*	Disadvantaged Investment *($mm)*	Frequency
No	49.34	16.47	4.83	230
Yes	39.32	21.50	8.16	171
Total	45.07	18.62	6.25	401

*Data obtained from CARB

Table 4 shows the average auction revenue generated by counties, as well as their corresponding investments, during senate election years. The average total auction revenue generated during non-election years is approximately $10M higher than during election years. However, the total investment dollars allocated to counties during election years is around $5 million higher than non-election years, and the total investment that benefitted disadvantaged communities is approximately $3.3 million higher during election years. This raises an interesting question regarding the effect that senate election years have on the allocation of investments, especially since total auction revenue is higher during election years. This question is explored in the empirical analysis of this paper.

Table 5: Average Total Revenue, Total Investment, and Total Disadvantaged Community Investment Before and After COVID-19 Pandemic in Millions of Dollars

Pre or Post COVID-19 Pandemic	Total Revenue *($mm)*	Total Investment *($mm)*	Disadvantaged Investment *($mm)*	Frequency
Pre-COVID-19	38.28	13.67	5.36	286
Post-COVID-19	61.94	30.91	8.47	115
Total	45.07	18.62	6.25	401

*Data obtained from CARB

Table 5 shows the average total revenue and corresponding investments before and after the onset of the COVID-19 pandemic. Post-COVID averages of revenue and investments are significantly higher than the generated revenue and corresponding investments prior to the COVID-19 pandemic.

The summary statistics pertaining to the auction revenue generated, as well as the corresponding investments that are made using that revenue, imply that political party affiliation, senate elections, and the COVID-19 pandemic could have an effect on the generation of auction revenue and the investments allocated from auction revenue to specific counties in California. These relationships are explored in the next several sections of this paper.

4. Methodology

The main methods used to analyze the relationship between carbon allowance auctions and the corresponding investments are two sets of separate OLS regressions that include different factors as the independent variables. In total, four OLS regressions are run for each dependent variable with various predictors. The dependent variable for the first set of regressions is the natural log of total auction revenue at the county level, described below by equation (1)

$$\ln rev = \alpha + \beta X_1 + \gamma_t + \varepsilon \quad (1)$$

Where ln*rev* is the natural log of total auction revenue, α is the constant, β is the coefficient, X_1 is the independent variable, γ corresponds to a year dummy control variable, and ε is the error control variable. Taking the natural log of total auction revenue creates a better-behaved distribution and helps rein in outliers in the dataset. Including γ when reporting the regression results controls yearly political, social, and economic changes in different counties such as tax revenues, economic growth, etc. It also makes the regression stronger and more robust.

4.1: Effect of Investment in Disadvantaged Communities on Auction Revenue

The natural log of total auction revenue is the dependent variable of the first regression analysis. This analysis includes the natural log of total investment that benefits disadvantaged communities as the main independent variable, seen in Equation (1). This regression shows the relationship between the investments in disadvantaged communities and total auction revenue, controlling for all other economic and political factors between counties.

4.2: Effect Senate Election Years on Auction Revenue

Next, the same regression is repeated, as shown in Equation (1), where the independent variable is a dummy variable showing whether or not a senate election occurred in a given year. This shows the effect that senate elections have on the total revenue that is generated by specific counties in allowance auctions.

4.3: Effect of Mismatched Parties Between County and State on Auction Revenue

The third regression includes a dummy variable as the independent variable, which indicates whether the political party in control in a given county differs from the political party in control of the state of California. In this case, the state of California has been controlled by the democratic party throughout the duration of this dataset. Therefore, the mismatch party dummy variable is equal to 1 if the political party in control in a county is republican. This shows the effect that differing political parties between state and county have on the auction revenue generated by that county.

4.4: Effect of COVID-19 Years on Auction Revenue

The final regression that is run with auction revenue as the dependent variable includes a dummy variable as the main independent variable, which indicates whether or not a given year is before or after the onset of the COVID-19 pandemic. As it pertains to this data, years 2020-2021 are considered to be "Covid Years". This OLS regressions shows the effect that the COVID pandemic may have had on the auction revenue generated in specific counties.

The next set of regressions include the natural log of total GGRF funding implemented in a given county during a given year, or investment, as the dependent variable. This is described below in Equation (2).

$$\ln inv = \alpha + \beta X_1 + \gamma_t + \varepsilon \quad (2)$$

Where ln*inv* is the natural log of total GGRF funding, or total investment, that is implemented in a given county during a given year. Taking the natural log of investment improves the overall distribution and negates any outliers in the data. The year dummy control is included in Equation (2) in order to make the regression stronger and more robust, similar to Equation (1).

4.5: Effect of Investment in Disadvantaged Communities on Total Investment

I run the regression with the natural log of total investment as the dependent variable and the natural log of total investment in disadvantaged communities as the main independent variable. This shows the effect that investment in disadvantaged communities has on total investment. In theory, there should be a positive relationship between the two, given that an increase in total investment should yield higher investment in disadvantaged communities.

4.6: Effect of Senate Election Years on Total Investment

I run the same regression again, however, the new independent variable includes the senate election year dummy variable. This shows the effect that senate elections have on the total investment that is appropriated to a given county. If there is a positive relationship between these variables, it could imply that politicians push for increased funding during election years in order to gain popularity for senate elections.

4.7: Effect of Mismatched Parties Between County and State on Total Investment

Equation (2) is used again to run another regression that includes the mismatched party variable as the main independent variable. This shows the effect that differing political parties between county and state have on the total investment that is allocated to specific counties. Again, since the state of California is democratic-controlled, the mismatched party variable tells whether the political party in control in a given county is republican.

4.8: Effect of COVID-19 Years on Total Investment

Lastly, I run the same regression with the Covid Year dummy variable as the main independent variable. This shows the effect that the COVID-19 pandemic had on the total investment allocated to specific counties.

5. Results

Table 5: Effect of Investment in Disadvantaged Communities on Total Auction Revenue

VARIABLES	Log Total Revenue
Log Total Disadvantaged Investment	0.223***
	(0.016)
Report Year	
2016	-1.028**
	(0.414)
2017	0.605
	(0.421)
2018	-0.054
	(0.425)
2019	-0.293
	(0.409)
2020	-0.192
	(0.406)
2021	0.887**
	(0.412)
Constant	12.81***
	(0.324)
Observations	401
R-squared	0.368

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 shows the effect of total investment in disadvantaged communities on total auction revenue generated by a given county. Overall, the total revenue generated by a given county is higher when more GGRF investments benefit disadvantaged communities, with a coefficient of 0.223 that is significant at the 1% level. Interestingly, when looking at the effect by year, total auction revenue generated by a given county in 2016 was significantly higher when less investments benefitted disadvantaged communities, with a coefficient of -1.028 being significant at the 5% level. Moreover, total auction revenue generated in 2021 was significantly higher when investments benefitted disadvantaged communities, having a coefficient of 0.887 that is statistically significant at the 5% level.

Table 6: Effect of Senate Elections on Total Auction Revenue Generated by a Given County

VARIABLES	Log Total Revenue
Senate Election Year	*0.341*
	(0.512)
Report Year	
2016	-1.026**
	(0.506)
2017	0.476
	(0.513)
2018	0.342
	(0.501)
2019	0.088
	(0.513)
2020	-
2021	1.438***
	(0.494)
Constant	14.43***
	(0.367)
Observations	401
R-squared	0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 displays the effect that senate elections have on the total auction revenue generated by a given county. Overall, senate elections do not have a significant effect on the total auction revenue generate. However, in 2016, the total auction revenue generated is lower if it was a senate election year in a given county with a coefficient of -1.026 that is significant at the 5% level. In 2021, total auction revenue was significantly higher in counties that had a senate election that year, with a coefficient of 1.438 that is statistically significant at the 1% level.

Table 7: Effect of Differing Political parties Between State and County on Total Auction Revenue

VARIABLES	Log Total Revenue
Mismatched Party	-1.563***
	(0.26)
Report Year	
2016	-0.698
	(0.495)
2017	0.462
	(0.491)
2018	0.488
	(0.493)
2019	-0.074
	(0.494)
2020	0.152
	(0.489)
2021	1.233**
	(0.482)
Constant	15.23***
	(0.388)
Observations	401
R-squared	0.129

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 shows that total auction revenue is lower in counties that are not represented by democratic officials within their respective senate districts. In fact, this relationship is statistically significant at the 1% level, with a coefficient of -1.563. Essentially, counties that are heavily represented by republican senate district officials generate significantly less auction revenue than their democratic counterparts. However, in 2021, the total auction revenue generated was significantly higher in republican counties with a coefficient of 1.233 that is significant at the 5% level.

Table 8: Effect of the COVID-19 Pandemic on Total Auction Revenue Generated by a Given County

VARIABLES	Log Total Revenue
Covid Year	*1.438****
	(0.49)
Report Year	
2016	-0.685
	(0.514)
2017	0.476
	(0.513)
2018	0.683
	(0.509)
2019	0.088
	(0.513)
2020	-1.097**
	(0.487)
2021	-
Constant	14.43***
	(0.367)
Observations	401
R-squared	0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 shows that the total auction revenue generated during years after the onset of the COVID-19 pandemic (2020-2021) was higher than the total revenue generated during non-COVID years. This relationship is significant at the 1% level, with a coefficient of 1.438. The strong, negative coefficient associated with year 2020 indicates that the total auction revenue generated by county in 2020 was lower in comparison to the total auction revenue generated during the other Covid year in 2021.

Table 9: Effect of Investment in Disadvantaged Communities on Total Auction Revenue

VARIABLES	Log Total Investment
Log Total Disadvantaged Investment	*0.228****
	(0.014)
Report Year	
2016	-0.083
	(0.365)
2017	0.694*
	(0.398)
2018	0.740*
	(0.381)
2019	1.141***
	(0.366)
2020	1.298***
	(0.347)
2021	1.023***
	(0.355)
Constant	12.03***
	(0.336)
Observations	401
R-squared	0.482

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 shows the relationship between the total investment allocated in a given county and the total investment that benefitted disadvantaged communities. Unsurprisingly, total investment is higher in a given county when more investments benefit disadvantaged communities. The overall coefficient of investments benefitting disadvantaged communities is 0.228, which is significant at the 1% level. In years, 2019-

2021, there is a very strong and significant relationship between total investment and how much of that investment benefitted disadvantaged communities.

Table 10: Effect of Senate Elections on Total Investment Allocated to a Given County

VARIABLES	Log Total Investment
Senate Election Year	*1.843****
	(0.46)
Report Year	
2016	-1.574***
	(0.452)
2017	0.561
	(0.528)
2018	(0.349)
	(0.390)
2019	1.531***
	(0.461)
2020	-
2021	1.587***
	(0.459)
Constant	13.69***
	(0.375)
Observations	401
R-squared	0.077

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 10 shows that the total GGRF investment that is appropriated to emissions reductions projects in a county is higher during senate election years. This relationship is statistically significant at the 1% level, which is extremely interesting considering there is not a statistically significant relationship between total auction revenue and senate election years. This points toward the idea that politicians are pushing for increased GGRF funding during senate election years even when the total auction revenue generated remains relatively unchanged during senate election years. However, similar to the relationship shown in Table 6, the total investment allocated to a given county was significantly lower for counties that had a senate election in that year. Contrastingly, the total investments allocated to counties that had senate elections in 2019 and 2021 were significantly higher.

Table 11: Effect of Differing Political Parties Between State and County on Total Investment Allocated to a Given County

VARIABLES	Log Total Investment
Mismatched Party	*-1.811****
	(0.23)
Report Year	
2016	0.253
	(0.485)
2017	0.546
	(0.495)
2018	1.268***
	(0.451)
2019	1.344***
	(0.429)
2020	1.624***
	(0.422)
2021	1.349***
	(0.432)
Constant	14.63***
	(0.363)
Observations	401
R-squared	0.207

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11 shows the relationship between the total GGRF investment in a given county and whether or not a county's senate district political party mismatched the political party in control of the state of California. Similar to the relationship in Table 3 with total revenue, total GGRF funding in republican controlled counties, based on elected senate district officials, is much lower than GGRF funding in democratic-controlled counties.

However, total investment allocated to non-democratic counties in years 2019-2021 was significantly higher than in democratic counties.

Table 12: Effect of the COVID-19 Pandemic on Total Investment Allocated to a Given County

VARIABLES	Log Total Investment
Covid Year	*1.587****
	(0.46)
Report Year	
2016	0.268
	(0.525)
2017	0.561
	(0.528)
2018	1.494***
	(0.472)
2019	1.531***
	(0.461)
2020	0.256
	(0.374)
2021	-
Constant	13.69***
	(0.375)
Observations	401
R-squared	0.077

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12 shows a statistically significant, positive relationship between total GGRF investment during Covid years, which is similar to the relationship shown in Table 4 with total auction revenue. The same relationship between investments and the COVID pandemic is shown in years 2018 and 2021.

6. Further Extensions of Empirical Analysis and Results

In order to further demonstrate the relationship between total auction revenue and the corresponding GGRF investments allocated to counties, I run another set of regressions showing the effect of the four independent variables on the ratio between GGRF investment and total auction revenue generated, described below by Equation (3).

$$dummyratio = \alpha + \beta X_1 + \gamma_t + \varepsilon \quad (3)$$

Where *dummmyratio* is equal to 1 if the ratio between total investment and total revenue in a county is greater than or equal to 5, equal to 0 if the ratio between investment and revenue is less than 5 and greater than 0.2, and equal to -1 if the ratio between investment is less than or equal to 0.2. All other aspects of the regression equation remain the same as Equation (1) and Equation (2). Using this equation with the *dummyratio* of total investments to total auction revenue in a given county, four separate multinomial logit regressions are run, each regression including one of the four main independent variables.

6.1: Effect of Disadvantaged Investment on Dummy Ratio

The first regression I run is a multinomial logit regression that includes the total GGRF investments benefitting disadvantaged communities as the main independent variable. This regression shows the likelihood of the size of the ratio of investments to revenue when funds benefit disadvantaged communities. The results of this regression are shown below in table 12.

Table 12: Multinomial Logit Regression Results for Disadvantaged Investments on Dummy Ratio

VARIABLES	-1	0	1
Log Disadvantaged Investment	0.967*		0.972
	(0.018)		(0.017)
Report Year			
2016	0.505		0.962
	(0.223)		(0.466)
2017	0.981		1.114
	(0.416)		(0.558)
2018	0.443*		0.977
	(0.202)		(0.475)
2019	0.229***		1.186
	(0.118)		(0.547)
2020	0.307**		1.605
	(0.154)		(0.738)
2021	0.761		0.835
	(0.323)		(0.424)
Constant	1.277		0.647
	(0.42)		(0.25)
Observations	401	401	401

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 12 indicates that the ratio between GGRF investments and total auction revenue is less likely to be smaller when GGRF investments are benefitting disadvantaged communities. The coefficient on disadvantaged investment for the -1 bucket is 0.967, which is significant at the 10% level. This shows that the ratio of investments to revenue is 13.3% (1 - 0.967) less likely to be smaller when more funds benefit disadvantaged communities. Moreover, this relationship is also present in years 2018-2020 and is significant at the 1% and 5% levels in 2019 and 2020 respectively.

6.2: Effect of Senate Elections on Dummy Ratio

Next, I run the same regression with senate election years as the main independent variable, which shows the likelihood of the size of the dummy ratio during senate election years. The results for this regression are shown below in Table 13.

Table 13: Multinomial Logit Regression Results for the Effect of Senate Election Years on Dummy Ratio

VARIABLES	-1	0	1
Senate Election Year	0.286**		1.506
	(0.142)		(0.687)
Report Year			
2016	1.69		0.614
	(0.872)		(0.266)
2017	1		1.133
	(0.422)		(0.565)
2018	1.4		0.594
	(0.737)		(0.256)
2019	0.219***		1.138
	(0.112)		(0.522)
2020	-	-	-
2021	0.704		0.781
	(0.296)		(0.394)
Constant	1.00		0.522*
	(0.295)		(0.186)
Observations	401	401	401

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13 shows the effect that senate elections have on the ratio between GGRF investments and total auction revenue. The coefficient on Senate Election Year is 0.286 for the -1 bucket and is statistically significant at the 5% level. This relationship indicates that the likelihood of the ratio of investments to revenue in a given county is less likely to be small if a county has a senate election during a given year, which is similar to the relationship shown between total disadvantaged investments and the dummy ratio. However, the relationship in this case is more significant than the relationship shown in Table 12. More specifically, the likelihood of the ratio of investments to revenue is 71.4% (1 – 0.286) less likely to be small when a given county has a senate election in that year.

6.3: Effect of Mismatched Parties on Dummy Ratio

The next regression that is run includes the dummy variable for mismatched parties as the main independent variable. Again, the mismatched party dummy variable is equal to 1 if the political party in control of a county does not match the party in control of the state of California. If the political parties match, then the dummy variable is equal to 0. This regression shows the effect that differences in political parties between county and state have on the ratio of total investment allocated to a given county and the total auction revenue generated by that county. The results of this regression are shown below in Table 14.

Table 14: Multinomial Logit Regression Results for the Effect of Political Party Differences Between County and State on Dummy Ratio

VARIABLES	-1	0	1
Mismatch Party	1.613*		1.158
	(0.41)		(0.29)
Report Year			
2016	0.481*		0.924
	(0.212)		(0.446)
2017	1.004		1.134
	(0.426)		(0.566)
2018	0.421*		0.908
	(0.191)		(0.438)
2019	0.227***		1.151
	(0.116)		(0.529)
2020	0.299**		1.527
	(0.150)		(0.698)
2021	0.747		0.795
	(0.316)		(0.402)
Constant	0.779		0.486*
	(0.253)		(0.183)
Observations	401	401	401

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 14, the coefficient on mismatch party is 1.613 and significant at the 10% level. This indicates that the ratio between total investments in a county and the total auction revenue generated by that county is much more likely to be smaller in counties that are not controlled by the democratic party. More specifically, the ratio is 61.3% (1.613 - 1) more likely to be small when the parties are mismatched. Thus, republican counties are more likely to receive less investment in proportion to the total auction revenue that those counties generate, in comparison to democratic counties.

6.4: Effect of Covid Years on Dummy Ratio

The final regression conducted in this analysis includes the dummy variable for Covid Years as the main independent variable, which shows the effect that the COVID-19 pandemic has on the ratio between total investments and total auction revenue generated in a given county. The results of this regression are shown below in Table 15.

Table 15: Multinomial Logit Regression Results for the Effect of the COVID Pandemic on Dummy Ratio

VARIABLES	-1	0	1
Covid Year	0.70		0.78
	(0.296)		(0.394)
Report Year			
2016	0.483*		0.925
	(0.212)		(0.446)
2017	1		1.133
	(0.422)		(0.565)
2018	0.400**		0.894
	(0.180)		(0.430)
2019	0.219***		1.138
	(0.112)		(0.522)
2020	0.406*		1.929
	(0.203)		(0.882)
2021	-	-	-
Constant	1.000		0.522*
	(0.295)		(0.186)
Observations	401	401	401

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 15, there is no significant overall effect of Covid years on the dummy ratio. Thus, these results indicate that the COVID-19 pandemic did not have a major effect on the ratio between total allocated investment in a county and the total auction revenue that the county generated.

7. Conclusion

7.1: Discussion of Results

This paper explores the county-level relationships between the auction revenue that is generated during a given year and the corresponding investments that are allocated to California counties. The results shown in my empirical analysis have several important implications. First, senate elections have no effect on the total auction revenue generated by a county during a given year, as shown in table 6. However, the GGRF investment that counties receive in the form of greenhouse gas emissions reductions projects is significantly greater during senate election years, shown in table 10. Given this difference in relationships between auction revenue and senate elections and GGRF investments and senate elections, it can be reasonably implied that politicians advocate for increased GGRF investment in counties during election years for the purpose of gaining popularity or attempting to win over more votes.

Additionally, the empirical results also indicate that a difference in partisan control of the state of California and a given county results in lower auction revenue generation and less investment to the mismatched counties. Moreover, the results show that the likelihood of the ratio of GGRF investment to total auction revenue is 61.3% more likely to be small when the political party of a given county is non-democratic. Therefore, this could imply that republican counties are receiving less funds, in proportion to their auction revenue generation, than their democratic counterparts. There are several speculations that could be made pertaining to this finding. One implication coinciding with these results is that the democratic-controlled state of California is less willing to allocate GGRF investments to republican counties than democratic counties. However, it could also very well be the case that republican counties are less willing to receive investments for emissions reductions projects. Regardless, this finding indicates that some political bias exists in this investment allocation process, which could result in these funds not being allocated in a way that most efficiently reduces carbon emissions throughout California.

Tables 8 and 12 show that the COVID-19 pandemic had a relatively positive effect on the total auction revenue generated as well as the total GGRF investment implemented in a given county. However, table 15 shows that the COVID-19 pandemic did not have a significant effect on the ratio between total investment and total revenue. Therefore, although the total auction revenue and total GGRF investment may have increased during COVID years, the increase was relatively proportional between the two variables.

7.2: Implications for Policymakers

A major implication for policymaking in the state of California pertaining to the allocation of Greenhouse Gas Reduction funds results from the findings of investment allocation during senate election years. The billions of dollars that are generated through the allowance auctions and allocated to counties through emissions reductions projects have significant benefits in terms of reducing emissions and California's overall carbon footprint. However, if elected officials and local governments are using the process of allocating these funds as a means to gain votes for elections, then it is uncertain whether these investments are being made properly. The results of my empirical analysis show major discrepancies between investments during election years and non-election years. As previously stated, the ratio between investment and total revenue was 71.4% less likely to be small during senate election years. Since senate election years do not have a significant effect on the total auction revenue generated in a given county, as shown in Table 6, it must indicate that GGRF investment increases disproportionately during senate election years.

Likewise, the empirical results show that GGRF funds are disproportionately allocated depending on the political affiliation of a given county. Tables 7 and 11 show that total auction revenue and total GGRF investment are both significantly smaller in non-democratic counties. Furthermore, Table 14 shows that the ratio between investment and revenue is 61.3% more likely to be small in counties that are not democratic-controlled. Overall, the results show that there are discrepancies in the allocation of funding during senate election years and also in non-democratic counties.

There could be several underlying reasons for these findings. However, the main implication when assessing these results is that these investments are not being efficiently allocated if political bias exists in the allocation process. Moreover, the California Air Resources Board (CARB), as well as other California state agencies, have emphasized the importance of allocating and appropriating these emissions reduction funds to disadvantaged communities, given that these communities are highly susceptible to pollution and increased emissions. Thus, the allocation of the investments for emissions reductions projects should be based on these disadvantaged communities, rather than politically-focused. The investments should be allocated in a way that most effectively reduces emissions throughout California, given that reducing emissions is the overarching goal of the entire California-Cap-and-Trade program.

7.3: Opportunities for Future Research

In terms of the potential for future research, I made several assumptions pertaining to the auction revenue generated by each county, political parties in control of counties, and the funding appropriated to each county based on the overall project. Due to a lack of county-level data, these assumptions were necessary in order to test the relationship between auction revenue generation and the corresponding investments made. With more specific data, it would be interesting to research the specifics pertaining to the exact amounts of auction revenue and accurate political affiliation of counties or congressional districts.

Additionally, it would be extremely beneficial to reconstruct this analysis with the inclusion of emissions reductions data. If each project has an estimated amount of emissions reductions, it would be interesting to compare how much investment is being allocated to specific counties in terms of estimated reductions in comparison to that county's overall carbon emissions. This would assess a counties emissions output in comparison to what they receive in emissions reductions projects. This brings about an important question that must be considered during the allocation process: Should the counties that produce higher carbon emissions be rewarded in the form of receiving emissions reductions projects?

Overall, there is an endless amount of research opportunity surrounding the economics of carbon emissions reductions systems, especially as climate change becomes a prevalent topic of discussion in today's world. The findings of this paper imply that there may be inconsistencies that exist within the GGRF investment allocation process, which could hinder the program's ability to efficiently reduce emissions throughout the state of California.

8. Bibliography

Berkeley Law. (2019, December). California Climate Policy Fact Sheet: Cap-and-Trade. https://www.law.berkeley.edu/wp-content/uploads/2019/12/Fact-Sheet-Cap-and-Trade.pdf.

California Air Resources Board. Auction Information. https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/auction-information

California Air Resources Board. Cost Containment Information. https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program/cost-containment-information

California Air Resources Board. Compliance Offset Program. https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/about

California Air Resources Board. Mandatory Greenhouse Gas Emissions Reporting. https://ww2.arb.ca.gov/our-work/programs/mandatory-greenhouse-gas-emissions-reporting

California Air Resources Board. Overview of ARB Emissions Trading Program, 2015, September 2, https://ww2.arb.ca.gov/ sites/default/files/cap-and-trade/guidance/cap_trade_overview.pdf.

California Air Resources Board. (2017, December 1). Facts About the Linked Cap-and-Trade Programs. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/linkage/linkage_fact_sheet.pdf

California Air Resources Board, Aug. 2018, *Funding Guidelines* https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/2018-funding-guidelines.pdf?a=88.

California Air Resources Board. (2021, June). Greenhouse Gas Reduction Fund Investments: Project Outcome Reporting Data Collection and Assessment. https://ww2.arb.ca.gov/sites/default/files/2022-01/CCI%20Investment%20Outcomes%20Project%20Final%20Report_2.pdf

California Climate Investments. (2022, August). Cumulative Outcomes Table. 2022 Mid-year Update. https://ww2.arb.ca.gov/sites/default/files/auction-proceeds /cci_2022_mydu_cumulativeoutcomes.pdf

California Climate Investments. (2022, August). Cumulative Outcomes and Annual Report.Detailed Implemented Projects Dataset. https://www.caclimateinvestments.ca.gov/ annual-report

California Environmental Protection Agency, "SB 535 Disadvantaged Communities." *The Office of Environmental Health Hazard Assessment*, May 2022, https://oehha.ca.gov/calenviroscreen/sb535.

California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, *CalEnviroScreen3.0*, January 2017, https://oehha.ca.gov/media/downloads/calenviroscreen/report/ces3report.pdf

California Office of Environmental Health Hazard Assesment, "CalEnviroScreen Version 2.0." *Oehha.ca.gov*, 8 Aug. 2014, https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-version-20.

California Office of Environmental Health Hazard Assessment, "Calenviroscreen 3.0." *OEHHA*, Jan. 2017, https://oehha.ca.gov/media/downloads/calenviroscreen/document/ces3newinces3.pdf.

Louis, Raphael Yolson, "An Evaluation of the Effectiveness, Efficiency, and Equity of California's Cap-and-Trade Program", 21 May 2022, Master's Projects and Capstones. 1356. https://repository.usfca.edu/cgi/viewcontent.cgi?article=2674&context=capstone

Schmalensee, Richard, and Robert Stavins. "Lessons Learned from Three Decades of Experience with Cap-and-Trade." *Review of Environmental Economics and Policy*, Volume 11, no. Issue 1, 2017, pp. 1–179., https://doi.org/10.3386/w21742.

Serrano, Kimberly. "Greenhouse Gas Reduction Fund Investments in and around Orange County." *UCI Community Resilience*, University of California Irvine Community Resilience Projects, Dec. 2017, https://communityresilience.uci.edu/wp-content/uploads/2018/ 02/UCI-OC-GGRF-Report-FINAL-1.pdf.

State of California, California Public Utilities Commission (CPUC), *Disadvantaged Communities*, February 2019, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/disadvantaged-communities

Wang, Alex, et al. *Emissions Trading in California: Lessons for China*. UCLA School of Law, 17 June 2022, https://law.ucla.edu/sites/default/files/PDFs/Publications/Emmett%20Institute/Emissions-Trading-in-California.pdf