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California's cap-and-trade program: is it effective in advancing social, economic, and environmental equity?

Alvin Holliman and Kimberly Collins
Public Administration Department, California State University San Bernardino, San Bernardino, USA

Abstract

Purpose – Companies affected by California's cap-and-trade legislation are allotted certain credits for production that can be used or sold and can purchase additional credits from the state, which become a revenue source to be used for activities that reduce carbon emissions. The purpose of this paper is to investigate who ultimately pays for this program, its effectiveness in reducing carbon emissions in accordance with established goals, and the related effectiveness to advance social, economic, and environmental equity.

Design/methodology/approach – The methodology used for this research is secondary data analysis, triangulating three sources: California's Climate Change Investment Reports, 2019-2021; repositories maintained by the California High-Speed Rail Authority and the California Air Resources Board; and a review of the literature and websites from other professional sources which addressed, directly and indirectly, the topics and questions explored in the study.

Findings – Key findings include evidence of enhancing social and environmental equity but ineffectiveness in reducing carbon emissions in accordance with state goals. Furthermore, the program displays evidence of economic inequity as it demonstrates characteristics of regressive taxation and an inability of low-income persons to acquire electric vehicles due to high costs.

Originality/value – The research effort is unique in that no other academic efforts were located which attempt to examine the cap-and-trade program's effectiveness in attaining its goals.

Keywords Greenhouse gas emissions (GHG), Regressive taxation, Social equity, Economic equity, Environmental equity

Paper type Research paper

Introduction

In 2006 the California Legislature approved Assembly Bill 32 (AB 32), that set the State's 2020 Green House Gas (GHG) reduction target, that also required the California Air Resources Board (CARB) to adopt a Scoping Plan for achieving the target. Under this bill, CARB was authorized to include a cap-and-trade program as a mechanism to help achieve the target. The program was not authorized to begin until 2013. AB-862 (2014) authorized establishment of numerous expenditure accounts for specified programs of which cap-and-trade revenues were to be deposited into them. Products and related entities, under the program include "those that have one or more of the following processes or operations: large industrial facilities (including cement, glass, hydrogen, iron and steel, lead, lime manufacturing, nitric acid, petroleum and natural gas systems, petroleum refining, and pulp and paper

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manufacturing, including cogeneration facilities co-owned/operated at any of these facilities); electricity generation; electricity imports; other stationary combustion; and CO2 suppliers" (International Carbon Action Partnership, 2021).

Cap-and-trade results in a fee/cost associated with production (importantly, oil refineries and oil imports) versus consumption (consumer purchase/usage of gasoline). However, the costs to oil companies and other affected industries (insulation manufacturing, for example) from purchasing the auction credits are typically passed on to the consumers (Noda, 2021).

California is a global leader in terms of environmental protection, and importantly, its cap-and-trade program has served as a role model for other governments. Given the present shift by the Biden Administration to a more focused approach in reducing GHG, this research is important and timely to the extent any federal programs mirror aspects of California's cap-and-trade program.

Research methodology, questions, and propositions

Essentially, the primary purpose of this study is to evaluate California's cap-and-trade program relative to the ability to reduce carbon emissions and achieve social, economic, and environmental equity.

The methodology used for this research is secondary data analysis, triangulating three sources. The first source is the Annual Climate Change Investments Report for the fiscal year ending June 30, 2021 (Annual Report), beginning with a detailed examination of all applicable components. The second source is based on the 2020 and 2019 Annual Reports as well as data repositories maintained by the California High-Speed Rail Authority and the California Air Resources Board. The third source consisted of a review of the literature and websites from other professional sources which addressed, directly and indirectly, the topics and questions explored.

The research question guiding this study consists of four parts:

In what ways does the California cap-and-trade program

a. display evidence of enhancing social equity?

b. display evidence of enhancing economic equity?

c. display evidence of enhancing environmental equity in a broad/holistic sense?

d. display evidence of reducing carbon emissions in a sustainable manner?

Discussion on the budgetary process

All fees collected under California's cap-and-trade program are deposited into the Greenhouse Gas Reduction Fund. Currently, these funds are allocated through a mandated investment plan (CARB, 2022a). This plan is developed by the California Department of Finance in consultation with the California Air Resources Board (CARB) and other state agencies. CARB is responsible for project funding decisions after various public meetings and input from other agencies and in consort with the legislative process, which is largely influenced by AB 32 (2014) as the cornerstone of the program. There are some limitations pursuant to SB-862 (2014) which prescribes that roughly 60 percent of the revenues are allocated by continuous appropriations (25 percent to high-speed-rail, 20 percent to transit oriented affordable housing, 10 percent to transit capital, and 5 percent to transit operations). In effect, approximately 40 percent of the revenue allocations are discretionary, dependent on legislative action, usually during the annual budget process. Summarily, legislation drives climate investments in numerous ways, including use of cap-and-trade auction proceeds, expenditure requirements, investment minimums for priority populations, appropriations

from the Greenhouse Gas Reduction Fund (GGRF), and California Climate investments program requirements (CARB, 2022a).

Mechanics of cap and trade, present GHG reduction data, and effects on gasoline prices

A Cap-and-Trade program does the following: (a) sets an annual declining emissions limit on the sources responsible for most of the State's GHG emissions; (b) provides free allowances to utilities and emission-intensive, trade-exposed (EITE) industries which cover a portion of that limit; and (c) provides trading and banking of those allowances to minimize the cost and volatility of pollution controls (Berkeley Law, 2019).

Per Assembly AB 32 (2006), GHG emissions should be at 1990 levels by 2020 (CARB, 2018). There have been a series of executive orders (EO) and legislative amendments since passage of the 2006 AB 32 that establish further GHG reduction goals (Center for Climate and Energy Solutions, 2021), notably:

1. EO B-30-15 set the interim goal of reducing emissions to 40 percent below 1990 levels by 2030. This was codified by SB 32 (2017)
2. EO B-55-18 set a goal of achieving carbon neutrality no later than 2045.

California met the 2020 goal, four years early in 2016. The criticism from environmentalists pertains to the 2030 goal and beyond because presently the GHG reduction approximates only 1 percent per year (Kuramochi *et al.*, 2020). To meet 2030 goals the GHG reduction under the program must be at least 4 percent per year. An additional critique is related to the lack of GHG reduction in high polluting communities where persons of color live (Cushing *et al.*, 2015; Becker, 2021).

Cap-and-trade programs cap the amount of carbon that emitters are allowed to produce, which are partially offset by state-issued allowances (Balmes, 2021). The difference between the allowances issued and the amount of carbon emitted must be accounted for through the purchase of additional allowances at state auction. Oil refineries must account for the embodied carbons in products they sell and buy allowances for them. The cap on allowable carbon pollution is set to decrease over time, enticing polluting entities to spend increasing sums at auction (Dechezlepretre and Sato, 2017). Costs are passed through to consumers in their entirety and, in the case of the refineries, result in gas prices borne by consumers at the pump (Noda, 2021).

Schatzki and Stavins (2018) describe in detail the California cap-and-trade fees, fuels under the cap (FUC), and those designated as meeting the low carbon fuel standard (LCFS) that are subsequently added to the price of gasoline at the pump.

1. FUC: This is part of California's cap-and-trade (C&T) program that requires fuel suppliers to purchase allowances (basically a license to emit a ton of greenhouse gas (GHG)) to offset the GHG from the combustion of the fuel. This fee will vary with the price of C&T Allowances. At recent C&T allowance prices, this corresponds to 14.3 cents per gallon
2. LCFS: This program began in 2011 and requires suppliers of high carbon intensity (CI) fuels, like the petroleum portion of gasoline, to purchase credits from suppliers of low-CI fuels. This fee will vary with the price of LCFS Credits and is designed to increase as the annual LCFS standard is scheduled to become stricter through 2030. Recent LCFS credit prices amount to 22.6 cents per gallon. The portion of the LCFS that relates to ethanol is not passed through to consumers. As a result, the 22.6 estimate is likely higher than what may be passed through, leading to overestimation of likely LCFS

price impacts. Furthermore, affected compliance entities have some lower-cost options versus the purchase of open-market credits (CARB, 2022a.; Brown *et al.*, 2021). These include such items as internally generated innovative crude or refinery investment projects and a variety of credit pass-through types of agreements with other fuels producers (CARB).

The cap-and-trade framework focuses on production rather than consumption (Li *et al.*, 2021). Because of current development models and lack of public investment in sustainable mass transit systems, most Californian's have no alternative to vehicle travel (Hasan *et al.*, 2020). Residents will generally drive their cars regardless of the cost of gasoline as there a few public choices (Adepetu and Keshav, 2017). As gasoline consumption increases so do the purchases of credits at auction, thus increasing gasoline prices, adding to the regressive tax/fee burden. The volume of vehicle and semi-truck diesel travel in California represent the largest polluting sources according to the California Air Resources Control Board (CARB). In particular, "trucks are the largest single source of air pollution from vehicles, responsible for 70 percent of the smog-causing pollution and 80 percent of carcinogenic diesel soot even though they number only 2 million among the 30 million registered vehicles in the state" (CARB, 2022a).

Aggravating this situation is the well-known situation that semi-trucks, commuting westward to the ports in Long Beach and Los Angeles or product delivery destinations, frequently fill their tanks in lower gasoline-cost border states, such as Nevada and Arizona, and then drive into California. The amount of gasoline purchased in border states escapes the cost effects of cap-and-trade (as well as other California gasoline taxes and fees). The revenue from Cap-and-Trade provides funds for GHG reduction projects, but as discussed further in this paper, many of the targeted projects have minimal effect on reducing GHG's based on CARB published costs per GHG (Industrial Strategies Division, California Air Resources Board, 2021).

Noteworthy, it is the primary use of CARB published data regarding costs per GHG reduction. Because this research effort is an analysis of California's cap-and-trade program and its published data, the CARB information will be utilized. In addition, the same studies supporting the decreasing effect of the cap-and-trade program on the direct reeducation of GHG emissions are reflected by several reports published by CARB (California Environmental Protection Agency, 2018; OEHHA and CEPA, 2018; Plummer *et al.*, 2022).

Summary of auction proceeds and uses

The following is a broad summary of cap-and-trade auction proceeds, appropriations, allocations, awards, and implementations. Of the US$15.8 billion in proceeds, in the program's history, 88.5 percent have been appropriated and nearly all appropriations have been allocated (98.7 percent of the appropriated amount). Project awards amount to 81 percent of the allocated amount of which 74 percent have been expended. Comparing actual project implementations to the total auction proceeds reveals that 52.3 percent of all proceeds have resulted in completed projects. It is a total non-implemented amount that exceeds US$7.5 billion (see Table 1).

The next section of this study discusses project specifics and begins with details in Table 2, which includes all funded Cap-and-Trade projects exceeding US$1 billion.

1. This category consists of US$558,300,000 in related awarded projects to the California Department of Transportation and US$1,961,700,000 to the California Air Resources Board.
2. This category includes US$153,500,000 in project awards and US$46,500,000 in implementations for sustainable agriculture (farmlands). Specific affordable housing projects total US$838,500,000 in awards and US$838,500,000 in implementations.

3. 3. As indicated in Table 2, projects awarded exceed appropriations by US$798,600,000. Under California state law, awards of projects or expenditures cannot exceed appropriations. However, implementations/expenditures are only US$389,900,000. The reason for the excess awards is not disclosed in the Annual Report.

Case study

The next section of this study discusses project specifics and details of all funded cap-and-trade projects exceeding US$1 billion.

Category	Year				
	Total Prior to 2018-19 (US$)	2018-19 (US$)	2019-20 (US$)	2020-21 (US$)	Cumulative Total to Date (US$)
Proceeds	7,859,405,312	3,207,445,517	2,105,810,362	2,623,651,181	15,796,312,372
1 Appropriations	6,105,000,000	3,227,000,000	2,292,000,000	813,000,000	13,980,000,000
2 Allocated					13,791,700,000
2 Awarded					11,177,200,000
2 Implemented					8,272,600,000

Table 1. Summary of Cap-and-Trade Auction Proceeds, Appropriations, Allocations, Awards and Implementations

Source: Compiled from CARB (2022b), pp. 11-12

Category	Summary of Project Funding - Appropriations, Awards, and Implemented – All Projects Greater than US$1 Billion in Total				
	2020-21 Appropriations	Cumulative Appropriations through June 30, 2021	Cumulative Allocations through June 30, 2021	Cumulative Awards through June 30, 2021	Cumulative Projects Implemented through June 30, 2021
High-Speed Rail 1	247,000,000	3,564,000,000	3,563,800,000	2,285,000,000	2,285,000,000
Low Carbon Transport 2	49,000,000	2,741,000,000	2,628,700,000	2,520,000,000	2,058,900,000
Affordable Housing & Sustainable Farmlands 3	196,000,000	2,469,000,000	2,272,400,000	992,000,000	885,000,000
Transit/Inter-City Rail CDF - Various	98,000,000	1,325,000,000	1,324,800,000	2,123,400,000	389,900,000
All Others	154,000,000	1,042,000,000	1,041,300,000	758,600,000	740,000,000
Totals	69,000,000	2,839,000,000	2,960,700,000	2,498,200,000	1,913,800,000
	813,000,000	13,980,000,000	13,791,700,000	11,177,200,000	8,272,600,000

Table 2. Project Specifics – Greater than US$One Billion per Project

Source: Compiled from CARB (2022b), pp. 15-20.

High Speed Rail

The total amount of identified federal and state funding for the High-Speed Rail Project is approximately US$20.6 billion to US$23.0 billion, with a medium forecast of US$21.8 billion through 2030 (State of California, 2021). The range is based on historical funding patterns from the cap-and-trade auction process, which presently only has US$3.3 billion in related appropriations for the project. As indicated in Table 1, these proceeds vary widely and cause concerns, regarding the viability of the cap-and-trade program, for environmentalists (Becker, 2021). They contend future reliability of this revenue source is questionable. Governor Newsome in his 2019 inaugural address (C-Span, 2019) posited that the High-Speed-Rail (HSR) cannot be completed as initially envisioned, and at best, only the leg between Merced and Bakersfield could be constructed. Nonetheless, the HSR Authority's website is replete with detailed information on current planning efforts for all legs of the project, from San Francisco to Los Angeles, including related planning expenditures (Barnett, 2020).

The portion of the project under construction, (i.e., the 119-mile portion of the Central Valley leg) currently consists of non-contiguous efforts. The tracks and bridges do not begin at one point and continue until that portion is completed. There have only been sporadic pieces of construction, most notably viaducts in and near Fresno (Walters, 2021). The high-speed rail in California still has a long way to go to be a viable project in California and there are few projections as to when the project will be completed. This is a controversial project that needs more focus and thoughts on how to move it away from public funds and increasing the level of private funding to complete the project.

Low carbon transportation

Obtaining a greater understanding of project appropriations and allocations for this category requires a certain level of detail as indicated in Table 3.

Specific analysis of every project in the low carbon transportation category is beyond the scope of this research. However, cursory analysis indicates a broad spectrum of projects focusing on reducing vehicle emissions. Data are presented regarding estimated greenhouse gas reductions (1,000 MTCO2e) and the cost of each project per GHG. This category covers 354,029 projects of which 338,658 represent rebates to hybrid or all electric consumer vehicles. Furthermore, the cost per GHG reduction is comparably low at US$131/per rebate and appears to indicate a cost-effective use of funds that directly benefit many California consumers.

More discussion regarding the rebate program seems warranted. Globally, "in 2021, EVs represented nine percent of all passenger car sales, growing from 4.1 percent in 2020. The supply chain, assembly line and design of an EV are different, and achieving scale seems difficult" (Paoli and Gül, 2022; Shine, 2022). As noted in the 2022 World Economic Forum, further adding to EV and hybrid vehicle production issues is a present shortage of lithium, a necessary component for the vehicle batteries. About 2 billion EV's need to be on the road by 2050 to enable achievement of net-zero carbon emissions, yet only 6.6 million EV's were sold worldwide in 2021.

As is the case globally and nationally, California's demand for EV's exceeds supplies, production capabilities, and clean vehicle rebate program (CVR) funding (Lopez, 2022). The CVR program ran out of funding in April for 2022, ten months into the fiscal year. These factors contribute to limitations on California's ability to fully incentivize more EV purchases with cap-and-trade resources, even though the rebate program provides a very efficient and cost-effective use of funds in terms of reducing GHG emissions (Trencher and Wesseling, 2022).

The use of hydrogen vehicles and fuel cells may be an option which could need more consideration by policy makers (Manoharan *et al.*, 2019). Thus far, little consideration has been given to the hydrogen infrastructure needed to support this segment of zero emission vehicles (ZEV) in the U.S. (Hall and Lutsey, 2019). The technology has advanced considerably

Summary of Project Funding -Allocated, Awarded, and Implemented – Low Carbon Transportation (California Air Resources Board – CARB, and California Department of Transportation – Caltrans)					
Projects	Cumulative Allocations through 6-30-2021 (US$)	Cumulative Awards through 6-30-2021 (US$)	Cumulative Implemented through June 30, 2021 (US$)	Cost per GHG (US$/ MTCO2e)	Number of Projects
Caltrans	606,700,000	558,300,000	558,300,000	90	719
CARB Projects:					
Van Pools	6,000,000	6,000,000	6,000,000	1,307	1
Ag.					
Clean Cars	102,000,000	102,000,000	73,000,000	1,299	9,128
Clean Mobility - Schools	24,600,000	24,600,000	24,600,000	2,453	3
Clean Mobility - All	55,200,000	51,600,000	10,700,000	3,312	31
Other Clean:					
Off-Road	44,200,000	44,200,000	18,800,000	1,472	133
Rebate Prgm	948,900,000	946,000,000	817,300,000	131	338,658
Fin Assist	33,900,000	15,900,000	5,900,000	1,038	923
Truck & Bus	486,400,000	475,300,000	271,700,000	244	4,298
Outreach	6,000,000	6,000,000	6,000,000	-	-
Rural Buses	61,600,000	58,600,000	35,100,000	1,107	116
Trans Equity	19,500,000	-	-	-	-
Zero Freight	148,700,000	148,700,000	148,700,000	2,997	10
Zero Trk/ Bus	85,000,000	82,800,000	82,800,000	778	9
Carb Sub-total	2,022,000,000	1,961,700,000	1,500,600,000	-	353,310
Totals	2,628,700,000	2,520,000,000	2,058,900,000	-	354,029

Source: Compiled from CARB (2022b), pp. 15-20.

Table 3.
Low Carbon Transportation

and is able to support longer travel distances, particularly in the heavy-duty vehicle market. Again, the largest inhibitor is the lack of a green hydrogen infrastructure that is robust enough to support mobility across large distances (Chakraborty *et al.*, 2022).

Pursuant to a study by the University of California Institute of Transportation Studies (Brown *et al.*, 2021), hydrogen cell vehicles only represent 1/100 percent of all California vehicles in use (5,138/30,087,116). The study also mirrors Chakraborty's comments regarding the lack of an adequate green hydrogen infrastructure and further indicates very low consumer demand for such vehicles. This stated, the work by Brown, Sperling, and Austin does express some possible opportunities for the use of hydrogen cell vehicles related to long-haul tractor trailers.

Affordable housing and sustainable agriculture lands

Combining affordable housing with sustainable agriculture as a project and appropriations category initially appears awkward relative to the weak overlap of their respective policy

goals and deserves further explanation. Per the 2021 Annual Report, the program objective is the "protection of critical agricultural lands at risk of conversion to more GHG-intensive residential uses by facilitating conservation easements and Agricultural Conservation Plans" (State of California, 2021, p. 126). With US$153.5 million in awards, covering 39 projects, a key assumption of this project is the notion that such farmland would be residentially developed and likely GHG intensive. Comparing this allocation to more direct and measurable uses may merit consideration and the confusing commingling with pure "affordable housing."

Actual affordable housing projects total US$838,500,000 in both allocations and awards, covering 85 projects at US$458 per GHG reduction. Of the 85 projects only the Santa Ana Arts Collective project was discussed in the 2021 Annual Report, even though the website of the developer, Meta Housing Corporation, indicates it was completed in 2019. The total cost of the project was US$30 million for 57 rental units (Hodgins, 2020) of which the cap-and-trade program contributed US$12 million (2021 Annual Report, p. 125). California's affordable housing problem is a topic of vast complication and importance, exceeding the scope of this article. What is pertinent is the high cost of US$458 per GHG reduction (2021 Annual Report, p. 20), compared to $US131 per GHG reduction for electric and hybrid vehicle rebates. Merely focusing on the high cost of GHG reduction in this category may be misleading, however. There are possible intangible benefits to affected households of a cost reduction nature such as more walkable communities, greater access to rail transit (potentially lowering commuting costs), enhanced health thus reducing medical costs, and more efficient, lower-cost, residential energy uses.

Transit/Inner City Rail

Per the 2021 Annual Report (pp. 103-104) the only project mentioned in the Transit/Inner City Rail category is Caltrain who is "undergoing a major transformation by electrifying the railroad to provide cleaner, quieter, and more efficient service." The precise nature of the other projects was not determined, but noteworthy is the relatively low cost of GHG reduction at US$153 per GHG, US$389,900,000/2,557,000 units of reduction (State of California, 2021). Furthermore, given the current legislative push to use rail transit bond proceeds for more regional and inner-city rail projects versus the High-Speed-Rail (HSR) (Cervero, 2020) prospects for increased commuter rail projects may be improving. Also due to growing dissatisfaction with the HSR (Becker, 2021), which has no quantifiable GHG reduction data, it appears this category is a candidate for more future allocations, awards, and projects.

California Department of Forestry and Fire Protection (CDF)

Projects in this category represent US$740 million in implementations versus US$758.6 million in awards (Table 2) and cover seven project categories. Appropriations total slightly more than one billion dollars. Noteworthy is US$317.8 million implemented for the forest health program at a very low cost of US$29 per GHG reduction (State of California, 2021, p. 30). The other six project categories do not indicate any GHG reduction data, except for the Urban and Community Forestry Program which has a low GHG reduction cost of US$143 and reflects implementations of US$56.2 million (p. 30). In general, allocations and awards to CDF appear to be cost-effective, as related to GHG reduction, and should be a candidate for additional funding. This assertion is also based on the poor and fire-susceptible condition of California's forests and open spaces, and some climate change mitigation proponents advocate forest management as an effective tool (Hessburg *et al.*, 2021).

Answers: social, economic, environmental equity, and GHG reduction

Social equity

The National Association of Public Administration describes social equity as the "fair, just and equitable management of all institutions serving the public directly or by contract, and

the fair, just and equitable distribution of public services, and implementation of public policy, and the commitment to promote fairness, justice, and equity in the formation of public policy" (Svara and Brunet, 2005, p. 256). One major lynchpin of the cap-and-trade program is promotion of social equity through an emphasis on assisting disadvantaged or underserved communities. The program objective of assisting these priority populations spells out a 50 percent allocation of all funds and projects. To date, this goal has been consistently met with slightly over US$4 billion in climate investments/projects (State of California, 2021, p. ii).

Given the breadth and depth of the programs and related projects, again covering twenty-three state related agencies and totaling forty-two different and varied projects, nearly all of these efforts allocated some portion to priority populations. The answer to research question 1a is that the California cap-and-trade program displays sufficient evidence of enhancing social equity.

Economic equity

Economic equity is distinguished from social equity in that social equity emphasizes access to fair and reasonable public services and related public policy. Economic equity is more concerned with enhancing the overall financial well-being of poorer or disadvantaged persons by having progressive tax and fee policies as well as assisting in jobs creation and economic development of communities. Sales and other consumer level taxes and fees are very regressive in nature in that economically disadvantaged persons pay a greater proportionate share of their income. For instance, based on January, 2021 data, California's present gasoline taxes, cap-and-trade passed-on fees, and other state related gasoline revenue fee sources equate to approximately 98 cents per gallon; California excise (gas) tax, 50.5 cents, California sales tax, 10.7 cents, cap-and-trade pass-through costs, 14.3 cents, and LCFS fees, 22.6 cents (Noda, 2021). The federal taxes and fees amount to 20.4 cents of which 18.4 cents are excise taxes and 2 cents represent the UST fee. Totaling California and federal taxes and fees, yields an approximate cost of US$1.184 per gallon. Since publication of the Stillwater California data, the excise (gas) tax has increased to 54 cents per gallon.

In 2017, the California Legislative Analyst's Office projected the long-term impacts of the cap-and-trade program to be 60 cents per gallon in 2021 and 73 cents per gallon in 2031, under the higher cost Allowance Price Containment Reserve Price (APCR) assumption. Using the lower-cost Auction Reserves Prices assumption these equated to 15 cents in 2021 and 24 cents by 2031 (Taylor, M. (2017). Based solely on this information, it appears the LAO lower-cost assumption may have merit since the projection for 2021, made in 2017 at 15 cents per gallon, is very close to the computed costs by Noda (2021) at 14.3 cents per gallon. As noted previously in this report, the Noda data likely overstates the LCFS impacts as full pass-through of costs is assumed. The total government taxes and fees are a moving target as market conditions change rapidly, and legislation is always a potential factor, increasing or decreasing the taxes and fees.

As of 2019, 16.4 percent of Californians were in poverty and another 17.6 percent were very near the poverty line of US$35,600 for a family of four. This suggests 34 percent of California families were at or very near the poverty line (Danielson *et al.*, 2022). Therefore, the regressive effect reflects a reality that at least one-third of Californians are adversely impacted by the FUC and LCFS fees in addition to other state gasoline fees and taxes. Furthermore, it is unlikely that most of the poverty-level population can afford all electric or hybrid vehicles, thus resorting to cars of a more inefficient and costly nature. For instance, per the PEW Research Foundation (2014), a significant portion of low-income Hispanic immigrants work in the construction industry. Given the nature of that work, is it feasible that these workers will use public transportation or drive electric/hybrid vehicles? It seems unlikely since pickup trucks are the preferred transportation type of transportation, which result in higher gasoline prices and less-efficient miles per gallon.

Affordability of clean energy vehicles/trucks is a significant issue, and the rebate program thresholds appear insufficient to drive further demand among low-income commuting households.

Critics also contend that disadvantaged persons/households disproportionately live in more high polluting areas (Becker, 2021), which may justify a degree of economic equity by the cap-and trade program since some of the project allocations go to these areas. However, mere tallies of the number of projects and affected lower-income individuals indicate a very low proportionate impact on improving these lives. What is known and easily quantifiable is the adverse economic impact of the program on gasoline prices, again representing a clear regressive tax/fee effect that applies to 34 percent, or approximately 14 million persons in California. The answer to the research question 1b is inconclusive as some empirical evidence suggests the aforementioned regressive tax effects and unwieldy high costs of electric and hybrid vehicles that could benefit low-income households (in addition, to the funding limitations of the Clean Vehicle Rebate Program). Conversely, as indicated in the Affordable Housing and Sustainable Agriculture Lands section of this paper, there are possible, if not likely, intangible economic benefits to affected households. Determination of any future net economic equity benefits will likely take ongoing analysis over an extended period of time.

Environmental equity and greenhouse gas reduction

According to the UCLA Luskin Center for Innovation, environmental equity means protection from environmental hazards as well as access to environmental benefits, regardless of income, race, and other characteristics (Banzhaf *et al.*, 2019). Pursuant to this definition, as is the case with Social equity section in this paper, the cap-and -trade program exhibits broad evidence of reaching numerous communities and individuals in California, with 50 percent of projects going to disadvantaged/priority communities. Despite an alleged failure to achieve its primary goal of carbon emission reductions (Becker, 2021) and environmentalists' concerns of not doing enough to reduce GHG's in communities of color, the depth, breadth, and varied types of projects appear to advance environmental equity. The answer to 1c is that the California cap-and-trade program does display sufficient evidence of enhancing environmental equity. However, evidence suggests a likely failure of the program to reduce future carbon emissions in accordance with original goals (Becker, 2021). While the California cap-and-trade program enhances environmental equity in a broad sense, the answer to 1d is the California cap-and-trade program does not display sufficient evidence of reducing carbon emissions in a sustainable manner.

Recommendations

It appears, given the large and varied number of beneficiaries, that cap-and-trade allocations may have been based on policies to "spread the wealth around" versus a more refined approach to identify the most cost-effective uses in reducing carbon emissions, which benefit he greatest number of residents. While the program appears to support both social and environmental equity, the lack of targeting highly efficient carbon reduction programs versus the "something for all environmental interests" approach has likely contributed to the inability of meeting carbon reduction goals. Furthermore, the failure of the High-Speed-Rail to make progress as initially planned, presents an opportunity for an orderly and timely termination of public funds for this project.

Based on the data sources and literature reviewed, there appear to be some viable recommendations for significantly enhancing carbon emission goals and economic equity which will entail re-examination of the program's goals and objectives. The following are the recommendations, stemming from the discussion above:

1. Eliminate the High-Speed-Rail as a project to receive cap-and-trade funds.
2. Focus all remaining auction proceeds and related appropriations on highly efficient carbon reduction projects (low GHG reduction cost per unit) which also benefit a broad array of priority populations as originally defined by the program:
    a. Increase the ceiling of electric vehicle subsidies pursuant to a sliding scale based on applicant income. Lower incomes receive greater subsidies.
    b. Related to the above, provide an extensive quantity of zero interest loans over a longer-term for lower income individuals.
    c. The combination of items a and b above should result in more realistic abilities of low-income individuals to acquire electric vehicles, including the high-cost pickup trucks. For financing, the state should consider guarantees of related car loans from banks, as well as interest subsidies, to entice lenders to participate.
    d. Direct more funding for inner-city and regional rail, including redirecting the remaining US$4 billion in rail transit bond funds for such efforts.
    e. Consider more funding for studies regarding hydrogen and alternative fuel programs as related to long-haul tractor trailers.
    f. With the exception of CDF projects, abandon all other projects in favor of items a through e above.
3. Create a public budgeting process to decide on the expenditures in the Greenhouse Gas Reduction Fund.

Areas for further study

While relatively extensive, this research effort did not explore many obvious areas of concern. Future research should consider:

1. Exploration of cost-benefit analyses in program project awards, with a focus on low cost GHG projects which benefit a wide array of California residents.
2. Quantitative and qualitative research regarding preferences and abilities of low-income individuals in acquiring electric vehicles and trucks.
3. Expansion of inner city and regional rail service in Southern California, including the large distance commuting High Desert areas.

Conclusions

The California cap-and-trade program has effectively distributed a wide array of projects benefitting the environment and low-income households/persons. While somewhat commendable on the surface, the program appears in jeopardy of not meeting future goals of carbon emissions reduction, possibly in part because the project awards were not focused on the most efficient uses in terms of cost per GHG reduction. An apparent flaw in the program is an orientation to production versus consumption, most clearly an inability to reduce vehicle and semi-truck travel, regardless of the cost of gasoline. Importantly, the program represents a regressive form of taxation due to its impact on increasing gasoline costs due to the FUC fees. Strong consideration should be given to significant amendments to the program, including elimination of High-Speed-Rail funding.

Lessons learned and/or recommendations for improving results from cap-and-trade research have broad applicability to national and global policies. Because costs associated

with California's program are passed on to consumers, such as fees attached to the price of gasoline, these costs ultimately represent a regressive tax/fee that disproportionately affects low-to-moderate income households. Any effort by other governments to implement a cap-and-trade program or GHG reduction type of fee should consider within a broad public policy context the likely impact on lower income households.

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About the authors

Alvin Holliman is a Lecturer in the Public Administration Department of California State University San Bernardino, since 1999, and was also an associate management professor at three other private universities during his career. He holds a Doctor of Management Degree from the University of Maryland University College and a Master of Arts Degree in Management from the Claremont Graduate School. Prior published and/or presented articles include performance management models in municipalities, leadership and faculty motivation at private universities, and the applicability of management theories at the American Red Cross. Alvin Holliman is the corresponding author and can be contacted at: aholliman@csusb.edu

Kimberly Collins, Ph.D. is the Executive Director of the William and Barbara Leonard Transportation Center (LTC) at California State University, San Bernardino. In addition to her role at the LTC, she is a Professor of Public Administration at CSUSB. Her current research focuses on technology integration, social equity, sustainability, networks, and democracy in communities. She received Ph.D. in 2006 from El Colegio de la Frontera Norte in Tijuana, Baja California and a MA in Political Science with a focus on International Relations from San Diego State University.