Unintended Consequences of California's Cap-and-Trade: An Examination of Industrial Electricity Productivity since California Enacted Assembly Bill 32, the California Global Warming Solutions Act

James J. Tanoos

***Abstract*—Greater American regulatory moving from federal to state governments has resulted in varying levels of environmental legislation and regulation. One example is the cap-and-trade system in California, which has been deemed a success in limiting greenhouse gas emissions as well as in earning revenue for the state. However, the coinciding production rates for polluting organizations has not been analyzed on a macro level. This study examined the air pollution and production rates of electricity organizations operating in California since cap-and-trade went into effect and found that since the legislation took effect, not only did production decreased slightly, but also, contrary to much analysis, the rates of air pollution from these organizations increased sharply.**

***Index Terms*—Air Pollution; Sustainability; Regulatory Authority; Energy Sector.**

I. Introduction

Enhanced regulatory authority in US state governments has resulted in disparate laws across states related to tax rates, drug laws, and laws affecting personal liberties, among other issues. This has also resulted in stringent environmental legislation in some areas and lax or nonexistent regulation in others, resulting in inconsistent air pollution regulations for industrial organizations. One innovative approach to limiting emissions is the cap-and-trade program in California.

Cap-and-trade has overwhelmingly been deemed a success in limiting greenhouse gas emission as well as in earning revenue for the state, but the efficiency of production for polluting organizations has not been analyzed on a macro level. Historically, inefficient electric utility productivity has been blamed on environmental regulations, but is this justified? Productivity in the California energy sector since the advent of cap-and-trade merits an analysis.

II. Literature Review and Background

In recent years, greater regulatory responsibility in numerous lawmaking areas in America has moved from the federal government to state governments [1]. Reference [2] indicated that local and state governments currently have a greater impact on the daily lives of Americans than the federal government. This is the result of a new phenomenon known as the devolution revolution, in which American state governments have established or reestablished themselves as powerful entities capable of spending time and effort on specific regulations and policymaking [3].

In particular, this enhanced state-level clout has resulted in varying levels of environmental legislation and regulation [4], [5]. Reference [6] confirmed that since environmental policy is now situated at the state level, non-uniform air pollution regulations and lower air quality standards have resulted.

Past studies of human activity related to climate change have concentrated on national-level issues [7], [8]. Most of the older literature related to environmental legislation and tactics to reduce greenhouse emissions has focused on national policies because it was taken for granted that environmental policies were enacted through federal mandates. However, the changing dynamics of state regulatory politics calls for a new look at state-level air pollution data. In addition, the study of environmentalism as it relates to economic growth is gaining in salience in the literature [9], [10].

Carbon-related emissions drive pollution, and can take many forms, including carbon compounds such as carbon monoxide and carbon dioxide [11]. The energy market has been the focus of cap-and-trade because electricity generation produces 40% of carbon dioxide, an especially harmful pollutant [12]. Electricity is the economic sector emitting the largest percentage of greenhouse gas at 29%, followed by the transportation sector, which emits 27% of the total, and the industry sector, which emits 21% of the total [53]. Of all greenhouse gas emissions, carbon dioxide accounts for 81% (Center for Sustainable Systems, 2017). Carbon dioxide constituted 35% of all US energy emissions in 2016, with coal-powered energy usage comprising 68% of that total, followed by natural gas-powered energy usage comprising 30%, and petroleum and other-powered energy usage at or below 1% [14].

The US state of California has had a history of state-level environmental regulatory policy [15]. California served as a laboratory for environmental innovation in the 1910s when the state's residents first developed hydroelectric power [16]. More recently, California enacted Assembly Bill 32 in 2006, which led the California Air Resources Board to adopt cap-and-trade on October 20, 2011, officially taking effect on January 1, 2013 [17]. This environmental program has been hailed as the "the flagship in an armada of global

Published on August 28, 2018.
J. J. Tanoos is with the Purdue University, Indiana, USA. (e-mail: jtanoos@purdue.edu)

warming policies" [18] and called the "most aggressive piece of climate change legislation ever adopted by an American legislature" [19]. Reference [20] claimed that cap-and-trade is "a crucial piece in California's war on climate change". As an entire system, it regulates the second-largest amount of emissions next to the EU's system [21].

Under a cap-and-trade model, a government-issued cap sets a maximum allowable level of pollution and penalizes companies that exceed that emission allowance [22]. The California state government annually determines the mandated maximum amount of pollution emissions that applicable industrial organizations can emit, with a more stringent allowance every year. An organization may gain emissions allowances for polluting at annual rates under the cap and then sell them in the open market. These organizations can sell these emissions permits through quarterly auctions in the open market or bank them and use those allowances in the future to cover their own emissions [23].

As such, the cap-and-trade system prompts a polluting organization to cut back on emissions or buy these allowances, also called "carbon permits" [24] or carbon credits for fair market prices in case they exceed the established cap [25]. The market mechanism is an important component of this process [26],[27]. Carbon permits can be sold or bought like a stock, and there is a real-time market value for them much like a stock market ticker, and with prices fluctuating over time [28]. Electricity organizations were most likely to engage in these trades. The private market from which the carbon permits can be bought or sold has also been labeled the "carbon market" [27].

Although this process has been used internationally, the cap-and-trade process in California has been called the US's "first economy-wide market trading system" to limit pollution [29]. The system has been deemed a success in part because it motivates organizations to make technological innovations to limit emissions: "if allowances are very expensive, the utility will be incentivized to make more expensive investments rather than risk having to buy additional allowances" [30]. As such, the price of the credits is directly impacted by the general costs of decreasing industrial emissions rates. From 2013-2015, cap-and-trade translated into regulated emissions in California dropping by 4% [22]. Through May of 2015, private sector auctions for the credits earned the state over $2 billion in revenue, which the state reinvests in clean air initiatives [17]. By 2017**,** there was a surplus of carbon credits available in the state [20]. Due to the success of the program, the state California extended cap-and-trade through 2030 in July of 2017 [24].

California's cap-and-trade program regulations are most impactful on the power-generating industry, more specifically, the electricity industry. It not only regulates state's electric power plants but also large industrial plants, as it was written to apply to stationary sources emitting over 25,000 metric tons of carbon dioxide equivalent annually [31]. To put this into perspective, one metric ton of emissions is the equivalent of 2,400 miles of driving [53]. In 2015, the success of the program allowed it to be expanded to fuel distributors, and thereafter cap-and-trade covered 85% of California's overall emissions [32].

Cap-and-trade has also had detractors, but to a lesser degree than its supporters. For instance, it has been said that fuel emission regulations have had a more profound impact on improving overall air quality than energy emission regulations and that special interests and lobbyists have had too powerful an impact on the trading of the carbon credits [33]. Claims have also been made that too many pollution permits have been given out and special interests have gained too much control [34]. An alternative plan to cap-and-trade has been a carbon tax on carbon-containing energy sources [29],[35],[36].

Legal hurdles have also impeded cap-and-trade. In 2011, a court ruled that California failed to research alternative means of greenhouse gas reduction [29]. Environmental groups have sued the state based on cap-and-trade, claiming that the market mechanism in the program would lead to rogue polluters in their neighborhoods [29]. In response, the state created a greenhouse registry so that the public would know where rogue polluters are located [29]. Further, there have been "carbon leakage" issues, such as California companies deciding to produce elsewhere because of the stringent regulations [37]. Reference [27] stated that the trading portion of cap-and-trade "remains rudimentary at best".

Historical studies analyzing regulations on pollution show negative relationships between manufacturing productivity and regulations [38],[39]. Further, environmental regulations have been blamed for inefficient electric utility productivity for decades [40]-[42]. More recently, scholars have also noted that California's cap-and-trade program did not take into account consumer energy rates and/or had a negative impact on energy consumers [43]-[45]. Recent scholars point to increased energy rates because of environmental legislation [46]-[49].

There has not been stringent enforcement of cap-and-trade violations as well as EPA violations across the country. Out of 64,000 facilities around the US that have violated environmental laws, only 0.5% have been prosecuted, and most of these have only received fines [50]. The main reason the EPA and Department of Justice avoid criminal cases is lack of manpower and resources. As a result, they throw out many moderate and low-impact cases and focus only on high-impact cases.

Nevertheless, cap-and-trade will continue in California for the foreseeable future. Dissolving cap-and-trade would prompt immediate and unwanted increases in carbon emissions [51]. However, the political and legal debates over the unintended consequences related to cap-and-trade continue today. While it is true that the literature proclaims the overwhelming success of the program in spite of occasional detractors, particularly those that advocate for energy consumers, there has been no analysis of the negative fallout generally associated with environmental regulations, in terms of the general efficiency and productivity of those organizations that are being newly regulated. It remains unclear whether or to what extent productivity at previously efficient electricity-producing organizations has lagged in the aftermath of cap-and-trade.

III. Data and Methodology

This study will examine the air pollution and production rates of electricity organizations operating in California since cap-and-trade went into effect. The number of total companies polluting in California was extracted from the Toxic Release Inventory (TRI), a publicly-available EPA database that contains information on the release of toxic chemicals into the atmosphere and the waste management concentration activities reported annually by certain industries as well as federal facilities.

TABLE I: EPA- Toxic Release Inventory, All Companies Operating in California

2009	4,001
2010	3,933
2011	3,872
2012	3,923
2013	3,913
2014	3,901
2015	3,813
2016	3,657

In order to ascertain the types of electricity organizations polluting during the production process, any organization emitting "carbon" (using column AD, the chemical pollutant column, or the 30th column of 111 total columns) was included in the subset, since cap-and-trade's carbon regulations are most impactful on the power-generating industry, more specifically, the electricity industry. Table 2 below lists the number of carbon-polluting organizations in its facility name or parent company name.

TABLE II: Number of Organizations Emitting Carbon

Carbon	California
2009	32
2010	32
2011	35
2012	32
2013	29
2014	29
2015	31
2016	31

This study wished to analyze composite air pollution. Providing assistance in this analysis was Nathan Byers, from the Office of Pollution Prevention and Technical Assistance at the Indiana Department of Environmental Management, defined fugitive air emissions as "all releases to air that are not released through a confined air stream including equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems, from Section 5.1 on the TRI Form R" [52].

In order to compare apples to apples for air emissions, Byers suggested combining columns: "This will be taking into account what is leaving the facility via air no matter what the process is. In this way, you can fairly compare facilities in one industry to facilities in another" [52]. He indicated that the "Total Air Emissions" column was the combination of types of air leaving a facility. As such, "Total Fugitive Air Emissions" and "Stack Air Emissions" were added for purposes to create the "Total Air Emissions" [54].

TABLE III: Total Air Emissions of carbon-emitting organizations, by year

	California
2009	45748.38
2010	53349.88
2011	51285.53
2012	45804.72
2013	61740.24
2014	53954.51
2015	96951.04
2016	87642.88

Another focus of this study is the coinciding output or production rates of these organizations, Timothy Antisdel, Specialist/Database Administrator for the EPA described how production rates can be determined [52]. Antisdel noted that in addition to collecting air pollution rates, the EPA also "collects a production or activity index which indicates the change in production or activity at the facility from year to year", which are included in column DB. As such, average annual productivity rates (as they compare to their productivity from the prior year) for companies from Table 2 were extrapolated from the TRI. Table 4 below summarizes the average productivity rates of these organizations.

TABLE IV: Average Annual Production of the Sample Set of Organizations, by year

2009	0.913103
2010	0.982667
2011	0.861714
2012	1.007188
2013	0.947931
2014	0.934483
2015	0.905484
2016	0.929355

In order to obtain a comparable method for assessing pollution as it relates to output, or pollution efficiency, variables for both pollution and productivity must be included. As such, the total air pollution, or the sum of the fugitive and stack air from Table 3, was utilized as the numerator and the average productivity rates from Table 4 were utilized as the denominator in order to ascertain a "pollution efficiency rate". Since Assembly Bill 32, which led the California Air Resources Board to adopt cap-and-trade on October 20, 2011 officially took effect on January 1, 2013, analysis of pollution efficiency rates compared that from 2009-2012 versus 2013-2016.

IV. Results and Reactions

Table 5 shows the average production of carbon-emitting organizations both before and after the legislation took effect. The total production of those organizations decreased from .941 in the period 2009-2012 to .929 in the period

2013-2016, or a reduction of 1.26%% from the previous period.

TABLE V: AVERAGE ANNUAL PRODUCTION, BEFORE AND AFTER POLLUTION LEGISLATION TOOK EFFECT

Year	Avg. Prod'n	Comparison
2009	0.913103	
2010	0.982667	
2011	0.861714	
2012	1.007188	0.941168
2013	0.947931	
2014	0.934483	
2015	0.905484	
2016	0.929355	0.929313

Table 6 below shows the average total emissions (fugitive plus stack) of the sample set of organizations both before and after the legislation took effect. The total emissions of those organizations increased sharply from 49,047 lbs. in the period 2009-2012 to 75,072 lbs. in the period 2013-2016, or 53.1% increase from the previous period.

TABLE VI: TOTAL AIR EMISSIONS OF THE SAMPLE SET, BEFORE AND AFTER COAL LEGISLATION TOOK EFFECT

Year	Emissions	Comparison
2009	45748.38	
2010	53349.88	
2011	51285.53	
2012	45804.72	49,047
2013	61740.24	
2014	53954.51	
2015	96951.04	
2016	87642.88	75,072

Since this study sought to utilize the "pollution efficiency rate" to ascertain production as it compares to emissions, the average production from Table 5 was divided by the total emissions from Table 6 for all companies in the sample set both before and after the respective legislation took effect, as seen in Table 7. As such, the pollution efficiency rate decreased (got worse) at a rate or 35.5% from the prior period.

TABLE VII: POLLUTION EFFICIENCY RATE, BEFORE AND AFTER LEGISLATION

Before/After	productivity/emissions
2009-2012	1.92E-05
2013-2016	1.24E-05

Electricity organizations using coal and operating in California since cap-and-trade went into effect had to make some changes to their organizational models. This study found that since the legislation took effect, production decreased slightly as emissions increased sharply. These factors contributed to a notable decrease in the pollution efficiency rate.

The history of inefficient electric utility productivity in California has been blamed on stringent environmental regulations. Reasons for the relative lack of productivity in the California energy sector since the advent of cap-and-trade should continue to face scrutiny.

REFERENCES

[1] Altshuler, A., & Luberoff, D. (2003). *Mega-Projects: The changing politics of urban public investment*. Washington, DC: Brookings Press.
[2] Donovan, T., Mooney, C., & Smith, D. (2009). *State and Local Politics: Institutions and Reform*. Florence, KY: Wadsworth Cengage Learning.
[3] Gerber, B., & Teske, P. (2000). Regulatory policymaking in the American states: A review of theories and evidence. *Political Research Quarterly, 53(4),* 849-886.
[4] Sapat, A. (2004, March-April). Devolution and Innovation: The adoption of state environmental policy innovations by administrative agencies. *Public Administration Review, 64(2),* 141-151.
[5] Daley, D., Haider-Markel, D., & Whitford, A. (2007). Checks, Balances, and the Cost of Regulation: Evidence from the American States**.** *Political Research Quarterly, 60(4),* 696-706.
[6] Potoski, M., & Woods, N. (2002). Dimensions of State Environmental Policies: Air pollution regulation in the United States. *Policy Studies Journal, 30(2),* 208-226.
[7] Harris, P. (2002). *The Environment, International Relations, and U.S. Foreign Policy.* Washington, DC: Georgetown University Press.
[8] Blonigen, B. (2005). A Review of Empirical Literature on FDI Determinants. *Atlantic Economic Journal, 33,* 383-403.
[9] Copeland, B. & Taylor, S. (2000, April). Free Trade and Global Warming: A trade theory view of the Kyoto Protocol. National Bureau of Economic Research: Cambridge, MA.
[10] Dasgupta, S., Hamilton, K., Pandey, K., & Wheeler, D. (2006, September). World Development. *Environment During growth: Accounting for governance and vulnerability. 34(9).*
[11] Williams, M. (2016, April 14). What causes air pollution? Retrieved from. https://phys.org/news/2016-04-air-pollution.html
[12] Burtraw, D., Linn, J., Palmer, K., & Paul, A. (2014). The Costs and Consequences of Clean Air Act Regulation of CO_2 from Power Plants. *The American Economic Review, 104(5),* 557-562.
[13] Center for Sustainable Systems University of Michigan. (2017, August). Greenhouse Gases Factsheet. Retrieved from. http://css.umich.edu/factsheets/greenhouse-gases-factsheet
[14] U.S. Energy Information Administration (EIA). (2017, May 10). Frequently Asked Questions? *How much of U.S. carbon dioxide emissions are associated with electricity generation?* Retrieved fromhttps://www.eia.gov/tools/faqs/faq.php?id=77&t=11%20EIA,%202017
[15] Williams, J. (1997, June 1). Energy and the Making of Modern California (Series on Technology and the Environment) Reprint, 1998 Edition. Akron, OH: University of Akron Press.
[16] Thompson, V. (2014, February 15). Sophisticated Interdependence in Climate Policy: Federalism in the United States, Brazil, and Germany (Anthem Environment and Sustainability). New York, NY: Anthem Press.
[17] Schmalensee, R. & Stavins, R. (2015). Lessons Learned from Three Decades of Experience with Cap-and-Trade (Rep.). *Fondazione Eni Enrico Mattei (FEEM).*
[18] Durning, A. & Bauman, Y. (2014, May 22). 17 Things to Know About California's Carbon Cap. The Golden (State's) rules.
[19] Ansolabehere, S. (2014, August 8). Cheap and Clean: How Americans Think about Energy in the Age of Global Warming. Cambridge, MA: The MIT Press.
[20] Kasler, D. (2016, August 23). California's cap-and-trade carbon program sputters again. Retrieved from. http://www.sacbee.com/news/politics-government/capitol-alert/article97380457.html
[21] Center for Climate and Energy Solutions. (2017). California Cap and Trade. Retrieved from https://www.c2es.org/content/california-cap-and-trade/
[22] Environmental Defense Fund (EDF). (2017). How cap and trade works. The system reduces emissions by setting a limit on pollution and creating a market.
[23] Bushnell, J. (2008, January). The design of California's cap-and-trade and its impact on electricity markets. *Journal of Climate Policy, 8(3),* 277-292.
[24] Murphy, K. (2017, September 12). Here's how California plans to spend $1.5 billion in cap-and-trade money. *The Mercury News.*
[25] Carmona, R., Fehr, M., Hinz, J., & Porchet, A. (2010). Market Design for Emission Trading Schemes. *SIAM Review, 52(3),* 403-452.
[26] Kaswan, A. (2012, April 24). Applying the Clean Air Act to Greenhouse Gases: What Does It Mean for Traditional Pollutants?
[27] Marland, E. & Domke, G. & Hoyle, J. & Marland, G. & Bates, L. & Helms, A. & Jones, B. & Kowalczyk ,T. & Tuseva, T. & Szymanski, C. (2017, March 30). *Understanding and Analysis: The California Air*

Resources Board Forest Offset Protocol (SpringerBriefs in Environmental Science). New York, NY: Springer.
[28] California Air Resources Board. "Quarterly auction information." Washington GPO, 22 Feb. 2017. Web. 21 Feb. 2017.
[29] Gallagher, D. (2012, September 19). *Environmental Leadership: A Reference Handbook 1st Edition*. Thousand Oaks, CA: SAGE Publications, Inc.
[30] Cook, J. (2013, December). The Future of Electricity Prices in California: Understanding Market Drivers and Forecasting Prices to 2040.
[31] Levin, A. & Pepper, R. (2017, July 28). California Extends Greenhouse Gas Cap-and-Trade Program Through 2030. Retrieved from. https://www.environmentallawandpolicy.com/2017/07/california-extends-greenhouse-gas-cap-trade-program-2030/
[32] Purdon, M., Houle, D., & Lachapelle, E. (2014). The Political Economy of California and Québec's Cap-and-Trade Systems. Sustainable Prosperity Research Report.
[33] Reyes, O. (2016, August 26). State should look beyond cap and trade to develop more effective climate policies. Retrieved from http://www.sacbee.com/opinion/op-ed/soapbox/article97914327.html
[34] Broekhoff, D. (2015, February 18). There Are Still Promising Alternatives to Carbon Taxes. Retrieved from https://www.brinknews.com/there-are-still-promising-alternatives-to-carbon-taxes/
[35] Metcalf, G. (2009). Market-Based Policy Options to Control U.S. Greenhouse Gas Emissions. *The Journal of Economic Perspectives, 23(2)*, 5-27.
[36] Goulder, L. & Schein, A. (2013). CARBON TAXES VERSUS CAP AND TRADE: *A CRITICAL REVIEW*. *Climate Change Economics, 4(3)*, 1-28.
[37] World Bank Group. (2014, May). State and Trends of Carbon Pricing. *California Trade and Cap Program*. Washington, DC: Publishing and Knowledge Division.
[38] Nivola, P. (1997, July 1). *Comparative Disadvantages? Social regulations and the global economy*. Brookings Washington, DC: Institution Press.
[39] Managi, S. (2011, September 14). *Technology, Natural Resources and Economic Growth: Improving the Environment for a Greener Future*. Cheltenham, UK: Edward Elgar Pub.
[40] Gollop, F., & Roberts, M. (1983). Environmental Regulations and Productivity Growth*: The Case of Fossil-fueled Electric Power Generation. Journal of Political Economy, 91(4)*, 654-674.
[41] Gray, W. (1987). The Cost of Regulation: OSHA, EPA and the Productivity Slowdown. *The American Economic Review, 77(5)*, 998-1006.
[42] Weber, W., & Domazlicky, B. (2001). Productivity Growth and Pollution in State Manufacturing. *The Review of Economics and Statistics, 83(1)*, 195-199.
[43] Farber, D. (2012). Pollution Markets and Social Equity: Analyzing the Fairness of Cap and Trade. *Ecology Law Quarterly, 39(1)*, 1-56.
[44] Clarke, J. (2015). California's New Majority Confronts Climate Crisis. *Race, Poverty & the Environment, 20(1)*, 18-26.
[45] Cox, J. (2017, July 16). Cap and Trade opponent: Climate change gives California Democrats an excuse to raise taxes. *The Mercury News.*
[46] Lunsford, L. (2010, April 8). *You're Fired! Why Liberals should never run the Government*. (pp. 15). Bloomington, IN: Xlibris.
[47] Kryzanek, M. (2010, August 9). Debates, Differences and Divisions: The 25 Issues That Shape American Politics. Abingdon, UK: Routledge.
[48] Bakker, C. & Francioni, F. (2014, September 19). *The EU, the US and Global Climate Governance*. Abingdon, UK: Routledge.
[49] Raymond, L. (2016, September 16). Reclaiming the Atmospheric Commons: The regional greenhouse gas initiative and a new model of emissions trading. Cambridge, MA: The MIT Press.
[50] Brinkerhoff, N. Straehley, S. (2014, July 16). When Companies Break Environmental Laws, Why are Responsible Individuals Not Prosecuted?
[51] Kaufman, N. (2016, March 1). Carbon Tax vs. Cap-and-Trade: What's a Better Policy to Cut Emissions? Retrieved from. http://www.wri.org/blog/2016/03/carbon-tax-vs-cap-and-trade-what%E2%80%99s-better-policy-cut-emissions
[52] Antisdel, T. (2017). Specialist/Database Administrator for the United States EPA; personal communication.
[53] EPA. (2017, January 19). Greenhouse Gases Equivalencies Calculator: Calculations and references. Energy/Environment section. Retrieved from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.
[54] Tanoos, J. (2012). Who's Polluting the Hoosier Air? An Examination of International versus Domestic Industry Operating in Indiana. International Journal of Management Sciences, 1(9), 41-60.