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Filling the Federal Void? Determining the Effectiveness of State-Level Climate Policies

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An abstract of
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Abstract

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By Geoff Martin

States have historically been the primary drivers of climate change policy in the U.S., particularly with regard to climate pollution from power plants. States have implemented numerous policies designed to either directly curb greenhouse gas (GHG) emissions from power plants, or to encourage energy efficiency and renewable energy growth. With the fate of the proposed federal Clean Power Plan unclear, the need for effective state action is critical. There is an urgency to understand which state-level policies have successfully mitigated power plant emissions, but prior research has assessed policy effectiveness using data prior to the adoption of many policies. I assess 17 policies using the latest state-level power sector CO_2 emissions data. I find that GHG emissions caps, GHG emissions standards, and decoupling are associated with the largest reduction in emissions of all policies assessed, and that policies with mandatory compliance are reducing power plant emissions, while voluntary policies are not associated with a reduction in emissions.

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1. Introduction

As atmospheric carbon dioxide (CO_2) concentrations rise to levels unprecedented in human history and global mean temperatures continue to break records, there is an urgent need to aggressively curb greenhouse gas (GHG) emissions in order to avoid unmanageable impacts of climate change (NOAA 2017). The United States plays a particularly important role in the global effort to address climate change. The U.S. has historically been the world's largest emitter of CO_2, and is currently the world's second largest emitter of CO_2 (Friedrich and Damassa 2014). Within the U.S., the electric power sector is responsible for the largest share of the country's GHG emissions, contributing to 30% of total emissions in 2014 (U.S. EPA 2014). Yet to date, the U.S. federal government has not implemented any policies specifically addressing GHG emissions from the power sector.

States have historically been the primary drivers of climate change policy in the U.S. In the face of federal inaction, many states have adopted a wide range of policies designed to either curb power sector emissions or increase renewable electricity generation. Federal inaction is likely to continue under the current administration, which is looking to significantly cut funding for climate and environmental programs. Now more than ever, it is imperative that states rise to the occasion to help the U.S. meet its national emissions reduction targets under the Paris Agreement, and do its part to avoid unmanageable changes to the climate system. As a laboratory for policy experimentation, states have implemented numerous climate and energy policies designed to either explicitly or implicitly reduce GHG emissions from the electricity sector. As states aim to fill the federal void on climate leadership, they must know the answer to one critical question: which of these policies are significantly reducing electricity sector emissions? This study seeks to answer that question.

Understanding which state-level policies are effective at reducing power sector emissions is important for several reasons. First, for states seeking to make a measurable impact on their electricity sector emissions, state policy makers have the opportunity to learn from the successes and failures of their fellow states and enact those policies that are proven to reduce emissions over those that have not shown a significant effect. Second, as many states have already implemented one or more of the policies assessed in this study, state-level decision makers need to know which policies they should continue to pursue as they look to update their plans or set new targets for future compliance periods. Third, as the current administration in the White House aims to cut federal funding for the Environmental Protection Agency (EPA) and environmental regulations, including those targeting GHG emissions, it is important to know whether or not state-level policies can pick up the slack or if the argument for federal action should be strengthened. Finally, state-level policy experimentation provides the best available evidence for which policies work and which do not in the context of the United States. If and when the federal government does decide to address GHG emissions from power plants, it can look to the states to provide a template for meaningful action.

Carbon dioxide emissions at state, national or international scales are the result of many complex factors and mechanisms. Kaya (1990) proposed a framework (Figure 1) that allows for decomposing the complexity into four key variables that drive carbon emissions. The interactions of human population, gross domestic product per capita, energy intensity and carbon intensity has been used by the Intergovernmental Panel on Climate Change (Nakicenovic and Swart 2000) to develop future emissions scenarios. This simplified framework illustrates not only what factors influence carbon emissions, and are therefore important to consider in developing explanatory models, but also the levers that policy makers can utilize to reduce carbon emissions. Energy intensity and carbon intensity (Fig. 1) are what policy makers try to affect when designing climate and energy policies. Many policies are command and control style policies, in that they proscribe certain mechanisms for achieving their aims. For example, renewable portfolio standards policies require utilities to increase electric production using non-fossil fuel energy sources. Others are more flexible in their approach, or even employ market mechanisms, such as RGGI and California's cap-and-trade program authorized under AB 32. These types of policies set certain targets, but then allow utilities to determine the best path to compliance. Regardless of the lever that a climate or energy policy targets in its design, policies must overcome opposing forces, such as population or economic growth, in order to have an effect on emissions levels. Alternatively, policies implemented in the context of changing conditions that might independently reduce electricity emissions, such as technological improvements, might erroneously appear effective. Controlling for these independent factors can help reduce the chance of inaccurately attributing changes in emission levels to the implementation of policies.

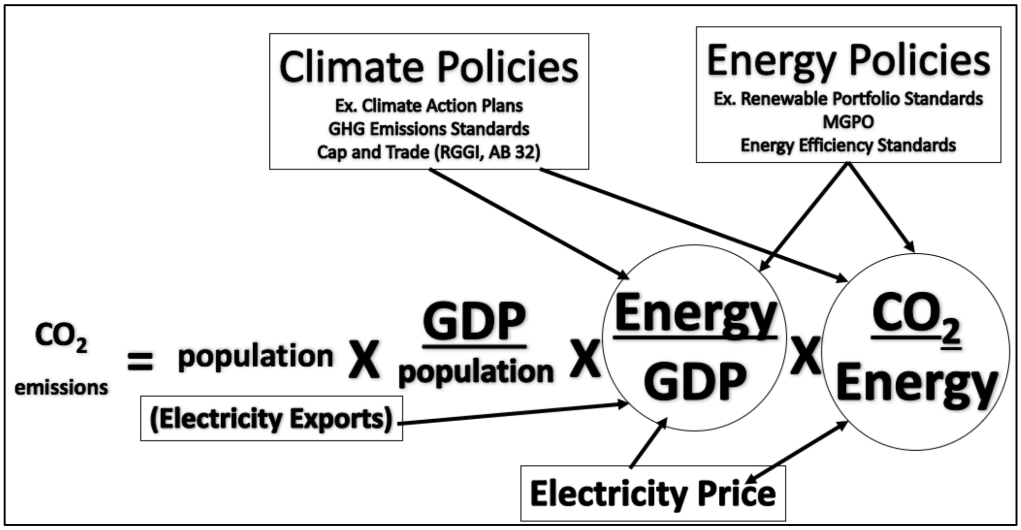

Figure 1. The Kaya Identity framework (Kaya 1990), indicating how carbon dioxide emissions are a function of population, gross domestic product (GDP), electrical energy production /GDP, and carbon dioxide emissions/electrical energy production. Price of electricity influences the production/GDP and carbon dioxide per energy produced. Polices that attempt to control emissions can be grouped into categories that focus on controlling emissions (climate policies), and those that indirectly effect emissions by focusing on energy efficiency and non-fossil fuel modes of production (energy policies).

As noted above, state policy makers have implemented climate-related policies that fall into two broad categories – climate policies and energy policies with climate implications (Rabe 2004, Grant, Bergstrand et al. 2014). Climate policies are those that explicitly target GHG emissions from power plants and thus the primary motivation for the policy is to address climate change. Climate policies include GHG emissions targets, which set state-wide targets for emissions reductions by a certain date, GHG emissions standards, which require power plants to reduce their emissions below a certain level, and climate action plans, which details the steps that a state plans to take to address climate change (C2ES 2016). While the mechanisms that climate policies use to reduce emissions vary substantially from one policy to the next, they all explicitly target GHG emissions in the policy design.

The second broad category of state-level climate-related policies are energy policies with climate implications, henceforth referred to as energy policies. These policies do not explicitly target GHG emissions or climate change in their design, but rather are intended to change the energy landscape in ways that have implications for GHG emissions and climate change. Included in this policy category are renewable portfolio standards (RPS), which require utilities to provide a certain amount of electricity from renewable sources, mandatory green pricing option (MGPO), which compel utilities to provide customers with the option of paying extra to have some or all of their electricity generated from renewable sources, and electric decoupling, which decouples utilities' revenues from sales volume (C2ES 2016). As with the climate policy category, the mechanisms through which energy policies work vary from policy to policy, yet all energy policies (with the exception of deregulation, discussed in Section 2) directly seek to either increase renewable energy growth or encourage energy efficiency. While climate change may motivate the adoption of energy policies, reducing GHG emissions is not explicit in the policy design. Energy policies can thus be framed in terms of economic opportunities or energy security, rather than as climate solutions, potentially making it easier to garner bipartisan support (Rabe 2004, C2ES 2011).

There are two final distinctions with regard to policy types. First, states can design both climate and energy policies to be either mandatory or voluntary. Mandatory policies establish legally binding targets, and non-compliance can result in penalties, whereas voluntary policies do not have a legal mechanism for enforcement. Most policies, with the exception of climate action plans, can be neatly assigned to either the voluntary or mandatory category. There is a wide variation, however, among and even within climate action plans, as plans can often contain both voluntary and mandatory components (Wheeler 2008). Finally, aside from state-level policies that are confined to state borders, there are also regional initiatives through which states collaborate to reduce emissions. Of these subnational efforts, two in particular address power sector emissions – the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI) – and are assessed in this study.

Much of the literature assessing the effectiveness of state-level climate policies has examined the impact of different policy measures on investment in renewables or increasing renewable capacity. The focus has largely been on renewable portfolio standards (RPS), which typically require electric utilities to provide a certain amount of electricity from renewable sources. Yin and Powers(Yin and Powers 2010) used fixed-effects regression models to show that, when taking stringency into account, RPS did increase in-state renewable energy development. Carley (2009) found that the presence of RPS increased renewable investment and deployment within a state, but did not effectively increase the percentage of renewable energy generation within a state's electricity portfolio. In contrast, Michaels (2008) argued that the adoption of RPS by a state was largely symbolic, as most states are not in compliance with their own goals, and that much of the impetus for RPS came from special interest groups. Delmas and Montes-Sancho (2011) provided empirical evidence to support the claim of Michaels (2008). They employed a two-step regression analysis to control for the natural and institutional context within states and found that, when controlling for the context within which the policy was implemented, RPS actually had a significant negative effect on investments in renewable capacity.

Others have gone beyond RPS in the assessment of the effect of state-level policies on renewables. Menz and Vachon (2006) used a regression model to evaluate the effect of RPS, retail choice, generation disclosure requirements, mandatory green power offering, and public benefit funds on wind power generation, and found that RPS and mandatory green power increased wind generation. (Shrimali and Kniefel 2011) assessed the impact of state policies on non-hydro renewable energy penetration, and found that RPS with mandatory targets, public benefit funds, and required green power options all had a significant positive effect.

Ultimately what matters from a climate lens is not whether policies benefit renewable energy, but rather if they are successful in sharply curbing GHG emissions. Increased investment in renewables, greater renewable capacity, or even higher renewable generation levels cannot serve as a suitable proxy for the decarbonization of the power sector, as simply increasing renewable capacity without decreasing fossil fuel electricity generation is not a solution to climate change. Little empirical research has been conducted demonstrating the strengths or weaknesses of various power sector climate-related policies with regard to their effectiveness at reducing carbon dioxide (CO_2) and other GHG emissions. Simply implementing energy efficiency and renewable energy policies may have little or even no effect on curbing CO_2 and other GHG emissions if the policies are not designed correctly. While many of the studies discussed above have analyzed whether certain policies increase renewable generation, none of them focused on the effectiveness of the policies for reducing CO_2 emissions.

The limited number of studies that have assessed the effect of state-level policies on CO_2 emissions are either outdated or are too narrow in focus. Drummond (2010) divided state climate actions into two broad categories – climate action plans and the presence of policy entrepreneurs – and assessed the impact of both on GHG emissions. Drummond (2010) also analyzed state-level GHG emissions by end-use sector, excluding the industrial sector, to determine the effect of climate actions on residential, commercial, and transportation sector emissions. He (op cit) found that climate action plans, policy entrepreneurs, and the combination of both climate action plans and policy entrepreneurs led to moderate reduction of GHG emissions from the non-industrial sector. Drummond (op cit) also assessed the specific mechanisms for achieving emissions reductions within climate action plans. In the non-industrial model, he(op cit) found that stakeholder participation and explicit reduction targets reduced emissions. Drummond's (2010) study, while illustrative, neglects a wide range of other climate and energy policies that states have used to control their GHG emissions. Furthermore, Drummond's (2010) time series data ends in 2007 and many states have implemented new policies or updated old ones over the past decade.

Grant et al. (2014) analyzed 2010 plant-level carbon emissions data under EPA's Greenhouse Gas Reporting Program to determine the effectiveness of a broader range of state climate policy on carbon emissions. Controlling for plant-specific factors such as size, fuel type, age, pollution control equipment, dispatch systems, and whether the plant is publicly or privately owned, they (op cit) examined GHG emissions standards, GHG targets, climate action plans, GHG registry and reporting, energy efficiency targets, RPS, public benefit funds, and electric decoupling. They (op cit) found that emission caps and GHG targets are both significant determinants of reduced plant emissions, while neither climate action plans nor GHG reporting/registry had a significant effect on emissions. They (op cit) also found that efficiency targets and RPS have no effect on plants' emissions, while public benefit funds and electric decoupling are significant determinants. Grant et al. (2010), examined data from 2010, prior to the start date of the compliance period for several of the RPS policies. For example, 118 climate-related policies were passed by 41 different states from 2010 through 2014 (C2ES 2016).

Prasad and Munch (2012) conducted the first multivariate analysis of the effect of renewable energy policy on carbon emissions from the electrical power sector. They (op cit) tested the effects of six renewable energy policies (net-metering, retail choice or deregulation, fuel generation disclosures, mandatory green power options, public benefit funds, and renewable portfolio standards) on CO_2 emissions. Among the six options, the study (op cit) determined that the introduction of a public benefit fund, a kind of carbon tax, was associated with a large and significant reduction in statewide carbon emissions. This study (op cit) provides a starting point for discussions on policy effectiveness, but the only analyzed data from 1997 to 2008, representing a period prior to adoption of broader policies. Furthermore, Prasad and Munch

(2012) only examined the 39 states with significant wind energy potential and expected that they would have lower carbon emissions. While this assumption may have held more weight in the early 2000s, solar and other renewable technologies have become increasingly cost-competitive with wind, and assessing only states with significant wind potential limits the generalizability of the results.

My study, using the most recent state-level CO_2 emissions data, is the first to broaden state-level CO_2 emissions analysis to include a wider range of climate-related policies. This is also the first study assessing policy outcomes across all 50 states from 1990-2014, all years for which power sector emissions data is available. My study seeks to answer the following questions. First, what is the effect of state-level climate-related policies on power sector emissions? And second, which policies can be labeled effective climate policies, and which can be labeled ineffective climate policies? By focusing on what policies lead to a significant reduction in CO_2 emissions, I hope to provide vital, generalizable information for policy makers to introduce smart strategies in addressing climate change.

2. Methods and Design

In this study I examine the effect of 17 state-level climate and energy policies on CO_2 emissions in the electricity sector using data from 1990-2014. I do so by constructing panel data to compare carbon emissions from the power sector over time in states that have passed climate and energy policies to emissions in states that have not passed these policies. This comparison tests whether these policies have a significant impact on emissions compared to a null hypothesis of no effect. I employ a fixed-effects regression model to control for unobserved state and year heterogeneity, as well as certain state-specific characteristics that may have an independent effect on power sector carbon emissions. My model utilizes a difference-in-differences approach, as it illuminates changes in emissions trends as a result of policy both between states that implement a policy and those that do not, as well as the trend within a state before and after policy implementation. The dependent variable is CO_2 emissions (tons of carbon dioxide/state/year) from the electric power sector within a state. The data were derived from EPA's "State CO_2 Emissions from Fossil Fuel Combustion, 1990-2014" report, using data collected by the EPA and the U.S. Energy Information Administration (U.S. EPA 2016). The emissions data cover all 50 states for each year between 1990-2014. Thus, my unit of analysis is the state-year, and I have 1,250 state-years.

I employ the following model for each policy:

$CO_2 = \alpha_i + \gamma_t + \beta_1 \text{policy}_{it} + \beta_2 \text{export}_{it} + \beta_4 \text{population}_{it} + \beta_5 \text{price}_{it} + \varepsilon$

In this model, α_i represents state fixed-effects, γ_t represents year fixed-effects, *policy* is a dummy variable for the presence or absence of a specific climate or energy policy for a given state-year, *export* is the percentage of a state's total electricity production that is exported to other states, *population* represents the state's population, *price* is the price of electricity within a state, and ε represents the error term. I run 17 separate models for each of the 17 policies assessed, and do not include multiple policies in the same model.

In addition to the control variables shown in Figure 1 and Table 2, I also control for state and year fixed-effects. State fixed-effects account for the wide variation among state's power sector emissions (Figure 2) by subtracting the state CO_2 emissions means, so that the models can compare changes in emissions within states, rather than comparing changes in emissions among states. The state-fixed effects variable will capture unobserved heterogeneity among states, including the renewable energy potential of states or infrastructural investments or other historical legacies that may be associated with a reliance on fossil fuels for power generation. Year fixed-effects control for year to year national emissions trends that might be associated with factors such as technological improvements that have driven declines in the cost of renewables and natural gas, or changing economic conditions. State-level policies that significantly reduce emissions must decrease emissions beyond expected emissions levels, given national trends.

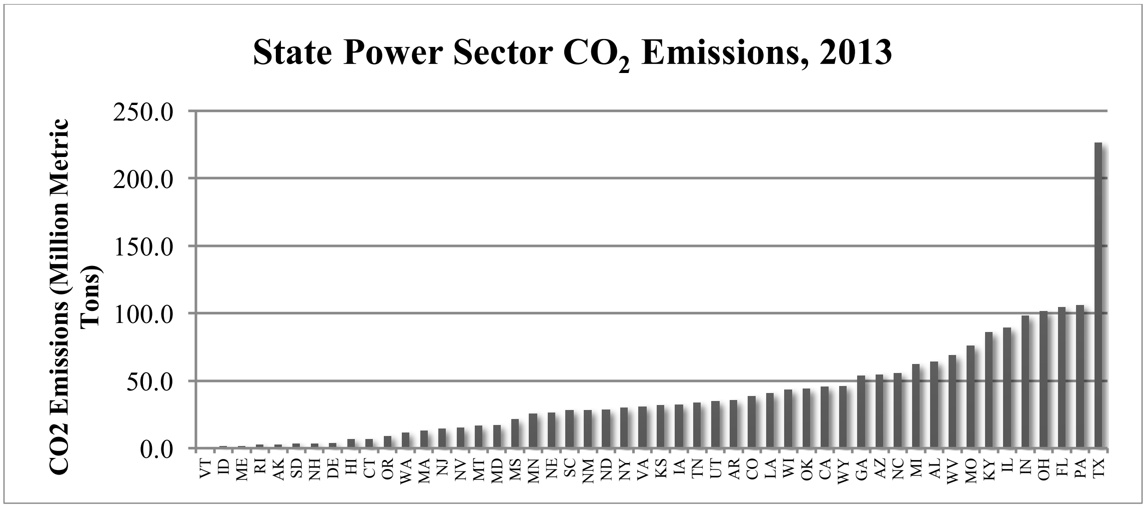

Figure 2. Carbon dioxide emission (million metric tons) from each state during 2013, ranked from lowest (Vermont) to highest (Texas). Source: U.S. Energy Information Administration (2015).

Table 1 provides a description of the policy variables tested, and the number of states that have implemented these policies as of May 2015 (C2ES 2016). Table 2 defines the dependent and control variables and provides their sources. Descriptive statistics of all variables employed in this study are shown in Appendix 1. I conducted variance inflation factor analysis (Appendix 2) for all models, and did not find evidence of multicollinearity.

The independent policy dummy variables are set to 0 before adoption and 1 after adoption. The adoption year is defined as the year that the specific policy was signed into law. This may not correlate exactly with the year in which the policy took effect for all policies, but it is a standard that can be easily determined, and the signing of a policy into law sends a signal to firms and sets expectations for their future requirements. There is also variance among policies of the same name – I did not code based on the stringency of requirements or dates for compliance. I did, however, separate policies based on whether or not they had mandatory or voluntary requirements.

Climate and Energy Policies

I test how much the climate-related policies shown in Table 1 affect plant-level CO_2 emissions. These policies have all been adopted by various states either to explicitly address climate change and CO_2 emissions, or to change the energy landscape in a way that has implications for the climate. All information on the adoption of these state-level policies is obtained from the Center for Climate and Energy Solutions (C2ES 2015). A few policies deserve further explanation. Quasi-public benefit funds, as defined by C2ES (2014), allow utilities to add charges to customers' utility bills to fund renewable energy or develop energy efficiency programs. They are quasi-public benefit funds because the state does not formally maintain a public benefit fund (PBF). The Western Climate Initiative (WCI) started in 2007 as an agreement between five western states to develop a regional target for curbing GHG emissions and design and implement a market-based mechanism for doing so. I use 2007 as the start date for the WCI, but the program has undergone significant changes since then. To date, only California has implemented a cap-and-trade system and is working with Canadian provinces to harmonize their emissions trading programs under the direction of the nonprofit corporation WCI, Inc. I thus test California's cap-and-trade program, mandated under AB 32, the California Global Warming Solutions Act of 2006 (henceforth referred to as AB 32), separately to determine if California's program is successful outside of the WCI. It is important to stress that because AB 32 is clearly not a replicated policy intervention, the results from the AB 32 model run cannot be interpreted with authority. Finally, while Kim et al (2016) show that deregulation leads to higher levels of renewable energy policy, it is unclear whether this leads to lower carbon emissions. It is also possible that deregulation, by opening generation up to market competition from competitors potentially looking to use cheap fossil fuels, is correlated with higher emissions.

Table 1. Seventeen state-level climate and energy policies used in this study. Acronyms, a brief description, as well as the number states that have implemented each policy.

Policy (Acronym)	Description	Number of States Implemented

Climate action plan (CAP)	Detail steps that a state plans to take to address climate change	34
Binding renewable portfolio standards (RPS)	Requires electric utilities to generate a specified amount of electricity from renewable sources	30
Voluntary GHG registry/reporting	Voluntary or market-based registries	26
Public benefit fund	Provide money for renewable energy, energy efficiency, and R&D	22
Mandatory Energy Efficiency Target	Encourage more efficient generation, transmission, and use of electricity	21
GHG targets	Goals for emission reduction levels by a certain time period	20
Mandatory GHG registry/reporting	Requires power plants to register and record their emissions	18
Electric decoupling	Compensates utilities for selling less electricity	16
Deregulation	Consumer choice of electricity generation suppliers	14
Mandatory Green Power Option (MGPO)	Requires utilities to offer customers electricity generated from renewable sources	12
Regional Greenhouse Gas Initiative (RGGI)	First U.S. cap-and-trade program to reduce GHG emissions from the power sector, comprised of 9 northeastern states	9
Non-binding RPS	Same as RPS but the adherence to RPS is not enforceable	7
Emission Performance Standards	Performance standards designed to reduce CO_2 emissions	6
Quasi-Public Benefit Fund	Allows utilities to collect fees from customers for renewable energy or energy efficiency	5
Western Climate Initiative (WCI)	Collaboration of states working to identify, evaluate, and implement emission-trading programs	5
Voluntary Energy Efficiency Goal	Same as EERS/mandatory energy efficiency target, but adherence is not enforceable	5
California Global Warming Solutions Act (AB 32)	The act requires the state to return to 1990 GHG emission levels by 2020	1

Control Variables

In addition to state and year fixed-effects, I control for factors that might independently affect power sector emissions to tease out the effect of the policies. Table 2 provides a summary of these control variables, as well as the data sources. Descriptions of the state characteristics and their significance follow.

Table 2. Description and sources of data used as control variables in the regression model.

Variable	**Definition**	**Source**
Population	State population	United States Census Bureau, (2002, 2012, 2016)
Export Ratio	Exports of electricity as a percent of total electricity produced, 0 if state is net importer of electricity	United States Energy Information Administration (EIA 2016)
Electricity Price	Total electric industry in-state average price of electricity (cents/kWh)	United States EIA, (2016b)

Population

The Kaya identity, discussed above, states that there is a direct association between population and CO_2 emissions (Kaya 1990, Kaya 1997, Rosa and Dietz 2012). While there has been much debate about the impact of a growing population on the environment in general, there is less debate about the impact of population size on CO_2 emissions. Here it is clear that larger populations generate higher emissions.

Importer/Exporter of Electricity

Electricity markets are not bound by state borders; indeed, some states are net importers of electricity while others are net exporters. A state that exports electricity might have higher emissions simply because the state is generating for consumers beyond its borders, and not because of the ineffectiveness of its climate-related policies. For example, if a state increases its renewable energy generation in order to comply with its RPS, but sells the electricity across state lines, the effect on emissions may only be seen in the importing state. Alternatively, a state could reduce its emissions by importing electricity (effectively “exporting” emissions), regardless of the effectiveness of the state’s climate policies. As Prasad and Munch (2012) note, however, with existing data it is impossible to know the exact fuel source of all imports and exports of electricity. Therefore, the interpretation of controlling for electricity imports would be impossible.

Instead, I use the ratio of electricity exported to the total in-state electricity production (setting this variable to 0 for importing states) to control for the potential impact electricity exports might have on emissions.

Electricity Price

Lyon and Yin (2010) note the importance of controlling for the average in-state electricity price. A higher electricity price may be correlated with decreased emissions, as it might encourage end users such as households and businesses to either conserve electricity or to invest in more efficient technologies. Alternatively, higher electricity prices could put pressure on policy makers to rely on more generation from fossil fuels, having a positive effect on emissions.

3. Results and Discussion

The regression models attribute the variation in emissions from year to year to policy variables as indicated by the goodness of fit coefficients (Table 3, 4, 5 and 6, Figure 3). Detailed regression results, including results for the control variables, are shown in Appendix 3 and Appendix 4. While state-fixed effects play a large role in these high R-squared values, removing state-fixed effects from the models still yields R-squared values between 0.44 and 0.50, explaining much of the variation. Ten of the seventeen policy variables are significant at the 0.05 level, and nine out of those ten variables are significant at the 0.01 level. With the exception of voluntary GHG registry and reporting, all coefficients of the statistically significant policies had a negative sign, indicating that these policies are effectively decreasing emissions from the electricity sector. The policies that significantly reduce emissions vary from approximately 1.2 million metric tons (MT) of CO_2 per year (Mandatory Green Pricing) to approximately 10.3 million $MTCO_2$ per year (AB 32). In other words, the policies associated with a significant reduction in emissions reduced emissions by about 2.7-25% of average state-level annual emissions from the power sector.

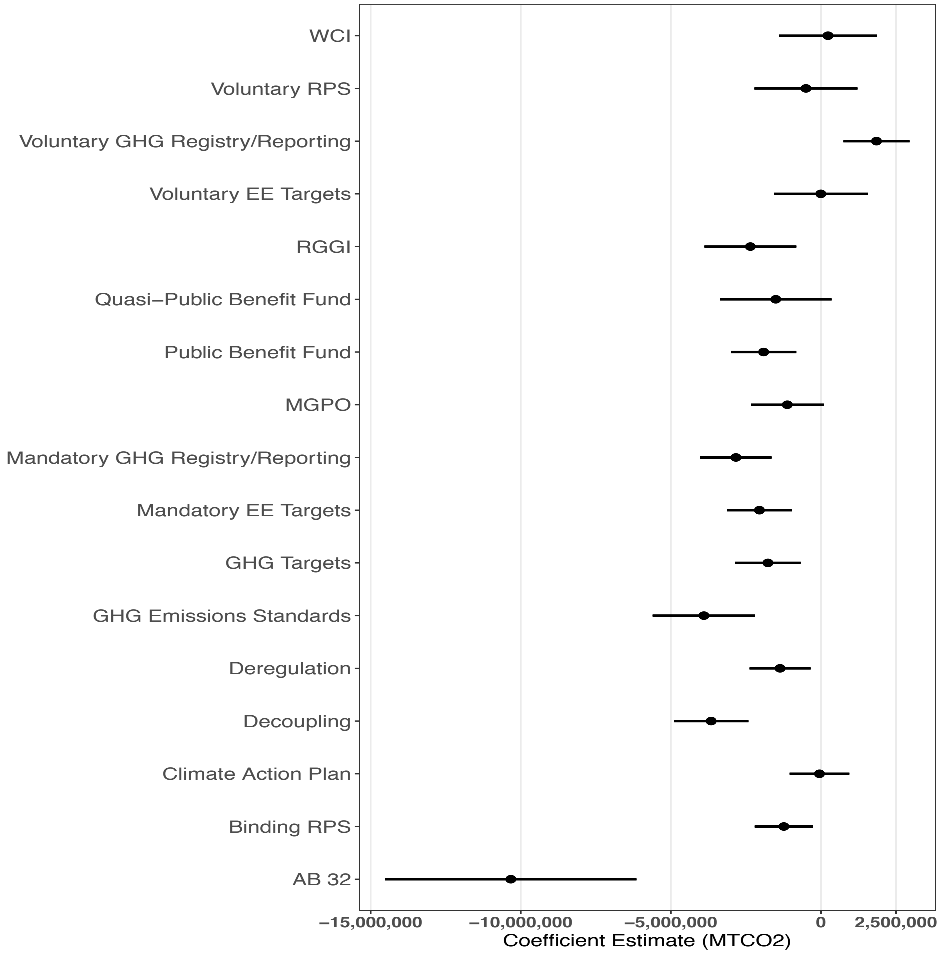

Figure 3. Effect of State-Level Climate and Energy Policies on CO_2 Emissions. Policies are described in Table 1. Dots represent mean carbon dioxide emission (million metric tons/year), bars represent 95% confidence interval.

The results provide insight into efficacy of voluntary and mandatory policies. All but one of the mandatory policies assessed are associated with a significant reduction in emissions (Table 3, Figure 3). While the MGPO policy reduced emissions, the results were not statistically significant. In contrast, none of the voluntary policies are associated with a significant reduction in emissions (Table 4). These results provide powerful evidence

that policy makers that are serious about reducing power sector emissions should use mandatory policies with binding targets, as relying on voluntary compliance appears to be an ineffective

Table 3. Effect of Policies on Power Sector CO_2 Emissions, Mandatory Policies Highlighted

Policy	Coefficient (MTCO2)	p-value
AB 32	-10,330,000	<0.001
GHG Emissions Standards	**-3,899,000**	**<0.001**
Decoupling	**-3,657,000**	**<0.001**
Mandatory GHG Registry and Reporting	**-2,832,000**	**<0.001**
RGGI	-2,350,000	0.002
EERS/Mandatory Energy Efficiency Targets	**-2,049,000**	**<0.001**
Public Benefit Fund	**-1,909,000**	**<0.001**
GHG Targets	**-1,765,000**	**<0.001**
Quasi-Public Benefit Fund	-1,449,000	0.139
Deregulation	**-1,361,000**	**0.009**
Binding RPS	**-1,235,000**	**0.013**
Mandatory Green Pricing Option	**-1,120,000**	**0.071**
Voluntary RPS	-498,700	0.569
Climate Action Plan	-48,370	0.924
Voluntary Energy Efficiency Targets	-2,877	0.997
Western Climate Initiative	235,400	0.777
Voluntary GHG Registry and Reporting	1,851,000	0.001

policy. The policy associated with the largest reduction in CO_2 emissions that has been implemented in more than one state is GHG emissions standards, reducing emissions by 3,899,000 $MTCO_2$ per year. The finding agrees with the study by Grant et al. (2014), who found that emissions standards significantly decreased emissions at the power plant level. Yet in terms of political feasibility, emissions standards might not be the most viable option as policy makers look to adopt effective policies in their states or at the national level. There is a substantial literature indicating that market based mechanisms, such as a tax or cap and trade program, can achieve the same result as regulation at lower costs (Pigou 1920, Montgomery 1972, Stavins 1998, Goulder and Parry 2008). Nonetheless, policymakers in the states that have implemented GHG emissions standards should be encouraged by the evidence that their policies are having the desired effect.

In contrast to other studies (Prasad and Munch 2012, Grant, Bergstrand et al. 2014)

Table 4. Effect of Policies on Power Sector CO_2 Emissions, Voluntary Policies Highlighted

Policy	Coefficient (MTCO2)	p-value
AB 32	-10,330,000	<0.001
GHG Emissions Standards	-3,899,000	<0.001
Decoupling	-3,657,000	<0.001
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Western Climate Initiative	235,400	0.777
Voluntary GHG Registry and Reporting	**1,851,000**	**0.001**

which find no impact of RPS on power sector emissions, the results of my analyses show that binding RPS significantly reduce emissions by 1,235,000 MT of CO_2/year. These apparently conflicting results could be due to the fact that neither study separated RPS with binding commitments from those that have non-binding renewable energy goals. Given that voluntary RPS do not show a significant decrease in emissions in my analysis, it is very possible that the ineffectiveness of the voluntary RPS is absorbing some of the strength of the binding RPS in the previous studies. As a sensitivity test, however, I created models that control for both RPS and each of the significant policies from Table 5 and found that RPS no longer had a significant effect on emissions when controlling for the adoption of GHG emissions standards, mandatory energy efficiency standards, decoupling, GHG targets, GHG registry and reporting, and PBF (Appendix 5). When RPS is modeled with either MGPO or RGGI, the policies, including RPS, significantly decrease emissions. These results indicate that while binding RPS may effectively reduce emissions, other policies should be prioritized.

I do not find evidence that voluntary policies are reducing power sector emissions. Lyon (2007) also found voluntary programs to be ineffective. None of the voluntary policies assessed in my study (voluntary RPS, voluntary energy efficiency targets, nor voluntary GHG registry and reporting) are associated with a significant reduction in emissions, indicating that voluntary programs do not provide enough incentive for utilities or energy providers to reduce their emissions. While concluding that these policies are completely ineffective may be misguided, as voluntary programs might have beneficial spillover effects, or may be the only politically feasible strategy for some states and therefore are preferable to the alternative of no policy (Matisoff 2014), given the urgent need for substantial cuts to GHG emissions, the case for voluntary climate and energy programs and policies appears weak. Voluntary GHG registry and reporting policies appear associated with a large increase in carbon dioxide emissions, as indicated by a positive, statistically significant coefficient (Figure 3, Table 3). This positive coefficient may be due to selection bias, as states that are either aware that their emissions are increasing or are less committed to controlling their GHG emissions may choose to participate in the voluntary reporting program only.

The implementation of a climate action plan, the most common policy with adoption by 34 states, is not associated with a significant reduction in emissions from the power sector. This is in line with previous research testing the effect of climate action plans on CO_2 emissions from the power sector (Grant et al. 2014), and in contrast to research examining the effect of CAP on nonindustrial emissions (Drummond 2010). These results make sense, as CAP typically cover all sectors, not just the electricity sector. Another reason CAP may not be reducing emissions from the power sector is that some CAPs contain binding commitments for emissions reductions, while others are simply “one-off bureaucratic reports” (Grant et al. 2014). Classifying states’ CAP based on their content, and then testing the effectiveness of separate categories of CAP might yield different results. Finally, CAP policies do not necessarily address mitigation (the reduction of GHG emissions), and may include a focus on adaptation. This might explain the statistically insignificant result, as using CO_2 emissions from the power sector as the dependent variable might not capture the intent of some CAP, thus underestimating the impact of those for which mitigation is the intent.

Four out of the five most effective policies at reducing carbon dioxide emissions are climate policies (Table 5). The climate policy of California (AB 32) resulted in the largest significant reduction, but these results should be interpreted extreme caution, as discussed in detail below. Climate policies are more effective at reducing power sector CO_2 emissions (Table 5). While this is perhaps an intuitive finding, these results offer empirical evidence for policy makers that policies that explicitly target GHG emissions more effectively reduce those emissions than energy policies that address GHG emissions in a less direct manner.

California's cap-and-trade program has the largest impact of any policy tested here by an order of magnitude. These results should be taken with caution for several reasons. First, because AB 32 is not a replicated policy intervention, there is a much higher chance that the reduction in emissions associated with the policy is actually correlated with other changes specific to California that occurred around the time of the policy implementation. Second, I used 2006 as the start date because that was the year AB 32 was signed, authorizing the cap-and-trade program. The coefficient, however, is undoubtedly overestimated, as California is of course the only state to have implemented AB 32, and six policies (CAP (2008), mandatory GHG registry and reporting (2006), binding RPS (2006), GHG emissions standards (2006), and the WCI (2007)) were all implemented in California either during or after 2006. Furthermore, two of those policies (CAP and mandatory GHG registry and reporting) were also authorized as part of AB 32. Thus, it is impossible to tease interpretation of this result is that the suite of policies that California adopted

Table 5. Effect of Policies on Power Sector CO_2 Emissions – The top five policies for reducing emissions are highlighted, and four of the top five are climate policies

Policy	Coefficient (MTCO2)	p-value
AB 32	**-10,330,000**	**<0.001**
GHG Emissions Standards	**-3,899,000**	**<0.001**
Decoupling	**-3,657,000**	**<0.001**
Mandatory GHG Registry and Reporting	**-2,832,000**	**<0.001**
RGGI	**-2,350,000**	**0.002**
EERS/Mandatory Energy Efficiency Targets	-2,049,000	<0.001
Public Benefit Fund	-1,909,000	<0.001
GHG Targets	-1,765,000	<0.001
Quasi-Public Benefit Fund	-1,449,000	0.139
Deregulation	-1,361,000	0.009
Binding RPS	-1,235,000	0.013
Mandatory Green Pricing Option	-1,120,000	0.071
Voluntary RPS	-498,700	0.569
Climate Action Plan	-48,370	0.924
Voluntary Energy Efficiency Targets	-2,877	0.997
Western Climate Initiative	235,400	0.777
Voluntary GHG Registry and Reporting	1,851,000	0.001

in 2006, either under AB 32 or otherwise, greatly reduced that state's emissions. A sensitivity analysis using 2012, the year that the cap-and-trade program authorized under AB 32 was adopted, as the start date yields a negative effect on emissions that is large but insignificant at the 0.05 level. It would be unfair, however, to conclude that the cap-and-trade program is ineffective at reducing emissions for two reasons. First, AB 32 established a GHG emissions reduction target and authorized the use of a cap-and-trade program to achieve that target. This target, along with the authorization of the cap-and-trade program, could have sent a strong signal to the power sector to begin reducing emissions and a portion of the effect of the cap-and-trade program could have been absorbed in the years leading up to 2012. Second, my analysis includes state-level emissions up to 2013, only one year into the program and likely too early to see a significant reduction in emissions.

Table 6. Effect of Policies on Power Sector CO_2 Emissions. Highlighted rows represent policies that cover regional and single state scales.

Policy	Coefficient (MTCO2)	p-value
AB 32	**-10,330,000**	**<0.001**
GHG Emissions Standards	-3,899,000	<0.001
Decoupling	-3,657,000	<0.001
Mandatory GHG Registry and Reporting	-2,832,000	<0.001
RGGI	**-2,350,000**	**0.002**
EERS/Mandatory Energy Efficiency Targets	-2,049,000	<0.001
Public Benefit Fund	-1,909,000	<0.001
GHG Targets	-1,765,000	<0.001
Quasi-Public Benefit Fund	-1,449,000	0.139
Deregulation	-1,361,000	0.009
Binding RPS	-1,235,000	0.013
Mandatory Green Pricing Option	-1,120,000	0.071
Voluntary RPS	-498,700	0.569
Climate Action Plan	-48,370	0.924
Voluntary Energy Efficiency Targets	-2,877	0.997
Western Climate Initiative	**235,400**	**0.777**
Voluntary GHG Registry and Reporting	1,851,000	0.001

The analysis indicates that the Western Climate Initiative is not associated with a significant reduction in emissions in participating states. The result that this policy led to an insignificant increase in emissions can be due to a number of factors. First, the start date for this policy – 2007 – is the year in which WCI member states (Arizona, California, New Mexico, Oregon, and Washington) signed an agreement establishing the program. This initial agreement, however, only established an economy-wide GHG emissions target of 15 percent below 2005 levels by 2020 (C2ES 2017), but did not create the market-based mechanism to achieve that goal. Second, as discussed above, to date California is the only U.S. state within the WCI that has actually implemented a market-based mechanism for achieving the reduction targets established under the WCI. Clearly for the other four states within the WCI the signing of the agreement in 2007 did not send a strong enough market signal to see a noticeable decrease in emissions. While the WCI, at least in 2014, is a weak alliance of states lacking a clear mandate or mechanism for reducing emissions, RGGI is quite the opposite.

The results from the model show that RGGI is associated with a significant reduction in CO_2 emissions. It is important to note, however, that an internal review of the program conducted in 2012 by participating states found that there was a “significant excess supply of allowances relative to actual emission levels in the region” and subsequently lowered the cap to ensure a stricter standard (RGGI 2012). As shown in Figure 4, emissions in the states participating in RGGI were already declining before RGGI’s implementation. It is possible, therefore, that the significant negative effect on emissions attributed to the policy were in fact due to factors not captured by the model. Similarly, as with all policies tested in the models, there is no way to prove causation. It is possible that regulators in the Northeast and Mid-Atlantic states implemented RGGI because emissions were declining, rather than the alternative.

Turning to the control variables (Appendix 3 and Appendix 4), the results showing the effect of electricity price and population on emissions are intuitive, while the effect of the electricity export ratio variable is not. As expected, emissions significantly increase as population increases, and the price of electricity has a strong effect on emissions, with the latter decreasing by almost 700,000 MT CO_2 for every $0.01/kWh increase in the former. The ratio of electricity sold across borders to total within-state generation is not a significant determinant of emissions. One explanation for this might be that states that are exporting electricity produce more renewable electricity than importing states, or that importing states are demanding clean energy from exporting states, perhaps to meet renewable energy requirements. As Prasad and Munch (2012) note, “…there is a clear need for good data on the size of interstate renewable energy flows”.

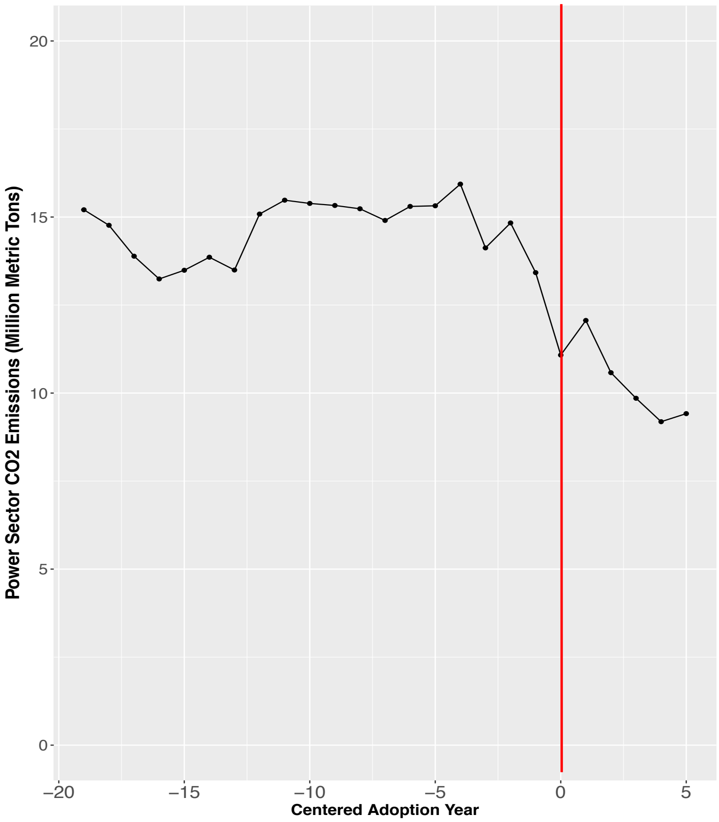

Figure 4. Mean Emissions of Adopting States Before and After Implementation – RGGI

Conclusion

Much of the previous research on state-level climate and energy policy has focused either on one policy in particular, such as RPS or CAP, or has analyzed policy effectiveness based on a measure other than its ability to reduce carbon emissions. My study provides a thorough analysis of some of the most prominent climate and energy policies used by states and their ability to reduce emissions from the power sector. Many states are taking action in the absence of federal leadership to address climate change by targeting emissions from the power sector. The results of this study indicate that many of these actions are paying off. Ten of the 17 policies analyzed are associated with a significant decrease in power sector emissions. Importantly, all of the effective policies are mandatory or have binding targets, while none of the voluntary policies are associated with a reduction in emissions. As regulators, either at the state or federal level, look to implement policies that will significantly decrease emissions from the power sector, they should pursue mandatory policies with binding targets. In particular, GHG emissions caps, GHG emissions standards, and decoupling are associated with the largest reduction in emissions. Furthermore, the results indicate that regulators should prioritize climate policies over energy policies, as climate policies are associated with a stronger negative effect on power sector emissions. Learning from state-level actions, policymakers should implement these policies in order to have the most significant impact on power sector emissions.

There are several limitations to this study. One major limitation is that it does not assess the differences within policies. For instance, there are many different forms of RPS, with varying ambition, degrees of stringency, enforcement mechanisms, or compliance periods. While I capture perhaps the largest difference between policies of the same type – voluntary versus mandatory or binding – I do not capture other differences that might matter in terms of their effect on emissions.

Another limitation to this analysis is the chosen start date for the policy variables. I have chosen to use the year that the policy was signed into law, which may or may not be the same as the start of the compliance period. I used this start date because, firstly, it can be tracked clearly and consistently across all policies. Secondly, even if the start of compliance did not begin in the same year as the law was signed, the law itself arguably sends a signal to the market and other actors to begin to take the steps necessary to comply. It is possible, however, that a policy's effect on emissions is not recognized until years after it becomes law. It is likely, therefore, that the policy variables are underestimated by the models, and future studies might assess policies based on the start of compliance periods or after a specified lag period.

Furthermore, my models might underestimate the effect of policies because of the inclusion of the electricity price variable. Aside from the direct effect that policies have on emissions, they may also indirectly affect emissions by increasing the price of electricity. For example, if GHG emissions standards force utilities to employ more expensive technologies, this would drive up the price of electricity, indirectly incentivizing consumers to conserve electricity and thus further reducing emissions. A portion of this indirect effect would be absorbed by the electricity price variable rather than being attributed to the policy.

The effects of policies may be overestimated due to the possibility of reverse causation. While I control for state and year fixed effects, it is still possible that policymakers decided to enact a policy because their state's emissions were declining, or as a result of the declining cost of renewables. If this were the case, then a policy model might overestimate the strength or significance of a policy.

While some of the policies assessed are designed specifically to address CO_2 emissions from the power sector, such as GHG emissions standards or GHG emissions targets, others address GHG emissions less explicitly. CAP, for example, likely provide a plan for GHG mitigation, yet the extent to which the electricity sector is targeted varies by state, as well as the extent to which adaptation is prioritized over mitigation. Other policies, such as RPS or efficiency targets, may not explicitly address emissions at all and rather focus on achieving a certain level of renewable generation or a certain reduction in energy consumption within a state. While an implicit goal of such policies may be to reduce CO_2 emissions, these policies might be more concerned with creating jobs or enhancing energy security. It is important to stress, therefore, that this study does not assess the effectiveness of each policy based on its specific or stated goals, but rather only on its ability to reduce emissions from the power sector. The hope, then, is to provide policymakers and relevant actors with information on which policies to pursue when attempting to reduce power sector emissions – and not on policy effectiveness more broadly.

Finally, this study does not assess the strength of the policies analyzed relative to U.S. emissions targets under the Paris Agreement, or relative to a 1.5°C or 2°C warming limit. Future studies are needed to assess the progress of the U.S. contribution to global climate change mitigation absent federal leadership. Furthermore, this study includes power sector emissions through 2013. It is imperative that studies continue to monitor policy effectiveness as new data becomes available. This is particularly important, given that many targets within policies become increasingly stringent as time progresses. Similarly, the U.S. EPA collects emissions information from large stationary sources under its GHG Reporting Program (GHGRR), with data up to 2015 as of the writing of this paper. Future studies could work to normalize data collected under the GHGRR with the state-level emissions data used in this study in order to test policies over a longer time period.

Despite these limitations, my study provides evidence that many policy innovations implemented at the state level are successfully reducing carbon emissions from the power sector. This is a heartening finding for those states that have implemented these successful climate and energy policies. For those that have not yet implemented these policies, or that have implemented policies that do not have a significant negative impact on emissions, this study provides guidance as to which strategies to pursue. Finally, if and when the federal government takes leadership in climate mitigation efforts, it can learn from the successes of state-level actions analyzed here.

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Appendix 1. Descriptive Statistics of All Variables Used

Variable	***Mean***	***Median***	***Standard Deviation***	***Minimum***	***Maximum***
CO_2 (million metric tons)	42	32.5	39.8	0.00	237.8
Electricity Price	7.966	7.070	3.101	3.370	34.040
Export Ratio	0.118	0.000	0.254	0.000	0.952
Population (thousands)	5,688	3,920	6,259	454	38,335
Year	2002	2002	7.214	1990	2013
AB 32	0.006	0.000	0.762	0.000	1.000
Binding Energy Efficiency Targets	0.285	0.000	0.452	0.000	1.000
Climate Action Plan	0.216	0.000	0.412	0.000	1.000
Decoupling	0.081	0.000	0.273	0.000	1.000
GHG Emissions Standards	0.043	0.000	0.204	0.000	1.000
GHG Targets	0.133	0.000	0.340	0.000	1.000
Mandatory GHG Registry/Reporting	0.085	0.000	0.279	0.000	1.000
Mandatory Green Pricing Option	0.103	0.000	0.303	0.000	1.000
Public Benefit Fund	0.289	0.000	0.453	0.000	1.000
Quasi-Public Benefit Fund	0.030	0.000	0.171	0.000	1.000
RGGI	0.042	0.000	0.200	0.000	1.000
RPS	0.258	0.000	0.437	0.000	1.000
Voluntary Energy Efficiency Targets	0.065	0.000	0.247	0.000	1.000
Voluntary GHG Registry/Reporting	0.122	0.000	0.327	0.000	1.000
Voluntary RPS	0.031	0.000	0.173	0.000	1.000
Western Climate Initiative	0.041	0.000	0.198	0.000	1.000

Appendix 2. Variance Inflation Factors (VIF) Analysis for All Models

Climate Action Plan

Variable	**VIF**
Climate Action Plan	1.35
Electricity Price	1.41
Export Ratio	1.11
Population	1.10

Decoupling

Variable	**VIF**
Decoupling	1.28
Electricity Price	1.28
Export Ratio	1.11
Population	1.12

Emissions Performance Standards

Variable	**VIF**
Emissions Performance Standards	1.05
Electricity Price	1.05
Export Ratio	1.11
Population	1.15

GHG Targets

Variable	**VIF**
GHG Targets	1.44
Electricity Price	1.47
Export Ratio	1.11
Population	1.11

Mandatory Energy Efficiency Targets

Variable	**VIF**
Mandatory Energy Efficiency Targets	1.24
Electricity Price	1.21
Export Ratio	1.11
Population	1.16

Western Climate Initiative

Variable	**VIF**
Western Climate Initiative	1.03
Electricity Price	1.05
Export Ratio	1.13
Population	1.12

Voluntary Energy Efficiency Targets

Variable	**VIF**
Voluntary Energy Efficiency Targets	1.00
Electricity Price	1.06

Export Ratio	1.11
Population	1.10

Mandatory GHG Registry and Reporting

Variable	**VIF**
Mandatory GHG Registry and Reporting	1.17
Electricity Price	1.20
Export Ratio	1.11
Population	1.11

MGPO

Variable	**VIF**
MGPO	1.03
Electricity Price	1.07
Export Ratio	1.11
Population	1.11

Public Benefit Fund

Variable	**VIF**
Public Benefit Fund	1.34
Electricity Price	1.30
Export Ratio	1.11
Population	1.14

Quasi-Public Benefit Fund

Variable	**VIF**
Quasi-Public Benefit Fund	1.00
Electricity Price	1.05
Export Ratio	1.11
Population	1.10

RGGI

Variable	**VIF**
RGGI	1.22
Electricity Price	1.26
Export Ratio	1.11
Population	1.11

RPS

Variable	**VIF**
RPS	1.32
Electricity Price	1.35
Export Ratio	1.11
Population	1.10

Voluntary GHG Registry and Reporting

Variable	**VIF**

Voluntary GHG Registry and Reporting	1.04
Electricity Price	1.08
Export Ratio	1.13
Population	1.10

Voluntary RPS

Variable	**VIF**
Voluntary RPS	1.02
Electricity Price	1.05
Export Ratio	1.13
Population	1.10

Appendix 3. Effect of State-Level Climate and Energy Policies on CO_2 Emissions (Effective Policies)

	AB 32	***GHG emissions Standards***	***Mandatory GHG Registry/Reporting***	***Decoupling***	***RGGI***
Exports	-4,457,000 (2,898,000)	-4,025,000 (2,898,000)	-4,031,000 (2,881,000)	-3,368,000 (3,172,000)	-2,533,000 (3,185,000)
Population	3,178*** (238)	2,860*** (219)	2,713*** (215)	2,966*** (226)	2,758*** (228)
Price	-689,400*** (107,800)	-710,300*** (107,900)	-505,000*** (112,700)	-768,300*** (112,300)	-752,000*** (113,700)
AB 32	-10,330,000*** (2,136,000)	-	-	-	-
GHG Emissions Standards	-	-3,899,000*** (872,500)	-	-	-
Mandatory GHG Registry and Reporting	-	-	-2,832,000*** (607,200)	-	-
Decoupling	-	-	-	-3,657,000*** (634,900)	-
RGGI	-	-	-	-	-2,350,000** (782,300)
R-squared	0.99	0.99	0.99	0.99	0.99

*p >0.05, **p>0.01, ***p>0.001
Dependent variable – power sector CO_2 emissions, metric tons.
Standard errors in parentheses. 1990-2014

Appendix 3 Cont. Effect of State-Level Climate and Energy Policies on CO_2 Emissions (Effective Policies)

	Mandatory Energy Efficiency Targets	***PBF***	***GHG Targets***	***Deregulation***	***Binding RPS***
Exports	-2,036,000 (2,933,000)	-2,959,000 (2,912,000)	-3,110,000 (2,912,000)	-3,044,000 (2,919,000)	-2,717,000 (2,934,000)
Population	2,814*** (219)	2,703*** (217)	2,754*** (218)	2,678*** (218)	2,721*** (218)
Price	-628,800*** (110,100)	-600,100*** (112,500)	-614,900*** (112,000)	-686,000*** (108,700)	-646,000*** (111,100)
Mandatory Energy Efficiency Targets	-2,049,000*** (549,600)	-	-	-	-
PBF	-	-1,909,000*** (556,900)	-	-	-
GHG Targets	-	-	-1,765,000*** (556,100)	-	-
Deregulation	-	-	-	-1,361,000* (520,000)	-
Binding RPS					-1,235,000* (496,900)
R-squared	0.99	0.99	0.99	0.99	0.99

**p* >0.05, ***p*>0.01, ****p*>0.001

Dependent variable – power sector CO_2 emissions, metric tons.

Standard errors in parentheses. 1990-2014

Appendix 4. Effect of State-Level Policies on CO_2 Emissions (Ineffective Policies)

	Quasi-PBF	***MGPO***	***Voluntary RPS***
Exports	-3,975,000 (2,928,000)	-2,879,000 (2,943,000)	-3,552,000 (2,921,000)
Population	2,715*** (218)	2,648*** (219)	2,683*** (292)
Price	-723,400*** (109,300)	-699,100*** (108,700)	-710,400*** (109,200)
Quasi-PBF	-1,505,000 (949,900)	-	-
MGPO	-	-1,120,000 (621,100)	-
Voluntary RPS	-	-	-498,700 (876,900)

**p* >0.05, ***p*>0.01, ****p*>0.001
Dependent variable – power sector CO_2 emissions, metric tons.
Standard errors in parentheses. 1990-2014

Appendix 4 Cont. Effect of State-Level Policies on CO_2 Emissions (Ineffective Policies)

	Climate Action Plan	***Voluntary Energy Efficiency Targets***	***Western Climate Initiative***	***Voluntary GHG Registry/Reporting***
Exports	-3,582,000 (2,921,000)	-2,498,000 (3,200,000)	-3,520,000 (2,930,000)	-3,922,000 (2,909,000)
Population	2,694*** (218)	2,858*** (227)	2,683*** (221)	2,682*** (217)
Electricity Price	-703,800*** (109,600)	-794,200*** (114,100)	-701,700*** (109,400)	-699,300*** (108,300)
Climate Action Plan	-48,370 (508,700)	-	-	-
Voluntary Energy Efficiency Targets	-	-2,877 (799,400)	-	-
Western Climate Initiative	-	-	235,400 (830,800)	-
Voluntary GHG Registry/Reporting	-	-	-	1,851,000** (563,000)
R-squared	0.99	0.99	0.99	0.99

**p* >0.05, ***p*>0.01, ****p*>0.001
Dependent variable – power sector CO_2 emissions, metric tons.
Standard errors in parentheses. 1990-2014

Appendix 5. Effect of RPS and selected policies on emissions

	Decoupling	*GHG Targets*	*Mandatory Energy Efficiency Targets*	*Mandatory GHG Registry and Reporting*	*MGPO*	*PBF*
Exports	-2,206,000 (3,183,000)	-1,196,000 (3,209,000)	-625,400 (3,222,000)	-2,586,000 (3,206,000)	-486,100 (3,246,000)	-1,141,000 (3,206,000)
Ideology	57,500* (26,540)	60,760* (26,840)	54,580* (26,790)	63,940* (26,730)	64,190* (27,120)	69,380* (27,080)
Population	2,896*** (223)	2,926*** (226)	2,979*** (228)	2,976*** (225)	2,822*** (228)	2,875*** (225)
Price	-574,000*** (118,000)	-675,500*** (117,100)	-700,400*** (115,900)	-729,700*** (114,700)	-737,300*** (115,400)	-662,500*** (117,200)
Binding RPS	-665,900 (512,300)	-742,800 (539,600)	-713,900 (545,900)	-834,700 (512,500)	-1,104,000* (512,200)	-615,000 (545,300)
Decoupling	-3,602,000*** (672,000)	-	-	-	-	-
GHG Targets	-	-1,700,000** (607,800)	-	-	-	-
Mandatory Energy Efficiency Targets			-1,655,000** (907,100)	-	-	-
Mandatory GHG Registry and Reporting	-	-	-	-2,754,000*** (646,500)	-	-
MGPO	-	-	-	-	-1,311,000* (643,300)	-
PBF	-	-	-	-		-1,936,000** (608,200)
R-squared	0.99	0.99	0.99	0.99	0.99	0.99

*$p<0.05$, **$p<0.01$, ***$p<0.001$

Dependent variable – power sector CO_2 emissions, metric tons.

Standard errors in parentheses. 1990-2013