Agricultural and Resource Economics
UPDATE
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS • UNIVERSITY OF CALIFORNIA
V. 14 no. 1 • Sep/Oct 2010

Special Issue: California's Climate Change Policy: The Economic and Environmental Impacts of AB 32—Notes from the Editors

The UC Giannini Foundation and Agricultural Issues Center held a conference on "California's Climate Change Policy: The Economic and Environmental Impacts of AB 32" on Monday, October 4 at the California Museum in Sacramento. The conference brought together leading economists, analysts, and executives from academia, California state government, and industry to discuss the impacts of climate change and AB 32, California's climate change legislation, on the California economy and the environment. Webcasts of all speakers, along with their visual presentations, are available at the conference website, http://giannini.ucop.edu/AB32/AB32conference.htm.

This special issue contains five papers prepared by presenters at the conference. Although the direct challenge to AB 32 in the form of Proposition 23 was defeated in November, climate change and policies to address it remain at the forefront of policy debates within California, nationally, and, indeed, globally. The papers collected in this issue will play a key role in informing this debate.

AB 32 will have almost no direct impact on climate change because it is a global problem, and effective climate change policies need to involve international, if not global, cooperation. Professor Robert Stavins of Harvard University discusses the interactions of subnational policies, such as AB 32, with federal policies. He concludes that the interactions can be problematic, benign, or positive and offers important examples in each category.

Professor David Victor of UC San Diego tackles the political context for California's climate change policy. He argues that California's policy makes sense only if it inspires broader efforts within the U.S. and globally. He proposes four criteria to shape a successful policy as California moves to implementing its climate change policy.

Professor Matthew Kahn of UCLA addresses why climate change legislation is stalled at the national level. He shows that Congressional voting on the 2009 Waxman-Markey American Clean Energy and Security Bill can largely be explained by the household income in a representative's district, his/her political ideology, and the per-capita carbon emissions emanating from the district. Kahn argues that by acting as a "green guinea pig," California can stimulate new ideas for green technology that can tilt public opinion and politicians in favor of climate change policies.

Professor Christopher Knittel of UC Davis evaluates and summarizes economic models that have been used to study the impacts of AB 32 on economic activity and employment in California. Although the models differ in some key respects, Knittel's analysis reveals that most forecast relatively modest losses in gross state product, household income, and employment from implementation of AB 32.

Agricultural emissions are not scheduled to be capped under AB 32, but Professor Dan Sumner and John Thomas Rosen-Molina of UC Davis note that agriculture will be impacted through higher energy costs for farming, processing, and transportation. The authors also raise serious concerns about the certification of carbon offsets from agriculture and argue that some of the incentives could paradoxically cause global emissions from agriculture to increase.

In this issue

AB 32 and Climate Change: The National Context of State Policies for a Global Commons Problem

Robert N. Stavins

Because climate change is a global problem, climate change policies should involve the highest levels of effective government. However, absent effective action at the national or international levels, some states and regions are enacting subnational climate change policies. This article examines the positive, negative, and benign interactions of state policies such as California's AB 32 with federal policies, and explores whether such policies can provide an impetus for further action at the federal level.

Why should anyone be interested in the national context of a state policy? In the case of California's Global Warming Solutions Act (AB 32), the answer flows directly from the very nature of the problem—global climate change, the ultimate global commons problem. Greenhouse gases (GHGs) uniformly mix in the atmosphere. Therefore, any jurisdiction taking action—whether a nation, a state, or a city—will incur the costs of its actions, but the benefits of its actions (reduced risk of climate change damages) will be distributed globally. Hence, for virtually any jurisdiction, the benefits it reaps from its climate-policy actions will be less than the cost it incurs. This is despite the fact that the global benefits of action may well be greater—possibly much greater—than global costs.

This presents a classic free-rider problem, in which it is in the interest of each jurisdiction to wait for others to take action, and benefit from their actions (that is, free-ride). This is the fundamental reason why the highest levels of effective government should be involved, that is, sovereign states (nations). And this is why international, if not global, cooperation is essential. (See the extensive work in this area of the Harvard Project on International Climate Agreements.)

Despite this fundamental reality, there can still be a valuable role for subnational climate policies. Indeed, my purpose in this essay is to explore the potential for such state and regional policies—both in the presence of federal climate policy and in the absence of such policy. I begin by describing the national climate policy context, and then turn to subnational policies, such as California's AB 32 and the Regional Greenhouse Gas Initiative (RGGI) in the northeast. My focus is on how these subnational policies will interact with a federal climate policy. It turns out that some of the interactions will be problematic, others will be benign, and still others could be positive. I also examine the role that could be played by subnational policies in the absence of a meaningful federal policy, with the conclusion that—like it or not—we may find that Sacramento comes to take the place of Washington as the center of national climate policy.

The (Long-Term) National Context: Carbon Pricing

I need not tell readers of *ARE Update* that virtually all economists and most other policy analysts favor a national carbon-pricing policy (whether carbon tax or cap-and-trade) as the core of any meaningful climate policy action in the United States. Why is this approach so overwhelmingly favored by the analytical community?

First, no other feasible approach can provide truly meaningful emissions reductions (such as an 80% cut in national CO_2 emissions by mid-century). Second, it is the least costly approach in the short term, because abatement costs are exceptionally heterogeneous across sources. Only carbon pricing provides strong incentives that push all sources to control at the same marginal abatement cost, thereby achieving a given aggregate target at the lowest possible cost. Third, it is the least costly approach in the long term, because it provides incentives for carbon-friendly technological change, which brings down costs over time. Fourth, although carbon pricing is not sufficient on its own (because of other market failures that reduce the impact of price signals—more about this below), it is a necessary component of a sensible climate policy, because of factors one through three, above.

But carbon pricing is a hot-button political issue. This is primarily because it makes the costs of the policy transparent, unlike conventional policy instruments, such as performance and technology standards, which tend to hide costs. Carbon pricing is easily associated with the dreaded T word. Indeed, in Washington, cap-and-trade has been successfully demonized as "cap-and-tax." As a result, the political reality now appears to be that a national, economy-wide carbon-pricing policy is unlikely to be enacted before 2013. Does this mean that there will be no federal climate policy in the meantime? No, not at all.

The (Short-Term) National Context: Federal Regulations on the Way or Already in Place

Regulations of various kinds may soon be forthcoming—and in some cases, will definitely be forthcoming—as a result of the U.S. Supreme Court decision in Massachusetts v. EPA and the Obama Administration's subsequent endangerment finding that emissions of carbon dioxide and other greenhouse gases endanger public health and welfare. This triggered mobile source standards earlier this year, the promulgation of which identified carbon dioxide as a pollutant under the Clean Air Act, thereby initiating a process of using the Clean Air Act for stationary sources as well.

Those new standards are scheduled to begin on January 2, 2011, with or without the so-called "tailoring rule," that would exempt smaller sources. Among the possible types of regulation that could be forthcoming for stationary sources under the Clean Air Act are: new source performance standards, performance standards for existing sources (Section 111(d)), and New Source Review with Best Available Control Technology standards under Section 165.

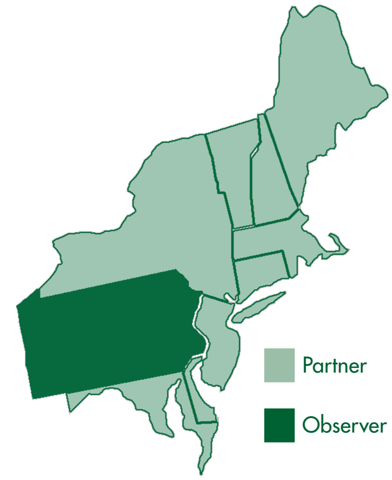
The merits that have been suggested of such regulatory action are that it would be effective in some sectors, and that the threat of such regulation will spur Congress to take action with a more sensible approach—namely, an economy-wide cap-and-trade system. However, regulatory action on carbon dioxide under the Clean Air Act will accomplish relatively little and do so at relatively high cost, compared with carbon pricing. Also, it is not clear that this threat will force the hand of Congress; it clearly has not yet done so. Indeed, it is reasonable to ask whether this is a credible threat, or will instead turn out to be counterproductive (when stories about the implementation of inflexible, high-cost regulatory approaches lend ammunition to the staunchest opponents of climate policy).

It is also possible that air pollution policies for non-greenhouse gas pollutants, the emissions of some of which are highly correlated with CO_2 emissions, may play an important role. For example, three-pollutant legislation focused on sulfur oxides (SO_X), nitrogen oxides (NO_X), and mercury could have profound impacts on the construction and operation of coal-fired electricity plants, without any direct CO_2 requirements. Without any new legislation, a set of rules which could have significant impacts on coal-fired power plants are now making their way through the regulatory process—including regulations affecting ambient ozone, SO_2/NO_2, particulates, ash, hazardous air pollutants (mercury), and effluent water.

There is also the possibility of new energy policies (not targeted exclusively at climate change) having significant impacts on CO_2 emissions. The possible components of such an approach that would be relevant in the context of climate change include: a national renewable electricity standard; federal financing for clean energy projects; energy efficiency measures (building, appliance, and industrial efficiency standards; home retrofit subsidies; smart grid standards, subsidies, and dynamic pricing policies); and new federal electricity-transmission siting authority.

Even without action by the Congress or by the Administration, legal action on climate policy is likely to take place within the judicial realm. Public nuisance litigation will no doubt continue, with a diverse set of lawsuits being filed across the country in pursuit of injunctive relief and/or damages. Due to recent court decisions, the pace, the promise, and the problems of this approach remain uncertain.

Figure 1. Map of the Regional Greenhouse Gas Inititative (RGGI)



RGGI is the first mandatory U.S. cap-and-trade program for carbon dioxide. It was established in December 2005 by the governors of seven Northeastern and Mid-Atlantic states; three additional states joined in 2007, and Pennsylvania remains an observer.

Source: www.pewclimate.org/what_s_being_done/in_the_states/rggi

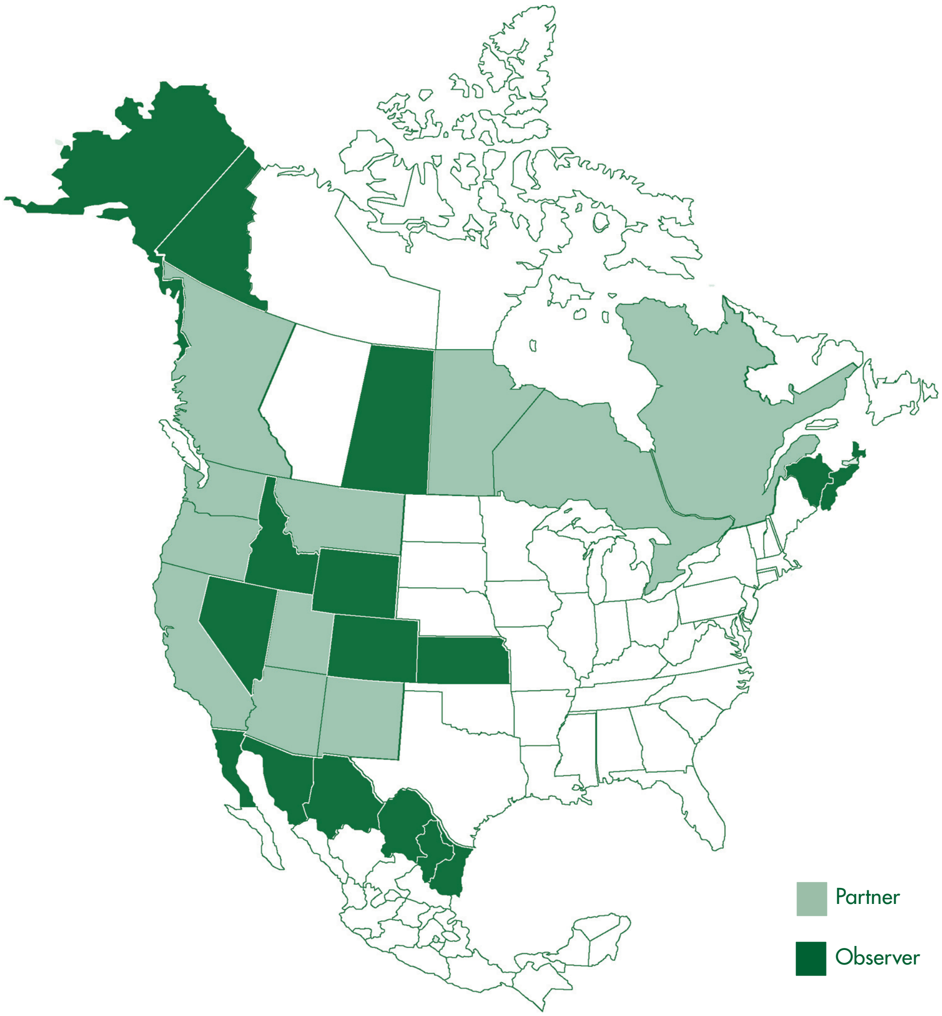
Beyond the well-defined area of public nuisance litigation, other interventions which are intended to block permits for new fossil energy investments, including both power plants and transmission lines, will continue. Some of these interventions will be of the conventional NIMBY character, but others will no doubt be more strategic.

But with political stalemate in Washington on carbon pricing or national climate policy, attention is inevitably turning to regional, state, and even local policies intended to address climate change.

Subnational Climate Policies

The Regional Greenhouse Gas Initiative (RGGI) in the Northeast (Figure 1) has created a cap-and-trade system among electricity generators. More striking, California's Global Warming Solutions Act (Assembly Bill 32, or AB 32) will likely lead to the creation of a very ambitious set of climate initiatives, including a statewide cap-and-trade

Figure 2. Map of the Western Climate Inititative (WCI)



The WCI is a collaboration of independent jurisdictions who work together to identify, evaluate, and implement policies to tackle climate change at a regional level. Other U.S. states, Canadian provinces, Mexican states and tribes are encouraged to participate in the WCI as either partners or observers.

Source: www.westernclimateinitiative.org/wci-partners-and-observers-map

system. The California system is likely to be linked with systems in other states and Canadian provinces under the Western Climate Initiative (Figure 2). Currently, more than half of the 50 states are contemplating, developing, or implementing climate policies.

In the presence of a federal policy, will such state efforts achieve their objectives? Will the efforts be cost-effective? The answer is that the interactions of state policies with federal policy can be problematic, benign, or positive, depending upon their relative scope and stringency, and depending upon the specific policy instruments used. This is the topic of a paper which Professor Lawrence Goulder (Stanford University) and I have written, "Interactions Between State and Federal Climate Change Policies." (National Bureau of Economic Research Working Paper 16123, June 2010).

Problematic Interactions

Let's start with the case of a federal policy which limits emission quantities (as with cap-and-trade) or uses nationwide averaging of performance (as with some proposals for a national renewable portfolio standard). In this case, emission reductions accomplished by a "green state" with a more stringent policy than the federal policy—for example, AB 32 combined with Waxman-Markey/H.R. 2454—will reduce pressure on other states, thereby freeing, indeed encouraging (through lower allowance prices) emission increases in the other states. The result would be 100% leakage, no gain in environmental protection from the green state's added activity, and a national loss of cost-effectiveness.

Potential examples of this—depending upon the details of the regulations—include: first, AB 32 cap-and-trade combined with federal cap-and-trade (H.R. 2454) or combined with some U.S. Clean Air Act performance standards; second, state limits on GHGs/mile combined with federal Corporate Average Fuel Economy (CAFE) standards; and third, state renewable fuels standards (RFS) combined with a federal renewable fuels standard, or state renewable portfolio standards (RPS) combined with a federal RPS. A partial solution would be for these federal programs to allow states to opt out of the federal policy if they had an equally or more stringent state policy. Such a partial solution would not, however, be cost-effective.

Benign Interactions

One example of benign interactions of state and federal climate policy is the case of the RGGI in the Northeast. In this case, the state policies are less stringent than an assumed federal policy (such as H.R. 2454). The result is that the state policies become nonbinding and hence largely irrelevant.

A second example—that warms the hearts of economists, but appears to be politically irrelevant for the time being—is the case of a federal policy that sets price, not quantity, i.e., a carbon tax, or a binding safety valve or a price collar in a cap-and-trade system. In this case, more stringent actions in green states do not lead to offsetting emissions in other states induced by a changing carbon price. It should be noted, however, that there will be different marginal abatement costs across states, and so aggregate reductions would not be achieved cost-effectively.

Positive Interactions

Three scenarios suggest the possibility of positive interactions of state and federal climate policies. First, states can—in principle—address market failures not addressed by a federal carbon-pricing policy. A prime example is the principal agent problem of insufficient energy-efficiency investments in renter-occupied properties, even in the face of high energy prices. This is a problem that is best addressed at the state or even local level, such as through building codes and zoning.

Second, state and regional authorities frequently argue that states can serve as valuable "laboratories" for policy design, and thereby provide useful information for the development of federal policy. However, it is reasonable to ask whether state authorities will allow their "laboratory" to be closed after the experiment has been completed, the information delivered, and a federal policy put in place. Pronouncements from some state leaders should cause concern in this regard.

Third, states can create pressure for more stringent federal policies. A timely example is provided by California's Pavley I motor vehicle fuel-efficiency standards and the subsequent change in federal CAFE requirements. There is historical validation of this effect, with California repeatedly having increased the stringency of its local air pollution standards, followed by parallel federal action under the Clean Air Act. This linkage is desirable if the previous federal policy is insufficiently stringent, but whether that is the case is an empirical question.

Thus, in the presence of federal climate policy, interactions with subnational policies can be problematic, benign, or positive, depending upon the relative scope and stringency of the subnational and national policies, as well as the particular policy instruments employed at both levels. (For a more rigorous derivation of the findings above, as well as an examination of a larger set of examples, please see my paper with Lawrence Goulder, referenced below.)

But comprehensive federal carbon-pricing policy appears to be delayed until 2013, at the earliest. And it is possible that pending federal regulatory action under the Clean Air Act will be curtailed or significantly delayed either by the new Congress or by litigation. Therefore, it is important to consider the role of state and regional climate policies in the absence of federal action.

Subnational Climate Policies in the Absence of Federal Action

In brief, in the absence of meaningful federal action, subnational climate policies could well become the core of national action. Problems will no doubt arise, including legal obstacles such as possible federal preemption or litigation associated with the so-called "Dormant" Commerce Clause.

Also, even a large portfolio of state and regional policies will not be comprehensive of the entire nation, that is, not truly national in scope (for a quick approximation of likely coverage, check out a recent map of blue states and red states).

And even if the state and regional policies were nationally comprehensive, there would likely be different policies of different stringency in different parts of the country. As a result, carbon shadow-prices would not be equivalent, and overall policy objectives would be achieved at excessive social cost.

Is there a solution (if only a partial one)? Yes. If the primary policy instrument employed in the state and regional policies is cap-and-trade, then the respective carbon markets can be linked. Such linkage occurs through bilateral recognition of allowances, which results in reduced costs, reduced price volatility, reduced leakage, and reduced market power. Good news all around.

Such bottom-up linkage of state and regional cap-and-trade systems could be an important part, or perhaps even the core, of future of U.S. climate policy, at least until there is meaningful action at the federal level. In the meantime, it is at least conceivable —and perhaps likely—that linkage of state-level cap-and-trade systems will become the (interim) de facto national climate policy architecture.

In this way, Sacramento would take the place of Washington as the center of national climate policy deliberations and action. No doubt, this possibility will please some, and frighten others.

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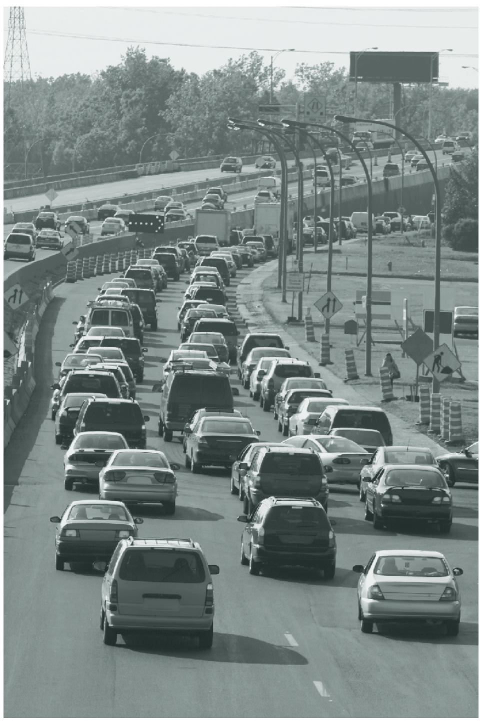
For additional information, the author recommends:

"Interactions Between State and Federal Climate Change Policies." Goulder, Lawrence and Robert Stavins. 2010. Cambridge, Massachusetts: National Bureau of Economic Research Working Paper 16123.

The Political Context for California's Climate Change Policy

David G. Victor

Although much has been written about the economic impacts of California's AB 32, the most important questions are political. AB 32 and other policies make sense only if they inspire other parts of the U.S., and even other countries, to control their emissions.



Traffic is often congested on California's highways, such as the Los Angeles freeway depicted here. California's AB 32 will enforce new low-carbon fuel and clean car standards.

California is a big state, but in the global picture we are a small emitter of the gases that cause global warming. Californians account for perhaps 1.4% of the world's total emissions—or possibly a bit more when the emissions linked to all the products we import are properly included in the accounting. As we think about AB 32 and the future of global warming policy in the state, we must focus not just on the economics for California but on the political effects of California's leadership on the rest of the country and the planet.

Nearly all of the logic for AB 32 and other state global warming laws is political. It is based on a theory that by starting first in California, we will raise the odds that other jurisdictions will follow. We need to design AB 32 in ways that are economically smart for California, but the most important questions for AB 32 hinge on the political logic of leadership.

Leading the Way in Climate Change Policy

The political theory works in several ways. State actions help demonstrate that practical emission controls are feasible and not overly costly. The states are also "laboratories" where new ideas are tested. State policies might also help create local jobs, which will amplify political support—although there is little evidence to support this argument. Perhaps most important is that when the states lead, they sow a measure of chaos in the nation's regulatory system which creates political pressure for meaningful federal action.

As analysts, we are guilty of focusing too much on the economics of schemes like AB 32 and not enough on the political theory. How good is the evidence that the political theory that inspires state action is actually valid? My read is that while the literature on this topic is mixed, it is generally supportive of the political theory. Most studies of regulatory competition show that there is a large role for "races to the top," which suggests that jurisdictions that start first help trigger efforts in other jurisdictions.

California's own experience with triggering such races is uneven. The effort on zero-emission vehicles in the 1990s was largely a failure and might even have distracted serious regulatory efforts from vehicle options that would have been more viable. But the many California-led efforts on broader air pollution regulation have largely been a success, as has much of California's leadership on appliance standards.

The lesson for AB 32 is that the political benefits of moving first will not arise automatically. They must be built into how the state actually implements AB 32. Moreover, the political logic for implementation will often conflict with the economics. Since the underlying rationale for AB 32 isn't as an optimally designed economic policy but rather a political effort to inspire action elsewhere, we in the analyst community must face the reality that the best choices for AB 32 will often be those that violate our sensibilities about the best economic design. I illustrate in four areas.

Four Criteria Shape a Successful Policy

First is credibility. Most of the global warming problem comes from the energy sector, and most energy infrastructure is long-lived. Thus, investors in energy technologies are particularly skittish when they face the need for large investments within a regulatory environment that is shifting. The most effective rules in such settings are those that are highly credible because they allow investors to sink capital and other resources with a reasonable expectation of earning a return. Across the nation (and much of the rest of the world), the political momentum for serious global warming policy is evaporating. In that context, the economic logic for doing something in California would seem to weaken because a strict island of policy in California, when the rest of the world economy is a sea of inaction, raises the odds that California will bear unequal and distorting costs.

My view is the opposite. When the rest of the world is losing momentum is a time when efforts by California are most needed—as a way to signal credibility. Investors who back clean energy are in the early stages of what could be a bloodbath as clean energy rules lose momentum in most of the country. If California signals that its own laws aren't credible, then it will take a long time—perhaps a generation—before investors come back.

Second, is the strategy for California's engagement with developing countries. Put differently, what is California's foreign policy on global warming? While most of the political attention on AB 32 focuses on whether this will help inspire action in Washington DC, the questions about foreign policy are ultimately much more important. Every credible forecast for fuel consumption and emissions shows that essentially all the growth in future warming emission will come from developing countries—especially China, but also India, South Africa, and the forest-rich nations such as Indonesia and Brazil.

If the central goal of AB 32 is rooted in a political theory that sees efforts by California spreading to other jurisdictions, then we should evaluate AB 32, ultimately, by whether it helps change the game in the developing world. California could have a big impact here—in part by generating pressure for more credible action at the federal level that will, in turn, make the U.S. Government a more effective negotiator with foreign countries. But, so far, there isn't much evidence that will happen soon.

Good economic design is important. But the ultimate success of AB 32 must be measured in terms of leverage. Is California changing the game in the rest of the United States and the world?

The biggest foreign policy leverage that California has is rooted in how the state implements its rules for emission offsets. By far, the largest scheme for international emission offsets is the Kyoto Protocol's Clean Development Mechanism (CDM). To date, the experience with the CDM has been disastrous. A large fraction of CDM credits are not genuine—they reflect investments that would have happened anyway and wrongly earn credit as "additional."

The scheme is designed to reward relatively small projects that are discrete and relatively easy to measure and assess. Yet all the evidence suggests that the really big reductions in emissions from developing countries will come not from little projects that tinker at the margins, but from bigger schemes that alter these countries baselines—such as schemes to introduce more advanced, efficient coal-fired power plants in India, or schemes to make natural gas-fired electricity more viable in China. Serious leverage in the developing countries will come from engaging with how these nations actually plan and implement their industrial policies.

California can help alter the political incentives for developing countries to control emissions by opening part of the AB 32 market to international offsets. Success on this front will require navigating between the local pressure here in California to make offset rules generous (and thus help local companies comply with AB 32's emission limits), and the political goal of using the California market to gain leverage on emissions around the world. The former suggests that transaction costs should be low and rules as generous as possible.

Indeed, most discussions of offsets around U.S. federal legislation have pointed in this direction, with such generous rules for offsets that the problems already evident in the CDM are likely to get even worse under a U.S. scheme. My view is that California should look in the other direction—it should set tough offset rules so that the California market (which will be the largest carbon-trading market in the U.S.) triggers a race to quality. Not only will this help ensure that offsets awarded in California are high quality, but it will demonstrate to other jurisdictions a better way to manage an offsets scheme.

Third, the same logic I have spelled out for California's foreign policy on global warming can also guide how the state deals with other states. If AB 32 is successful, then other states might create their own cap-and-trade systems. A few are already far along in the effort, and the Northeastern states already have a somewhat odd cap-and-trade system in place. Should these state systems be linked? Good economic policy would say "yes" because linked markets create more opportunities for trade and thus offer more potential for lowering costs and increasing leverage on emissions.

But good politics suggests the answer should be "maybe." California should be wary about too much linkage. Linking to states that have lax or flaky rules will create the carbon equivalent of Gresham's law, and political support for serious efforts in California will evaporate if people see their money flowing to other states where the effort isn't genuine.

When cheap, bogus emission credits are allowed into a trading system, then investors will focus on earning those credits and their efforts will drive high-quality (and more expensive) credits out of circulation. There is already evidence that under the Kyoto Protocol's Clean Development Mechanism, such behavior is appearing; with it, the credibility of emission offsets is increasingly in question.

Instead of welcoming all linkages, California should make links conditional on serious actions in other states and on solid administration of state markets. That approach will raise the odds that AB 32 will trigger other states to adopt serious policies because it will offer a bigger reward to states that meet California's conditions. I worry that, at present, we here in California have not yet articulated a conditional linking policy for other states—nor much grappled with other practical issues surrounding linkage such as the troubles lurking in the Commerce Clause. With the federal government in gridlock, the need for such a policy is rising quickly.

Fourth, and briefly, what happens here in California might help provide practical models for progress in international negotiations. Those negotiations are largely stalled today because they involve too many countries and issues and are not anchored in practical realities. They are based on targets and timetables that many countries can't honor. California and like-minded jurisdictions—such as the EU—can offer practical examples of real actions, around which more credible international coordination can emerge.

Concluding Remarks

California has dodged its biggest threat to AB 32 to date—Proposition 23, which would have halted AB 32 and a lot more. I sympathize with the economic logic that inspired Proposition 23, and the many voters who backed it are a reminder that AB 32 must stay aligned with the burdens that the California public is willing to bear. Indeed, the economic logic of one state acting alone is hard to fathom. That is because most of AB 32 isn't about economics—it is about political leverage on emissions outside California. As we shift into actually implementing AB 32, it is important to keep that fact at the center of whatever we do.

Good economic design is important. But the ultimate success of AB 32 must be measured in terms of leverage. Is California changing the game in the rest of the United States and the world? Answering that question in the affirmative will require ensuring that AB 32—along with the rest of California's efforts on global warming—rewards the jurisdictions that move forward with California.

Success in gaining leverage around the world will require that California implement AB 32 in ways that will often be seen as economically inferior, such as by segmenting California's offsets markets and being picky about which states we allow linkage through carbon markets. The result will be something very different from the emission markets we learn about in economics textbooks. It will be fragmented and filled with transaction costs. It will reward jurisdictions that make real reductions in emissions, while not linking to many markets that risk triggering Gresham's law. And these markets will exist along side a large array of regulatory policies that may be economically inferior, but are politically attractive because they hide the real cost of action. All of this will be a horror to those of us who like transparent, broad, and efficient markets. We should get used to the horror because it is unavoidable when the main objective is political leverage rather than economic efficiency.

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The Political Economy of Climate Change Legislation: An Economist's Perspective

Matthew E. Kahn

Credible efforts to reduce greenhouse gas emissions will help to reduce the impacts of climate change on our quality of life. While many agree about the benefits of such efforts, the world's leading economies have been slow to take significant action. This paper reports on new research investigating why legislation to combat climate change has not been enacted.

As the world's population and per-capita income grows, the only way we can combat climate change is if we collectively commit to sharply reduce emissions per dollar of world economic output. In the absence of a global carbon tax or global cap-and-trade program, this is a daunting task. Nations such as China have said that they want to reduce their energy intensity (measured as energy consumption per dollar of GNP). So far, their announced goals have not been large enough to achieve the aggregate greenhouse gas emissions reductions that climate scientists say we must achieve to stabilize global atmospheric carbon at a safe level.

Mitigation optimists have hoped that the election of President Obama in 2008 would be a first step in setting off a "green chain reaction," in which the United States would pass credible legislation to battle climate change, and the whole world would benefit as our actions would trigger a green-tech revolution that would decouple economic growth from greenhouse gas production. If the United States could develop "game changing" new energy-efficient technologies, then these could diffuse around the world and allow nations to enjoy the "win-win" of economic growth without increased greenhouse gas emissions.

But, the United States did not enact such regulation. Both in Copenhagen in late 2009 and in the U.S. Senate in the summer of 2010, diverse coalitions have not been able to hammer out a mutually agreeable deal to credibly incentivize polluters to internalize the social harm caused by greenhouse gas production.

Economists view voters and politicians as self-interested maximizers. If politicians are voting against certain legislation, then they must perceive that the total costs that their constituents would face from such legislation must exceed the benefits. While measuring the determinants of perceived costs and benefits from a specific piece of carbon legislation (such as higher gasoline taxes or higher electricity prices) is quite complicated, recent events provide some relevant clues for improving our understanding of the political economy of enacting climate change mitigation legislation.

The Determinants of Congressional Voting on Carbon Legislation

The popular media has emphasized the growing political polarization between Republicans and Democrats on the broad issue of climate change. In 1997, 37% of Republicans and 27% of Democrats agreed with the statement "The seriousness of global warming is generally exaggerated in the news." In 2008, 59% of Republicans and only 17% of Democrats agreed with that statement. The causes of this divergence in attitudes remain an open question, but in our democracy it raises a fundamental challenge for those who hope to see the Congress enact credible carbon legislation.

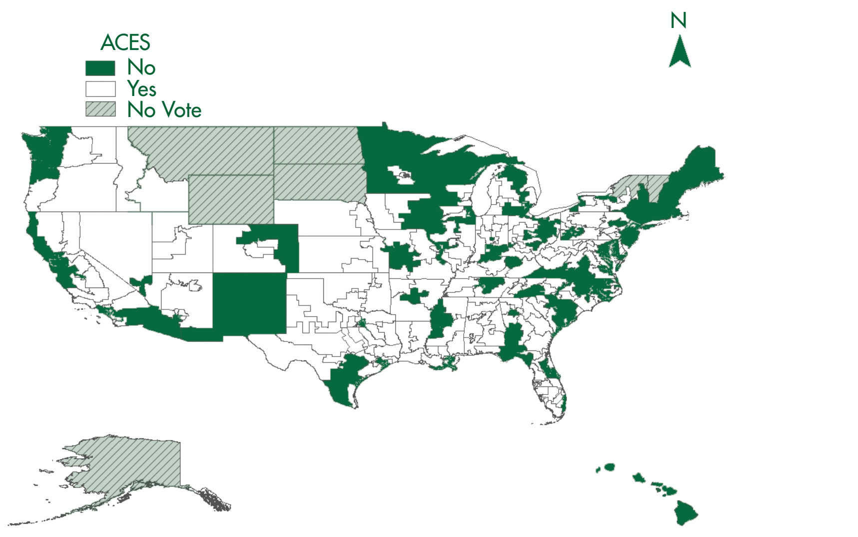
Evidence supporting this fact is based on recent research I have conducted with Michael Cragg, Kevin Gurney, and Yuyu Zhou. We examine U.S. Congressional voting trends on major pieces of legislation related to mitigating greenhouse gases. The most prominent example we study is the June 2009 Waxman-Markey American Clean Energy and Security Bill (ACES), which passed in the U.S. House of Representatives with 219 yes votes and 212 no votes. For each member of the House, we observe how the Congressperson voted. We seek to explain why some Representatives vote "yes" and others vote "no."

Figure 1 (page 10) presents a map of the votes on this bill, based upon the location of the Congressperson's district. Our statistical model is based on three key explanatory variables. For each Representative, we collected data on: 1. Her district's average household income (based on year 2000 Census data); 2. her ideology score—a standard measure used by political scientists to judge whether a Representative is a liberal or a conservative; and, 3. the per-capita tons of carbon created within the district.

This last measure has been created under the Vulcan Project at Purdue University (www.purdue.edu/eas/carbon/vulcan/research.php). It represents a measure of the "stake" that the Representative has in avoiding legislation that puts a price on carbon.

Our empirical results are intuitive. Representatives who are liberal, represent richer districts, and whose districts have a small per-capita carbon footprint are much more likely to vote

Figure 1. Congressional Voting Record for Waxman-Markey American Clean Energy and Security Bill (ACES)



yes (think of Nancy Pelosi). Representatives from a poor, conservative district, whose members have a larger carbon footprint, are much more likely to vote no on this carbon mitigation legislation. Political ideology is the dominant determinant of voting on the ACES bill.

While many environmentalists are concerned about the consumption-scale effects associated with income, these results highlight that Representatives from richer districts are more likely to support carbon regulation. My prior work documents that more educated people are more likely to support environmental regulation (Kahn 2002), and education and income are highly correlated.

Our results highlight the fundamental political economy challenge of persuading the U.S. Congress to support carbon mitigation legislation. President Obama faces the challenge that there are too many pockets of the country where the districts are poor, conservative, and have high carbon emissions. Most of the residents of these areas do not prioritize climate change as a serious threat, and they are aware that their district relies on coal-fired power plants to produce electricity. Some of these districts have low population density and are reliant on private vehicles. Many of these districts are located off of the coasts in humid, hot areas that require ample electricity to combat summer humidity. During a time of deep budget deficits, the Obama Administration faces the challenge of how it can offer "carrots" to such swing districts to compensate them for the expected transition pain that significant carbon incentives would pose.

The Prolonged Recession Has Chilled Interest in Carbon Mitigation Legislation

The prolonged recession poses another major challenge to enacting credible carbon mitigation regulation. In November 2010, the major ballot initiative in California was Proposition 23. This proposition sought to suspend California's landmark AB 32 climate change legislation until the state's unemployment rate drops below 5.5%. Although Proposition 23 was defeated at the polls, its sponsors were no fools. They recognized that during a deep recession, voters might be willing to scuttle such innovative regulation due to basic pocketbook concerns. While this conjecture is intuitive, surprisingly little economic research has formally examined it.

In joint work with Matthew Kotchen, we investigate how changes in economic conditions—proxied with state monthly unemployment rates—affect three different indicators of environmental concern. We first use data on keyword searches through the Internet, as complied by Google Insights. Recent studies have also shown that Google searches are a powerful tool for predicting economic activity such as product demand for automobiles, home sales, retail sales, and travel behavior (Choi and Varian 2009).

Using panel data by month for each state, we find that an increase in a state's unemployment rate is associated with a decrease in keyword searches within the state for "global warming," and an increase in searches for "unemployment." We also find that in more Democratic-leaning states, the decline in global warming searches is larger, but the increase in unemployment searches is smaller.

We also use more conventional survey data in which households are polled about their public policy priorities. We find, after controlling for standard demographic factors such as age and education, that respondents who live in counties with a higher unemployment rate are less likely to rank the environment as a major policy priority and are more likely to emphasize basic economic concerns.

Figure 2 provides a sense of our data. For California, I present a graph of the Google Search Volume per month searching for the term "Global Warming" versus the state's unemployment rate in that month. A clear negative correlation is observed. It is relevant to note that Google scales the data so that units on the y-axis are not informative in absolute value, but month-to-month relative comparisons can be made.

Our work supports the conventional wisdom that the deep recession has hindered efforts to embrace carbon legislation. There is a certain irony here. Many environmentalists view economic growth as the cause of environmental degradation. After all, the American Dream of a private home, a lawn, and two cars is resource-intensive, but as documented in the work on Congressional voting patterns and individual Google search behavior, richer people who live in areas featuring lower unemployment rates are more willing to support anti-climate change regulation.

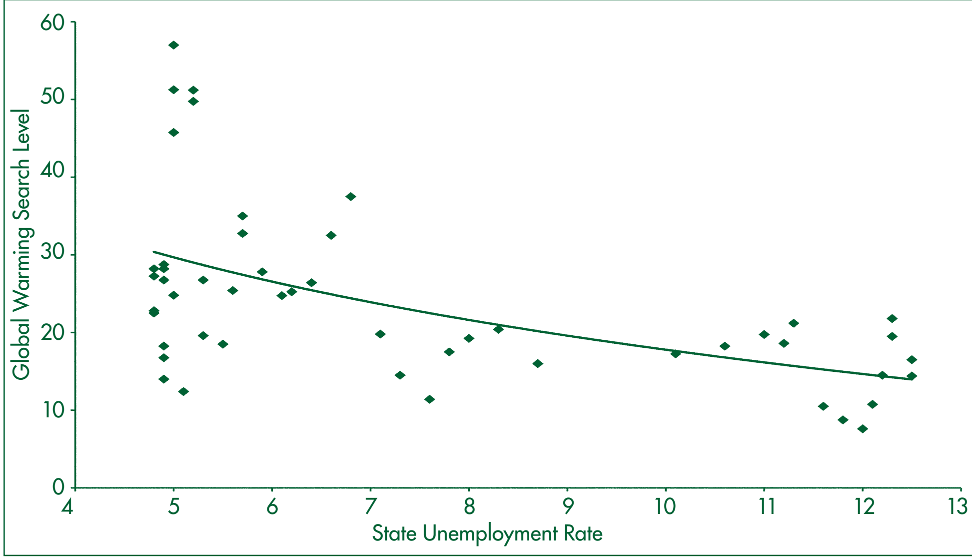
Political Economy Failure Makes it Even More Important for California to be a "Green Guinea Pig"

Given the failure globally and domestically to enact significant carbon regulation, California's nascent efforts with rolling out AB 32 become even more crucial. As highlighted by the recent debate over California Proposition 23, even the progressive state of California faces key political economy issues concerning support for this regulation. New ideas are public goods. If California's entrepreneurs, universities, and state government incentives embedded in AB 32's implementation could generate new "green tech" ideas, then these new approaches can be exported around the world and decouple economic growth and greenhouse gas production. I believe that AB 32 will accelerate green learning and experimentation, and some of the resulting ideas will be game changers.

A surprising fact that has emerged is the diversity among the business community in its support for climate change regulation. California's venture capitalists actively raised money to support AB 32 and to oppose Proposition 23. They view the continuation of AB 32 as offering a credible set of incentives and "carrots" that will make their investments in the nascent green economy more likely to payoff.

For example, a big piece of AB 32 is the electric utility renewable portfolio standard which mandates that 33% of the state's power will be generated by renewables. If investors have the assurance that this mandate will remain in place, then this increases their willingness to invest in such new and risky technology. While venture capitalists have supported this effort, there are traditional manufacturing interests that are energy-intensive (such as primary metals) which could face an increase in cost if AB 32 significantly raises energy prices.

Figure 2. Relationship between California Google Search Activity on Global Warming and the Unemployment Rate: 2006–2010



The fact that some businesses will be "winners" due to AB 32, while others may suffer from facing higher costs of doing business, highlights how carbon regulation shakes up the status quo. A fundamental asymmetry exists. The current beneficiaries from not having carbon regulation know that they benefit from the status quo. In contrast, the new firms that will thrive because of carbon regulation may not even exist yet and thus do not have a seat at the bargaining table to lobby Sacramento politicians. To fully appreciate both the benefits and costs of regulation requires imagination. Those who will face higher costs because of regulation have an incentive to overstate the size of the costs that they will face.

At a time when China and India are growing and the federal government is unable to pass significant regulation, California has the opportunity to play a crucial role as a "green guinea pig." Some of our ideas will fail, but I am optimistic that others will succeed. Will our new good ideas create the vaunted "green jobs"? This is uncertain but if we believe this claim, then this will tilt public opinion, and thus politicians, to support legislation such as AB 32 in the United States and abroad, regardless of whether they are genuinely concerned about battling climate change.

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Note: The two papers discussed in this article are NBER Working Papers #14963 (Cragg and Kahn) and # 16241 (Kahn and Kotchen).

For additional information, the author recommends:

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Economic Models of AB 32: An Evaluation

Christopher R. Knittel

Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006, requires California to reduce its greenhouse gas emissions to 1990 levels by 2020, representing roughly a 25% reduction compared to business as usual. In this note, I summarize and discuss the key assumptions of a number of economic models estimating the costs of AB 32. Despite ignoring many of key benefits of AB 32, the model suggests the costs of AB 32 are likely to be small.

Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006, requires California to reduce its greenhouse gas emissions to 1990 levels by 2020, representing roughly a 25% reduction compared to business as usual. AB 32 is the most comprehensive climate change bill ever passed within the United States and is on par with the goals and actions of the European Union. AB 32 represents the first major piece of climate change legislation within the United States.

While the science is clear that greenhouse gas emissions are causing global temperatures to increase, regulating greenhouse gas emissions has an extra layer of complexity compared to regulating other pollutants such as nitrogen oxides (NOx) and carbon monoxide (CO). Unlike these other pollutants, greenhouse gases are a global pollutant; one ton of carbon dioxide (CO_2) emitted in California does the same amount of damage as one ton of CO_2 emitted elsewhere. This brings up a number of challenges to forming climate change public policy. Most importantly, it means that there is a significant free-rider problem since the benefits from any reductions in greenhouse gases are diffuse. That is, the ideal regulatory jurisdiction is at the global level. Any smaller scale than this will imply that jurisdictions may have an incentive to do nothing, relying instead on others to bear the cost burden of greenhouse gas reductions.

Despite this, a number of jurisdictions have passed climate change regulations at this smaller scale (e.g., Europe and Australia). At a national level, the United States has lagged the world on climate change policy.

Because the benefits of AB 32 accrue to both Californians and non-Californians, understanding the costs of AB 32 is perhaps more important. A number of cost estimates exist, often relying on highly technical and complicated models of economic activity. In this note, I discuss the basic structure of these models and the importance of several key assumptions. Several of the key models that exist largely agree on the bottom line of AB 32: ignoring many of the key benefits from the legislation, the cost of AB 32 is likely to be small.

Climate Change Policies: The Basic Economics

Climate change policies carry a number of costs. At the most basic level, you can categorize these costs into three groups. First, firms may change their product design or how they produce their products, relying on less greenhouse-gas-intensive technologies. For example, in the transportation sector, the policy may incentivize firms to produce more fuel-efficient vehicles by spending more on the technologies that go into those vehicles. Or, in the electricity side, firms may switch from burning coal to burning natural gas when generating electricity.

Second, consumer welfare may fall because the price of greenhouse-gas-intensive products rises. Under a command-and-control system, this may occur as a result of changing the product or how the product is produced. In a cap-and-trade or carbon-tax regime, this may occur because the firm must buy allowances or pay the carbon tax, or because the firm changes how the product is made. Finally, there may be macroeconomic costs associated with changes in the relative prices within the economy.

Climate change polices are also likely to carry benefits. Again, we can classify these into three groups. First, the policy may alleviate some of the negative consequences of climate change. These benefits will, of course, accrue to the entire world population and not just those within the jurisdiction of the policy, if that policy is more local.

Second, some of the product changes described above may lead to benefits. For example, while the more fuel-efficient vehicle costs more to produce, the lifetime fuel costs of that vehicle will fall, benefiting the owner. Finally, insofar as the policy generates revenue (e.g., auctioning off allowance or a carbon tax), the revenues from the policy can be used to lower distortionary taxes, such as income taxes, leading to macroeconomic benefits.

In principle, the benefits can outweigh the costs. Greenhouse gas emissions are a classic example of a negative externality. That is, when I emit greenhouse gases I don't fully face the cost of that decision. Therefore, I will continue to emit greenhouse gases even though my incremental benefit is less than the social cost of that action. Policies that lead me to reduce my consumption of these greenhouse-gas-intensive products can lead to a positive social benefit, even though my utility may fall.

A second reason why climate change policies may lead to a net benefit is that there may be other facets of the economy, other than the negative externality just described, that keeps the market from achieving the socially optimal mix of goods and services—other so-called market failures. In the context of climate change policy, people often point to market failures that lead consumers to undervalue energy efficiency. For example, when purchasing a vehicle a consumer is unwilling to pay an extra $100 at the time of the purchase even though this investment will save more than $100 in lifetime fuel costs, suitably discounted.

Whether the policy is a net benefit depends not only on the presence of the negative externality and these other market failures, but also on whose benefits are included in the calculation (e.g., do we restrict ourselves to those within the policy's jurisdiction) and how efficient the policy is. Furthermore, the efficiency of the policy will critically depend on whether we think other market failures are present.

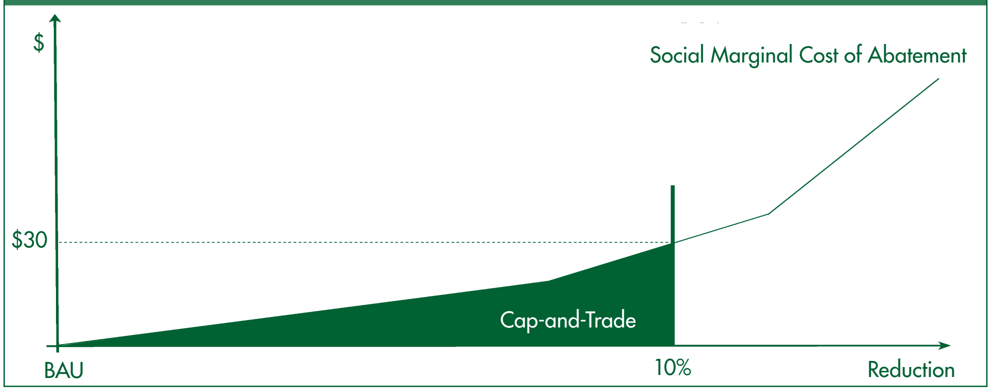
Climate Change Policies: The Models

At the most basic level, modeling the costs of a climate change policy requires four separate components. First, the modeler requires "technology cost curves," those costs faced by firms from de-carbonizing their products. Again, this can come from either product changes (more efficient vehicles), or process changes (switching from coal to natural gas).

Second, calculating the consumer costs associated with buying less of a product requires a system of demand curves. The key components in this system of demand curves are the own-price elasticity of the demand for products, as well as the cross-price elasticities across products. With these in hand, the modeler can then calculate the loss in consumer surplus from a change in prices and the cost of firms producing lower greenhouse-gas-intensive products.

The third part of the model is a macroeconomic model relating general

Figure 1. Stylized Marginal Abatement Cost Curve and an Efficient Policy



macroeconomic activity to prices. Finally, the modeler requires a model of "business as usual." That is, what would happen in the absence of the policy.

More extensive models will also include models of "offsets"—the cost of achieving greenhouse gas emission reductions outside of the jurisdiction or covered industries, as well as models of leakage or reshuffling. Leakage occurs when firms not regulated under the policy increase their output in response to regulated firms reducing their output. Reshuffling occurs when more of the high greenhouse gas products get sold outside of the regulated jurisdiction, as a result of the policy.

The Model's Outputs

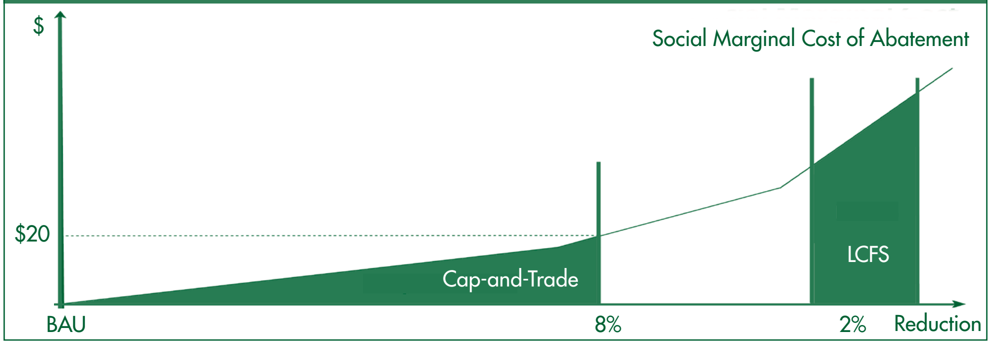
The outcome of the climate change model is a marginal social cost of abatement. That is, for any source of greenhouse gas reduction, the model predicts the cost of this reduction. The information about both technology costs and consumer demand allows the model to trade-off increases in the amount of technology embedded in products versus simply consuming less of the current set of products. In equilibrium, both occur. The macroeconomic model allows the modeler to account for any macroeconomic changes caused by a given change in product mix or prices.

Ranking these from lowest to highest yields the social marginal cost of abatement—a stylized example is in Figure 1—where we impose emission-reduction policies beginning from a no-reduction or (business as ususal—BAU) scenario. Three important features of this curve are worth noting. First, while this cost curve incorporates the benefits from product design changes that alter the lifetime operating cost of the product, it ignores the other two benefits discussed above: benefits from a cooler climate and any benefits from lowering distortionary taxes. Second, the total cost of the policy is the area under the curve where the reductions come from (this area need not be contiguous). Third, in the presence of other market failures, the social cost of some reductions may be negative.

Greenhouse gas reductions under an efficient policy will move along this curve from left to right, yielding the lowest total cost for a given reduction. In the absence of other market failures, a greenhouse gas tax or a cap-and-trade system achieves the lowest cost among those sectors included in the tax or cap-and-trade system. This is also depicted in Figure 1, where the cap-and-trade system reduces emissions by 10%.

A hybrid system of both a cap-and-trade system and other complementary policies (e.g., the Low-Carbon Fuel Standard), such as AB 32, is not guaranteed to minimize costs. Figure 2 represents such a case where the cap-and-trade portion of the policy reduces emissions by 8% and a Low-Carbon Fuel Standard (LCFS) reduces emissions by 2%. The curve is drawn consistent with my recent work with Holland and Hughes, which suggests that a Low-Carbon Fuel Standard is an expensive

Figure 2. Stylized Marginal Abatement Cost Curve and an Inefficient Complementary Policy



way to achieve emission reductions from the transportation sector.

In the presence of other market failures, the "lowest hanging fruit" may not be picked under a greenhouse gas tax or a cap-and-trade system because of other impediments in the market. When this occurs, complementary programs may be cost effective, minimizing the total cost of the reductions. Figure 3 represents such a case. Here, the complementary measure, building efficiency standards, falls to the left of the marginal abatement costs of reduction under cap-and-trade.

A final point, going back to Figure 1. In this scenario, cap-and-trade achieves a 10% reduction in emissions and the allowance price trades at $30 per ton of CO_2e. A frequent misconception is that the cost of these reductions is $30 times the total number of allowances. That is not the case! As noted, the total cost of the policy is the area under the curve.

Discussion of Models Related to AB 32

During my experience on the California Air Resource Board's Economic and Allocation Advisory Committee (EAAC), I reviewed the results and assumptions of a number of models specific to AB 32. The two most comprehensive models of the costs of AB 32 are the California Air Resource Board (ARB) and Charles River and Associates (CRA) models. Both employ detailed models of the energy sectors and a computable general equilibrium model, meaning they allow for the equilibrium mix of inputs to change as a result of the regulations.

Being a member of the EAAC's economic modeling subcommittee afforded me the opportunity to learn more about both models. I was impressed with the breadth of each model and the responsiveness of the modelers to our concerns.

Table 1 compares the results of the two models on a number of metrics. Each of the reports provide results under a variety of different assumptions, so a range is given. The sensitivity analysis changes such things as the supply curve of offsets, changes in the reductions from complementary measures (thus the required reductions from the cap-and-trade program), etc.

In terms of aggregate economic activity, the model results are consistent with each other—suggesting a relatively small impact on gross state product. The variation in household income is larger, with the CRA model predicting much larger reductions to household income.

Why the diferences? CRA present results in which "as best as possible employ the same assumptions as ARB." This holds constant many of the features of each model. The differences between the CRA and ARB results appear to come from different assumptions regarding the existence of other market failures. For example, when CRA replaces all of the complementary measures with a broader cap-and-trade program, CRA estimates that the costs of AB 32 fall by 50%.

Indeed, in the EAAC's discussions with both ARB and CRA, this underlying issue—the presence of other market failures—did vary across models. The ARB's model assumes that certain investments, such as fuel economy and energy effciency, are not made even though consumers would be better off. It appears as though this is pervasive in their model. That is, these net-benefit investments are assumed to exist across a variety of facets of the economy. Given these, many of the complementary measures proposed under AB 32 will decrease its cost; some may even have negative net costs.

In contrast, CRA assumes that these other market failures do not exist; firms and consumers optimize without the aid of complementary policies. Under the CRA assumption, complementary measures can only have either no effect on costs or increase them. If the outcome of the complementary measure would have occurred under a broader cap-and-trade program, then its inclusion will have no affect on costs; if the outcomes would not have occurred under the broader cap-and-trade program, then it will increase the aggregate cost of AB 32.

Which assumption is more correct is an open question. Many argue that

Figure 3. Stylized Marginal Abatement Cost Curve and an Efficient Complementary Policy

a vast number of negative-cost investments are not made by households and firms. Indeed, the well-known "McKinsey Curve," a supply curve for greenhouse gas-reducing investments, contains a large amount of negative-cost investments. Others argue the extent of these negative-cost investments is more limited. The empirical literature in economics is also mixed.

It is also worth noting that both models disregard two potentially large benefits from AB 32: the reduction in co-pollutants and the macroeconomic benefits of using revenues to lower distortionary taxes. Co-pollutant benefits exist because many criteria pollutants are positively correlated with greenhouse gases. Therefore, regulations that lead to greenhouse gas reductions are also likely to reduce these other pollutants. To date, a comprehensive study that seeks to measure these two benefits does not exist.

A Quick Note on Other Modeling Efforts

Two other models have garnered attention: reports by T2 and Associates, and the Brattle Group. While, again, the exact details of the T2 are not available, it appears as though their model is on a much smaller scale compared to the ARB and CRA model. In particular, there appears to be limited scope for the economy to adjust to the regulations. Consumers appear not to be able to change which appliances and automobiles they own, and firms appear not to be able to adjust the input shares of their production process. Furthermore, the T2 study assumes an allowance price, it does not actually use a model to predict an allowance price.

Table 1 reports the assumed allowance prices, the predicted change in gross state product and the estimated impact on household consumption. This last number is essentially taking the estimated change in prices (allowance prices are assumed to be fully passed on to consumers) and multiplying it by the current quantities of these products that consumers purchase.

Table 1. Key Results from Three Models Related to AB 32

	ARB	CRA International	Tanton
Emissions Reduction	25%	25%	25%
Allowance Price Range	$25 to $162	$52 to $78	$20, $60, $200 (assumed)
Percent Change in Gross State Product	-0.2 to -1.4	-1.4 to -2.2	-2.0
Income Gain/Loss per Household	+$86 to $270	-$1175 to $1380	-$930, -$2800, -$9300*

** Based on three assumed allowed prices*

This greatly overstates the impact on consumers for two reasons. First, the T2 study must be assuming that all of the allowances are given away to firms, while at the same time assuming that firms pass all of the increases in cost for these allowances onto consumers.

This need not be the case. How allowances are allocated is up to the discretion of the ARB. Since, under this assumption, firm profits increase by the same amount that consumers' consumption falls, in that sense AB 32 is largely a "wash." Second, it implicitly assumes that consumers don't change their purchasing behavior. In the presence of a $200 allowance price, with all of this being passed through to prices, consumers are likely to react. They may react by cutting back consumption and/or investing in energy efficiency. These important decisions are incorporated in ARB and CRA's models.

The second study, done by the Brattle Group, focuses on the effects of AB 32 on small business. Similar to the T2 study, the Brattle Group estimates how AB 32 will change energy prices, using two assumed values of the allowance price and two allocation methods, and then calculates the cost impact of small businesses. They focus their report on two sets of results, representing the lowest and highest impact on energy prices. Their bottom line is that energy is a small share of the costs of small businesses, thus AB 32 will have a small impact on small business profits. The Brattle Group study misses two key indirect effects. First, they do not model the macroeconomic effects of AB 32. Second, they do not model the likely occurrence that in response to higher energy prices, households will have less disposable income to spend at many of these small business.

Conclusions

AB 32 is a broad set of policies aimed to reduce greenhouse gas emissions to their 1990 levels by 2020. A number of economic studies exist estimating the costs of AB 32. Despite not incorporating a number of potentially large benefits from AB 32, they all agree that AB 32 is likely to have a relatively small impact on the California economy.

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For more information, the author recommends:

Holland, S. P., J. E. Hughes, and C. R. Knittel. 2009. "Greenhouse Gas Reductions under Low Carbon Fuel Standards?" *American Economic Journal: Economic Policy*, 1(1), 106-146.

Impacts of AB 32 on Agriculture

Daniel A. Sumner and John Thomas Rosen-Molina

AB 32 is not scheduled to cap agricultural emissions. The main impacts of the legislation include higher energy costs for farming, processing, and transport. The induced changes in California farm practices will do little to reduce net global emissions.

California climate policies under the implementation of AB 32 have the potential for significant effects on agriculture in California. Although much of agricultural production and processing will not fall under mandatory greenhouse gas (GHG) emission caps, the *Climate Change Scoping Plan,* developed to implement AB 32, includes: (a) voluntary measures for GHG reductions in agriculture, (b) potential for supplying GHG offsets to capped industries and firms, (c) GHG emission regulations affecting producers and processors, and, perhaps most importantly, (d) increases in costs of energy inputs that will affect farming and processing industries.

This article focuses specifically on likely effects of the implementation of AB 32 on agriculture in California, and does not deal with the effects of agriculture on climate change or the effects of climate change itself on agriculture. Details of implementation are not yet known and many potential effects have not been studied in detail. Nonetheless, we consider potential impacts on the agricultural economy and consequent effects on the environment, including global emissions.

The California Agricultural Economy and its Contributions to Greenhouse Gas Emissions

The 2007 Census of Agriculture reports that there are more than 25.3 million acres of land in California farms. About 52% of this land is in permanent pasture and rangeland, while cropland, mostly irrigated, makes up about 37% of land in California farms.

Farm sales vary from year to year, with variations in commodity prices and yields. Variations for individual commodity industries are even larger than the aggregate, and as a result, the shares of individual commodities in total farm sales also vary substantially over time. Gross farm sales in California for 2008 and 2009 averaged about $36.6 billion, with dairy accounting for about 16% and beef cattle another 5% of the total. Among the crops, grapes (used for wine, table grapes, raisins, and grape juice) accounted for about $3.1 billion, followed by almonds with $2.3 billion in gross sales. Tree and vine crops were 31% of gross sales, vegetables and melons were 22%, greenhouse and nursery products 10%, and field crops 8%. The large share of dairy and beef cattle in California agriculture has important implications for greenhouse gas emissions and the potential for reductions. Similarly, the large share of tree and vine crops indicates the potential for additional plantings as a mitigation strategy.

While California agriculture is the largest among the states, production agriculture accounts for only a bit more than 1% of gross state product. When upstream and downstream industries are included, agriculture, broadly defined, accounts for less than 7% of the California economy.

Farming is a significant contributor to GHG emissions in California. The greenhouse gas inventory, developed by the California Air Resources Board (ARB), indicates that agriculture and forestry account for about 6% of total California greenhouse gas emissions. Dairy and other livestock production account for almost 60% of the farm emissions. Enteric fermentation (internal fermentation in the gut) that leads to methane releases from livestock, mostly cattle, is responsible for nearly one-third of GHG emissions from forestry and farming (Figure 1). Manure management accounts for another 27%. Soil management yields about one-quarter of all emissions from farming. Energy use on farms and other activities make up the remaining 17%, of which methane from rice cultivation alone accounts for about 2% of emissions.

Estimated emissions from agriculture are large relative to agriculture's share in the total economy. However, such calculations are only approximations and are not based on tracing all emissions back to the source. For example, agricultural emissions do not include the emissions from fertilizer production, just as food retailing emissions do not include the emissions that occur on the farm. Sectors such as electricity generation (both within the state and imported into California) account for a significant share of total GHG emissions for the economy, even though this industry is a small share of the whole economy. As with food and raw materials produced from farming, electricity is a crucial input to household consumption and other industries. And, of course, even if food were not produced within California, residents here would still consume and the production of food would continue to have global GHG impacts.

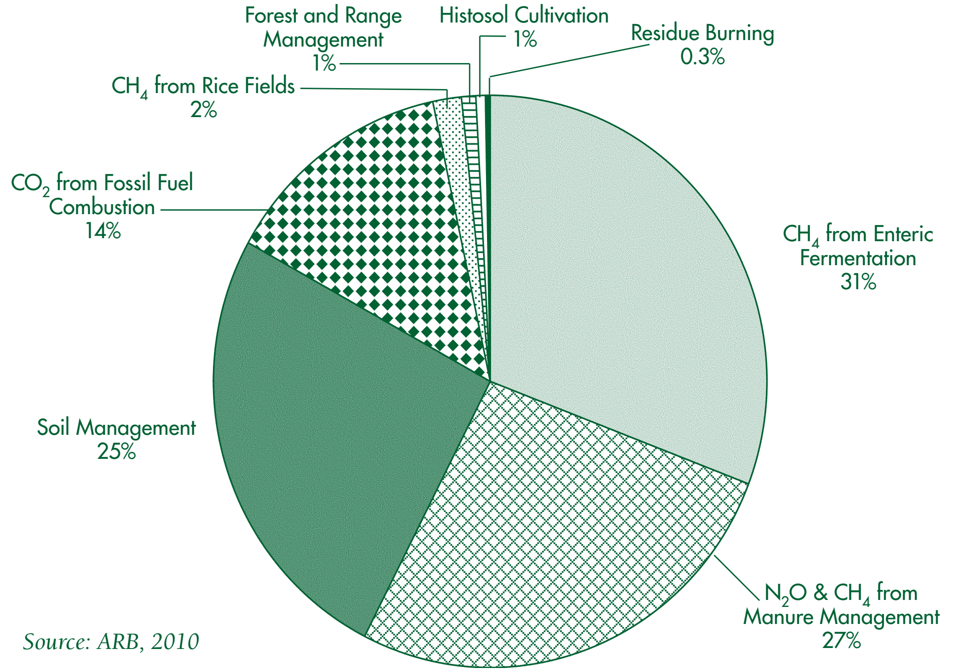
Agricultural Emissions and AB 32

Agricultural emissions are not scheduled to be capped under AB 32. Nonetheless, the California ARB assumes that by 2020, the implementation of AB 32 will reduce emissions of greenhouse gasses by about 1–3%, compared to estimates for business as usual. Given the wide range of uncertainty about emissions accounting and projections, such small changes cannot be considered significant. Moreover, these reductions are not included in the ARB's overall GHG reduction calculations.

ARB assumes that agriculture will undertake "voluntary" measures to reduce GHG emissions, including methane capture by digesters at dairy operations. ARB estimates that implementation of these digesters will reduce GHG emissions by the equivalent of about 7.7% of 2008 emissions from dairy cattle. The technology for methane digesters has existed for decades, but widespread commercial adoption has not occurred without subsidies. As it stands now, AB 32 does not provide incentives for, or mandate the use of, methane digesters. Nonetheless, ARB sees them as the driving force behind GHG reductions in the agricultural sector and is currently developing compliance-offset protocols for their implementation. (If the price for offsets is high enough, they could encourage adoption of digesters that would not otherwise occur.)

AB 32 will mainly affect farming through measures that affect the cost of farm inputs—such as fuel, fertilizer, and energy for irrigation—and costs of processing of agricultural outputs. Emissions from food processing plants, such as dairy, tomato and wine processors, will be capped under AB 32 if they emit more than 25,000 tons of carbon dioxide equivalent (CO_2eq) GHG per year.

Figure 1. 2008 California GHG Emissions from Farming and Forestry by Activity



Source: ARB, 2010

GHG emissions are reported by facilities through the ARB's Mandatory Reporting Program and the average reported emissions for food processors in California in 2008 was about 46,700 tons of CO_2eq. Tomato-processing facilities emitted an average of about 47,000 tons, wine distilleries 44,000 tons, and dairy and cheese plants about 49,000 tons of CO_2eq. These processors and others will face higher costs of meeting the cap by making costly adjustments, or by buying emission-allowance credits. Returns will fall for processor cooperatives, leading to a reduced demand for farm raw materials and lower prices offered to growers. Together with higher energy costs, higher compliance costs will encourage some firms to raise prices or reduce their operations in California.

Energy is a significant input to farm production, farm raw material processing, and agricultural inputs—such as fertilizer and irrigation water. Moreover, the shares of energy costs in producers' total operating costs tend to be relatively high for crops that are grown in California. For example, the share of energy costs out of total operating costs for rice cultivation is about 9.2%, counting only oil and fuel inputs. If the energy used in the manufacture of fertilizer inputs is included, the share increases to about 16.7%. The corresponding shares for wine production are about 6% and 9.3%.

When complementary input costs rise in processing and marketing, the demand for farm raw materials falls. Therefore, as energy costs to processors rise, farm prices and quantities demanded by California processors decline. Shifts of production are more likely for intensive livestock industries such as dairy or poultry, which are more mobile and not as land-dependent as crop cultivation. For crop industries that are land- and climate-dependent, shifting production out of California is not likely. In such cases, higher California processing and marketing costs will lead farmland prices to be lower than they would be otherwise. For crops where California's market share is high, higher farm and processing costs will tend to cause consumer prices to rise. As a result, it is likely that some food prices, especially for tree crops and vegetables, will rise as a result of the energy cost impacts of AB 32.

AB 32 and Agricultural Emissions Trading

AB 32 distinguishes between "allowances" and "offsets." As with other cap-and-trade programs, capped firms can choose to abate their emissions more than required and trade excess allowances with other firms in the "capped" sectors. "Offsets" refer to GHG reductions that occur outside of the capped sectors, and are purchased by firms in the capped sectors to meet their emissions reduction requirement.

Under AB 32, farmers will be outside of the regulated cap but may be able to sell offsets. AB 32 stipulates some requirements for offsets to be certified as acceptable to the cap-and-trade program. First, offsets must be additional, meaning only GHG reductions that would not have otherwise occurred can be counted and sold. Second, reductions must be non-reversible. That is, a firm cannot sell emissions reductions that can be overturned by another action a short time later. Third, offsets must be quantifiable, in that reductions must be demonstrable against a known baseline and follow standard protocols. Fourth, offsets must be verifiable and enforceable; meaning that practices must allow a transparent verification process and firms receiving offset credits must be accountable if they fail to comply with regulations.

Although ARB has acknowledged some practices as potentially valuable for GHG reductions, including the use of methane digesters on dairies, no farm offsets are currently certified by ARB and the development of protocols and certification may be a long and difficult process.

In its *Climate Change Scoping Plan* (2008), ARB outlines suggested practices for agriculture, indicating that potential certified offsets will fall into three categories—abatement, sequestration, and efficiency gains. Abatement refers to the removal or destruction of GHGs before their release into the environment. Examples of abatement activities include the conversion of methane gas in digesters to provide fuel or power, and the use of feed additives for livestock that reduce an animal's production of methane.

Sequestration is the removal of carbon dioxide from the atmosphere through biological, chemical or physical processes, and long-term storage of this GHG in a reservoir. For example, farmers could sequester carbon through minimal or "conservation" tillage. Cover crops also sequester carbon, at least temporarily. However, neither conservation tillage nor the planting of cover crops are widely practiced in California because the benefits are small relative to the losses, including loss of yield potential.

Efficiency gains outlined by ARB include increased irrigation efficiency, which would reduce energy for pumping water and may lower N_2O emissions. Nitrogen-use efficiency can be raised by applying fertilizer more precisely on the places and in the amounts most needed by the crop. Abatement, sequestration, and efficiency-enhancing techniques may eventually be certified by ARB as potential offsets that could be sold.

Practices for GHG Offsets from California Crop Production

There is still debate over the potential for some alternative practices to mitigate GHG emissions, and considerable study is needed before these can be certified for offsets. De Gryze et al. (2009) consider GHG reductions from alternative-cropping practices such as conservation tillage, cover cropping, and organic fertilization in the Sacramento and San Joaquin Valleys. The emission reductions modeled by the authors were mostly attributable to increased carbon sequestration in the soils. Additional decreases in N_2O emissions from reduced fertilizer application were more modest. However, unlike reductions in nitrogen application that generate permanent GHG reductions, increases in carbon sequestration do not lead to permanent GHG reductions. In addition, the authors' results imply that up to a 25% reduction in nitrogenous fertilizers could cause up to an 8% decrease in crop yields.

Importantly, De Gryze et al. observe that changes in GHG emissions differed across location and crops. For instance, conservation tillage slightly increased GHG emissions for wheat (due to a rise in N2O), but decreased emissions for tomatoes. The modeling in this study considers alternate practices for production of each crop, but not the potential shifts of land between crops. Shifts between crops are an important consideration in the computation of overall changes in GHG emissions from all of agriculture.

The simplest way to reduce GHG emissions from farming is to reduce farm production. However, reducing emissions for offsets is surely not the only objective for agriculture—food, fiber, and foliage remain valuable. Therefore, it is important to consider measuring GHG reductions in terms of emissions per unit of output, not simply on a per-acre basis.

Consider, as an example, a potential GHG-reducing practice that could be adopted by rice growers. Rice is a significant GHG contributor, in part, because of methane emissions. When fields are flooded during the winter, straw residue on the fields decomposes anaerobically, emitting methane in the process. Draining fields mid-season and exposing straw residue to a shorter decomposition period should therefore reduce methane emissions. However, adopting alternate practices such as mid-season drainage is not without costs to producers, and compensation may be necessary to encourage them to implement these potential GHG-reducing practices. To evaluate whether it is economically feasible for producers to adopt a particular practice, one should compare increased costs with decreased GHG emissions to trace out GHG reductions per dollar of reduced returns.

The University of California Agricultural Issues Center (AIC) has examined practices across more than 6,000 rice fields in the Sacramento Valley (see recommended reading box below). That work finds that the greatest cost to producers, from mid-season drying of rice fields and other practices thought to reduce methane emissions, is low rice yields. Preliminary findings indicate that several alternative practices have, at most, modest GHG reductions per acre, and that withdrawal of mid-season floodwater is not among the most effective practices to reduce GHG emissions per ton of rice. There is also substantial heterogeneity in emissions across fields by soil type in the California rice belt.

GHG emissions from some changes in crop and livestock practices would be relatively simple to measure and evaluate. These include reductions in fossil-fuel use or nitrogen fertilizer application. However, other processes make it difficult to apply AB 32 to agriculture. Agriculture is dependent on biological processes, and these are highly variable and challenging to monitor. Moreover, many potential offsets, such as forest sequestration projects, have a significant lag before they become effective. Sequestration is not a constant process and estimates of carbon storage require frequent calculation of biomass carbon over the project lifetime.

Sequestration also introduces the complex issue of permanence. Permanence requires that sequestered biomass not be removed in order for the stored carbon not to be re-released into the environment. This means that there exists the potential for release of GHGs at any time during the life of the project. Stored carbon would be released if, for example, trees and vines in orchard plantings were replaced as markets shifted or if trees were pruned. Given the high productivity of California cropland, the permanent displacement of crops with forest is unlikely.

Broad Concerns and Concluding Remarks

Perhaps paradoxically, the effective use of offsets to pay for changes in crop practices could actually increase GHG emissions from California agriculture. Offsets for practices are likely to be certified crop-by-crop—and thus would not account for shifting land across crops—and there are big differences in emissions by crop. A certified practice that allows payment for offsets for, say, tomatoes would likely raise per-acre tomato revenues and encourage more acres of tomatoes. The result would likely be fewer acres of competing crops such as wheat, which tends to have low GHG emissions relative to tomatoes. Thus, marketable offsets certified for tomatoes could cause a net *increase* in GHG emissions from agriculture.

Moreover, even a carefully implemented AB 32 for California agriculture could lead to increased GHG emissions from global agriculture. Because agricultural markets are global and food demand does not fall much when prices rise, policies that raise costs or reduce farm production in California tend to raise production elsewhere. That means global GHG emissions from agriculture are unlikely to fall. In fact, production practices elsewhere are often more land-intensive and emit more GHG units per unit of food, leading to more GHG emissions globally, which, of course, is the only scale that matters.

This paper focused on the effects of California climate change policy on California agriculture and, specifically, the potential responses of California agriculture to AB 32 implementation. Because agriculture is outside the reach of cap-and-trade, AB 32 will primarily affect agriculture through higher energy prices that will affect farming directly and through farm inputs and post-harvest processing and marketing. We also find difficulties with certification of emission offsets from agriculture, including the inherent complexity of biological processes and issues of permanence. And, even if offsets are correctly certified, shifts between crops and out-of-state may lead to net increases in global agricultural emissions.

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For more information, the author recommends:

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Agricultural and Resource Economics
UPDATE
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS • UNIVERSITY OF CALIFORNIA

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Davis CA 95616
GPBS

ARE Update is published six times per year by the Giannini Foundation of Agricultural Economics, University of California.

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