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Climate Change Policy Formation in Michigan

The Case for Integrated Regional Policies

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Like most other states in the U.S., Michigan recently began addressing the problem of climate change. The Michigan initiative involves combining a stakeholder process and technical analyses to formulate a climate action plan. This paper reports on how regional scientists collaborating with facilitators of the policy-making process and state government decision-makers addressed two key aspects. First is the choice and design of policy instruments to use to implement greenhouse gas (GHG) mitigation and sequestration. Second is the decision on whether the state should pursue its target for net GHG reduction on its own or in cooperation with other states. We summarize the results of applying a formal model for analyzing the implications of

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alternative environmental policy instruments. The model was applied to data on the costs and applicability of a spectrum of GHG reduction options developed by a consensus of stakeholders from all segments of the Michigan population. We recommended that a combination of regulatory and market incentive-based policies be implemented and that Michigan join with other Midwestern States in developing the cap and trade aspect of its climate action plan.

Keywords: *climate change economics; environmental policy instruments; greenhouse gas mitigation costs; stakeholder processes; regional cooperation*

Introduction

Since 2000, thirty U.S. states have completed or are developing comprehensive multisector greenhouse gas (GHG) reduction plans that establish and demonstrate specific policy actions required to attain science-based climate stabilization targets, typically at or below 1990 levels by 2020. The portfolio of mitigation actions developed through these plans includes all economic sectors and a variety of policy instruments, including innovative approaches such as market-based cap-and-trade (C&T) systems, and a combination of price and nonprice policy measures.

The State of Michigan has joined the Midwestern Greenhouse Gas Reduction Accord (MGA), which calls for a number of interstate actions, including the design and implementation of a regional C&T program covering Michigan, Minnesota, Wisconsin, Iowa, Illinois, Kansas, and the Canadian Province of Manitoba. Three additional states are participating in the project as observers. Two other regions are pursuing C&T programs to limit GHG emissions: the ten-state northeast Regional Greenhouse Gas Initiative (RGGI) and the seven-state, four-province Western Climate Initiative (WCI). In addition, there are numerous bills before Congress to create a national C&T program for this purpose. Michigan will almost certainly become a participant in a regional, super-regional, or national C&T program to limit and then reduce GHG emissions. Nonetheless, questions are arising as to whether a pure C&T system is the best approach at both the regional and the national levels. Some have suggested that alternatives, such as a carbon tax, a portfolio of additional, sector-based policies and measures, or a combination of them, would be preferable. Formal analyses of policy alternatives have offered valuable early guidance to policy makers, who will need to confront the complex policy choices demanded of these programs.

For the recommended configuration of regions, sectors, and program designs, formal modeling indicates that the implementation of the MGA regional C&T program can achieve a 35.3 percent reduction in GHG emissions in Michigan at a net cost of at least U.S.$193 million less than without the C&T program.

This article has two major objectives. The first is to show how research was integrated into the policy process to inform decision makers about the workings of a novel environmental policy instrument. The second is to estimate the potential gains from implementation of alternative environmental policy instrument designs in the State of Michigan and the Midwest Greenhouse Gas Reduction Accord (or, alternately, a federal system). Both the process and the results are important because many states are still formulating climate action plans and more than 80 percent of all states have either not formally joined a regional consortium or not joined one that has been fully implemented. As well, Congress is likely to try to incorporate state and regional C&T programs into a unified federal program.

The following section provides an overview of the C&T, carbon tax, and the direct regulation approaches. Section The Policy Formation Process analyzes the policy formation process in the State of Michigan. Section Policy Instrument Modeling presents a summary of our policy instrument analysis model and its data underpinnings. Results are presented and interpreted in section Simulation Results. Section Overview of Recommendations provides an overview of policy design recommendations for Michigan. In section Conclusion, we conclude with a brief set of lessons learned that might benefit policy makers and analysts in other states.

Overview of Policy Instruments for GHG Reduction

Cap and Trade

C&T programs limit emissions by placing a ‘‘cap,’’ on the total tons of pollutants that will be permitted to be released from regulated, or ‘‘covered,’’ sources of GHG emissions within a specified geographic area and interval of time. The cap is enforced by the issuance of permits, or ‘‘allowances,’’ for each ton of GHG emissions, which must be surrendered by each covered source in an amount equal to its emissions. Over time the number of allowances issued can be decreased, thereby further reducing total emissions.

Since the government regulates only the total emissions, the means by which the reductions are achieved are left to each covered source (although many reduction activities may be covered by other sector-based policies and measures). Creating a market gives these allowances a financial value, which encourages the covered sources to collectively implement the least-cost measures among all covered sources to achieve the capped emission reductions. Once allowances are allocated to emitters, a trading system allows participants with lower costs of compliance to overcomply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, the C&T lowers the overall costs of compliance. In an auction-based system, all emitters must purchase allowances to meet the caps; those with lower costs of compliance will need to purchase fewer allowances at auction.

It should be noted that the most cost-effective or highest value (including cobenefits) approach for some sectors or sources may not be C&T; it may instead be technology-forcing or incentive policies that address specific market barriers (often referred to as "policies and measures" or "non-price instruments"). A C&T program will not necessarily remove market barriers or lead to the fastest or broadest adoption of new technologies and practices. For instance, split incentives exist between the suppliers and the consumers of energy or products. Suppliers may not be able to participate in the benefits of lower carbon goods or services provided to consumers at a higher production cost and lack an incentive to shift production even though the net benefit of such action to society is positive. Accordingly, electric utilities may not see it in their self-interest to provide energy-efficient technology options that reduce sales to consumers. Automobile companies may not see it in their self-interest to supply low-emitting vehicles that save consumers energy costs.

C&T has a solid foundation in theory and practice. It is based on the property rights approach to eliminating externalities, the most vivid example of which is environmental pollution. The seminal work was done by Nobel laureate Ronald Coase (1960), and its refinement for application to pollution problems was done by many others (see, e.g., Tietenberg 1985, 2007; Rose, 2009).

The practice of C&T was given a major boost in the 1990 Clean Air Act Amendments and is the basis for the U.S. sulfur allowance trading program for electric utilities (Ellerman et al. 2000). With respect to GHG reduction, the major experience has been the European Union Trading System (EUTS), which, after a rocky start due to some design flaws, is proving successful as well (Ellerman 2008).

Carbon Tax

There are two types of carbon taxes. One is a conventional tax imposed for the purpose of generating government revenue, the size of the tax being driven by the need for revenues. The second type of carbon tax operates on the same principle as C&T, that is, it imposes a cost on regulated entities for the purpose of affecting behavior and investments through a price signal. In this form, a carbon tax may generate revenue or it may be "revenue neutral" by allowing dollar-for-dollar reductions in other taxes and government fees.[1] The discussion here considers only the "price signal" form of carbon tax.

At first blush, the similarities between the C&T and the carbon tax are striking; both represent a fee imposed on the release of GHGs designed to create an incentive for investments in reduced emissions and other beneficial behavioral changes. With C&T, the government sets a limit on the total emissions and the market, through allowance trading or auctions, establishes the price. With the carbon tax, the government sets the price, or tax rate, and the market response to that price determines the total resulting emissions.

The carbon tax has some distinct advantages over C&T, notably its administrative simplicity for both the government and the regulated community and the wide familiarity with taxation in general. The wide familiarity and broad unpopularity of taxation, however, work against the carbon tax, at least in the political realm (although such taxes currently exist as surcharges on electricity bills, gasoline prices, etc.). British Columbia began administration of a nearly economy-wide carbon tax without having to add a single new position to its taxation ministry. Regulated industries often favor the carbon tax over C&T because of the stability of the cost imposed by the tax, as opposed to the C&T allowance price whose cost fluctuates as set by the market.

Most environmentalists and some political leaders tend to favor C&T due to the programmatic integrity offered by the cap and the fear that emissions reduction targets will not be met due to the uncertainties associated with predicting industry and public response to the carbon tax price signal. The inclusion of cost containment mechanisms may, however, reduce environmental certainty and reduce the relative advantage of C&T to other approaches in this regard.

Policies and Measures

The traditional and by far most common approach to limiting emissions of pollutants is through sector-based policies and measures, including direct regulation (or the "command-and-control" approach) as well as other incentive systems in which emissions are limited at the source by enactment of codes and standards, funding and technical assistance, or by various forms of limited permitting, incentives or disincentives. Source-based standards, for instance, are set by rule and enforced by some combination of permit-based source monitoring, reporting, and inspection or verification. These systems can, and often do, include substantial flexibility and tailoring to local circumstance. They also can be constructed to allow "extra credit" for surplus environmental achievement that can be transferred to or purchased by entities that need additional help in meeting standards. In fact, this type of performance-based system of credits for over achievement largely defined early concepts of C&T. Financial incentives or assistance are often provided in conjunction with regulation to reduce cost, compensate losses, and/or accelerate responses.

Direct regulation can carry a heavy administrative burden and lack the flexibility to allow sources to seek and fund least-cost mitigation opportunities (depending on the design of the program). However, through rulemaking, permit writing, and review, this approach has the advantage of flagging specific concerns with the proposed limits. Barriers to compliance are often identified and addressed through the close interaction between the regulator and the regulated community. These barriers may take the form of contradictory government regulation, such as when an excessive occupational health and safety requirement for workplace air exchanges prevents an employer from effectively reducing heating or cooling loads. Barriers may also take the form of market failures where the entity responsible for the capital investment to improve efficiency cannot reap the benefits of lower energy use, for example, rental housing where the tenants are responsible for heat, electricity, or water heating.

Direct regulation offers the greatest opportunity to identify and address such barriers. Absent resolution of these barriers, a C&T, or carbon tax policy may not have access to the lowest cost mitigation opportunities. A price signal without concurrent policies and measures to reduce barriers could be more expensive.

The Policy Formation Process

The Stakeholder Process

The Center for Climate Strategies (CCS) has facilitated comprehensive, economy-wide, stakeholder-driven climate mitigation planning in Michigan and in many other states. These states have studied portfolios of direct regulation, market-based, and incentive-based policies. Their resulting plans match the strengths of each policy measure with desired sector reductions, seeking the most effective, lowest cost mitigation opportunities. By so doing, direct regulation and incentive-based policies are teamed with market-based mechanisms to maximize the effectiveness of all.

Through its projects, CCS addresses climate, energy, and economic policy needs and opportunities across all sectors by working closely with government officials, institutional experts, and members of the stakeholder community. CCS provides the technical assessments, start-up planning, independent facilitation, policy design and analysis, and capacity building needed for successful consensus building and climate mitigation policy development. The CCS stakeholder process has been successfully used in twenty state climate change planning efforts and has to date included a combined total of over 1,500 stakeholders and experts across all geographic regions and economic sectors. The process combines the traditional facilitated conflict resolution model with corporate planning, community collaboration, expert technical assistance, and analysis. The development and analysis of policy options occurs at two levels. First is the ‘‘commission’’ composed of governor-appointed representatives of groups, interests, and parties that have a direct stake in the effects of climate change or efforts to mitigate them. Second is a set of sector-focused Technical Work Groups (TWGs) or subcommittees made up of members of the commission plus other individuals with special expertise.

In Michigan, the commission was the ‘‘Michigan Climate Action Council’’ or MCAC. The TWGs were aligned in traditional CCS fashion with one exception. They were Energy Supply (ES), which studied electricity generation, transmission and distribution, and fossil fuel extraction, processing, and transportation;

Residential, Commercial, and Industrial (RCI), which studied emissions from stationary sources such as industrial processes and fuel and electricity use in residential and commercial buildings; Transportation and Land Use (TLU), which studied mobile sources of GHG emissions and related drivers associated with land use, availability of alternative transportation options and so on; Agriculture, Forestry and Waste (AFW), which examined emissions and carbon sequestration opportunities in AFW management; Cross-Cutting Issues (CCI), which examined opportunities for emissions mitigation across sectors and so-called ''enabling policies''; and Market-based Policies (MBP), which examined opportunities for C&T, a carbon tax and related policies. The MBP Technical Work Group (TWG) was formed midway through the Michigan process when the ES and CCI TWGs observed that the complexity of the issue demanded the full-time attention of a special committee.[2]

The economic benefits of the market-based approaches depend upon the availability of a variety of low-cost or high value-added mitigation options. Logically, programs with a larger scope—either by geography or sector—will enjoy a larger pool of mitigation options, and therefore a greater availability of low-cost options. The modeling in support of the Minnesota and Florida processes bore this out both in terms of inclusion of all sectors and inclusion of other states. Michigan had joined the MGA C&T initiative before the TWG began work, so the only regional configuration studied was the six-state, one-province MGA group.[3]

At the start of its deliberations, the notion that the group could agree upon any strong recommendation may have seemed somewhat remote. It is our experience in facilitating, observing, and participating in several C&T policy design processes; participants and commenters tend to focus on a small subset of policy questions. At least at the start, the positions taken may appear to be irreconcilable. The facilitator's challenge where this occurs is to allow the participants to articulate their positions in terms of specific issues the group can resolve.

The Michigan MBP TWG was divided from the start over the issue of carbon tax versus C&T. Through several discussions, the group agreed that the two policies should not be presented or studied as mutually exclusive; rather, at least two scenarios modeling combined policies would be commissioned. The first scenario would assume a minimal C&T, regulating only electrical generating units, and fashioned after the Northeastern RGGI. For this scenario, the carbon tax would be applied broadly across all fossil fuels and sectors, except the electricity generation sector to prevent C&T regulated entities from also being subject to the carbon tax. The second scenario would assume a broad C&T covering the whole economy except the AFW management sectors which would serve as the source of offset projects. This C&T would be modeled after the WCI. Under this scenario, the carbon tax would be very small, applying only to the C&T-exempt AFW operations.

Unlike in many other states, Michigan Governor Granholm did not set a GHG reduction goal[4] at the outset of the MCAC process and challenge the group to meet it. Instead, the charge to the MCAC was to recommend a goal or goals that could be achieved through aggressive mitigation measures. The MCAC proposed a range of goals about half way through the process, and then in their final face-to-face meeting selected a specific goal as their recommendation. As a result, the C&T and carbon tax modeling had to run multiple scenarios reflecting each potential goal. The MCAC range created three goal scenarios, but subsequent to the MCAC choosing their range, the MGA selected a different range using a different base year and different target year. This required six goal scenarios for each of the two C&T/carbon tax program designs.

As the policy instrument model delivered its early results, the MBP TWG's recommendations began to coalesce. The option of a narrow C&T and a broad carbon tax became less attractive as it became apparent that the tax rate required to achieve the goal-driven reductions under nearly any goal would have to be untenably high. The option of a broad C&T and a carbon tax applied only on AFW management was more attractive and better aligned with the emerging direction of the MGA. Further modeling demonstrated that a bounty of negative cost mitigation and sequestration options within the AFW sectors indicated that nearly any of the goals could be achieved within those sectors without the carbon tax incentive. In other words, with a comprehensive C&T the carbon tax was not needed to achieve the goals. In the end, the MBP TWG, and by unanimous vote the MCAC, recommended only the broad C&T program and not the carbon tax.

Perhaps the most significant contribution the policy instrument model made to the MCAC process was to inform the final goal recommendation decision. The MCAC and MGA goals were so different that it was not intuitively apparent which range was more aggressive. The MCAC range was 25 to 35 percent below 2002 emission levels in 2025, and the MGA range was 15 to 25 percent below 2005 in 2020. By modeling the same C&T and carbon tax scenarios across all potential goals, the MBP TWG quickly realized that the original MCAC range was dramatically more aggressive than the MGA range, to the point that the upper MCAC goals might prove unachievable. The MBP modeling results were shared with the CCI TWG, which was responsible for recommending the goals, and they, and ultimately the MCAC, settled upon the middle MGA goal of 20 percent below 2005 by 2020 as their final recommendation.

Policy Instrument Modeling

Nonlinear Programming Model

The model we use for the Michigan C&T analysis is based on established economic principles. The model can be solved either as a system of simultaneous equations (equilibrium) or as a nonlinear program (optimization). It has been applied to the analysis of C&T associated with the international compliance to the Kyoto Protocol, EUTS, RGGI, ten U.S. Environmental Protection Agency (EPA) regions covering all states of the United States, Pacific Rim states and countries (see Rose et al. 1998; Zhang 2000; Rose and Zhang 2004; Rose, Peterson, and Zhang 2006; Rose and Wei 2008). This C&T model has also been applied at the state level and in conjunction with the policy-making process to examine coverage of all GHG emissions statewide (see, e.g., Minnesota Climate Change Advisory Group [MCCAG], 2008; Florida Governor's Action Team on Energy and Climate Change [FGAT], 2008).

The model is based on the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities (see, e.g., Tietenberg 2007). Where a strict cap implies unique GHG emission reduction requirements, the individual state and overall regional optimization can be accomplished without explicit consideration of the benefits side of the ledger (i.e., it yields "efficiency without optimality"). Therefore, the model simply requires equalization of marginal costs of all entities with the equilibrium permit price (see, Zhang 2000; Loeschel and Zhang 2002; Rose and Zhang 2004). Each state (or sector) would choose to purchase the allowances to emit or to mitigate emissions on its own, whichever is the cheaper alternative.[5]

Assumptions

We adopted the following general assumptions in the C&T analysis.

Emissions:

- All six GHGs from the covered sectors are included.
- Gross emissions (excluding forestry and agriculture soils sinks) are considered.

Marginal cost curves:

- Embody direct mitigation costs only.
- Do not include various transactions costs.
- Do not distinguish between producer versus consumer allocation of permits.

Basic design:

- Offsets are not included.
- No safety valve (permit price limit) is included.
- Recycling of auction or carbon tax revenues is not analyzed.
- Banking and borrowing of permits are not considered.

Data

Data requirements for the C&T model are parsimonious: GHG emissions projections, specification of the cap, and sectoral- or state-level marginal cost functions for mitigation and sequestration. Table 1 presents the climate mitigation options from the ES, RCI, and TLU sectors analyzed in a quantitative manner as part of the development of the Michigan Climate Action Plan (MCAC 2008). In Table 1, both the 2020 annual GHG reduction potentials and the per ton cost/savings for each option are presented. The original quantification data for Michigan are for Year 2025. To perform the C&T analysis for Year 2020, we estimate the cost curve for that year based on Year 2025 data and adjusting for an assumed 2 percent annual technical improvement or innovation rate.

Based on the options' data, the economy-wide (excluding AFW) stepwise marginal cost function for Michigan in 2020 is first drawn in Figure 1. In the stepwise function, each horizontal segment in the figure represents an individual mitigation option. The figure indicates that, collectively, the reduction potential of options from all economic sectors (excluding AFW) can reduce about 40.8 percent of 2020 baseline emissions in Michigan.[6]

Next, we fit a smooth curve through the data using regression analysis (see Figure 1). We weight each policy option based on its GHG mitigation potential to give relatively greater influence to those options that have the potential for higher levels of application. This fitted curve is used in both our C&T and carbon tax analyses model. The marginal cost curve is a powerful yet simple concept. Its dominant influence on the results makes the analysis very transparent.[7]

The 2020 marginal cost curves of the other MGA states/province are presented in Figure 2. Marginal cost curves of Minnesota and Iowa are developed based on mitigation options data in the Climate Change Action Plan of these two states, respectively. Because of the lack of direct cost and reduction potential data, the marginal cost curves of Manitoba and Wisconsin are approximated based on Minnesota data, and the cost curves of Kansas and Illinois are approximated based on Iowa and Michigan data, respectively. The approximation was done based on the assumption of identical costs for each option but adjustments for mitigation potential in each sector in each state.

Simulation Results

We simulated various types of policy instrument designs for Michigan for the year 2020 and year 2025. For the C&T system, the base case consists of the following:

- Economy-wide (except AFW)
- MGA regional partners

Table 1
GHG Mitigation Options of Michigan (All Sectors Excluding AFW), 2020

Sector	Climate Mitigation Actions	2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Cost or Cost Savings Per Ton GHG Removed (U.S. $)	Reduction Potential as Percentage of 2020 Baseline Emissions[a]	Cumulative GHG Reduction Potential (Percent)	Weights (add-up to 100)
TLU-6	Land Use Planning and Incentives	0.410	−$171.18	0.16	0.16	0.38
TLU-2	Eco-Driver Program	2.097	−$159.41	0.80	0.96	1.96
TLU-3	Truck Idling Policies	0.725	−$76.99	0.28	1.23	0.68
TLU-5	Congestion Mitigation	0.172	−$73.36	0.07	1.30	0.16
RCI-4	More Stringent Building Codes for Energy Efficiency	9.247	−$31.70	3.53	4.83	8.64
RCI-7	Promotion and Incentives for Improved Design and Construction in the Private Sector	0.000	−$28.08	0.00	4.83	0.00
RCI-2	Existing Buildings Energy Efficiency Incentives, Assistance, Certification, and Financing	51.288	−$25.36	19.58	24.40	47.94
ES-3	Energy Efficiency Portfolio Standard	13.918	−$17.21	5.31	29.72	13.01
RCI-1	Utility Demand-Side Management for Electricity and Natural Gas	0.000	−$17.21	0.00	29.72	0.00
ES-13	Combined Heat and Power (CHP) Standards, Incentives and/or Barrier Removal	0.477	$4.52	0.18	29.90	0.45
ES-11	Power Plant Replacement, EE, and Repowering	1.907	$10.40	0.73	30.63	1.78
ES-10	Biomass Cofiring at 10%	0.477	$11.84	0.18	30.81	0.45
TLU-1	Promote Low-Carbon Fuel Use in Transportation	5.625	$17.70	2.15	32.96	5.26
ES-6	New nuclear power	6.006	$28.74	2.29	35.25	5.61
RCI-6	Incentives to Promote Renewable Energy Systems Implementation	0.000	$29.87	0.00	35.25	0.00
TLU-8	Increase Rail Capacity, and Address Rail Freight System Bottlenecks	0.181	$38.72	0.07	35.32	0.17

(continued)

Table 1. (continued)

Sector	Climate Mitigation Actions	2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Cost or Cost Savings Per Ton GHG Removed (U.S. $)	Reduction Potential as Percentage of 2020 Baseline Emissions[a]	Cumulative GHG Reduction Potential (Percent)	Weights (add-up to 100)
ES-1	RPS and Distributed Generation "Carve-Out"	13.918	$53.10	5.31	40.63	13.01
TLU-7	Transit and Travel Options	0.515	$204.66	0.20	40.83	0.48
TLU-4	Advanced Vehicle Technology	0.029	$1,612.97	0.01	40.84	0.03

Notes: AFW = Agriculture, Forestry and Waste; ES = Energy Supply; GHG = greenhouse gas; RCI = Residential, Commercial, and Industrial; TLU = Transportation and Land Use
[a] Michigan 2020 projected consumption-based gross GHG emission level excluding AFW sector is 261.99 $MMtCO_2e$.

Figure 1
Economy-wide (Excluding AFW) Stepwise and Fitted Marginal Cost Curve for Michigan, 2020

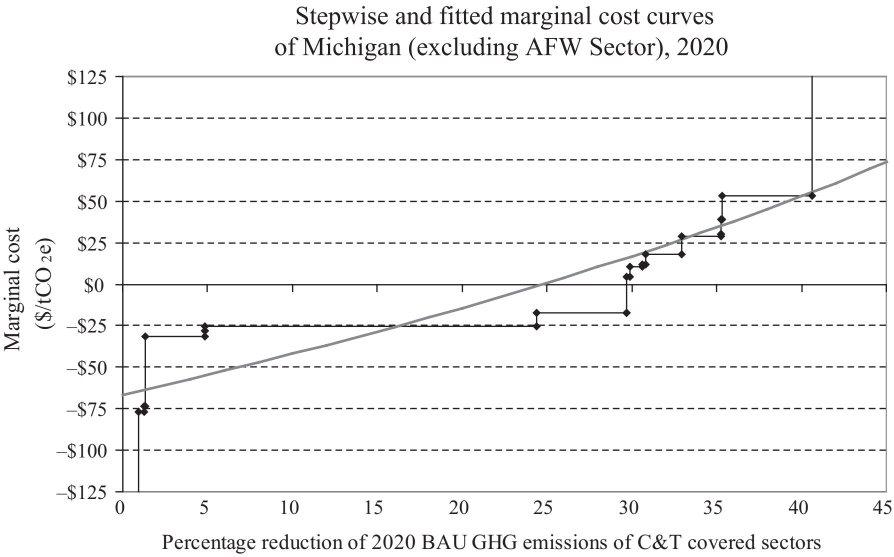
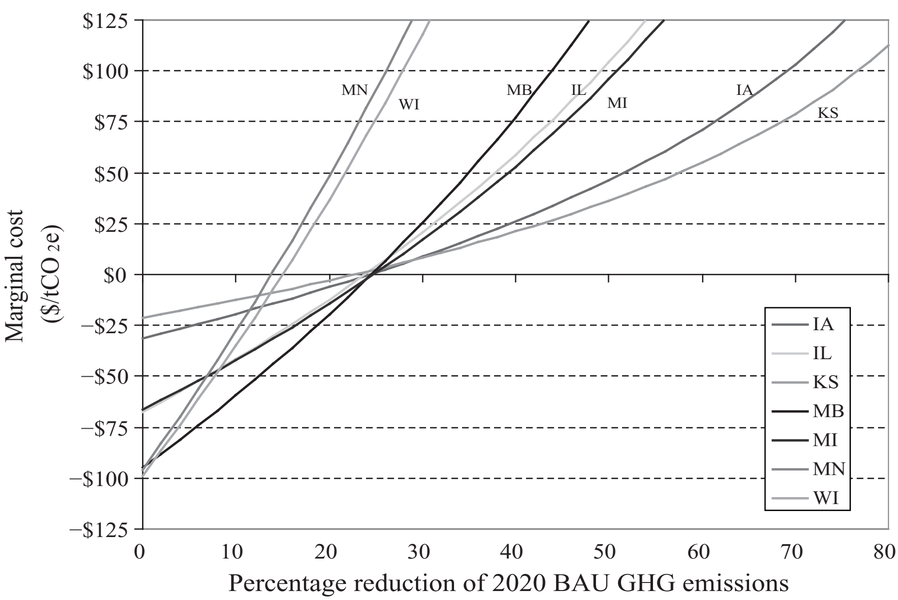


Figure 2
Marginal Cost Curves of MGA Partners (All Sections Excluding AFW), 2020



- 20 percent below year 2005 emissions level by year 2020
- Free granting of permits

The simulation results of the base case are presented in Table 2. The findings from the simulation are summarized below.

The base case simulation yields an equilibrium permit price of U.S.$35.35/t$CO_2$e in 2020. The total emission permits traded in the market would be 44.71 MMtCO_2e.

Michigan and Kansas are the two biggest permit sellers in the market. Minnesota is the biggest permit purchaser, followed by Wisconsin and Manitoba.

The factors that have the greatest influence on the simulation are the absolute and relative levels of the marginal mitigation cost curves. The former has the greatest influence on the potential for cost savings, while the latter has the greatest influence on the extent of permit trading across trading partners, including whether each partner is a permit buyer or seller.

For all of the MGA partners, the total net cost of achieving the carbon emission caps (the sum of the mitigation cost and the trading cost) under the C&T Program is negative. This means that compliance with the caps will result in overall cost

Table 2

Economy-Wide (Excluding AFW) Emission Trading Simulation among MGA Partners in 2020: MGA Goal 20 Percent Below 2005 Levels, With Free Granting of Allowances (Million Dollars or Otherwise Specified)

	Before Trading	After Trading				Permits Traded	Emission Reduction With Trading		Emission Reduction Goal
State/ Province	Mitigation Cost (U.S. $)	Mitigation Cost (U.S. $)	Trading Payments/ Revenues[a] (U.S. $)	Net Payment/Revenue + Cost (U.S. $)	Cost Saving (U.S. $)	($MMtCO_2$)	($MMtCO_2$)	(Percent from BAU)	(Percent from BAU)
IA	–$334	–$58	–$371	–$429	$96	–10.51	49.53	44.87	35.35
IL	–$2,111	–$1,993	–$126	–$2,119	$8	–3.55	100.93	34.02	32.82
KS	–$202	$183	–$608	–$425	$222	–17.20	48.83	49.41	32.00
MB	–$21	–$186	$82	–$104	$84	2.32	5.48	32.05	45.60
MI	–$2,195	–$1,788	–$601	–$2,389	$193	–17.00	92.48	35.30	28.81
MN	$1,592	–$928	$866	–$61	$1,653	24.51	28.40	18.37	34.22
WI	$1,168	–$939	$758	–$181	$1,349	21.45	27.44	19.82	35.31
Total	–$2,102	–$5,708	$0	–$5,708	$3,606	44.71[b]	353.08	32.75	32.75

Notes: AFW = Agriculture, Forestry and Waste; MGA = Midwestern Greenhouse Gas Reduction Accord.

[a] Permit price = $35.35/tCO_2e$.

[b] Represents number of permits bought or sold.

Table 3
Economy-Wide (Excluding AFW) Emission Trading Simulation among MGA Partners in 2020: MGA Goal 20 Percent Below 2005 Levels, With Auction of Allowances (Million Dollars or Otherwise Specified)

State/ Province	Total BAU Emissions in 2020 ($MMtCO_2$)	Emission Reduction Undertaken by Emission Sources[a]		Emission Allowances Bought From Auctioneer ($MMtCO_2$)	Auction Payment by Emitters/ Revenue to the State (Million U.S.$)[b]	Mitigation Cost (Million U.S.$)	Total Payments and Costs (Million U.S.$)
		(Percent from BAU)	($MMtCO_2$)				
IA	110.39	44.87	49.53	60.86	$2,151	–$58	$2,093
IL	296.69	34.02	100.93	195.76	$6,920	–$1,993	$4,927
KS	98.82	49.41	48.83	49.99	$1,767	$183	$1,951
MB	17.09	32.05	5.48	11.61	$410	–$186	$224
MI	261.99	35.30	92.48	169.51	$5,992	–$1,788	$4,205
MN	154.59	18.37	28.40	126.19	$4,461	–$928	$3,533
WI	138.44	19.82	27.44	111.00	$3,924	–$939	$2,985
Total	1,078.01	32.75	353.08	724.93	$25,626	–$5,708	$19,918

Notes: AFW = Agriculture, Forestry and Waste; MGA = Midwestern Greenhouse Gas Reduction Accord.
[a] In equilibrium, each state will choose to mitigate the same level of emissions as they would do in a permit trading market.
[b] The auction price would be at the same level ($33.35/$tCO_2e$) as the equilibrium price in a permit trading market.

savings. This result is due to the existence of an extensive range of cost-saving options, such as improvements in energy efficiency.

The emission reductions from the C&T covered sources within Michigan are expected to be 92.48 $MMtCO_2e$ in 2020. Since Michigan is expected to be a permit seller in the market, the emission reductions undertaken by the instate C&T covered sources would exceed the reduction requirement indicated by the state emission caps. Michigan would gain a profit by selling the surplus permits to the other MGA partners.

All states/province are better off as a result of participating in GHG allowance trading, since all the posttrading net costs are smaller than the pretrading net costs. Compared with the pretrading situation, Michigan can achieve cost savings of U.S.$193 million in 2020.

In the analysis below, we examine variations on the base case scenario, including auctioning of the permits and alternative reduction goals. Table 3 presents the simulation results for the 100 percent auction-based MGA C&T. In the auction case, all permits would be purchased from the government auctioneer and there would be no permit trading among partners. In equilibrium, each partner would choose to mitigate the same level of emission as it would in a permit trading market (after trading), and then buy allowances for its remaining emissions from the auctioneer. The auction price would be at the same level as the equilibrium price in a permit trading market. The total auction payments of the MGA partners are U.S.$25.6 billion. The Michigan emitters would pay about U.S.$6 billion to purchase 169.5 MMtCO_2e permits from the auctioneer. Note, however, the auction costs are not real resource costs to society but are simply transfer payments from one entity to another. Our analysis does not include the impacts of recycling the auction revenues through government investment in new research and development in energy-efficiency technologies, direct efficiency investments, tax relief, or other measures.

We also simulated free-granting and auction-based C&T for two alternative MGA 2020 reduction goals: 15 percent and 25 percent below 2005 levels by Year 2020. The equilibrium permit price of these two cases is U.S.$21.2/t$CO_2$e and U.S.$50.82/tCO_2e, respectively. In the free-granting C&T cases, the outcomes in terms of which partners are the permit sellers or buyers did not change in these two alternative goal simulations. By joining the MGA economy-wide C&T program, Michigan can achieve cost savings of U.S.$187-207 million in 2020. In the auction simulations, the auction payments of Michigan range from U.S.$3.8 to U.S.$8.1 billion in 2020.[8]

It was also recommended that a carbon tax to be pursued in sectors that are not covered by the C&T program. Since we assumed the C&T program would be economy-wide except for the AFW sector, the carbon tax was modeled to be applied to the AFW sector only. MCAC 2025 goals instead of the MGA regional goals are used in the study, since the carbon tax program is assumed to be internal to the state of Michigan only.

Our modeling results indicate that the three alternative 2025 reduction goals for Michigan for the AFW sector can be met by using cost-saving policies and measures from this sector alone, that is, the carbon tax is not needed to achieve the reductions. Although these targets could be met without any incentives to mitigate or disincentives to emit because they are cost-saving, such an outcome does not always take place because of obstacles to implementation. Therefore, we simulate the response to five hypothetical carbon taxes.

With a hypothetical carbon tax at U.S.$1/t$CO_2$e, the AFW sector can reduce around 65 percent of its 2025 baseline emissions. When the tax rate increases to U.S.$25 or higher, the AFW sector would have the incentive to abate over 90 percent of its emissions to avoid paying the tax. This is mainly because of the existence of substantial cost-saving and low-cost mitigation/sequestration options in the AFW sector. The total carbon tax payments increase from U.S.$5.8 million to U.S.$41.9 million when the tax rate increases from U.S.$1 to U.S.$25.[9]

Overview of Recommendations

The MBP TWG presented four policy recommendations to the MCAC for their consideration. They were MBP-1, C&T; MBP-2, Carbon Tax; MBP-3, Michigan

Joins the Chicago Climate Exchange; and MBP-6, Market Advisory Group. The latter was an enabling recommendation and MBP-3, Michigan joins the Chicago Climate Exchange (CCX), was a "lead-by-example" recommendation for Michigan State Government, as an emitting entity, to voluntarily join the CCX, which contractually requires members to monitor, report, and reduce GHG emissions overtime.

After analyzing the two C&T and Carbon Tax scenarios across six potential sets of goals and considering the most recent direction from the MGA discussions, the TWG recommended the broadest C&T program studied, the "economy-wide except for AFW management" proposal. The MCAC unanimously supported the TWG recommendations.

The carbon tax, or MBP-2, was designed to mesh with the C&T to ensure all economic sectors participated, but no entity would be required to pay the tax and also be subject to C&T regulation. Given the "economy-wide except AFW" recommendation, this left the AFW sectors subject to the tax. The carbon tax modeling demonstrated that the Michigan goals could be achieved within these sectors without the need of a carbon tax price signal. Furthermore, the MCAC reasoned that C&T offsets would come from the AFW sectors because all remaining sectors were regulated under the program. Therefore, these AFW sectors would in fact participate in the C&T. Finally, the prospect of assessing an emissions tax on GHG releases from farms was not favored by most members. In the end, the MCAC failed to recommend the Carbon Tax for lack of a majority in support.

As discussed in The Policy Formation Process section, the policy instrument model played a pivotal role in the selection of a GHG reduction goal for Michigan. The model's presentation of expected allowance prices for each scenario and each potential goal equated to projecting the marginal cost of mitigation for the last (most expensive) ton of CO_2 reduced to meet the goal. This information critically informed the MCAC's final selection of the mid-range MGA goal as the most appropriate for the State of Michigan.

Conclusion

This article has illustrated how research can directly support facilitation of the joint fact-finding and policy-development process at the state and regional level in the case of climate policy. Incentive-based systems, such as emissions allowance trading and carbon taxation, are attractive policy instruments because they afford the opportunity to meet environmental targets at the lowest possible cost (under certain market conditions and for some actions), while allowing emitters freedom of choice in their response, a feature that promotes compliance. Moreover, the potential cost-effectiveness of the policy instrument can further be enhanced by broadening the geographic coverage, thereby providing an inducement for interregional cooperation, and by coordinating the incentive-based system with conventional policies and measures that enhance access to low-cost mitigation.

Also important, however, is the clear need to implement nonprice instruments and actions (sector-based policies and measures, such as energy efficiency) to complement and enable market-based instruments to remove or reduce market barriers for emissions markets and enable focus on cobenefits. By fully integrating comprehensive policy actions, overall costs are reduced and cobenefits are expanded, along with political acceptance.

Still, state-level policy makers have little experience with these policy instruments, especially C&T. Moreover, C&T is complicated by a variety of possible design configurations relating to how emissions are allocated, the extent of coverage of emission sources in terms of sectors and political jurisdictions, the role of safeguards for the allowance price, and the potential of combining this instrument with others, such as regulation. It is helpful for policy makers to know how these policy instruments work and to have a prediction of the cost implications of alternative designs.

This article has shown how simulations of incentive-based policy instruments can inform the policy process. The model used is highly transparent and capable of simulating a wide variety of design features. Of course, the model also builds on a legion of scholarly research that established the conceptual and empirical basis for emissions trading and carbon taxes, as well as experience at the national level with similar instruments such as sulfur emissions allowance trading and energy taxes. The articel is intended to provide a template for research and policy formation interaction for the many state-level entities in the United States and other countries that are now or are likely soon to be designing and implementing climate change policy.

Notes

1. The Province of Quebec, for example, has enacted a revenue-driven carbon tax for the purpose of funding provincial climate change programs. The Province of British Columbia enacted a revenue-neutral carbon tax in mid-2008, with 100 percent of the carbon tax revenues applied to reductions in other personal income, payroll and business taxes.

2. CCS had previously been involved with similar TWGs in Minnesota and Florida. CCS also assisted Maryland in analyzing a C&T program within its Energy Supply TWG, but Maryland had already joined the Northeast's Regional Greenhouse Gas Initiative, and therefore the analysis was limited to that alignment. Another state that CCS facilitated the C&T and carbon tax analysis is Iowa. The study was undertaken within the Clean and Renewable Energy (CER) Subcommittee.

3. The benefits of national or regional action were sufficiently well understood that the MCAC included a specific recommendation opposing a Michigan-only market-based mechanism.

4. State goals are typically stated as total emissions in some future year shall be at or below some historical benchmark, such as "20 percent below 2005 by 2020."

5. The model can readily be adapted to include such alternative design features as: variations in sector and source coverage, implications of the cap on emission reduction requirements overtime, offsets, variations on auctioning, upstream versus downstream application, borrowing and banking, and any explicit

constraints on the permit price or trading (see Stevens and Rose 2002). With a few minor modifications, the same model can also be used to simulate a carbon tax.

6. Our approach to develop the marginal cost function enables the analysis of sensitivity cases of mitigation options. For example, accounting for different learning and penetration effects or technological innovations can be readily reflected in the cost function by variations in the width (usually lengthening) and height (usually lowering), as well as the sequencing of the corresponding segments of the options.

7. For example, as a cross-check, an analyst or policy maker need only identify a carbon tax rate or an allowance price on the vertical axis, and then, noting its intersection with the curve, be able to identify the GHG emission reduction forthcoming for a given state. Analogously, one can begin with the emission reduction target and work backward to find the carbon tax rate or the allowance price needed. Emissions trading can be determined by looking at the relative positions of the curves for the states included in the consortium. Auction and carbon tax revenues can be readily determined as well. In the case of the carbon tax, it is simply the tax rate multiplied by the emissions. In the auction case, it is equal to the allowance price times the number of allowances auctioned.

8. The MGA regional reduction goals were announced midway of our C&T analysis for Michigan. Before the release of the MGA goals, we had been examining an alternative and much more stringent set of goals based on the Michigan Climate Action Council (MCAC) tentative target for the Year 2025: to reduce GHGs by 25 percent to 35 percent from the 2002 emissions level in 2025. It is not surprising to find that a MGA economy-wide C&T program following the MCAC goals would yield much higher permit prices than in our base case: U.S.\$74.99/tCO_2e to U.S.\$113.52/tCO_2e. Michigan would still be a permit seller in the market and would achieve U.S.\$344 to U.S.\$394 million cost savings in 2025 by joining the MGA C&T program.

9. Note that the tax payments are not a real social cost (of using up resources) but simply a transfer from one entity to another within the state. In addition, the analysis does not consider the direct or indirect benefits resulting from the use of carbon tax revenues by the government for various purposes.

Appendix

Table 1 identifies a large number of cost-saving options in the C&T program covered sectors to mitigate GHGs in Michigan. To provide some perspective, we summarize some of the literature on this subject. McKinsey & Company (2007) researchers estimated the net costs and CO_2 equivalent reduction of more than 250 mitigation and sequestration options for the United States. This study indicated that a significant number of options yield long-term net cost savings. The McKinsey study analyzed three alternative scenarios of abatement potentials (low-range, mid-range, and high-range) in which the cost-saving mitigation potentials in 2030 range from 6 to 18 percent. However, the report also suggested that the sectoral distribution of the costs is likely to be uneven and the availability of low-cost abatement options differ substantially across regions.

In the IPCC (2007) Fourth Assessment Report of Working Group III, GHG emission reduction potential and associated costs were evaluated by sector and by cost categories. The IPCC report indicated that the abatement potentials at negative cost would be considerable. For the Transportation, Buildings, Forestry, and Waste sectors, the total cost-saving mitigation potentials for the Organisation for Economic Co-operation and Development (OECD) countries in 2030 are 2.2 gigatons of CO_2e, or 11 percent of the OECD 2030 baseline emissions level. Most of the cost-saving potentials come from the buildings sector. For all the economic sectors, reduction potentials with cost less than U.S.$20/t$CO_2$e are reported to be 4.3 gigatons of CO_2e, or 21.5percent of the OECD 2030 baseline emissions level.

In contrast to the above studies, others challenge the existence of substantial cost-saving mitigation opportunities. Sutherland (2000) points out that most "no cost" analyses belong to the methodological framework of "engineering-cost" analysis or "bottom-up" analysis (see, e.g., previous criticisms of such approaches by Jacoby 1999). Critics charge that these evaluation methods are inconsistent with, and thus not supported by, mainstream economics. In a recent study by Stavins Jaffe, and Schatski (2007), the authors questioned the validity of the results in three studies (performed by California's Climate Action Team, the Center for Clean Air Policy, and University of California, Berkeley Professors), which indicated that the California's 2020 emissions target can be achieved through a portfolio of options resulting at a negative net cost. Although Stavins and his colleagues did not quantify the extent of cost underestimation, they identified the following factors that could have caused the over-optimistic estimation of cost-saving potentials in these studies: (1) omission of important components of costs of emission reductions; (2) overestimation of future savings that some of the mitigation efforts can yield; (3) improper evaluation of how energy users discount the value of future savings; (4) incorrect forecast of baseline behavior; and (5) underestimation of the effectiveness and cost of policies that would be necessary to implement the mitigation actions.

The stakeholder and TWG process in Michigan represented a diversity of interests and including over 100 participants. The groups collaborated intensively over a twelve-month period, and generated policy-specific and state-wide cost estimates, including consideration of a wide range of existing studies and choices regarding specific data sources, assumptions for analysis, and a variety of policy instruments, including price and nonprice mechanisms. This in-depth process reduced any biases or errors in the cost estimation.

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