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The SO_2 Allowance Trading System: The Ironic History of a Grand Policy Experiment

Richard Schmalensee and Robert N. Stavins

In the late 1980s, there was growing concern in the United States and other countries that acid precipitation—the result of emissions of sulfur dioxide (SO_2) and, to a lesser extent, nitrogen oxides (NO_x) reacting in the atmosphere to form sulfuric and nitric acids—was damaging forests and aquatic ecosystems, particularly in the US Northeast and southern Canada. In the United States, flue gas emissions from coal-fired, electric generating plants were the primary source of SO_2 emissions and a major source of NO_x emissions. In response to this and other concerns, the US Congress passed and President George H. W. Bush signed into law the Clean Air Act Amendments of 1990. Title IV of this law (which took up only 16 percent of its total pages) launched a grand experiment in market-based environmental policy: the path-breaking SO_2 allowance trading program.

The concept of allocating permits to emit a certain quantity of pollution that would phase down over time, while allowing permit-holders to trade their permits, is now broadly familiar. But two decades ago, this cap-and-trade approach to environmental protection was quite novel. Many in the environmental community—with the prominent exception of the Environmental Defense Fund—were hostile to the notion of trading "rights to pollute"; others doubted the workability of such a scheme. Nearly all pollution regulations took a much more prescriptive

■ *Richard Schmalensee is the Howard W. Johnson Professor of Economics and Management, Emeritus, Massachusetts Institute of Technology, Cambridge, Massachusetts. Robert N. Stavins is the Albert Pratt Professor of Business and Government at the Harvard Kennedy School, Cambridge, Massachusetts, and a University Fellow of Resources for the Future, Washington, D.C. Both authors are also Research Associates, National Bureau of Economic Research, Cambridge, Massachusetts. Their email addresses are rschmal@mit.edu and robert_stavins@harvard.edu.*

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"command-and-control" approach, either by setting uniform emission rate limits on classes of emitters or by specifying the type of pollution-control equipment to be installed. Of course, such inflexible regulations impose the same abatement path upon a range of heterogeneous facilities and ignore the fact that the costs of compliance might vary widely across individual facilities depending on their age, technology characteristics, operating conditions, and characteristics of fuel used.

By the close of the twentieth century, the SO_2 allowance trading system had come to be seen as both innovative and successful (for discussion in this journal, see Schmalensee, Joskow, Ellerman, Montero, and Bailey 1998; Stavins 1998). It has become exceptionally influential, leading to a series of policy innovations in the United States and abroad to address a range of environmental challenges, including the threat of global climate change (Stavins 2003). Most prominent among these innovations has been the European Union Emission Trading System, a carbon dioxide (CO_2) cap-and-trade system adopted in 2003 that is by far the world's largest environmental pricing regime (European Commission 2012).

However, the design and implementation of the landmark SO_2 cap-and-trade system have led to a number of striking ironies, which are the focus of this essay. First, subsequent research indicates that in enacting an ambitious—and successful—policy to reduce SO_2 emissions in order to curb acid rain, the government essentially did the right thing for the wrong reason. Second, although the program appears to have been successful, a substantial source of its cost-effectiveness was an unanticipated consequence of the deregulation of railroad rates in the late 1970s and early 1980s. Third, market-based, cost-effective policy innovation in environmental regulation—in particular, cap-and-trade—was championed and implemented by Republican administrations from that of President Ronald Reagan to that of President George W. Bush, but in recent years Republicans have led the way in demonizing cap-and-trade (as an approach to limiting carbon emissions). Fourth and finally, court decisions and subsequent regulatory responses have led to the virtual collapse of the SO_2 market, demonstrating that what the government gives, the government can take away. In order to explore these four ironies, we first briefly review highlights of the system's design and performance.

A fifth, long-recognized irony deserves brief mention. Acid rain itself was largely a consequence of compliance with national ambient air quality standards set in the 1970s for SO_2 and other localized pollutants. In order to reduce local concentrations of these pollutants, electric utilities built more than 400 tall smokestacks, many greater than 500 feet in height (Regens and Rycroft 1988), which successfully dispersed the stack gases, but did so by injecting them high enough into the atmosphere that they precipitated out tens or hundreds of miles downwind as acidified rain, snow, or particles.

Design

Any cap-and-trade policy must face two basic decisions, the level of pollution to be permitted over time and how the initial allocation of permits will be set. The

objective of the SO_2 trading program was to reduce total annual US SO_2 emissions by 10 million tons relative to 1980. Phase I (1995–1999) of the trading program required significant emissions reductions from the 263 most-polluting coal-fired electric generating units, almost all located east of the Mississippi River. Phase II, which began in 2000, placed an aggregate national emissions cap on approximately 3,200 electric generating units—nearly the entire fleet of fossil-fueled plants in the continental United States (Ellerman, Joskow, Schmalensee, Montero, and Bailey 2000). This cap—affecting almost exclusively the power sector—represented a 50 percent reduction from 1980 levels. The permits were demarcated by vintage, with the total number decreasing for successive vintages, thereby achieving a declining cap. (The discussion in this section draws on Chan, Stavins, Stowe, and Sweeney 2012; also see Ellerman et al. 2000.)

How was this target selected? When the policy was enacted, no credible estimates of economic benefits of alternative target levels were available. (Actually, this is true of most environmental policies.) Instead, the target was selected largely based on what was believed to be the "elbow" of the abatement cost curve—that is, a level of abatement that was possible at relatively low costs, and above which the marginal costs of reducing emissions would climb dramatically. This process was consistent with the Baumol and Oates (1971) model of policy making, whereby a politically acceptable target is chosen with an eye toward avoiding regions of steep change in the policy's impact on social welfare. Also, there was a political desire to choose a target level of reductions that was big enough to gain the support of the environmental community and to be seen as satisfying a campaign pledge of newly elected President George H. W. Bush.

The government *gave* permits to emit called "allowances"—denominated in tons of SO_2 emissions—to power plants covered by the law. (The term "permit," which is standard in the economics literature, had another long-established meaning in US environmental law, so the new term "allowance" was coined and used instead.) If annual emissions at a regulated facility exceeded the allowances allocated to that facility, the owner could buy allowances or reduce emissions, whether by installing pollution controls, changing the mix of fuels used to operate the facility, or scaling back operations. If emissions at a regulated facility were reduced below its allowance allocation, the facility owner could sell the extra allowances or, since damages were understood to reflect cumulative emissions over time rather than annual emissions, bank them for future use. EPA's role was essentially to keep score by monitoring emissions on a continuous basis, tracking the ownership of all outstanding allowances (that is, recording initial allocations and subsequent trades), and withdrawing allowances corresponding to each facility's emissions from its account annually. As opposed to a command-and-control regulatory scheme that would have specified an across-the-board timeline for reductions in emissions or dictated specific technologies for pollution control, a cap-and-trade system created incentives to find ways to reduce SO_2 emissions at the lowest cost and to take advantage of low-cost abatement options as soon as they became available.

The free allocation of allowances posed some tradeoffs. After all, government auctioning of allowances would have generated revenue that could, in principle, have been used to reduce distortionary taxes, thereby reducing the program's social cost (Goulder 1995). But this efficiency argument was not advanced at the time; and the affected utilities and their customers' representatives would have strongly opposed auctioning.

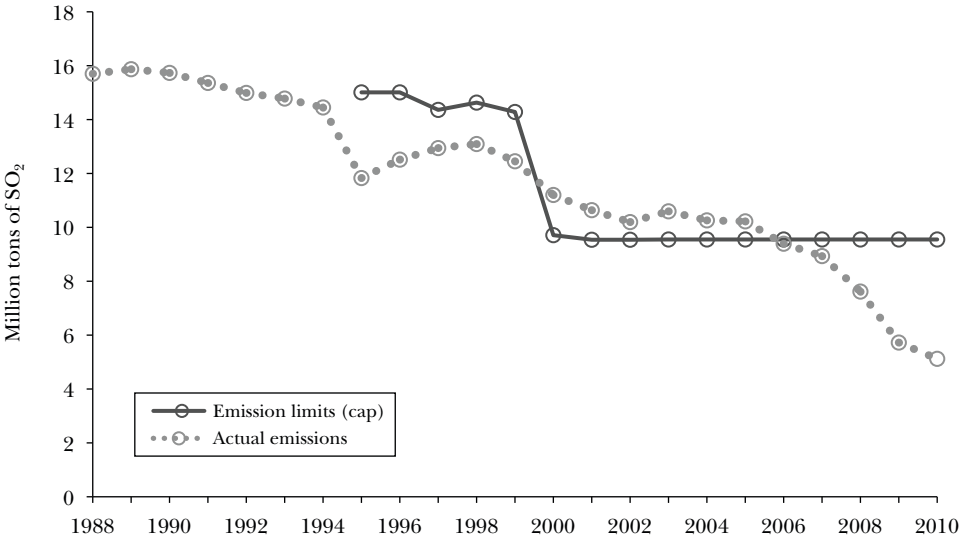
The case for free allocation rested on several arguments. Because cost-of-service regulation characterized the entire investor-owned electric utility industry in 1990, it was assumed that the value of free allowances would be passed on to consumers and would not generate windfall profits for providers. (The use of any allowance involves an opportunity cost because the allowance could be sold instead of used. Absent regulation, output prices would be expected to increase to reflect these opportunity costs, and because the allowances were in fact freely allocated, windfall profits would result.) As important, the political value of being able to allocate free allowances to address differential economic impacts across regions, states, and Congressional districts as well as other concerns was substantial (Joskow and Schmalensee 1998). This was possible because the equilibrium allocation of pollution permits, after trading has occurred, is independent of the initial allocation (Coase 1960; Montgomery 1972)—at least barring particularly problematic types of transaction costs (Stavins 1995; Hahn and Stavins 2011). This means that the initial allocation of allowances could be designed to ensure the greatest political support without fear that this would jeopardize the system's environmental performance or economic cost.

Performance

Beginning in 1995 and over the subsequent decade, the SO_2 allowance trading program performed exceptionally well along all relevant dimensions. SO_2 emissions from electric power plants decreased 36 percent—from 15.9 million to 10.2 million tons—between 1990 and 2004 (US Environmental Protection Agency 2011b), even though electricity generation from coal-fired power plants *increased* 25 percent over the same period (US Energy Information Administration 2012). The program's long-term annual emissions goal was achieved in 2006, and by 2010, SO_2 emissions had declined further, to 5.1 million tons, as shown in Figure 1.

Overall, the program delivered emissions reductions more quickly than expected, as utilities, particularly Phase I units, took advantage of the freedom to bank allowances for future use. (Phase I units were expected, in aggregate, to have lower costs of emissions reduction than Phase II units). Hence, emissions from Phase I units fell well below their cap from 1995 to 1999 and then total emissions temporarily exceeded their cap as banked allowances were used for compliance. After 2006, total emissions (from all units combined) dropped to well below the aggregate cap because of other regulations that imposed tighter restrictions, as we discuss later. With the program's $2,000/ton statutory fine for any emissions exceeding allowance holdings and continuous emissions monitoring, compliance was nearly 100 percent.

Figure 1
SO_2 Caps and Emissions, 1988–2010



Source: Ellerman (2003); US Environmental Protection Agency (2012).
Notes: The emission limits shown for the period 1995–1999 are equal to the Phase 1 units' cap plus Phase 2 units' emissions. Actual emissions shown for all years are the sum of emissions from Phase 1 and Phase 2 units.

The costs of achieving these environmental objectives with cap-and-trade were significantly less than they would have been with a command-and-control regulatory approach. Cost savings were at least 15 percent, and perhaps as much as 90 percent, compared with counterfactual policies that specified the means of regulation in various ways and for various portions of the program's regulatory period (Carlson, Burtraw, Cropper, and Palmer 2000; Ellerman et al. 2000; Keohane 2003). In addition to static cost effectiveness, there is evidence that the program brought down abatement costs over time by providing incentives for innovation and diffusion that were generally much stronger than those provided by traditional command-and-control regulation. Utilities learned how to burn cost-effective mixtures of different types of coal,[1] how to take allowance prices into account in operating decisions, and how to build more cost-effective flue gas desulfurization devices, called "scrubbers" (Ellerman et al. 2000, pp. 235–48; Popp 2003; Bellas and Lange 2011; Frey 2013).

[1] Coal is often divided into three categories: anthracite, bituminous, and lignite. Anthracite is the highest-quality coal, burning with the most energy. Much eastern coast coal is bituminous, and is of intermediate quality. Much of the Powder River Basin coal is "sub-bituminous." Lignite is the lowest quality.

While the SO_2 trading program was less costly than a conventional approach, the costs may or may not have been as low as they could have been. There was significant trading—about 20.3 million tons of allowances were bought and sold by March 1998 (Ellerman et al. 2000, p. 176)—but the implications of this large amount of trade are not obvious. The efficient volume of trade depends on the difference between the initial allocation of allowances and the efficient distribution of emissions among regulated entities, thus very low volumes of trading could also be consistent with overall cost minimization. That said, marginal abatement costs did vary significantly across facilities, at least in the program's first two years (Carlson, Burtraw, Cropper, and Palmer 2000).

There is evidence that the intertemporal allocation of abatement cost (via allowance banking) was at least approximately efficient (Ellerman and Montero 2007), with greater-than-required emissions reductions in Phase I used (via banking) to delay more expensive reductions by Phase II units. In addition, the pattern of voluntary compliance was consistent with cost-effective compliance strategies (Montero 1999). Finally, it is worth noting that the volume of trading grew substantially during the program's early years as utilities gained experience, from 1.5 million tons in the April 1994 to March 1995 period, to 8.4 million tons in the April 1997 to March 1998 period (Ellerman et al. 2000, p. 176).

The following factors could have kept costs above the theoretical minimum, though their influence has been debated: 1) certain provisions in the 1990 legislation that encouraged early use of scrubbers instead of switching to low-sulfur coal, provisions included in an attempt to limit effects of the legislation on high-sulfur coal producers (Ellerman et al. 2000, pp. 301–302); 2) lack of information about marginal abatement costs on the part of market participants, particularly in the early years; 3) state regulations intended to protect domestic high-sulfur coal interests that, particularly in the early years of the program, had the effect of distorting or constraining utilities' responses to federal environmental regulation (Arimura 2002; Bohi and Burtraw 1992; Ellerman et al. 2000, pp. 190–95); 4) interactions between the SO_2 program and other federal regulations, such as New Source Review and New Source Performance Standards, which constrained the program's operation (Gruenspecht and Stavins 2002); and 5) policy uncertainty when regulators and policy makers subsequently considered further reductions in the national SO_2 cap, as we discuss later.

The program can also be evaluated based on the geographic distribution of impacts. Recall that the program came into being mainly in response to concerns about acid rain in the US Northeast. Although it was clear at the time the program was enacted that emissions from different plants had different impacts, the Title IV emissions trading scheme ignored this fact. Most coal-fired power plants were located east of the Mississippi, and model-based analyses predicted that the largest share of cost-effective emissions reductions would come from plants having the greatest impact on lakes and forests in the Northeast. Nonetheless, some worried that emissions would end up disproportionately concentrated and would produce "hot spots" of unacceptably high SO_2 concentrations. Despite these concerns, the

geographic pattern of emissions reductions was broadly consistent with model predictions, and the program did not generate significant hot spots (Ellerman et al. 2000, pp. 130–31; Swift 2004).[2]

In sum, the SO_2 allowance trading system's actual costs, even if they exceeded the cost-effective ideal for a cap-and-trade system, were much lower than would have been incurred with a comparable traditional regulatory approach. The program's goals were achieved with less litigation (and thus less uncertainty) than is typical for traditional environmental programs, both because firms that found it particularly costly to reduce emissions had the option of buying allowances and because firms could not complain about the exercise of administrative discretion by the US Environmental Protection Agency, as the law gave it essentially no discretion. Overall, there is broad agreement that the SO_2 allowance trading system provided a compelling demonstration of the advantages of a market-based approach to environmental protection. With this background on design and performance, we turn to four significant ironies.

Doing the Right Thing for the Wrong Reason

The central purpose of the SO_2 allowance trading program was to reduce the acidification of forest and aquatic ecosystems by cutting precursor SO_2 emissions, primarily in the northeastern United States (National Acid Precipitation Assessment Program 1998). The goal of reducing SO_2 emissions was met and exceeded. However, it turns out that the ecological benefits of the program have been relatively small, largely because it takes much longer than thought to reverse the acidification of ecosystems (National Acid Precipitation Assessment Program 2005). On the other hand, other completely unanticipated benefits of the program have been massive.

Whereas some studies at the time of the program's enactment predicted that its benefits would be approximately equal to its costs (Portney 1990), more recent estimates suggest annual benefits of between $59 and $116 billion, compared with annual costs of $0.5 to $2 billion, as shown in Table 1. However, more than 95 percent of these benefits are associated not with ecological impacts—including acidification of aquatic ecosystems—but instead with human health impacts of reduced levels of airborne fine sulfate particles less than 2.5 micrometers in diameter ($PM_{2.5}$), particles which derive from SO_2 emissions. Epidemiological evidence of the harmful human health effects of these fine particulates mounted rapidly in the decade *after* the CAAA was enacted (Chestnut and Mills 2005).

Estimates of these health benefits vary widely, but they appear to be on the order of $50 billion to more than $100 billion per year (Burtraw, Krupnick, Mansur,

[2] Muller and Mendelsohn (2009) suggest that the use of damage-based trading ratios, where allowances might be adjusted for the marginal environmental damage each source of emissions would do, rather than using a single allowance price, could have been welfare-improving. Of course, the practical challenges of setting such ratios—particularly in a political environment—would be serious.

Table 1
Estimated Annual US Benefits and Costs of the SO_2 Allowance Trading Program; Title IV, Clean Air Amendments of 1990
(billions of US 2000 Dollars)

Benefits	
Mortality	50–100
Morbidity	3–7
Recreational visibility	2–3
Residential visibility	2–3
Ecosystem effects	0.5
Total	**59–116**
Costs	**0.5–2.0**
Net benefits	**58–114**

Source: Burtraw, Krupnick, Mansur, Austin, and Farrell (1998); Burtraw (1999); Chestnut and Mills (2005); Banzhaf, Burtraw, Evans, and Krupnick (2006).

Austin, and Farrell 1998; Burtraw 1999; Chestnut and Mills 2005; National Acid Precipitation Assessment Program 2005; Shadbegian, Gray, and Morgan 2005; US Environmental Protection Agency 2011a).[3] As Table 1 shows, strict ecosystem benefits are probably considerably less than program costs, though at least one study (Banzhaf, Burtraw, Evans, and Krupnick 2006) suggests that ecosystem benefits alone have exceeded costs. But estimated human health benefits of the program may have exceeded annual costs by a factor of more than fifty! With its mandated 50 percent cut in SO_2 emissions, the government did what turned out to be the right thing for the wrong reason.

An Unanticipated Consequence of Deregulation

The realized costs of the SO_2 allowance trading program were substantially less than forecasts made prior to implementation (National Acid Precipitation Assessment Program 2005).[4] Part of this discrepancy was due to technological innovation and the speed with which the allowance market matured. But another major factor in low realized compliance costs was the emergence of input substitution,

[3] The lower end of this range of benefit estimates is linked with the possibly nonlinear relationship between cuts in SO_2 emissions and reductions in $PM_{2.5}$ deposition (West, Ansari, and Pandis 1999).
[4] A revolutionary aspect of the cap-and-trade approach was that for the first time regulators had instantaneous information in a summary statistic (the allowance price) of the marginal cost of compliance, but the program's design did not allow for any response to that information, such as changing the cap.

from high- to low-sulfur coal, as a cost-effective strategy for reducing SO_2 emissions. Indeed, the attractiveness of switching to low-sulfur coal was increasing *before* the program even went into effect due to a public policy change *unrelated to the environment* and initiated long before 1990.

The three major coal deposits in the United States are located in the Powder River Basin of Wyoming and Montana, the Illinois Basin, and Central Appalachia. Of these, Powder River Basin coal is cheapest to mine and has the lowest sulfur content (though considerable low-sulfur coal was also produced in the East, particularly after the acid rain program took effect). However, the majority of coal-fired power plants in the United States are located along or east of the Mississippi River, making Powder River Basin the most distant option for major sources of demand.

Prior to 1976, the Interstate Commerce Commission set rates for freight rail, which is the main way in which coal is transported. The Railroad Revitalization and Regulatory Reform Act of 1976 and the Staggers Rail Act of 1980 gave rail carriers the ability to set their own rates and legalized private railroad-shipper contracts. As a result, shipping rates for coal (and other products) declined significantly (Winston 2005; US Government Accountability Office 2007). The cost of bringing coal from the Powder River Basin to centers of high demand east of the Mississippi River fell dramatically (Ellerman et al. 2000)—even though the existence of only two major rail lines kept shipping costs above competitive levels (Busse and Keohane 2007).

Deregulation gave the freight carriers flexibility and incentive to contract with eastern utilities, and, as noted above, these same utilities developed cost-effective ways to burn sub-bituminous coal (which had lower energy content as well as lower sulfur content) (Ellerman et al. 2000, pp. 243–45). The average sulfur content of coal burned at electric generating units began to fall. In fact, SO_2 emissions at units covered by the allowance trading program were actually falling from 1985 to 1993, *before* the acid rain program took effect (Ellerman and Montero 1998). The main source of this decline was the increased use of Powder River Basin coal, with average rail rates of shipping that coal from Wyoming and Montana to Midwest generators falling by over 50 percent from 1979 to 1993 (Gerking and Hamilton 2008).

For some power plants, fuel-switching from high- to low-sulfur coal was cost-effective even without acid rain legislation; and for many other eastern power plants, rail deregulation made fuel-switching less expensive than installing scrubbers in response to the legislation. Of the 263 units regulated in Phase I of the allowance trading program, 52 percent primarily pursued fuel-switching or blending low-sulfur coal with higher-sulfur coal, accounting for 59 percent of emissions reductions; and scrubbers were installed at about 10 percent of the units, accounting for 28 percent of emissions reduction (US Energy Information Administration 1997).[5] About one-third of SO_2 emissions reductions in the early years of the program were due to

[5] In addition, 32 percent of the units complied by obtaining additional allowances as well as switching to lower-sulfur coal, accounting for 9 percent of emissions reductions; 3 percent of the units were retired, accounting for 2 percent of emissions reductions; and 3 percent of the units used other compliance methods, accounting for 2 percent of emissions reductions (US Energy Information Administration 1997).

prior railroad deregulation and two-thirds to the SO_2 allowance trading program (Ellerman et al. 2000, p. 122).

It could be argued that because these reductions in delivered fuel costs would have occurred in the absence of the SO_2 allowance trading program and would have reduced the costs of a command-and-control SO_2 program as well, the cost savings attributed to the SO_2 allowance trading program (relative to a command-and-control system) should be adjusted downward (Carlson et al. 2000). This point has some validity, but it is also true that a prescriptive regulatory approach—say, a policy that required installing scrubbers at all power plants—might have prevented electricity companies from taking advantage of some of these alternative compliance options. In any event, it is clear that significant shares of the emissions reduction—about one-third in the early years—and of the cost savings associated with the SO_2 allowance trading system were actually an unanticipated consequence of an earlier, unrelated public policy change.

Conservatives Demonize Their Own Innovation

For a long time, market-based approaches to environmental protection, such as cap-and-trade, bore a Republican label. In the 1980s, President Ronald Reagan's Environmental Protection Agency put in place a trading program to phase out leaded gasoline. It produced a more rapid elimination of leaded gasoline from the marketplace than had been anticipated, and at a savings of some $250 million per year compared with a conventional no-trade, command-and-control approach (Stavins 2003). Not only did President George H. W. Bush successfully propose the use of cap-and-trade to cut US SO_2 emissions, his administration advocated in international forums the use of emissions trading to cut global CO_2 emissions, a proposal initially resisted but ultimately adopted by the European Union. In 2005, President George W. Bush's EPA issued the Clean Air Interstate Rule, aimed at reducing SO_2 emissions by a further 70 percent from their 2003 levels. Cap-and-trade was again the policy instrument of choice. (More about this rule below.)

When the Clean Air Act Amendments were being considered in the US Congress in 1989–1990, political support was not divided on partisan lines. Indeed, environmental and energy debates from the 1970s through much of the 1990s typically broke along geographic, rather than partisan, lines,[6] with key parameters being degree of urbanization and reliance on specific fuel types, such as coal versus natural gas. Thus, the Clean Air Act Amendments of 1990 passed the US Senate by a vote of 89–11 with 87 percent of Republican members and 91 percent of Democrats voting yea, and the legislation passed the House of Representatives by a vote of 401–21 with 87 percent of Republicans and 96 percent of Democrats voting in support.

[6] The same was true of trade policy debates until the early 1990s, that is, they were driven by economic impacts on various sectors and populations, which resulted in geographic, not partisan, divisions.

However, 20 years later when climate change legislation was receiving serious consideration in Washington, environmental politics had changed dramatically, with Congressional support for environmental legislation coming mainly to reflect partisan divisions.[7] In 2009, the US House of Representatives passed the American Clean Energy and Security Act of 2009 (H.R. 2454)—often known as the Waxman–Markey bill—that included an economy-wide cap-and-trade system to cut carbon dioxide (CO_2) emissions. The Waxman–Markey bill passed the House by a narrow margin of 219–212, with support from 83 percent of Democrats, but only 4 percent of Republicans. In July 2010, the US Senate abandoned its attempt to pass companion legislation. In the process of debating this legislation, conservatives (largely Republicans and some coal-state Democrats) attacked the cap-and-trade system as "cap-and-tax,"[8] much as an earlier generation of liberals had denigrated cap-and-trade as "selling licenses to pollute."

Many conservatives in the Congress undoubtedly opposed climate policies because of disagreement about the threat of climate change or the costs of the policies, but instead of debating those risks and costs, they chose to launch an ultimately successful campaign to demonize and thereby tarnish cap-and-trade as an instrument of public policy, rendering it "collateral damage" in the wider climate policy battle. This scorched-earth approach could come back to haunt conservatives if future environmental initiatives with widespread support are enacted without making use of the power of the marketplace to reduce compliance costs. It is ironic that conservatives chose to demonize their own market-based creation. It is perhaps even more ironic that this tactic seems to have been effective despite their creation's excellent performance.

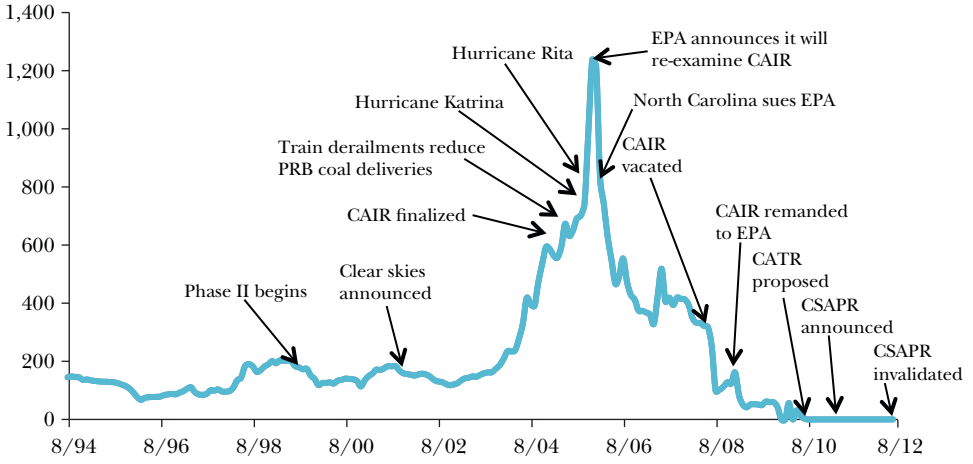
What the Government Gives, It Can Take Away

A major source of uncertainty about any government-created market is that the government can undo what it created—possibly unintentionally. In essence, this happened in the SO_2 allowance market. Through a series of new Clean Air Act regulations, court rulings, and regulatory responses, the courts affirmed that EPA could not set up a new interstate trading system or modify the Title IV system in the absence of new legislation from Congress. In response, state-level and source-level constraints were put in place that ultimately rendered the SO_2 cap-and-trade system itself nonbinding and effectively closed down the allowance market.

[7] This polarization between the two political parties on environmental issues (Shipan and Lowry 2001) was and is part of a gradually widening gulf between the parties on virtually all issues (Fleisher and Bond 2004; Poole and Rosenthal 1997, 2007). Moderates have been gradually disappearing for decades (Lowry and Shipan 2002; Theriault 2008).

[8] They may have been helped by President Obama's February 2009 budget message to Congress, which provided for revenues from an auction of 100 percent of the allowances under such a scheme (Chan, Stavins, Stowe, and Sweeney 2012).

Figure 2
SO_2 Allowance Prices and the Regulatory Environment, 1994–2012
(1995 dollars per ton)



Source: Data on spot prices compiled by Power & Energy Analytic Resources (PEAR) Inc. from Cantor Fitzgerald until September 11, 2001, and from ICAP United thereafter.
Notes: CAIR is "Clean Air Interstate Rule." CATR is "Clean Air Transport Rule." CSAPR is "Cross-State Air Pollution Rule."

Prices for SO_2 allowances were remarkably stable throughout the program's first decade, as shown in Figure 2, and then we see a steep spike. What happened? It was widely recognized by the late 1990s that SO_2 reductions in excess of those resulting from the trading program of Title IV would be required by other provisions in the Clean Air Act dealing with air quality standards because of the significant adverse health effects of fine particulates associated with SO_2 emissions. But the law did not give the EPA authority to adjust the Title IV program, such as by tightening the overall cap, in response to new information about the benefits (or costs) of emissions reductions. This crucial fact drove the chain of events leading to the ultimate collapse of the SO_2 allowance trading program.

In early 2002, President George W. Bush proposed the Clear Skies Act, which would have greatly tightened the SO_2 cap. Prices in the allowance market did not immediately budge, however, which suggests it was no surprise to market participants when this proposal died in March 2005, having failed to move out of committee. The Bush administration then promulgated its Clean Air Interstate Rule in May 2005, with the same purpose of lowering the cap on SO_2 emissions (to 70 percent below the 2003 emissions level). This rule sought to apply more stringent emission requirements on states that were contributing to violations of EPA's primary ambient air quality standards for fine particulates in the eastern United States (Palmer and Evans 2009). It required sources within those states to surrender two additional allowances for every ton of SO_2 emissions—effectively reducing the cap by two-thirds. Because

the Clean Air Interstate Rule provided that firms could bank their existing SO_2 allowances for use in the new program, prices rose further in anticipation of this more stringent cap, with spot prices increasing from $273 per ton in EPA's 2004 auction to $703 in the 2005 auction.[9]

After peaking in 2005 at more than $1,200 per ton (see Figure 2), SO_2 allowance prices dropped just as fast as they had risen, aided by an announcement from the US Environmental Protection Agency that it would reexamine the Clean Air Interstate Rule (Samuelsohn 2005) and speculation about impending legal challenges (Samuelsohn 2006a; Kruse 2009).[10] On June 26, 2006, North Carolina and other states and a number of utilities sued the Environmental Protection Agency over the Clean Air Interstate Rule (Samuelsohn 2006b). The states argued that the interstate trading allowed under the rule was inconsistent with Section 110(a) of the Clean Air Act, which obliges each state to prevent emissions that interfere with any other state's attainment or maintenance of air quality standards. This meant that the EPA could not set up a new trading program built on the SO_2 allowance trading system by regulatory means and would therefore have to focus on source-level or other types of regulation in its efforts to reduce emissions below the limits established in Title IV in order to meet new local-air-quality standards. Because the new, required regulation, rather than Title IV, would become the binding constraint on emissions, trading under the original SO_2 allowance trading system would be rendered unimportant.

Two years later, on July 11, 2008, the Circuit Court of Appeals for the District of Columbia (*State of North Carolina v. Environmental Protection Agency*, 531 F. 3d 896 [D.C. Cir. 2008]) vacated the Clean Air Interstate Rule in its entirety on the grounds that, under the Clean Air Act, the Environmental Protection Agency could not ignore the relationship between sources and receptors in matters involving air quality standards (US Environmental Protection Agency 2011a). Thus, without new legislation, the Title IV program, with interstate trading at its core, could not be

[9] An array of other factors contributed to the run-up and eventual spike in SO_2 allowance prices, including Hurricanes Katrina (August 2005) and Rita (September 2005), which impaired petroleum refining and natural gas capacity. In addition, delivery of low-sulfur coal from the Powder River Basin to Midwestern power plants was disrupted by track failures (May 2005) on both the Union Pacific and Burlington Northern Santa Fe railroads, which caused low-sulfur coal prices in the Midwest to peak in December 2005, at a level three times greater than a year earlier. As a result, some power companies switched to higher-sulfur coal from the east, increasing demand for SO_2 allowances. A final factor was features of the allowance trading program's design that interacted with the tax system and utility regulation to restrict the number of allowances actually available for trading at any time (the "float"), thus compounding the price impacts of the other factors (Parsons, Ellerman, and Feilhauer 2009).

[10] Also contributing to the fall in allowances prices from their peak was a drop in natural gas prices, the restoration of refining and gas capacity in the Gulf of Mexico following Hurricanes Katrina and Rita, and the realization of a likely adequate supply of allowances and installed scrubber capacity to comply with the Clean Air Interstate Rule (Burtraw and Szambelan 2009). In addition, many expected an economy-wide CO_2 cap-and-trade system, which all three major Presidential candidates—John McCain, Hillary Clinton, and Barack Obama—in 2007 supported and which would have led to an exogenous, long-run decline in coal usage and thus in SO_2 emissions, and hence to a decline in the value of banked allowances.

modified to drive further reductions in SO_2 emissions to meet air quality standards. On that single day, the SO_2 allowance price fell from $315 to $115 (Burtraw and Szambelan 2009). The Bush administration, followed by the subsequent Obama administration, chose not to appeal that ruling. The court allowed the Clean Air Interstate Rule to remain in effect while the EPA devised a replacement that addressed its concerns, but it remained clear that unlimited interstate trading was doomed. Prices continued to fall, returning to the range of their pre-2004 levels. At the 2009 auction, spot allowances (which could be used in 2009 or later) sold for $70 per ton, compared with $390 a year earlier (Burtraw and Szambelan 2009).

In July 2010, the Obama administration proposed an alternative rule to limit annual SO_2 (and NO_x) emissions in 28 states, as a replacement for the Clean Air Interstate Rule. The proposed rule established state-specific emissions caps for power plant SO_2 emissions, thereby limiting interstate trading. The rule was finalized in July 2011 as the Cross-State Air Pollution Rule, allowing only intrastate trading and limited trading between two groups of states. Predictably, this rule too was challenged in court, by 27 states and 18 other parties; in August 2012, the US Court of Appeals for the D.C. Circuit invalidated the rule (*EME Homer City Generation, L.P. vs. Environmental Protection Agency, et al.*, No. 11-1302).

While the SO_2 allowance market functioned well, the broader regulatory environment served to end its effective life. The allowance market remains nominally in place, but the imposition of state-level and source-specific prescriptive regulation has virtually eliminated the demand for federal SO_2 allowances. By the time of the Environmental Protection Agency's 2012 auction, market-clearing prices had fallen to $0.56 in the spot auction and $0.12 in the seven-year advance auction.[11] Those states with binding caps for SO_2 under the Cross-State Air Pollution Rule must still reduce their emissions, whether by mandating the use of scrubbers, retiring coal-fired power plants, or setting up intrastate trading of emission allowances.

In essence, the series of regulations, court rulings, and regulatory responses that followed Congress's rejection of the George W. Bush administration's Clear Skies Act affirmed that: 1) EPA cannot set up an interstate trading system under the Clean Air Act in the absence of specific legislation from Congress (which, of course, it had for the SO_2 allowance trading system under Title IV of the Clean Air Act amendments of 1990); and 2) consequent state-level and source-level constraints following the Clean Air Interstate Rule rendered the SO_2 cap-and-trade system itself nonbinding.

One more irony: the SO_2 program's success may have weakened the case for continuing the allowance market by reducing the heterogeneity of abatements costs across sources, thus reducing potential gains from trade (Newell and Stavins 2003).

[11] When new Mercury and Air Toxics Standards affecting coal-fired power plants take effect—likely in 2015–2016—they will likely be so stringent that SO_2 constraints under the Cross-State Air Pollution Rule will be rendered nonbinding in one of the two SO_2 trading zones. Further, the Mercury and Air Toxics Standards explicitly do not allow trading, and so assuming these rules are finalized and implemented as expected, there will be only a minimal market for SO_2 (Burtraw, Palmer, Paul, Beasley, and Woerman 2012).

When the government creates a market, it can also destroy it, possibly fostering a legacy of increased regulatory uncertainty and reduced investor confidence in future cap-and-trade regimes, and hence reduced credibility of pollution markets more broadly.

Conclusions

More than 20 years ago, the Clean Air Act amendments of 1990 launched the path-breaking SO_2 allowance trading system, the world's first large-scale market-based environmental initiative. That grand experiment in public policy continues to enjoy its reputation around the world as a great success. Although it is true that the system performed at least as well as its advocates had anticipated through its first decade of operation—reducing emissions cost-effectively—it is also true that reflections from our current perspective yield a considerably more nuanced assessment of performance. The actual costs of compliance turned out to be lower than expected, but this was in substantial part an unintended consequence of other, nonenvironmental policy innovations: specifically, the earlier deregulation of US railroads that allowed less-expensive delivery of low-sulfur coal from the Powder River Basin to the Midwest. The actual benefits turned out to be substantially greater than originally expected but not because of ecological benefits. Rather, reductions in SO_2 emissions resulted in substantial decreases in downwind concentrations of small particulates, thereby producing great benefits to human health.

What appeared in 1990 to be a quintessential moderate Republican approach to environmental protection—cap-and-trade—generated great hostility from conservatives 20 years later. In the process of opposing Congressional climate policy initiatives in 2009–2010, conservatives demonized cap-and-trade proposals as "cap-and-tax" and may have thereby tarnished this market-based approach to environmental protection for years to come. Ironically, an attempt by a Republican administration to use the cap-and-trade approach to reduce the SO_2 emissions cap eventually led, through a series of court cases and regulatory responses, to the virtual closure of the SO_2 allowance market.

What are some lessons of this history of the SO_2 allowance trading program for future market-based and other public policies? First, much is often learned over time regarding any policy's benefits and costs. What may appear to be wise initially may not turn out to be wise in the long term, and what appears to be unwise initially may turn out to be very attractive in the long term. Thus it can be important for policies to be flexible and responsive to changes in knowledge and technology. On the other hand, policy stability encourages efficient investment, so unnecessary changes can be destructive. It can be argued that the SO_2 cap-and-trade system provided valuable stability, but the legislation also made it impossible to make what would have been responsive, effective, and efficient changes in the policy.

Second, unintended consequences of policies are almost inevitable. They can sometimes be beneficial, as in the case of the effects of rail deregulation on the

performance of the SO_2 allowance trading system. They can sometimes be negative, as when regulatory responses to invalidation of the Clean Air Interstate Rule led to the virtual collapse of the SO_2 market. But by definition, such changes are almost impossible to predict. The implication is to be very careful and modest with forecasts and assessments. This can be demonstrated by a retrospective review of initial (under)estimates of the consequences of the Staggers Rail Act of 1980 and (overly hopeful) assessments of the promulgation of the Clean Air Interstate Rule in 2005.

Third, in most cases, politics trumps science and economics. The target of Title IV to reduce SO_2 emissions by 50 percent was set neither on the basis of the science, drawing on the findings of the National Acid Precipitation Assessment Program, nor economics, drawing on a comparison of anticipated benefits and costs. The implication is not to ignore politics but, rather to design policies that are likely to succeed in real-world political settings. Cap-and-trade systems can facilitate sound performance in political settings because of their ability to build constituencies of political support through free allocation of allowances without this negatively affecting the system's aggregate performance, either environmentally or economically.

Fourth, market-based policies have great cost and feasibility advantages, but like any public policy, the government can change or repeal these initiatives, or render them irrelevant. Market-based and other public policies can be constrained by other policies. Economists and other analysts tend to examine policies one at a time, but this misses potential interactions, which can be exceptionally important (Goulder and Stavins 2011).

Finally, what are the implications for future climate change policy? The bad news seems to be that "cap-and-tax" rhetoric may make it hard to use this approach in the United States to deal with climate change. Emissions of CO_2 from coal-fired power plants will no doubt be reduced by EPA rules on SO_2, NO_x, mercury, coal fly-ash, and cooling-water withdrawals that are working their way through the regulatory process and that will drive up the cost of generating electricity with coal. But these rules, and those likely to be adopted by the Environmental Protection Agency in response to the US Supreme Court decision in *Massachusetts et al. v. Environmental Protection Agency et al.* (549 US 497 [2007] (at http://www.supremecourt.gov/opinions/06pdf/05-1120.pdf) that it regulate CO_2 under the Clean Air Act, are unlikely to be cost-effective policies for reducing greenhouse gas emissions in the long run. At a time when environmental protection in general and climate policy in particular have become highly partisan in the US Congress, the outlook for an efficient and effective national climate policy is not very promising.

The good news, however, is that cap-and-trade is no longer just a subject for academic seminars and journal articles; it is a proven, viable option for tackling large-scale environmental problems. It is now being used around the world, including for addressing CO_2 emissions linked with global climate change. Even if the SO_2 allowance trading program's performance was enhanced by unanticipated benefits and declines in coal prices, and even if it has been essentially wiped out by later policy changes, the fact is that the allowance trading program achieved its

target emissions reductions rapidly and cost-effectively. Few other environmental programs of any sort have performed as well.

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