Interactions Among Climate Policy Regulations

Arik Levinson
aml6@georgetown.edu

Prepared for
"The Design and Implementation of U.S. Climate Policy"
May 13-14, 2010
Washington DC

Abstract

With few exceptions, economic analyses of "cap-and-trade" permit trading mechanisms for climate change mitigation have been based on first-best scenarios without pre-existing distortions or regulations. The reason is obvious: interactions between permit trading and other regulations will be complex. However, not only will climate policy proposed for the U.S. certainly interact with existing laws, but it will also likely include additional regulatory changes with their own sets of interactions. Major bills introduced in the U.S. Congress have included both permit trading and traditional command and control regulations. This paper discusses interactions between these instruments, and begins to lay out a framework for thinking about them systematically. The most important determinant of how the two types of instruments interact involves whether or not the cap-and-trade permit price would induce more or less abatement than mandated by the more traditional regulatory standards. Moreover, economists' experience predicting the costs of environmental regulations suggests we are more likely to overstate the costs of cap-and-trade, and therefore the price of carbon permits, than we are to overstate the costs of a traditional regulatory standard, and that therefore the regulatory standards will likely reduce the cost-effectiveness benefits of cap-and-trade.

Interactions Among Climate Policy Regulations

Introduction

Climate policy, if it is to be successful, will be large. Aldy and Pizer (2008) put the cost to the U.S. as comparable to the "total cost of all existing environmental regulation." Unfortunately, economists' models work best at the margins, predicting the consequences of small incremental changes in policy that affect isolated sectors of the economy. Models work less well for large discrete shifts in policy that affect many sectors simultaneously, the type of regulation likely to be necessary to reduce greenhouse gas (GHG) emissions. The difficulty inherent in assessing large policy changes is that their general equilibrium effects can be vast – even bigger than their direct effects.

Another word for general equilibrium effects, broadly speaking, is "interactions." The size and scope of proposed climate legislation means there will be important interactions with most of the economy, including government tax revenues, other environmental problems aside from climate change, labor markets, terms of trade effects, and other government regulations.

To define a reasonably limited area of attention, I focus on the simplest and most direct form of interaction – those between the tradable GHG emissions permit systems ("cap and trade") that are part of most proposed and enacted new climate bills around the world, and the more traditional command-and-control regulatory standards. For climate regulations that have already been passed, mostly in Europe, and for the climate regulations that have been proposed in the U.S., the coexistence of these multiple instruments is "the norm, rather than the exception" (Bennear and Stavins, 2007). In part, that coexistence has emerged because the cap-and-trade climate laws have been laid down on top of decades of traditional standards. But the coexistence is also written into the language of climate bills that typically include both tradable permits and traditional standards. Either way, we need to think about interactions between the two types of regulatory instruments.

The coupling of tradable permits with traditional standards has been called a "belt-and-suspenders" approach (Pearlstein 2009). In this case, however, it is not clear whether the belt and suspenders are mutually reinforcing, redundant but harmless, or working at cross-purposes. All three viewpoints have appeared in print. Krugman (2010) articulates the mutually reinforcing viewpoint: "I would advocate supplementing market-based disincentives with direct controls." Sijm (2005) makes the case for redundancy: "the coexistence of EU ETS and policies affecting fossil fuel use by participating sectors is hard to justify and, hence, these policies could be considered to be redundant and ready to be abolished." And the U.S. Congressional Budget Office (2009) sees the two as sometimes conflicting: "regulatory standards combined with market-based approaches often will increase the cost of meeting an environmental goal."

Which viewpoint is correct? The answer can be seen in a simple reinterpretation of the standard textbook partial-equilibrium model illustrating the cost-effectiveness of tradable permit schemes. And that answer depends on whether the price of the tradable GHG emissions permits, and hence the marginal cost of compliance with the cap-and-trade legislation, is higher or lower than the marginal cost of compliance with the traditional regulatory standard. Intuitively, if the permit price exceeds the regulatory compliance costs, firms and industries would exceed the regulatory standard anyway, in response to the cap-and-trade incentives, and the regulatory standard is ineffectual. If the permit price falls below the regulatory compliance costs, the regulatory standard changes the way polluters meet the emissions cap, and raises the cost of meeting that cap without any resulting increase in abatement. But if there are other market failures aside from the GHG externality, or there are logistical complications in directly targeting GHG emissions, there can be compelling reasons to pair the cap-and-trade mechanism with a traditional regulatory standard. And finally, economists' demonstrated experience forecasting regulatory costs suggest we are more likely to overstate the costs of meeting a cap-and-trade regulation than a traditional standard, and that therefore where the two instruments are paired, they are likely to increase costs without accompanying abatement benefits.

Before turning to focus on interactions between cap-and-trade and traditional standards, it is worth recognizing a few of the many important interactions that discussion leaves out.

Other Interactions -- An Aside

U.S. climate policy with interact with a long list of other important considerations. For example, analysts have long recognized that policies aimed at reducing one pollutant may result in more emissions of another (Sigman, 1996). For another, an enormous literature exists on spillover effects across countries, either because environmental regulations in one country move polluting industry to less stringent countries (Brunnermeier *et al.*, 2004), or because, more subtly, environmental regulations have terms of trade effects (Bohringer *et al.*, 2010). Another vast literature looks interactions between pollution taxes and other government tax revenues (Goulder, 2002) and expenditures (Metcalf, 2008).

The focus here, broadly speaking, is about how environmental regulations targeted at the same pollutant interact with one another. Economists have begun to recognize the importance of these interactions, as policies have begun to pile up and interact in complex ways (Oikonomou and Jepma, 2008; Sorrel and Sijm, 2003; Either and Pethig, 2009). This work tends to either provide semantic taxonomies of interactions, elaborate charts of interactions, or models with features designed to study specific but very complex parts of the EU's existing tradable permit system. And, to my knowledge, there has been no empirical work that would shed light on the extent of the possible interactions or their consequent effects.

The Textbook Model

For a long time, economists have focused on persuading policymakers to use market-based instruments – emissions taxes or cap-and-trade – *instead of* traditional regulatory standards rather than in *addition to* traditional standards. Some version of figure 1 appears in most undergraduate environmental economics texts, as a means of illustrating the cost-effectiveness of a tradable permit system compared with a regulatory standard. The bottom axis displays the total uncontrolled pollution from two sources. The sources could be two factories, two industries, two different control strategies, etc. Source one, for example, could be carbon mitigation from utilities using renewable energy portfolios, and source 2 could represent carbon mitigation from increased energy efficiency. Each source has a marginal abatement cost curve (MAC). Regulatory standards mandate a certain amount of abatement from each source. Figure 1 depicts two such standards, where the standard imposed on source 1 (Std_1) leads to lower marginal abatement costs than the standard imposed on source 2 (Std_2). The point of tradable permits is to allow source 1 to do more abatement and source 2 to do less abatement, until the MACs are equal (to **P***) and no further gains are possible. The cost savings are areas ***c+d−b***, or equivalently the shaded areas ***a+c.*** These cost savings provide the justification for replacing standards with tradable permits.

In practice, however, US climate legislation will likely contain a tradable permit scheme along with regulatory standards, either because the standard predates the newer tradable permit scheme, or because the new legislation has both parts. For example, Title III of H.R. 2454, the bill the U.S. House of Representatives passed in 2009, would impose a tradable cap on GHG emissions, while Title I of the same bill requires electric utilities to generate up to 25 percent of their output from renewable sources.

First suppose the renewable standard is like "Std_1" in figure 1, and the cap on total emissions is the same as if both sources had been regulated – i.e. the emissions cap alone would lead to a permit price of **P***. In this case, the marginal cost of meeting the renewables standard is less than the marginal cost of meeting the tradable emissions cap. The standard is effectively irrelevant. Polluters faced with the tradable cap would choose to do more abatement than required by the standard, even if the standard did not exist. There may be some regulatory costs associated with administering the standard (monitoring, compliance paperwork, etc.), but other than that the standard has no economic costs.

On the other hand, suppose the standard is like "Std_2" in figure 1. Here the marginal cost of meeting the standard exceeds the marginal costs of meeting the tradable emissions cap. Polluters faced with the tradable cap alone would choose to do less abatement via source 2 than required by the standard. By forcing more abatement via source 2, the standard lowers the market price of the tradable permits, reducing the incentives for polluters to abate via source 1. In this simple two-source model, the efficiency costs from standard 2 are the shaded areas, ***a+c***, the same as if both standards had been imposed on both sources. The cost savings from the tradable permit scheme are eliminated by the imposition of standard 2.

How can we tell if a standard combined with a tradable permit scheme is irrelevant, like standard 1, or cost-ineffective, like standard 2? The key distinction is whether the marginal compliance costs are higher for meeting the tradable cap or the standard. If the costs from the tradable cap are higher, the standard is largely irrelevant; if the costs from the standard are higher, it imposes real costs.

The CBO (2009) estimates that the renewable portfolio standards in Title I of H.R.2454 are like standard 1 in figure 1 – largely irrelevant economically because the estimated cost of meeting the standard will fall short of the estimated tradable GHG emissions permit price. By contrast, Abrell and Weight (2008) examine the European Union's Emissions Trading System, in conjunction with the renewable portfolio standards in Germany. They find the German renewable portfolio standard to be much more costly than the price of GHG permits, and that the renewable standards push the carbon price to zero. In other words, all of the abatement necessary will come from the one source – renewables, despite the fact that other sources are less costly.[1]

Gonzalez (2007) surveys a number of papers that examine this tradeoff between tradable emissions permits and renewable electricity standards. The studies he examines find that the coexistence of the two instruments is generally costly, because renewable electricity sources are not typically the least-cost means of abating GHG emissions. For example, Unger and Ahlgren (2005) examine tradable GHG permits for the Nordic countries, and find that a renewable electricity standard of 10 percent reduces carbon emissions at a cost seven times higher than a pure cap-and-trade system.

All of these studies make predictions about whether the non-market regulations will be inframarginal, inducing less compliance than predicted by response to cap and trade, or binding, inducing more compliance. This turns out to be a difficult forecast, because the whole rationale for cap-and-trade is that compliance costs are difficult to predict. In fact, Harrington, *et al.* (2000) compare ex ante and ex

[1] In fact, if Abrell and Weight are correct, the cost-inefficiency of Germany's renewable portfolio may have a silver lining. The standards would lead to an excess supply of permits, meaning that they reduce GHG emissions by more than the total required by the carbon cap. In other words, renewables alone as a source of abatement reduce GHG by more than would be reduced by all sources combined under the tradable cap.

post assessments of U.S. regulations issued by EPA and OSHA, and find that the ex ante forecasts of costs are typically too high.

> "Of the rules initially examined, 14 projected inflated total costs, while pre-regulation estimates were too low for only 3 rules. These exaggerated adjustment costs are often attributable to underestimates of the potential that technological change could minimize pollution abatement costs."

Moreover, the largest overestimates occurred in the case of the market-based policies – taxes and tradable permit schemes, which makes sense because those rules leave polluters the most scope for flexible technological responses. This in turn means that we are more likely to overstate the costs of a cap-and-trade component of any new climate bill, and less likely to overstate the costs of any preexisting or accompanying traditional regulatory standards, leaving those standards more likely to interact badly with the permit trading mechanism, reducing its cost effectiveness. In other words, even if we predict that the renewable portfolio standards will be inframarginal, as the CBO (2009) predicts for the renewable portfolio standards in Title I of HR 2434, experience suggests that prediction is likely to overstate the carbon permit prices relative to renewable portfolio standards, and therefore to understate the degree to which the cost-effectiveness of carbon trading is undermined.

In an important sense, the problem here is worse than the usual comparison between standards and tradable permits. In the standard case, highlighted famously in a table in Tietenberg's textbook[2] documenting the efficiency gains from moving to a market-based policy, there is a hidden benefit of traditional regulatory standards. Under standards, some sources of pollution over-abate. For example, Atkinson and Lewis's (1974) study of particulates in St. Louis found that a market-based system that equated marginal abatement costs would meet the ambient standards at only one-sixth the cost of existing regulatory standards. But Oates *et al,* (1989) point out that one of the reasons the regulatory standard's costs are high is that they over-regulate some sources in order to meet the ambient pollution standard everywhere. An ideally-designed market-based system would just meet the constraint at every locale, and hence yield more pollution in some places than would the non-market standard. If we take into account

[2] See Tietenberg (2006), table 16.2.

the *net* benefits of the market-based standard, the difference between market-based and non-market regulations is much smaller.

In this, case, however, there would be no such net adjustment. We are comparing two policies with the same total global pollution. There are no geographic differences, or "hot spots" in climate change. If a regulatory standard induces over-abatement by once source, that depresses the permit price for all sources, reducing abatement by other sources so as to completely offset the over-abatement in the first place. The silver lining of non-market policies described by Oates *et al.* does not apply in the case of this global pollutant.

Rationales for Multiple Policies: Other Market Failures and Complexity

Figure 1 and the accompanying text describe two possible results of interacting tradable permit schemes and traditional regulatory standards: the standards could be irrelevant, or they could increase compliance costs with no associated benefits. But there is a third possibility. There could be an economically sound rationale for enacting a tradable permit regulation in combination with a traditional regulatory standards. These rationales fall into two categories: (1) other market failures, and (2) logistical complexity.

Other market failures refers to the fact that the pollution externality is likely not the only departure from perfectly competitive assumptions affecting GHG emissions. One additional market failure, for example, involves research and development (R&D) in new GHG-abating technologies. If one firm invests in R&D and invents a new abatement technology, some benefits spill over to other firms, because they either imitate the technology or build upon it with further R&D. Consequently, firms will likely underinvest in R&D, relative to what would be optimal, unless they receive some sort of government subsidy – a second policy instrument.

In theory, however, R&D market failures can work in the opposite direction, and lead to overinvestment relative to the optimum. Competitive firms may duplicate each other's R&D efforts, resulting in wasteful investment by some firms. Firms may also compete to invent a new technology that generates a competitive advantage and economic rents.[3] Similarly, firms may invest in rent-seeking R&D aimed at slight innovations that would replacing existing technologies with new ones that are only marginally better, but would capture market rents.

On balance, empirical studies find that the industry-wide return to R&D is approximately two to four times as high as the returns to any one firm, suggesting underinvestment in R&D (Jones and Williams, 1998). Jaffe *et al.* (2005) nicely summarize the interactions between these two market failures: "Pollution creates a negative externality, and so the invisible hand allows too much of it. Technology creates positive externalities, and so the invisible hand produces too little of it." Pairing a tradable permit scheme to address the first market failure with an R&D subsidy to address the second seems like a sensible strategy.[4]

Another oft-cited market failure involves the seeming insensitivity of consumers and businesses to energy price signals. Hausman (1979) noted that implausibly high discount rates would be needed to justify the choices consumers were making among room air conditioners with varying energy efficiency and prices. This "energy paradox" has been explained in various ways. Hassett and Metcalf (1993) point out that future energy prices are uncertain, but that energy saving investments are irreversible, leading to rational unwillingness to invest. Levinson and Niemann (2004) note that landlords often make the energy efficiency investments, but tenants pay the utility bills, again leading to underinvestment in efficiency. These market failures mean that a tradable permit scheme might lead to price signals that go unnoticed. One solution entails energy efficiency standards for appliances and building codes. Another is product labeling, which has been shown to be effective in combination with energy price increases (Newell *et al.*, 1998). Either way, some form of regulatory standard may complement a GHG emissions permit system.

The second broad justification for pairing traditional regulatory standards with tradable permit schemes involves complexity, from a number of possible sources. One source of complexity in permit

[3] Jones and Williams (1998) name this spillover aspect of R&D the "standing on shoulders" effect, and the socially wasteful duplication the "stepping on toes" effect.
[4] Of course, nothing about the R&D market failure is particular to the environment, and there is no reason a sensible R&D policy shouldn't be economy-wide.

trading mechanisms relates to the inability to accurately predict abatement costs. Since Weitzman (1974), economists have recognized that uncertainty in marginal pollution abatement costs means there is an important distinction between quantity regulations (cap-and-trade) and price regulations (pollution taxes). Cap-and-trade leads to certainty about the quantity of pollution, but uncertainty about the costs imposed on polluters. Pollution taxes yield certain costs, but uncertain pollution quantities. Roberts and Spence (1976) proposed pairing the two, so that a set amount of pollution permits are traded, but polluters can exceed their permitted quantities by paying a pollution tax. The tax puts a known ceiling on the otherwise uncertain permit price. One could also imagine a price floor where the government would agree to purchase all permits at some set price (Pizer, 2002). This type of price "collar" is contained in both the CLEAR Act proposed in 2009 by Senators Cantwell and Collins, and is expected to be part of the bill under discussion by Senators Kerry, Graham, and Lieberman.

These price collars, however, are not quite the type of multiple instrument setup imagined in figure 1, in that both the tradable permits and the price cap and floor are market-based instruments. Moreover, in several cases where the price caps have been implemented along with tradable permit schemes, those price caps have never been reached and were therefore irrelevant – much as a low-cost standard would be. For example, the Danish CO2 trading mechanism has a price cap at 40 DKK/ton, which has never been reached (Johnstone, 2003). Similarly, the US Acid Rain program set an initial SO2 permit price cap at $1500/ton. Permit prices mostly traded between $100 and $3000, and the price cap was quietly scrapped. In both cases, however, it seems the existence of the price cap may have appeased fears of high costs and eased passage of the legislation, but imposed no economic consequences.

Complexity that justifies regulatory standards typically involves more than just price uncertainty. For example, unlike GHG emissions, most pollutants have spatially differentiated damages – the effect of the pollutant differs depending where it is emitted. The makes organizing a tradable permit scheme complicated. One could imagine, for example, a matrix of pollution transfer coefficients mapping pollution from each location of emission and to each location of deposition (McGartland and Oates, 1985). Designers of the U.S. SO2 trading program intentionally simplified the system. One ton of SO2 is treated the same whether it is emitted on the Atlantic coast and drifts out to sea, or emitted in the Midwest and falls on New England. Some states have responded to this by enacting command-and-control regulations on top of the SO2 trading program, or by prohibiting trades. Wisconsin prevented some local utilities from buying SO2 permits, Illinois mandated scrubber installation, and in Los Angeles, the RECLAIM permit trading program prohibits trades between coastal and inland sources (Johnstone, 2003). These constraints, coupling tradable permit and traditional regulations, can be seen as a response to the complexity of regulating heterogeneous sources. Of course, for GHG emissions, no such heterogeneity of damages exist.

Bennear and Stavins (2007) provide an example of a tradable permit system combined with a standard regulation in a completely different setting – fisheries in New Zealand. Fishing boats are subject to both a transferable quota that limits their catch and gear restrictions that limit net and mesh sizes. Each instrument addresses a slightly different aspect of the renewable resource / open-access problem. The transferable quotas limit the total volume of fish caught, and the gear restrictions limit the types of fish caught.

A source of complexity perhaps more relevant to climate change involves high transaction costs. For some sources of pollution, a permit trading scheme would be impractical. Automobile tailpipe emissions provide one example. Another would be emissions in a developing country where monitoring and enforcement systems are inadequate. In these cases, permit trading seems less practical than taxes on complementary goods (gasoline), subsidies to substitute goods (public transport), or enforcement of traditional regulatory standards (fuel efficiency standards). Fullerton and West (2002, 2010) show how a tax on gasoline *plus* a subsidy to newer cars can beat a tax on gasoline alone, in that the two instruments combined yield more pollution reduction at lower cost.[5]

Together, these other market failures and sources of complexity provide economic rationales for combining cap-and-trade with more traditional regulations.

---

[5] Walls and Palmer (2001) also model combination instruments for multiple pollutants where direct taxes are not available.

Conclusion

Climate policy in the U.S. is likely to combine tradable permits with more traditional regulatory standards. These standards have the potential to be harmlessly redundant, to reduce the cost-effectiveness of the tradable permits, or to solve a problem involving multiple market failures or logistical complexity. In the worst-case scenario, the market parts of the climate bill could undo the pre-existing non-market policies, or the non-market parts of the bill, if polluters are allowed to sell permits based on their compliance with non-market regulations.

To assess in advance whether the traditional regulatory components of new legislation are redundant or interact to reduce the cost effectiveness of the cap-and-trade components, we need to forecast the compliance costs of both components. But as Harrington *et al.* (2000) show, we are likely to overstate the compliance costs with cap-and-trade, relative to traditional regulations, and therefore to understate the degree to which the traditional regulations erode the cost-effectiveness of cap-and-trade.

In a best-case scenario, polluters would not be allowed to sell emissions permits based on compliance with the other non-market parts of the law. This is a legislative issue, but the economic rationale is that if polluters can meet their tradable caps by complying with the non-market regulation, that regulation is either irrelevant and a waste of administrative resources, or binding and damaging to the cost-effectiveness of the tradable permit system. If the non-market component of the legislation has an economic rationale – a second market failure, or difficulty regulating the externality directly – then it should not be substitutable for the market component of the regulation.

References

Abrell, Jan and Hannes Weigt. 2008. " The Interaction of Emissions Trading and Renewable Energy Promotion" Dresden University of Technology WP-EGW-05.

Aldy, Joseph, and William Pizer. 2008. "Issues in Designing U.S. Climate Change Policy" Resources for the Future DP 08-20.

A.H. Barnett. 1980. "The Pigouvian Tax Rule Under Monopoly" *American Economic Review* 70(5): 1037-1041.

Bennear, Lori Snyder and Robert N. Stavins. 2007. " Second-best theory and the use of multiple policy instruments" *Environ Resource Econ* 37:111–129.

Bohringer, Christoph, Henrike Koschel, and Ulf Moslener. 2008. "Efficiency Losses from Overlapping Regulation of EU Carbon Emissions" *Journal of Regulatory Economics* 33. pp.299-317.

Boehringer, Christoph , Carolyn Fischer, and Knut Einar Rosendahl . 2010. "The Global Effects of Subglobal Climate Policies"

Brunnermeier, Smita and Arik Levinson. 2004. "Examining the Evidence on Environmental Regulations and Industry Location" *Journal of the Environment and Development* 13(1): 6-41.

Congressional Budget Office (CBO). 2009. "How Regulatory Standards Can Affect a Cap-and-Trade Program for Greenhouse Gases" September 16, 2009.

Congressional Budget Office (CBO). 2009. "Cost Estimate for H.R. 2454 American Clean Energy and Security Act of 2009" June 5, 2009.

Egenhofer, C. 2002. "The Compatibility of the Kyoto Mechanisms with Traditional Environmental Instruments", in C. Carraro and C. Egenhofer (eds), *Firms, Governments and Climate Policy: Incentive Based Policies for Longterm Climate Change*, Cheltenham, Edward Elgar.

Eichner, Thomas, and Rudiger Pethig. 2009. "Efficient CO2 Emissions Control with Emissions Taxes and International Emissions Trading" *European Economic Review* 53. pp.625-635.

Fischer, Carolyn and Louis Preonas. 2010. "Combining Policies for Renewable Energy: Is the Whole Less than the Sum of Its Parts?" Resources for the Future DP 10-19.

Fullerton, Don and Sarah West. 2010. “Tax and Subsidy Combinations for the Control of Car Pollution” *The B.E. Journal of Economic Analysis & Policy* 10 (1): Iss. 1 (Advances), Article 8.

Fullerton, Don and Sarah West. 2002. “Can Taxes on Cars and Gasoline Mimic an Unavailable Tax on Emissions?” *Journal of Environmental Economics and Management* 42: 135-157.

Gonzalez, Pablo del Rıo . 2007. " The interaction between emissions trading and renewable electricity support schemes: An overview of the literature" *Mitigation and Adaptation Strategies for Global Change* 12:1363–1390.

Goulder, Lawrence. 2002. *Environmental Policy Making in Economies With Prior Tax Distortions.* Edward Elgar.

Grubb, M. and Ulph, D. 2002. "Energy, Environment, and Innovation" *Oxford Review of Economic Policy* 18:92-106.

Harrington, Winston, Richard D. Morgenstern, and Peter Nelson. 2000. "On the Accuracy of Regulatory Cost Estimates" *Journal of Policy Analysis and Management* 19(2): 297-322.

Harrington, Winston, Richard D. Morgenstern, and Peter Nelson. 2010. "How Accurate are Regulatory Cost Estimates?" Resources for the Future.

Hassett, Kevin A. and Gilbert E. Metcalf. 1993. "Energy conservation investment: Do consumers discount the future correctly?" *Energy Policy* 21(6): 710-716.

Hausman, J. 1979. "Individual discount rates and the purchase and utilization of energy-using durables" *Bell Journal of Economics* 10: 33–54.

Jaffe, Adam, Richard Newell, and Robert Stavins. 2002. "Technological Change and the Environment" in Karl-Göran Mäler and Jeffrey Vincent, eds, *Handbook of Environmental Economics.* Amsterdam: North-Holland.

Jaffe, A. B., R. G. Newell, & R.N. Stavins. 2005. "A Tale of Two Market Failures: Technology and Environmental Policy" *Ecological Economics* 54: 164-174.

Johnstone, Nick. 2002 "The Use of Tradable Permits in Combination with Other Policy Instruments" Working Party on National Environmental Policy, Document No. ENV/EPOC/WPNEP/(2002)28, Paris, Organization for Economic Cooperation and Development.

Johnstone, Nick. 2003. "Efficient and Effective Use of Tradeable Permits in Combination with Other Policy Instruments" Organization for Economic Cooperation and Development.

Jones, C. and J. C. Williams. 1998. "Measuring the Social Return to R&D". *Quarterly Journal of Economics* pp. 1119-1135.

Kolstad, Charles D. 2011. *Environmental Economics* 2nd Edition. New York: Oxford University Press.

Konidari, Popi and Dimitrios Mavrakis. 2006. "Multi-Criteria Evaluation of Climate Policy Interactions" *Journal of Multi-Criteria Decision Analysis* 14: pp. 35-53.

Krugman, Paul. 2010. "Building a Green Economy" *New York Times*. April 10.

Lehmann, Paul. 2008. "Using a Policy Mix for Pollution Control – A Review of Economic Literature" Helmholtz Centre for Environmental Research - UFZ Leipzig, MPRA Paper No. 21354.

Levinson, Arik and Scott Niemann. 2004. "Energy Use by Apartment Tenants when Landlords Pay for Utilities" *Resource and Energy Economics*, 26(1) 51-75.

Metcalf, Gilbert. 2008. "Using Tax Expenditures to Achieve Energy Policy Goals" *American Economic Review Papers and Proceedings* 98: 90-94.

McGartland, Albert M. and Wallace E. Oates. 1985. "Marketable permits for the prevention of environmental deterioration" *Journal of Environmental Economics and Management* 12(3): 207-228.

Oates, Wallace E., Paul R. Portney and Albert M. McGartland. 1989. "The Net Benefits of Incentive-Based Regulation: A Case Study of Environmental Standard Setting" *American Economic Review* 79(5): 1233-1242.

Oikonomou, V. and C. J. Jepma. 2008. " A framework on interactions of climate and energy policy instruments" *Mitigation and Adaptation Strategies for Global Change* 13:131-156.

Pearlstein, Steven. 2009. "Climate-Change Bill Hits Some of the Right Notes but Botches the Refrain" *Washington Post*. Friday, May 22.

Pizer, William A. 2002. "Combining price and quantity controls to mitigate global climate change" *Journal of Public Economics* 85(3): 409-434.

Roberts, Marc J. and Spence, Michael. 1976. "Effluent charges and licenses under uncertainty" *Journal of Public Economics* 5(3-4): 193-208.

Sigman, Hilary. 1996. "Cross-Media Pollution: Responses to Restrictions on Chlorinated Solvent Releases" *Land Economics* 72: 298–312.

Sijm, J. 2005 "The Interaction between the EU Emissions Trading Scheme and National Energy Policies: A General Framework" *Climate Policy* 5, 7996.

Smith, S. 1999. "The Compatibility of Tradable Permits with Other Environmental Policy Instruments", in *Implementing Domestic Tradable Permits for Environmental Protection*, Paris, OECD.

Sorrell, S. and J. Sijm. 2003. "Carbon trading in the policy mix" *Oxford Review of Economic Policy*, 19(3) pp. 420-437.

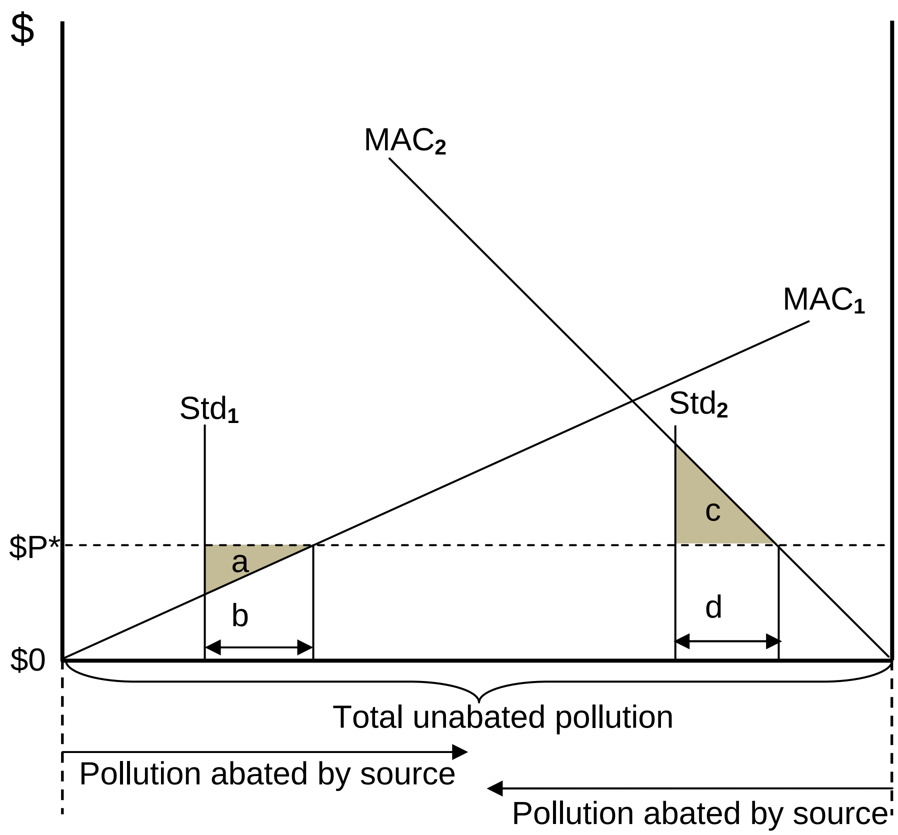
Tietenberg, Thomas. 2006. *Environmental and Natural Resource Economics* 7th Edition. New York: Pearson Education Inc.

Unger, T., and E.O. Ahlgren. 2005."Impacts of a common green certificate market on electricity and CO2 emission markets in the Nordic countries" *Energy Policy* 33:2152–2163.

Walls, Margaret and Palmer, Karen. 2001. "Upstream Pollution, Downstream Waste Disposal, and the Design of Comprehensive Environmental Policies" *Journal of Environmental Economics and Management* 41(1): 94-108.

Weitzman, Martin. 1974. "Prices vs. Quantities" *Review of Economic Studies*. 41(4): 477-491.

Figure 1


$
MAC2
MAC1
Std1
Std2
$P*
a
b
c
d
$0
Total unabated pollution
Pollution abated by source
Pollution abated by source