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A Comment on "Efficient Pollution Regulation: Getting the Prices Right" by Muller and Mendelsohn

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RESOURCES FOR THE FUTURE

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Abstract

In their recent paper , Efficient Pollution Regulation: Getting the Prices Right (henceforth, EPR), Muller and Mendelsohn describe a broader, more appealing concept of efficiency that incorporates information on damages caused by emissions from specific sources: "The science and economics related to pollution control", they write, "have advanced to the point where regulations can now move from cost-effectiveness to efficiency." We argue that despite the appeal of the EPR solution, its conclusion that source-specific marginal damage estimates are ready for use in regulations is simply incompatible with the empirical evidence presented in EPR. In particular, we explore the implications of the EPR finding of negative marginal damages from NOx emissions for many heavily populated counties. The associated nonconvexities, we show, imply that the source-specific trading ratios that EPR advocates lead to unattractive outcomes not likely to be efficient. We also discuss how the EPR assumption that the regulators know damages with certainty oversimplifies key aspects of efficient air pollution regulation.

Contents

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Art Fraas and Randall Lutter*

Introduction

For the last 20 years, the established wisdom among most environmental economists and policymakers is that a cap-and-trade system is the most desirable approach to controlling emissions because it is cost-effective. But in their recent paper, "Efficient Pollution Regulation: Getting the Prices Right" (henceforth, EPR), Muller and Mendelsohn describe a broader, more appealing concept of efficiency that incorporates information on damages caused by emissions from specific sources: "The science and economics related to pollution control," they write, "have advanced to the point where regulations can now move from cost-effectiveness to efficiency" (Muller and Mendelsohn 2009, 1735). They recommend a regulatory program that would equate marginal abatement costs with marginal damages—expressed as dollars per ton of pollutant emitted--for each source.

This recommendation constitutes a large departure from existing policy, going well beyond the modest regional refinements to ton-for-ton trading approaches that the U.S. Environmental Protection Agency (EPA) already considered and rejected (U.S. EPA 1998a,1998b). It also departs from recommendations by other researchers to differentiate tons by region (e.g., Banzhaf et al. 2004). As a result, it merits scrutiny and discussion.

We argue that despite the appeal of the EPR solution, its conclusion that source-specific marginal damage estimates are ready for use in regulations is simply incompatible with the empirical evidence presented in EPR. In particular, we explore the implications of the EPR finding of *negative* marginal damages for many heavily populated counties. The associated nonconvexities, we show, imply that the source-specific trading ratios that EPR advocates lead to unattractive outcomes not likely to be efficient. We also show how the EPR assumption that the regulators know damages with certainty oversimplifies key aspects of efficient air pollution regulation.

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Negative Marginal Damage Estimates

EPR concludes that "the marginal damages of emissions are especially high in large metropolitan areas compared with low-population rural areas" (p. 1736). But this statement neglects the findings of EPR's Appendix B, which lists 42 counties with *negative* estimates of damages from ground-level sources of nitrogen oxides (NO_x). As shown in Figure 1, which zooms into counties in the eastern United States, most of the counties are heavily populated urban areas with large aggregate NO_x emissions. They represent parts of most major U.S. metropolitan areas, including Chicago, Washington, D.C., Philadelphia, New York City, Boston, Los Angeles and the Bay Area as well as the smaller cities of Pittsburgh, Detroit, and New Orleans.[1] The results are not minor modeling anomalies: the average marginal damages from emissions in these 42 counties are -$972 per ton of NO_x emitted, meaning there are benefits. Six such counties in the metropolitan areas of Los Angeles, Chicago, Washington, D.C., Philadelphia, and New York City have damages < -$2,000 per ton.

Fann et al. (2009) use a different model and definitions of sources and geographic areas than do Muller and Mendelsohn but find similar evidence. They report negative damages for NO_x emissions from mobile sources in Chicago and all sources except electric generating units in Atlanta, New York City and Philadelphia, Phoenix, and Seattle.[2] Fann et al. describe the effect of possible reductions in emissions of NO_x: "Less NO_x titration of O_3 results in more O_3 and oxidants available to oxidize NO_x to form HNO_3, which subsequently react with NH_3 to form more particulate nitrate (and thus disbenefit)" (2007, 175). EPA posted updates of the work by Fann et al. on its website earlier this year (U.S. EPA 2011).

These estimates of negative marginal damages in urban areas indicate nonconvexities because marginal damages are presumably positive at some lower level of emissions. The economics literature has recognized issues raised by nonconvexities in the context of pollution for decades (Baumol and Bradford 1972). In an evaluation of pollution control focused on ozone,

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1 The counties include Los Angeles County and nearby Orange County; Cobb County and DeKalb County, which includes Atlanta; Cook County and DuPage County, which include parts of Chicago; Jefferson Parish and Orleans Parish, which includes New Orleans; Baltimore County; Montgomery County and Prince George's County near Washington, D.C.; Macomb County outside Detroit; New York City's Kings County, Nassau County, and Queens County, plus nearby Westchester County; and Philadelphia County. These few counties alone have a population in excess of 30 million (U.S. Census Bureau 2010).

2 Note that the geographic areas Fann et al. analyzed are not counties or standard metropolitan areas. For example, the area dubbed "Chicago" includes parts of northwest Indiana and "New York/ Philadelphia" includes areas in five states from Connecticut to Delaware. See Fann et al. 2009, Table 2.

Repetto (1987, 14) states that in the presence of a nonconvexity, an "all-or-nothing choice is indicated."[3]

Negative marginal damage estimates prevent the use of trading ratios based on source-specific estimates of marginal damages. The EPR first-order conditions for minimization of costs subject to an overall cap on damages imply

1) $\frac{\partial C_i}{\partial X_i} / \frac{\partial D_i}{\partial X_i} = \frac{\partial C_j}{\partial X_j} / \frac{\partial D_j}{\partial X_j}$, for all i and j,

where the marginal costs of reducing emissions X_i are $-\frac{\partial C_i}{\partial X_i}$ and marginal damages are $\frac{\partial D_i}{\partial X_i}$.

But 1) cannot be satisfied if marginal damages are negative for some sources unless marginal control costs are negative for those same sources, a possibility inconsistent with Muller and Mendelsohn's empirical implementation for SO_2 (equation (32)).

Use of source-specific trading ratios, TR_{ij}, can ensure that trades do not increase damages, provided that TR_{ij} is set equal to

2) $\frac{\Delta X_i}{\Delta X_j} = -\left(\frac{\partial D}{\partial X_j}\right) / \left(\frac{\partial D}{\partial X_i}\right)$,

which can be derived by totally differentiating a general damage function $D(X_1, X_2 .. X_n)$, with damages and other emissions held constant. Competition in the market for permits serves to equalize the marginal cost of avoiding damages among all sources. But if marginal damages are negative for some source *i*, then use of source-specific trading ratios would mean source *i* could sell permits (while increasing emissions) to another source with positive marginal damages that also would increase its emissions. Trades where both sources *increase* their emissions do not represent a stable outcome because sources with negative estimated damages would generally supply permits at lower cost than other sources.[4] Put differently, the use of source-specific trading ratios in the presence of negative marginal damages for some sources could mean that

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[3] He also notes that a decentralized incentive system (such as Pigouvian taxes) may not result in an efficient allocation of resources.

[4] EPR contains another proposal—source-specific taxes based on estimates of marginal damages—that does not work much better with negative marginal damage estimates. It would lead to subsidies for some sources to *increase* their emissions. Unless the cost of an emissions increase also rises as emissions increase, such subsidies could entail substantial costs to the public treasury.

emissions grow everywhere, but especially in the urban areas with negative marginal damage estimates for NO_x. Adopting the EPR approach of damage-based trading would mean that emissions of *all* pollutants would grow with interpollutant trading, even though only NO_x emissions have negative marginal damage estimates.

Uncertainty

EPR assumes that the regulator knows damages with certainty. Yet the uncertainty is large enough that marginal damages from a specific source may be either positive or negative depending on how air quality is modeled; where geographic boundaries are located; whether the focus is on annual, seasonal, or daily effects; and how variable are the emissions. Consider, for example, the discrepancies between EPR and Fann et al.'s study. EPR provides negative estimates of marginal damages for NO_x emissions in Denver County, Colorado, and Alameda County, California, while Fann et al. report positive damage estimates for larger areas (mostly rural) that include these two counties. And for Atlanta, Fann et al. report negative damages (of -$4,100 per ton) for ammonia emissions, a result that is inconsistent with EPR.[5] Implausibly, the model used in EPR generates a quasi-checkerboard pattern of positive and negative damage estimates among some neighboring counties.[6] Since the sign of the marginal damage estimates is sensitive to small differences in air quality modeling, the full scope of the nonconvexity in damages is unclear without a better appraisal of how damage estimates change with alternative modeling approaches.

Uncertainty in even the sign of the marginal damage estimates undermines the claim in EPR that "regulations can now move from cost-effectiveness to efficiency" (p. 1735). Table 4 of EPR lists trading ratios between 1:1 and 10:1 for ground-level sources of sulfur dioxide and nearby power plants. The wide ranges of these trading ratios and adjacent counties' marginal damage estimates raise questions about whether specific trades would hurt the environment. EPA, state, and local regulatory authorities historically have been risk averse and will be reluctant to approve or endorse trades between neighboring sources without an assurance of

[5] A complete discussion of uncertainty also ought to include analysis of why the different models disagree on the direction (sign) of the effect for some pollutants in some specific places.

[6] Within the metropolitan area of Atlanta, Georgia, one county with positive damage estimates (Fulton) separates two contiguous counties with negative damage estimates (Clayton and DeKalb) from a third with a negative damage estimate (Cobb).

some environmental benefits. Their precaution has cause: when the D.C. Circuit remanded EPA's Clean Air Interstate Rule (CAIR), it cited EPA's failure to show that actual emissions reductions in neighboring states with the CAIR cap-and-trade program would protect the air quality in North Carolina.

Finally, the uncertainty associated with the marginal damage estimates suggests that adopting source-specific trading ratios may invite rampant rent-seeking. Sources would seek a re-estimation to yield a lower damage estimate, and dueling experts would debate the relative merit of various methods. The rent-seeking costs could be quite large, since the EPR approach would require the regulator to estimate environmental damages with greater precision than for environmental regulations generally. Lengthy litigation would be likely.

Summary

Muller and Mendelsohn's vision—a genuinely efficient approach to emissions regulation—surely merits attention. While a well-established economics literature identifies likely efficiency gains from equating marginal abatement costs and marginal damages for each source, the nonconvexities and uncertainties in marginal damage estimates preclude a claim that the science and economics have advanced to the point where regulations can adopt source-specific damage estimates to enhance efficiency. Simply excluding the sources with negative damages from the source-specific trading program may seem like an attractive and minor refinement of the EPR proposal, but in fact it raises important new challenges. What should be the control policy regarding NO_x emissions in the counties with negative damages? Should *any* emissions trading be allowed among these counties or between them and other sources? How much confidence should regulators have in marginal damage estimates before identifying some as positive and others as negative? Further analysis and review may later indicate that the EPR recommendation for source-specific trading could be gainfully applied to a specific subset of pollutants and sources—for example, only SO_2 emissions from electric generating units. Finally, although a comprehensive quantitative uncertainty analysis of the source-specific marginal damage estimates represents a significant technical challenge, regulatory authorities will need to consider the implications of these uncertainties before deciding whether to incorporate source-specific marginal damages into a regulatory program.[7]

[7] Office of Management and Budget's (2003) Circular A-4 requires agencies to provide a quantitative uncertainty analysis of major regulatory actions that would result in benefits or costs that exceed $1 billion per year.

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Figure 1. Marginal Damages in Dollars per Ton of NO_x Emissions, Selected Eastern Counties