



# Fiscal federalism and interjurisdictional externalities: New results and an application to US Air pollution<sup>☆</sup>

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## ABSTRACT

The economics of fiscal federalism has identified two book-end departures from first-best provision of a public good. Local governments may respond to local conditions, but ignore inter-jurisdictional spillovers. Alternatively, central governments may internalize spillovers, but impose uniform incentives ignoring local heterogeneity. We provide a simple model that demonstrates that the choice of pricing policy also depends crucially on a third factor, the shape of marginal costs of providing the public good. If marginal costs are convex, then marginal abatement cost elasticities will be higher around the local policies. This increases the deadweight loss of those policies relative to the centralized policy, *ceteris paribus*. If they are concave, then the opposite is true.

Using a detailed simulation model of the US electricity sector, we then empirically explore these tradeoffs for US air pollution. We find that US states acting in their own interest lose about 31.5% of the potential first-best benefits, whereas the second-best uniform policy loses only 0.2% of benefits. The centralized policy outperforms the state policy for two reasons. First, inter-state spillovers are simply more important than inter-state heterogeneity in this application. Second, because of the convexity of the marginal cost functions, elasticities are much lower over the range relevant to the centralized policy, dampening the distortions.

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## 1. Introduction

Provision of a public good typically takes place in the context of a federation with several levels of government, as in the United States or the European Union. Moreover, this federal context typically involves heterogeneity in the benefits experienced from providing the public good in different local jurisdictions, as well as spillovers from a public good provided in one local jurisdiction into others. Accordingly, a first-best policy would equate, in all locations, the marginal benefits of the public good with the marginal costs. However, this blackboard solution is typically impracticable.

Since the seminal work of Oates (1972) on fiscal federalism, a central question of public finance has been which level of a federation should be assigned the provision of the public good. On one hand, local jurisdictions are likely to account for local conditions but ignore inter-jurisdictional spillovers. On the other hand, central governments may internalize those spillovers but are likely to impose a one-size-fits-all policy that ignores local conditions.<sup>1</sup>

Both factors appear to be empirically relevant in environmental applications. Illustrating the importance of inter-jurisdictional spillovers, Sigman (2002) finds more pollution in international rivers than comparable rivers within nations, and Sigman (2005) likewise finds more pollution in interstate rivers in the US. Similarly, Burgess et al. (2011) and McWhinnie (2009) find that natural resources are depleted more rapidly when shared by more jurisdictions. Illustrating the ability of local jurisdictions to respond to local conditions, Chupp (2011) shows that US states are more likely to regulate air pollution beyond federal requirements when their intrastate benefits are higher; Gray and Shadbegian (2004) similarly show that states' regulation of pulp and paper mills appears to respond to proxies for benefits; and Helland and Whitford (2003) find

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<sup>1</sup> For reviews, see Alm and Banzhaf (forthcoming), Dalmazzone (2006), Levinson (2003), and Oates (1999, 2002a). But see Ogawa and Wildasin (2009) for a special case in which decentralized policies may be optimal even with spillovers.

states are more lax about pollution near their borders than in their interiors. And in an intriguing study of both sides of the coin, Sigman (2011) finds that long-lived water pollutants—those for which spillovers are the greatest concern—are lower in nations with more centralized governments, while all water pollutants have higher intra-national variation in nations with more federal governments.

These trade-offs represent the Scylla and the Charybdis of fiscal federalism. As Oates (2002a) summarized in the context of an environmental public good:

[W]e are left with a choice between two alternatives: suboptimal local decisions on environmental quality or inefficient uniform national standards. And which of these two alternatives leads to a higher level of social welfare is, in principle, unclear. Empirical studies of these alternative regimes are needed to shed light on this issue. (p. 8)

This paper contributes to this literature in two ways. First, it extends the traditional benefit-side factors of heterogeneity and spillovers to important interactions with the supply side of public goods. In particular, it identifies a third factor: the more convex the marginal cost of supplying the public good, the more centralized policies increase welfare relative to local policies. Second, illustrating the importance of all three factors, it fills the empirical gap highlighted in the above quotation, for arguably the most important environmental application facing developed economies over the last fifty years: ambient air pollution.

We begin with a simple model of a public good in a federation. The model includes heterogeneous marginal benefits of the good, inter-jurisdictional spillovers in benefits, and heterogeneity in the shapes of marginal cost (i.e. supply) functions. Regulation involves setting price incentives for providing the public good. In the specific context of our air pollution example, these prices can be interpreted as Pigovian taxes on pollution or, equivalently, because there is no uncertainty, they can be thought of as the price under a tradable pollution quota. More generally, the price could be interpreted as a unit subsidy for providing any public good, including education, public safety, transportation services, etc.

Analogous to the theory of optimal taxation, we show that the deadweight loss from errors in prices, whether from ignoring inter-state spillovers or from ignoring heterogeneity, depends in part on the slopes of the supply curves over the region of the error. If they are highly inelastic, deadweight loss from errors in prices will be small. This simple insight has an important—and to our knowledge previously unnoted—implication for fiscal federalism. Simply put, if (1) the devolved policy involves the mistake of systematically *under*-pricing the public good (because of ignoring inter-jurisdictional spillovers); (2) the centralized policy involves the mistake of *noise* around the optimal prices (from imposing some average price), and (3) the marginal cost function is convex, then the marginal cost function will tend to be more elastic in the region of the devolved policy. (The opposite is true when the marginal cost function is more concave.) *Ceteris paribus*, this tends to give an edge to centralization when marginal cost functions are convex and an edge to devolution when the marginal cost functions are concave.

After establishing these theoretical relationships, the remainder of this paper is an empirical examination of these tradeoffs for the case of sulfur dioxide (SO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) pollution from the US electricity sector, the most important source of ambient air pollution in the United States.<sup>2</sup> We use a detailed simulation model of the US

<sup>2</sup> Besides being an important public good with large benefits, US air quality is a fitting case study in other respects as well. Institutionally, air policy involves a federal structure, with Washington setting air pollution regulations and state governments enforcing them. And historically, policies were centralized following impatience with state governments. Yet List and Gerking (2000) find no evidence that Reagan's implementation of the "New Federalism," with its significant transfer of responsibility to state governments, had a negative effect on aggregate air emissions (see also Millimet, 2003, Millimet and List, 2003, and Fomby and Lin, 2006). This may be because, especially at the time, federal policies already under-controlled, so it was not necessarily in states' interests to reduce enforcement.

electricity sector, together with models of pollution dispersions and damages, to compute three policies for regulating emissions. First, we find a reference policy, with fully differentiated state-level pollution prices that internalize all spillovers.<sup>3</sup> Second, we find the "optimal" policies from the perspective of each state acting under autarky. Finally, following Banzhaf et al. (2004), we also find the second-best uniform policy.

We find that that the reference policy yields substantial benefits over no control (\$59.7 billion), consistent with the high benefit-cost ratios typically found for air pollution (Banzhaf et al., 2004; Muller and Mendelsohn, 2007; US EPA, 2011). The devolved policies lose 31.5% of those potential benefits. However, the second-best uniform policy loses only 0.2%. Thus, the uniform policy approximates the first-best and far out-performs the state policies. This occurs for two reasons. First, most straightforwardly, inter-jurisdictional spillovers appear to be a bigger problem in this application than heterogeneous benefits. Yet the heterogeneity in benefits is not trivial: the inter-state range in the marginal benefits of abatement varies by 6-fold. The second reason is that around the uniform policy, marginal abatement costs are quite inelastic, so the errors from ignoring the heterogeneity have little impact on over-all welfare. This is not true around the state policies, with the difference arising because of the convexity of marginal abatement costs.

In addition to our theoretical contributions, our welfare analysis is to our knowledge the first to consider *both* sides of the environmental federalism dilemma for a major policy from a normative perspective. However, other recent papers have considered various aspects of centralized policies. Banzhaf et al. (2004) estimate the second-best uniform prices of SO<sub>2</sub> and NO<sub>x</sub>, together with the resulting abatement, and find large welfare improvements from the status quo, but do not compare them either to the first-best case or to state policies. We follow their basic approach in this paper, extending it to these other policies.

Muller and Mendelsohn (2009) compare the relative welfare gains of switching from the *status quo* uniform price policy in the US (i.e. the acid rain trading program), which involves substantial under-abatement, to both a differentiated policy with the same aggregate emissions and to the first-best policy. They do not consider the second-best uniform price policy or the state policies. Thus, although both this paper and Muller and Mendelsohn (2009) cover similar ground, the two differ markedly in the questions they address. Muller and Mendelsohn consider how the status quo price policies can be improved, looking at two margins, more differentiation (holding aggregate emissions at their sub-optimal level) versus more abatement (holding relative inter-jurisdictional prices constant at 1:1). We compare a policy devolving authority to local governments to a uniform policy, assuming optimization in each regime.

Others have considered regulations imposing a uniform ambient standard in each jurisdiction, rather than a uniform pollution price. Oates et al. (1989) point out that, when these standards represent minimum environmental quality rather than a specific level, the costs of imposing this standard may not always be as high as one would expect. Nevertheless, they can be substantial. Dinan et al. (1999) consider drinking water quality, a local public good with little or no spillover effects. In this case, local jurisdictions have an incentive to mandate the efficient level. Thus, the devolved policy is equivalent to the first-best. In contrast, the centralized uniform standard will be very inefficient. Since there are economies of scale in the reduction of pollutants in drinking water, small systems have higher cost per individual benefiting. Dinan et al. find that some households may lose up to \$774 dollars per year requiring the uniform regulation. Thus, centralized uniform regulation is less efficient than

<sup>3</sup> This policy may be thought of roughly as the "first best", though it ignores within-state spatial heterogeneity in damages. Additionally, we abstract from the issue of pre-existing taxes on capital and labor (see Goulder et al., 1999 and Parry, 2005).

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