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Governance, Federalism and Organizing Institutions to Manage Complex Problems

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Abstract

In managing complex policy problems in the federal system, state and local governments are organized into different arrangements for translating policy goals into policy outcomes. The authors use air quality management as a test case to understand these variations and their impact on policy outcomes. With data from Clean Air Act implementation plans and a survey of state and local air quality managers, the authors identify five separate institutional designs: 1) central agencies; 2) top-down; 3) donor-recipient; 4) regional agencies; and, 5) emergent governance. Findings indicate that some arrangements (donor-recipient and emergent governance) result in notably better air quality than others (central agencies, top-down). Specifically, when designed to allow bargaining between state and local officials, intergovernmental management is still the most effective approach to complex policy problems; but, in absence of this, conventional federalism arrangements are less effective than public agencies self-organizing around shared policy goals.

Over the last several decades, national, state, and local governments have become interdependent as they work together to manage complex policy problems, with new sophisticated forms of governance emerging in recent years that challenge conventional hierarchies in the federal system (McGuire, 2006; Feiock and Scholz, 2009). Nevertheless, remnants of previous federalism eras are still present as some public agencies fail to adapt to new circumstances and fall back on outmoded forms of intergovernmental relations (Agranoff and McGuire, 2001). As such, distribution of administrative reforms and coordination mechanisms are uneven across the federal system, with some governments pro-actively pursuing innovative solutions while others rely on more traditional tools (Moynihan, 2005). Consequently, multiple institutional designs exist simultaneously. A fundamental issue determining the effectiveness of these designs is the creation and mitigation of transaction costs during service delivery, which affects process efficiency and program outcomes. While each institutional design has strengths and weaknesses, there are important tradeoffs made that affect public service delivery.

There are few comparisons of how such variations affect policy outcomes when dealing with complex policy problems, creating limitations in understanding how we govern these problems. This is especially important in relation to conventional forms of intergovernmental management compared to emergent governance approaches, which represents a contrast between traditional and state-of-the-art public management theory. A prime example of this is air quality management and implementation of the Clean Air Act (CAA), where, over time, separate arrangements for coordinating state and local resources developed across states (Woods and Potoski, 2010). Using data from State Implementation Plans (SIPs) and a survey of state and local air managers, we identify five separate institutional designs: 1) central agencies, where policy implementation is centralized within a single state agency; 2) top-down, where local agencies are co-opted as administrative sub-units of the state; 3) donor-recipient, where implementation involves bargaining between state and local agencies; 4) regional agencies, where intermediate agencies serve a specialized policy function at the regional-level; and, 5) emergent governance, where local agencies use innovation to govern policy problems outside of state-led management strategies.

As such, our goal here is to examine institutional designs in order to ascertain how complex policy problems are managed within a federal system, and to compare conventional forms of intergovernmental management to emergent governance approaches (Agranoff and McGuire, 2001; Feiock and Scholz, 2009). We first describe institutional designs in terms of organization, advantages, and constraints for air quality management. Then, we examine their effects on air quality outcomes with a dataset of 363 Air Quality Control Regions (AQCRs) (Woods and Potoski, 2010; Fowler, 2016). Findings indicate that some institutional designs (donor-recipient and emergent governance) result in notably better air quality than others (central agencies). More specifically, when designed to allow bargaining

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between state and local officials, intergovernmental management is still the most effective approach to complex policy problems; but, in absence of this, intergovernmental management is less effective than public agencies self-organizing around shared policy goals.

Context of Air Quality Management in the U.S.

Air quality provides an adept case to examine effects of institutional designs on an inter-jurisdictional policy problem with ambiguous causes, effects, and parameters (Cannibal and Lemon, 2000). Under the CAA, the Environmental Protection Agency (EPA) sets national standards and oversees states efforts, while states develop SIPs to achieve compliance with those standards. With a bevy of administrative rules, pollution control strategies, and monitoring sites, states organize managerial efforts differently based on unique circumstances within their jurisdictions. One key difference between states is how SIPs incorporate local governments into implementation systems, which ranges from explicit preemption to intergovernmental partnership. Local government roles in CAA implementation are primarily a function of the policy challenge that exists with worsening air quality increasing the likelihood that states rely on local agencies for implementation assistance. Additionally, local air agencies are more likely to emerge when there are strong environmental advocacy groups either as a result of states attempting to shift blame or local governments engaging in bottom-up activism. To this end, previous research indicates that local air agencies tend to have positive effects on air quality, but it depends on their authorities and relationships with state agencies (Woods and Potoski, 2010; Fowler, 2016, 2018b, 2019a).

For the most part, air quality policy is a function of specific technical and/or political challenges that are unique to local areas. As Woods and Potoski (2010) frame it: “the policy challenge underlying pollution is balancing its environmental and health costs against its economic benefits. Achieving the optimal balance between the two is easier when the pollution is narrowly concentrated in a region rather than widely dispersed across different local climates and geographies” (p. 722). Thus, local expertise is essential to policy implementation in order to develop policies, procedures, and strategies that address specific mixtures of pollutants, sources, and health impacts. Additionally, translating national programs into local communities requires creation and maintenance of political coalitions that legitimize and support administrative decisions, so local governments provide political capital to programs that is essential for success (Reed, 2014). While local agencies are an asset in intergovernmental implementation, they also create uncertainty in how policy implementation, so there are institutional barriers that constrain how state and local agencies interact (Potoski, 1999, 2002; Feiock and Scholz, 2009; Fowler, 2019b). As a result, recent scholarship notes an increasing level of policy innovation from local air agencies as they attempt to fill gaps in state and/or federal programs (Woods and Potoski, 2010; Fowler, 2018b, 2019b; Fowler and Rabinowitz, 2019).

Competing Institutional Designs

Using SIPs and a survey of air managers, we identify five institutional designs: 1) central agency; 2) top-down; 3) donor-recipient; 4) regional agency; and, 5) emergent governance. Institutional designs entail tradeoffs in transaction costs and local implementation capacities, so some designs are better suited for mediating circumstances in which air quality management occurs than others. Local managers serve as key agents in this by using their expertise to mitigate unique local challenges. Therefore, local agencies are included in several institutional designs, but with coordination mechanisms differing. Importantly, air quality is a complex regional problem, so local agencies may only have jurisdiction over a portion of an AQCR. As such, effects of institutional designs may be dependent on relative jurisdictional size, where benefits of integrating local agencies into institutional designs are a function of scale of local authority over air quality. Table 1 provides a comparison of institutional designs based on agencies, coordination mechanisms, advantages, and constraints.

[Table 1 about here]

First, central agency designs centralize CAA implementation within a state agency, so SIPs exclude local governments from directly implementing policy. In effect, state environmental agencies have a policy monopoly and rely solely on internal resources and capacity. Central agency designs are the most common approach to CAA implementation and are the exclusive mechanism for air quality management in 24 states, such as Georgia, Idaho, Michigan, New Hampshire, New Jersey and Virginia. In most of these states, SIPs explicitly preempt local governments from adopting or enforcing air quality regulations, so state agencies have exclusive authority over air quality. In other states, administrative regulations create institutional barriers to devolving powers to local agencies in order to reduce uncertainty in implementation choices (Potoski, 1999, 2002; Potoski and Woods, 2001; Woods and Potoski, 2010;

EPA 2018c; NACAA, 2018). Additionally, as state agencies have CAA primacy in all 50 states, they have primary responsibility for ensuring compliance, so this design is the default in absence of local agencies. As such, it exists in AQCRs across 49 states.[1]

Under this arrangement, costs principally arise in monitoring and enforcement, although production, finance, and delivery costs increase with organizational complexity. Thus, the basic structure of these designs minimizes transaction costs incurred from coordinating multiple organizations and reduces bureaucratic layers between decision-makers and enforcement or monitoring at the street-level. Although this may be the simplest solution, and therefore the one with the lowest effective transaction costs, there are drawbacks. Most significantly, these designs limit organizations to their own internal capacities, which may be insufficient to manage the existing air quality problems. State air managers lack access to local implementation expertise when developing management strategies, and are constrained by their own organizational boundaries (e.g., resources, authorities). Additionally, policy monopolies may result in high costs or inefficient services across systems due to ineconomies of scales, institutional barriers, or duplicated efforts (Waterman and Meier, 1998; Brown and Potoski, 2003; Hefetz and Warner, 2012). Central agency designs serve as a baseline for comparison for other types of designs, as they are both the simplest and most common.

Second, although decisions continue to be centralized, top-down institutional designs incorporate local governments (i.e., cities, counties) into CAA implementation as subunits of state agencies in order to establish a coordinated mission across levels of government (Woods and Potoski, 2010; Fowler, 2018a). For example, Tennessee's SIP establishes the Department of Conservation (TDEC) as the lead agency for CAA implementation, and provides TDEC the authority to develop pollution control strategies, regulations, and administrative procedures accordingly. In the Memphis area though, TDEC delegates enforcement authority to the Shelby County Department of Health (SCDH), which oversees permitting, inspections, enforcement, and manages compliance within the county's jurisdiction. In general, this places SCDH as a subordinate of TDEC, with TDEC dictating SCDH's role and responsibilities in regional air management. While local ordinances for air quality exist, they were crafted at the state-level and then adopted into code by local officials. For instance, with a few exceptions, Shelby's County Air Code is the state's Air Pollution Regulations with references to state agencies replaced with references to Shelby County agencies (SCDH, 2018). Other states with similar top-down arrangements for specific municipalities include Arizona, Iowa, Nebraska, and Florida.

In practice, subnational governments have limited autonomy and administrators serve primarily as compliance managers. From the state perspective, this provides additional administrative capacity and local expertise as well as resources and air quality specific assets (e.g., testing equipment). Furthermore, joint production reduces information asymmetries (i.e., one party having more or better information than the other) and fosters policy learning by creating cost or quality comparisons between producers. Additionally, multiple service agencies creates competition that puts further pressure on producers to find efficiencies, as well as safeguards against production failures (Brown and Potoski, 2003, 2004; Brown, Potoski, and Van Slyke, 2006, 2008; Hefetz and Warner, 2012). Some criticize top-down approaches for not accounting for either representative bureaucracy or the inherently political nature of public service delivery (Agranoff and McGuire, 2001; Lipsky, 2010).

More specifically, when constrained to a compliance role, local managers neither adapt policies nor experiment with different implementation mechanisms to match programs to local socio-economic, political, or technical challenges. Local expertise is then trapped in a rigid administrative framework, limiting its potential utility. Furthermore, working with external organizations creates transaction costs in communicating, coordinating, or managing that typically occur in the process of negotiating power dynamics, overseeing compliance, or dividing labor and benefits across organizations. Additionally, in principal-agent relationships, inefficiencies may result from goal incongruence, work shirking, or maximizing payoffs (Waterman and Meier, 1998; Brown and Potoski, 2003; Hefetz and Warner, 2012; Carr and Hawkins, 2013). This is particularly important if local managers view this relationship as coercive rather than cooperative, which increases potential for local agencies to take advantage of information asymmetries (Fowler, 2018a). Consequently, top-down designs limit the utility of incorporating local agencies into CAA implementation, so they rarely lead to real improvements in air quality compared to central agency designs.

[1] California solely relies on regional agencies.

***Top-Down Design Hypothesis:** In comparison to central agency designs, top-down designs will not be correlated with improved air quality.*

Third, donor-recipient institutional designs allow state and local agencies to bargain in the process of implementing the CAA in order to adjust the program to local realities. For example, although Alabama's SIP establishes the Department of Environmental Management (ADEM) as the lead agency for CAA implementation, it also delegates authorities to Jefferson County to develop a local implementation plan, with local officials developing administrative procedures as well as having authority to set air quality standards above state minimums (EPA, 2018c, Jefferson County, 2018). In addition to boilerplate goals established at federal and state-levels, Jefferson County specifically outlines as policy goals to "foster the comfort and convenience of the people, promote the social development of Jefferson County and facilitate the enjoyment of natural attractions…[by] provid[ing] for a coordinated program of air pollution prevention, abatement and control" (Jefferson County Board of Health, 2018). Consequently, in addition to enforcement of more convention command-and-control regulations, Jefferson County incorporates air quality issues into its larger transportation, energy, and smart growth planning. In other words, Jefferson County is aligning their efforts with state and federal policies, but also working to provide specific environmental benefits within its jurisdiction that would otherwise by superfluous for state or federal agencies. Other states with donor-recipient arrangements with specific municipalities include North Carolina, Pennsylvania, and Texas.

While this design runs into some of the same transaction costs incurred in top-down designs, local capacities are more effectively used to match national policy goals to subnational political realities. By actively negotiating resource exchanges, program requirements, and responsibilities with their state counterparts, local managers are able to develop process efficiencies and more effective regulatory strategies. While local agencies are still part of state-led systems, bargaining power provides local managers with opportunities to challenge that leadership, and creates more "buy in." Although these negotiations may create new transaction costs, over time, state and local officials become better at negotiating, which ultimately leads to reduced transaction costs and increased program effectiveness. While everyone may not always comply, donor-recipient designs create a more flexible framework than central agency or top-down designs, allowing state and local managers to be both opportunistic and cooperative (Liebschutz, 1991; Agranoff and McGuire, 2001; Brown and Potoski, 2003; Fowler, 2018a). As such, donor-recipient designs lead to a marked improvement in air quality compared to central agency designs.

***Donor-Recipient Design Hypothesis**: In comparison to central agency designs, donor-recipient designs will be correlated with improved air quality.*

Fourth, regional agency designs are an adaptation of donor-recipient designs, where new agencies are created for specified geographic areas via, in most cases, regional SIPs (Woods and Potoski, 2010; Fowler, 2016, 2018). Possibly the most textbook example of this approach is California, in which 35 regional agencies serve as lead agencies for managing airsheds under the umbrella of the California Air Resources Board (CARB). Under this system, CARB oversees state-level air quality policies and establishes state minimum standards, but regional agencies address local air quality through enforcement of state regulations and/or local regulations targeting specific issues within each district. Additionally, regional agencies work with local governments on issues, such as transportation or economic development planning, that may affect regional air quality. In essence, SIPs allot regional agencies a significant amount of discretion within their designated jurisdictions, but CARB retains oversight authority and serves as a state-level policymaking body to address issues that may stretch across regions (CARB, 2018; EPA, 2018c). Other states relying, at least partially, on regional agency designs include Ohio, Oregon, and Washington; however, California is the only state to rely solely on regional agencies.

Although similar to both top-down and donor-recipient designs, these designs generate new transaction costs and constraints on local implementation expertise that do not exist in other designs. Since their mission focuses on CAA implementation, regional air agencies largely function as extensions of state agencies, even though they have some bargaining power (Woods and Potoski, 2010). On the positive side, regional managers build specialized capacities without facing competing demands to deliver other services. In particular, air quality management tends to involve monitoring and testing equipment that is not applicable to other public services, which creates high fixed costs and barriers to market entry. Specialized agencies overcome these issues by developing specific capacities for a unique purpose (Cannibal and Lemon, 2000; Brown and Potoski, 2003, 2005; Brown, et al., 2008; Hefetz and Warner, 2012).

On the other hand, a single policy function limits the ability of regional managers to leverage resources, capacities, or expertise gained from other policies areas. Unlike city managers, regional air managers cannot learn ways to become more efficient from other implementation experiences, or supplement air programs with resources from other programs. Additionally, at intermediate governmental levels, regional agencies create new bureaucratic layers and face limitations in how well managers develop specific knowledge of local circumstances. Most importantly, policy monopolies and specialized expertise create high potential for information asymmetries, where legislatures have limited information about performance, costs, or service quality. Consequently, there is opportunity for specialized agencies to act opportunistically in expanding resources or maximizing payoffs (Waterman and Meier, 1998; Brown and Potoski, 2003; Brown, et al., 2006). As such, regional agency designs create more complexity than other designs, so they rarely lead to better air quality in comparison to central agency designs.

Regional Agency Design Hypothesis*: In comparison to central agency designs, regional agency designs will not be correlated with improved air quality.*

Finally, emergent governance institutional designs occur when local governments not included in CAA implementation find innovate ways to govern air quality from outside state-led systems. By nature, emergent governance designs are less of a conscious top-down effort at organizing institutions than other designs, and more of a result of bottom-up innovation in response to perceived deficiencies in state-led efforts (Agranoff and McGuire, 2001; Volden, 2005; Riverstone-Newell, 2013; Fowler, 2018b). For example, Colorado's SIP designates the Colorado Department of Public Health and the Environment (CDPHE) as the lead agency for CAA implementation, and CDPHE further delegates some responsibility to Larimer County's Department of Health in a top-down arrangement. Starting in the early 1990's, the City of Forth Collins's became more involved in air quality when EPA determined levels of carbon dioxide in the regional airshed exceeded national minimum standards. Early on, Fort Collins worked with state and county agencies to address this issue. By the mid-2000s, when carbon dioxide was reduced to acceptable levels, the City shifted its focus away from coordinating efforts and towards policy innovation in response to a citizen mandate that emphasized air quality standards beyond federal and state standards (Fort Collins, 1996, 2011).

Furthermore, the City's air quality plan identifies its goals as to "[c]omplement and fill gaps left by federal, state and county efforts" and "[r]espond to a strong citizen mandate for the City to protect and improve air quality" (Fort Collins, 2004, p. 4). This highlights perceptions that local agencies are addressing deficits in state and federal policies and developing their own distinct programs. To this end, Fort Collins adopted a plan to align citywide policies with its air quality goals and to work collaboratively across the region with public agencies as well as non-governmental organizations to reduce emissions. The City also routinely solicits public input on air quality issues (Fort Collins, 2011). Although Fort Collins is advanced in comparison to other cities, similar cases appear in Illinois, Indiana, Kansas, and New York. With the advent of self-organization around policy goals, emergent governance designs represent a shift from intergovernmental policy implementation to inter-organizational policy governance, so hierarchical coordination around legislatively mandated policy outputs is no longer a guiding principal (Osborne, 2006). Here, local air agencies do not have formal connections (e.g., mandates) to state agencies, and are not part of SIPs. Consequently, local managers do not participate in CAA implementation, so their focus is on managing air quality rather than implementing federal legislation.

Without the burden of policy implementation responsibilities, hierarchical controls on innovation, or resource dependencies, local agencies position themselves to solve problems through interactions with a variety of different organizations, but face institutional barriers to collective action in doing so (Feiock and Scholz, 2009). While strategic action or resource competition are a driving force for some, others focus on collaboration to pursue goals that cannot be achieved otherwise. These types of designs "often find reasonable solution approaches, but then run into operational, performance, or legal barriers that prevent the next action step… [and] face challenges in converting solutions into policy energy, assessing internal effectiveness, surmounting the inevitable process blockages, mission drift, and so on" (McGuire and Agranoff, 2011, p. 265). Furthermore, agency interactions may become excessively complex and lead to overprocessing, so there is an economy of scale for transaction costs that ultimately limits efficacy. Although scalability is a challenge, emergent governance designs improve upon designs that only rely on states agencies, by allowing local managers to act strategically in managing air quality (Agranoff and McGuire, 2001; Hicklin, O'Toole, and Meier, 2008; McGuire and Agranoff, 2011; Provan and Lemaire, 2012). As such, emergent governance designs lead to a marked improvement in air quality compared to central agencies designs.

Emergent Governance Design Hypothesis: *In comparison to central agency designs, emergent governance designs will be correlated with improved air quality.*

Methods

Data and Dependent Variable

The full dataset included 522 AQCRs that were air quality monitoring sites in both 2010 and 2013, but due to data limitations, our analytical sample includes 363 AQCRs that represent 47 states.[2] These AQCRs range in size from 9,470,069 (Chicago, IL) to 18,012 (Los Alamos, NM). There are no significant discrepancies between full and analytical datasets, with the latter appearing to be representative of the former in regards to major socio-economic factors. For instance, in the analytical dataset, average population and per capita income were 506,356 and $35,462, respectively, while in the full dataset, they were 511,262 and $35,484, respectively. Additionally, average 2010 air quality index (AQI) score for the full dataset was 39.17 compared to 39.20 for the analytical dataset. For our dependent variable, we measure air quality outcomes as annual median AQI for each AQCR, with data from EPA's AirData system. Since criteria pollutants are not directly comparable to each other, AQI creates a standardized measure to evaluate air quality and program success. AQI operates as a piecewise linear function of pollutant concentrations, measured on a scale from 0 to 500 (EPA, 2016b).

As previous research indicates a lagged dependent variable is necessary as changes in air quality take years to manifest, we use a three year lag, observing independent variables in 2010 and dependent variable in 2013, with 2010 to 2013 being a unique period for air quality (Ringquist, 1993a; Fowler, 2016). More specifically, after years of stagnant expenditure growth for pollution control and abatement (averaging 1.96% between 1993 and 2009), President Barack Obama increased spending in 2009 by 36.39% (largest annual increase since 1977). Spending levels were maintained until 2013 when the new Republican-controlled Congress return to previous spending levels (Office of Management and Budget (OMB), 2018). This short-lived boost in spending is also observable at state- and local-levels (Census, 2018; OMB, 2018). While previous periods of incrementalism likely lead to managerial stagnation, 2010 to 2013 created a radical change and challenged status quos. As a corollary, there are no discernible trends in air quality between 2000 and 2009, but from 2010 to 2013, the average AQI declined from 39.17 to 37.56. Consequently, this represents a radical period of change that allows us to compare initial air quality resulting from decades of status quo management to air quality resulting from three years of radical change. Therefore, if variation in institutional designs affect outcomes, then it is most likely to be observable during this period.

Institutional Designs

We classified institutional designs with a three-step methodology. First, we identified local air agencies, using the National Association of Clean Air Agencies (NACAA) and previous scholarship (e.g., Woods and Potoski, 2010). Second, we used SIPs and surveys of state and local members of NACAA to determine state-local relationships. We contacted the 168 members listed in the online directory three times via mail and email. Of 103 (61.3% response rate) total respondents, 19 (38% of state agencies) were state-level and 84 (71.2% of local agencies) local-level. Respondents represented 24 of 26 states with local air agencies.[3] We asked respondents to indicate whether four types of authorities were delegated to local agencies in their state: 1) to set criteria pollutant ambient standards; 2) to set new source performance standards; 3) to set hazardous air pollutant standards; and, 4) to enforce federal and/or state air standards (Woods and Potoski, 2010). Additionally, we asked respondents to identify types of policy tools they used (e.g., pollution prevention, outreach, regional cooperation, smart growth initiatives, or energy and transportation planning). Then, we reviewed SIPs to confirm.

Third, we created decision rules to classify AQCRs based on state and local authorities and policies. Initially, we classified any AQCR without a local air agency as central agency designs (417 total AQCRs; 281 in analytical sample). Next, if local agencies are not delegated authorities for setting air standards but do have authorities for enforcing state and federal standards, we assumed that they function as state administrative subunits in a compliance management

[2] Bureau of Economic Analysis (BEA) does not report data when doing so discloses confidential information. Outlier analyses indicated three AQCRs fell outside normal ranges for leverage and normalized residual values.
[3] For these two states, only SIPs were used to determine institutional designs.

role. Further analyses of SIPs and survey data related to policy tools indicates these agencies mostly enforce policies that align with state-led strategies (i.e., pollution prevention). As such, we classified AQCRs with these agencies as top-down designs (33 AQCRs in total; 29 in analytical sample).

Next, if local agencies are delegated regulatory and enforcement authorities, we assumed that they are semi-autonomous (i.e., not administrative subunits) and are central to intergovernmental management strategies. Additionally, SIPs and survey responses indicate that these local agencies manage policies that both align with state-led strategies and that provide local context to state-led strategies (i.e., smart growth initiatives). However, regional air agencies are a class unto themselves as they are not connected to a general purpose government (e.g., city or county), specialize in an asset specific service, operate on a regional scale, and function at an intermediate-level within the federal hierarchy (Fowler, 2016, 2018). In general, SIPs create regional air agencies to serve as lead agency for coordinating efforts across geographically defined airsheds. As such, we divided AQCRs with agencies that have both regulatory and enforcement authorities into two groups: donor-recipient as those associated with a city or county government (7 AQCRs in total; 6 in analytical sample); and, regional agencies as independent, regional agencies (48 AQCRs in total; 36 in analytical sample).

Finally, if local agencies are neither delegated authorities nor have formal roles, we assumed that they function outside of conventional management strategies coordinated by the state. While SIPs and survey data indicate these agencies have no formal authorities and do not enforce state-led policies, survey data also indicates that regional cooperation is most common policy tool, while policies that aligned with state-led strategies (i.e., pollution prevention) were not used. As such, we classified AQCRs with these agencies as emergent governance designs (16 AQCRs in total; 11 in analytical sample).

For statistical analyses, we operationalization institutional design variables in two ways. First, we use nominal dummy variables that compare AQCRs relying only on central agency designs (77.4% of AQCRs in analytical dataset) to those with top-down (8.0%), regional agency (9.9%), donor-recipient (1.7%), or emergent governance (3.0%) designs. In some cases, AQCRs within the same state may fall under different institutional designs. Second, since some local agencies only control a portion of AQCRs, their impact is likely a function of relative jurisdictional control. To account for these effects, we created interval variables by multiplying dummy variables by the portion of MSAs and µSAs falling under respective jurisdictions. We assumed that portions of MSAs and µSAs not within local agency jurisdictions default to central agency design. Therefore, in the analytical sample, central agency designs accounts for 81.7% of metropolitan populations within AQCRs, top-down 5.3%, regional agency 9.9%, donor-recipient 0.9%, and emergent governance 2.2%. However, as regional agencies are exclusively regional planning agencies with authority over entire AQCRs, there are only two values, 0 and 1 (i.e., 0% or 100%), causing this variable to default to a nominal dummy variable. As such, we include this variable alongside interval-level variables, but do not interpret as such.

Other Predictors

We control for state and federal management factors, local socio-economics, region, and existing air quality. First, as states play a central role in CAA implementation, we control for state environmental expenditures per capita and agency organization (Ringquist, 1993a, 1993b; Bacot and Dawes, 1997; Potoski and Woods, 2002; Fowler, 2016). We use a dummy variable to compare states using a pollution control agency to states with other types of agencies (e.g., health) (Ringquist, 1993b; Fowler, 2012). Additionally, since 2010 involved substantial growth in federal environmental expenditures, we control for percentage change of federal aid to state and local environmental programs from 2009 to 2010. Second, local socio-economic factors affect environmental outcomes through pollutant production, environmental attitudes, and political interests, so we control for both local population and per capita income (Ringquist, 1993a; Potoski and Woods, 2002). Additionally, we control for industry with percentage of local economies from manufacturing and transportation industries, which are key stationary sources of air pollutants. Third, since regional variations account for geographic trends that affect both environmental conditions and norms of environmental management, we control for region using dummy variables to compare the Northeast, Midwest, and West U.S. Census regions to the South (Emison and Morris, 2010). Finally, we control for existing pollution levels with annual median AQI for initial observation year (Ringquist, 1993b; Bacot and Dawes, 1997; Potoski and Woods, 2002; Fowler, 2012).

Analysis

Since we believe, it is likely that existing air quality affects institutional design and institutional design then affects future air quality; over time, there is likely reciprocal correlation. As such, it is not possible to control for initial AQI without adjusting for this endogeneity or to test the relationship between institutional design and air quality without controlling for existing differences in air quality. Consequently, we use two-stage least squares (2SLS) regression (Meier and O'Toole, 2002; Sovey and Green, 2011). We use as instruments four variables correlated with existing air quality (prior economic growth, prior population growth, AQI days above 150, and population centers within AQCRs)[4]; then, the purged form of initial AQI corrects for reciprocal correlation in the model.[5] We subsequently confirmed appropriateness of these instruments with both the Hansen J-statistic and Kleibergen-Paap test, which indicate that these variables satisfy the exogeneity and relevance conditions for instrumental variables (Gabel and Scheve, 2007; Sovey and Green, 2011). Further diagnostic tests indicated no other assumptions were violated. Finally, since unit of analysis is AQCR but CAA implementation tends to be coordinated at the state-level, we cluster standard errors at that level. As such, we assume that state-level factors cause model errors for AQCRs in the same state to be correlated while errors for AQCRs in different states to be uncorrelated (Primo, Jacobsmeier, and Milyo, 2007).

Results and Discussion

Table 1 displays 2SLS results with nominal and interval institutional design variables. In general, findings indicate that institutional designs have substantive effects on air quality outcomes, but these substantive effects are a function of jurisdictional sizes. First, based on nominal comparison (model 1.1), donor-recipient designs were correlated with AQI decreases of 4.45 compared to central agency designs (11.36% decrease over average 2010 AQI); and, based on interval comparisons (model 2.1), when jurisdictional sizes of donor-recipient agencies increase by 1% of metropolitan population, there is a corresponding decrease in AQI by 5.83 (14.88% decrease). On the other hand, emergent governance designs were correlated with AQI decreases of 3.96 compared to central agency designs (model 1.1) (10.11% decrease), and jurisdictional sizes increases of 1% corresponded to an AQI decrease of 4.94 (model 2.1) (12.61% decrease).

[Tables 2 about here]

[4] While population and economic growth are commonly associated with environmental conditions, changes in SIPs are incremental with few significant revisions occurring since the 1990 CAA amendments (Woods and Potoski, 2010). Number of AQI days above 150 and number of population centers measure extremes in AQI and areas of concentrated pollutant emissions. Conversely, since days above 150 mostly serves as a point of reference to communicate "bad air" days to the public, it is unlikely that states would design institutions around a measure of air quality that is not considered in performance goals (EPA, 2018d). Population centers would likely only be associated with institutional designs if SIPs required municipalities to be involved in air management. However, this is not the case, so there is no reason to believe an association between population centers and institutional designs exist. Correlation analyses confirmed these associations.

[5] Addressing temporal issues effectively enough to provide an accurate comparison between institutional designs that have been in place for four or five decades to more recent approaches that have been for less than two decades is the most challenging part of this research design. Our findings presented below provide evidence of notable differences, but there are important limitations to that evidence. Namely, we assume in instrumenting air quality that the chief concern here is that prior performance (i.e., air quality in 2010) is correlated with the error term of future performance (i.e., air quality in 2013). In other words, there are a series of socio-economic or environmental conditions that have led to both air quality conditions prior to 2010 and institutional designs that continue to effect air quality conditions in 2013. If left unattended, this then presents bias in our model, where those conditions may be more explanatory then institutional designs in themselves. In order to address this, we use instrumental variables on air quality in 2010), so we are then making a comparison based on unbiased prior performance. Thus, we assume that any differences are a result of institutional designs. On the other hand, we could assume that there are other contextual factors inherent in each design that are also correlated with air quality (i.e., managerial quality), and therefore should use instrumental variables on institutional designs. However, this runs into two distinct challenges. First, it requires us to make several assumptions about the evolution of institutional designs, and how those factors then may also impact air quality. In general, there is scant evidence suggesting why different institutional designs exist. Fowler and Jones (forthcoming) is the most recent and sophisticated analysis to date, and suggests there are at least two trends that explain why different types of local air agencies exist: one from the top-down where state make choices in delegating authorities, and one from the bottom-up where local governments choose to innovate. Second, and by extension, there would then need to be a distinct set of instrumental variables for each institutional design. In turn, this may create unintended consequences and introduce other forms of bias. Most importantly though, finding "good" instrumental variables is difficult and many of the unobserved differences in institutional designs may not be measurable (i.e., innovation capacity). Given the trade-offs in pursuing this research design, we erred on the side of caution in order to control for the bias that we can reasonably assume exists and make inferences about, rather than biases that we are unsure of and do not fully understand. In general, this research design looks at a "snapshot" in which institutional designs should be comparable in terms of the context of managing air quality as a way of determining if certain mechanisms of organization produce better outcomes.

These findings likely result from incorporating local expertise and capacity into managerial efforts, while minimizing transaction costs associated with inter-organizational interactions, which support our donor-recipient and emergent governance design hypotheses. In both cases, local managers likely adapt administrative processes to local circumstances better than in other designs. Rather than rely on state-led command-and-control regulatory approaches, local governments are integrating air quality into their decision calculus on numerous city and county policies as a means to coordinate environmental quality goals with urban growth and development, as well as experimenting with mechanisms to encourage emissions reductions. In effect, these institutional designs produce positive tradeoffs when shifting approaches to decision-making and goals from central agency designs. However, donor-recipient consistently outperforms emergent governance designs. Since results from interval variables indicate effectiveness of donor-recipient increases as jurisdictions expand at a higher rate than for emergent governance designs, findings likely reflect scalability of donor-recipient designs, where benefits and costs increase at comparable rates. On the other hand, managerial complexities in emergent governance designs likely cause transaction costs to increase at higher rates than benefits, slowing rates of increased effectiveness as jurisdictions grow (Hicklin, et al., 2008; McGuire and Agranoff, 2011). Consequently, when jurisdictions are large, transaction costs add up and effectiveness increases at a slower rate than in donor-recipient designs.

Second, regional agency designs are correlated with AQI increases of 2.34 (model 1.1) and 2.45 (model 2.1) compared to central agency designs (5.97% and 6.25% increase, respectively). While regional agency is used in model 2.1 with interval variables, it is measured as a nominal variable, so it is interpreted in the same way as findings from model 1.1. Although there is no data related to how variations in jurisdictional sizes affect outcomes, these findings support our regional agency hypothesis, and suggest these designs may not be a successful approach to adapting management strategies to local circumstances. This likely results from ineffective organization that include additional bureaucratic layers and policy monopolies. Additionally, these designs are more likely than others to produce information asymmetries that lead to self-interested bureaucratic behavior (Waterman and Meier, 1998; Brown and Potoski, 2003). However, these findings do not consider how operations may be affected by variations in regional agency structures, such as relationships with local or state agencies and roles of elected officials in agency oversight. While empirical findings suggest these designs are likely correlated with poor air quality, additional research is needed to further understand how policy implementation occurs under regional agencies. This is particularly important considering the regional nature of air quality, and stark contrasts between regional agencies and emergent governance designs, which also incorporate a regional component to air quality management.

Third, as findings for both top-down designs (models 1.1 and 2.1) were not statistically significant, it is difficult to determine what substantive effects these designs have on air quality outcomes. Nevertheless, at minimum, we can determine that top-down in comparison to central agency designs are correlated with generalizable improvements in air quality. While somewhat limited, these findings do provide support for our top-down hypothesis. Fourth, we also include models 2.1 and 2.2 as a baseline model (i.e., central agency compared to all other designs). Given competing directional effects for other institutional designs, it is unsurprising findings were not statistically significant. There is some probative value in these models though. Specifically, standard errors for central agency and regional agency designs were comparatively smaller than those for donor-recipient and emergent governance designs. This may suggest that although donor-recipient and emergent governance designs have a more substantive effect on air quality on average, there is a greater degree of inconsistency of those effects compared to other designs, which may result from greater opportunities for local agencies to work shirk. On the other hand, central agency designs may create a higher degree of regulatory consistency than designs that incorporate local agencies, which may be a key argument for central agency designs in the face of fragmented regulatory regimes.

However, the differences in standard error may also be explained by more observations of central agency compared to other designs. Specifically, central agency designs make up the lion's share (77.4%) of our dataset, so naturally, there would be less standard error in those results. Conversely, emergent governance designs and donor-recipient designs are relatively underrepresented in our dataset (3.0% and 1.7%, respectively). Of course, our chief constraint here is real world variation in agency designs, since our dataset includes almost the entire population for each of these designs. On one hand, our findings are statistically significant, which would indicate generalizability. On the other hand, we are attempting to draw conclusions based on a small number of agencies, which increase the likelihood of type-1 error (i.e., false positives). Consequently, we draw conclusions with a degree of circumspection as it relates to these designs. Regional agency and top-down designs make up relatively larger portions of our dataset (9.9% and 8.0%, respectively), so we have more confidence in those findings.

Other political, socio-economic, and environmental factors are also substantive predictors of air quality outcomes. Positive coefficients for regional variables indicate the Northeast and West regions are consistently more likely to have higher AQI than the South region. Negative coefficients for state environmental expenditures and mini-EPA indicates that increased state spending and state pollution control agencies (when compared to alternative types of environmental agencies) are correlated with decreased AQIs. However, previous research indicates expenditures rarely have a direct relationship with environmental outcomes, and other political and socioeconomic factors are typically more important predictors (Bacot and Dawes, 1997). This is particularly notable in relation to federal aid to state and local environmental programs, in which a positive coefficient suggests increased aid is correlated with higher AQIs; however, this finding was not statistically significant. Findings for existing air quality conditions were as expected, with current conditions as the best predictor of future conditions. Although not statistically significant, coefficients for population and per capita income indicate that economic development is positively correlated with AQI. These findings are consistent with previous literature on the relationship between socio-economics and air quality (Ringquist, 1993a, 1993b; Fowler, 2016).

While findings support our hypotheses, temporal issues in our research design create notable limitations. More specifically, institutional designs for managing air quality evolved over decades, but that evolution is inconsistent and somewhat unclear across states, which constrains our ability to incorporate temporal data into our research design. Given this, we rely on a cross-sectional "snapshot" to identify the relationship between institutional designs and air quality, but this does not incorporate potentially important observations concerning how these variables relate to each other over time. Most significantly, there is likely a degree of reciprocal correlation between institutional designs and air quality, where institutions affect air quality and then air quality affects institutional changes. We use 2SLS to correct for this, but this technique is limited by our identification and operationalization of instrumental variables. Additionally, institutional designs may be endogenous with each other. For example, designs that incorporate local agencies are likely a response to failures that occurred when states implemented the CAA under central agency designs. In fact, some states did not devolve authorities for air quality regulations to local governments until the 1990s, and emergent governance designs did not emerge until the 2000s. Furthermore, we may not be able to expect continual improvement in air quality over time as air pollutants can only be practically reduced to a minimal value.

As such, some institutional designs may produce large improvements initially before plateauing, others may lead to incremental changes over time, and still others may run into institutional barriers before producing gains. As these changes occurred incrementally at different times in different states, we cannot correct for this using instrumental variables, and data on local air agencies is not available prior to our survey. Thus, we assume that if we isolate these institutional designs within a unique time period in which radical changes in environmental management occurred at the national-level, then we can attribute fluctuations within AQCRs to contemporary institutional designs present at that time. However, this does not tell us how rates of change during any time period other than three-years accumulates; that is, our results are not nuanced enough to indicate whether small changes over time or one large change accounts for differences that manifest between 2010 and 2013.[6] Consequently, additional research is necessary to further parse out the specific rate of improvements that occur as a result of these institutional designs, and the comparative utility of incremental versus rational departures from the status quo when it comes to air quality and other environmental conditions.

Given this, we must also consider whether these findings are generalizable outside of the unique period from 2010 to 2013. Most likely, similar patterns occur during other time periods, particularly as it applies to comparisons between central agency and other designs as those findings are relatively strong. However, other findings discussed here may fluctuate with the ebb and flow of national environmental policies, as national and subnational governments jockey for position within the federal hierarchy. Most significantly, this likely effects the comparative efficacy of emergent governance designs as EPA shifts its approach to environmental regulation in response to presidential or congressional environmental agendas and sends ripples through the intergovernmental environmental management system (Konisky and Woods, 2016).

[6] Other lag periods produced similar results, but they were not as a good of a fit for the data. Previous research on this subject would suggest it takes time for policy differences to manifest in actual air quality conditions, because the causal change from policy to socio-economic changes to air quality is so complex. Thus, looking at shorter period of times may be misleading or create new avenue for bias.

Conclusions

Ideally, government is organized for purposes of effectiveness, efficiency, or democratic accountability; however, politicians make tradeoffs between political goals, transaction costs, performance, and accountability in designing institutions (Wood and Bohte, 2004). While innovative solutions for managing complex problems emerged in recent decades, more traditional approaches persist. As such, several institutional designs exist simultaneously and present tradeoffs in how subnational governments are organized. While some designs may appear antiquated, it is likely that they are either effective enough or at least not ineffective enough to warrant change. Findings for central agency and top-down designs suggest those approaches satisfice in maintaining air quality, which wards off challenges to their efficacy. In both cases, evidence is insufficient to determine directional effects and either may result in positive or negative changes in air quality under certain circumstances. In other words, it is not that there are no effects of these designs in comparison to other institutional designs. It is that effects may be too minimal or too variable to make a specific determination that alternative designs will lead to better performance, which likely provides sufficient cause for politicians to avoid uncertainty in administrative reform (Potoski, 2002; Wood and Bohte, 2004; Moynihan 2005).

More interestingly, findings indicate that when governmental units organize around shared policy goals and challenge formal hierarchies (i.e., emergent governance), policy outcomes are better than three of four conventional intergovernmental designs (i.e., central agency, top-down, and regional agency). However, emergent governance designs underperform compared to the fourth design (i.e., donor-recipient). Although emergent governance and donor-recipient designs partially rely on similar organizational mechanisms (i.e., empowering local managers to function as problem solvers), emergent governance designs place local managers outside of CAA implementation and are driven by bottom-up, rather than top-down, decisions. On the other hand, donor-recipient designs create avenues for bargaining between state and local managers, and capitalize on local expertise in adapting intergovernmental management strategies to local circumstances. Other intergovernmental designs are not organized to allow local managers to play similar roles though, and in many cases, there are institutional barriers to doing so. Consequently, how local agencies are incorporated into intergovernmental policy implementation is a pivotal question in determining how effective institutional designs are. In many cases, effectiveness comes down to specific contexts and policy enterprises, and whether organizations have necessary capacities to overcome barriers to their success (Brown and Potoski, 2003; McGuire and Agranoff, 2011). Nevertheless, given limitations to our analysis, we are cautious in drawing these conclusions, especially for emergent governance and regional agencies.

While alternative organizational approaches may provide better mechanisms to do this in some cases, those circumstances do not always exist, so conventional intergovernmental management still presents a viable option. Although organizing governmental units based on shared policy goals largely results from limitations created by complex policy problems, there are still mixed reviews of how effective these approaches are, especially in comparison to more conventional forms of intergovernmental management (Feiock and Scholz, 2009; Andrews and Entwistle, 2010; McGuire and Agranoff, 2011). For air quality, organizing around shared policy goals is only the best option if there are institutional barriers to bargaining between state and local officials. However, these institutional barriers are the circumstances that lead public agencies to re-organize themselves around shared policy goals in the first place (Feiock and Scholz, 2009). As such, our findings suggest two somewhat complementary conclusions. First, when institutions are designed to allow bargaining between local and state officials, intergovernmental management is the most effective approach for matching managerial efforts to complex policy problems. Second, in absence of those mechanisms, intergovernmental management is less effective than public agencies self-organizing around shared policy goals. These findings provide additional insights into why more governance-oriented strategies are necessary in the face of institutional barriers, as innovative actors can more effectively manage complex problems by breaking away from conventional approaches.

As findings are limited to a unique policy area in the U.S., this begs the question of whether these findings are applicable to other policy domains or federal systems. Although many other federal environmental (e.g., Clean Water Act) and social programs (e.g., Medicaid) rely on subnational governments for implementation, air quality is a high asset specific policy area and the CAA creates a somewhat rigid framework of state responsibilities compared to other policies (Brown and Potoski, 2003; Woods and Potoski, 2010). Most obviously, this causes a preponderance of central agency designs in our dataset, where alternative designs may be more common in other policy areas. Additionally, the U.S. is not the only federal system and emergent governance approaches are becoming more common worldwide as national and subnational governments grapple with institutional barriers to collective action (e.g., Tavares and Feiock, 2018 or Chen, Ma, Feiock, and Suo, 2019). A key component of our comparison of institutional designs is how subnational governments are coordinated to manage complex policy problems that challenge vertical and horizontal fragmentation of regulatory regimes. Although both our analysis and a mass of research has focused on the U.S., this a common problem in most advanced democracies with institutional authorities divided geographically.

While specific institutional features may vary, effectiveness is likely still a function of the tradeoffs made in balancing decision-making and transaction costs as implementation systems expand to incorporate different policy actors. Importantly though, effectiveness may not be the most important performance indicator in some policy areas or nations, so advantages or disadvantages of designs may lie elsewhere (e.g., equity) (Andrews and Entwistle, 2010). Consequently, whether conventional intergovernmental management outperforms emergent governance will depend on the problem parameters and how important local capacities are for policy success. As such, further research is necessary to consider these designs within the context of other federal programs, policy areas, and national systems to determine how policy problems affect the utility of certain institutional features. Additionally, scholars should further consider how spatial issues affect design efficacy as geographic distributions of environmental and institutional challenges vary across subnational governments. Institutional designs should also be examined as dependent variables, and how political transaction costs and performance outcomes lead to innovation (or lack thereof).

Finally, temporal challenges in our research design highlight how difficult it is compare institutional designs that have been operational for several decades to those that are still emerging. Given the rather piecemeal fashion in which administrative reforms occur in federalist systems, this draws important questions concerning whether initial transaction costs of redesigning intergovernmental systems are worth it and whether more conventional intergovernmental relations have plateaued in their effectiveness for managing complex policy problems. Our research design uses a "snapshot" of these designs during a unique period of time, but does not consider some potentially significant issues in how designs evolved and how the relationship between designs and air quality changes over time. To this end, scholars need to consider other more sophisticated methodologies to examine these types of differences in order to make more rigorous comparisons between traditional mechanisms of intergovernmental management and cutting edge trends in emergent governance. Despite recent innovations, more traditional approaches to managing policy problems in a federal system persist and have important implications for understanding governance of emerging challenges.

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Tables

Table 1. Comparison of Institutional Designs

Institutional design	*Agencies*	*Coordination mechanisms*	*Advantages*	*Constraints*
Central agencies	State	Policy monopoly	Minimizes coordination costs; reduces bureaucratic layers	No access to local capacities or resources
Top-down	State; local	Directed by state agency; local serves as state sub-unit	Incorporates local capacities and resources	Coordination costs; local agencies are compliance managers
Bottom-up	State; local	Bargaining between state and local	Incorporates local capacities and resources	Coordination and bargaining costs
Regional agencies	State; regional	Directed by state agency; some bargaining between state and regional	Development of specialized capacities	Additional layer of bureaucracy; information asymmetries
Emergent governance	State; local	Self-organization	Local flexibility	Economy of scale for transaction costs

Table 2. Results of 2SLS Models

	Model 1.1	Model 1.2	Model 2.1	Model 2.2
Central agency	-	-.480 (.800)	-	-1.356 (.875)
Top-down	.837 (1.330)	-	2.253 (1.602)	-
Donor-recipient	-4.453 (1.895)*	-	-5.826 (2.884)*	-
Regional agency	2.338 (.956)*	-	2.452 (.954)**	-
Emerg. governance	-3.960 (1.520)**	-	-4.939 (1.435)***	-
State Expenditures	-.034 (.009)***	-.030 (.009)***	-.037 (.008)***	-.032 (.009)***
Federal Aid	.008 (.010)	.006 (.009)	.008 (.010)	.007 (.010)
Mini-EPA	-2.284 (.881)**	-2.102 (.870)*	-2.328 (.875)**	-2.085 (.867)*
Population	.067 (.051)	.044 (.061)	.052 (.056)	.040 (.062)
Income	.071 (.060)	.062 (.062)	.070 (.061)	.061 (.063)
Industry %	-14.228 (410.563)	11.723 (411.861)	5.788 (406.362)	3.611 (406.064)
Northeast	4.179 (1.425)**	4.073 (1.514)**	4.194 (1.447)**	4.083 (1.523)**
Midwest	1.660 (1.324)	1.630 (1.296)	1.590 (1.272)	1.579 (1.271)
West	7.762 (1.534)***	8.168 (1.761)***	7.757 (1.537)***	7.813 (1.694)***
Initial AQI	.853 (.128)***	.860 (.137)***	.850 (.130)***	.854 (.135)***
Constant	-2.215	-1.620	-2.063	-.512
R-squared	.753	.743	.754	.745
BIC	2389.475	2386.126	2388.699	2383.767
N	363	363	363	363

Note: *<.05, **<.01, ***<.001. Standard errors in parenthesis.