Multilevel Instruments for Infrastructure Investment: Evaluating State Revolving Funds for Water

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In recent decades, the federal government has introduced complex, multilevel state-operated revolving loan fund programs as an instrument for promoting state and local investment in national infrastructure priorities while limiting direct federal involvement in implementation. A federally funded state revolving fund (SRF) program combines features of a categorical matching grant to states and a subsidized loan program to localities, both of which should lower the effective price of infrastructure investment and therefore promote higher levels of infrastructure investment. However, little evidence exists to date on whether these programs stimulate new subnational spending or instead displace spending that would have occurred otherwise. We evaluate the stimulus effects of SRFs by examining the two largest such programs, the Clean Water and the Drinking Water SRF Programs. Analyzing 17 years of state-level panel data, we find evidence that the flow of federal funds to states under the SRF programs stimulates new local investment in wastewater infrastructure, but not in drinking water infrastructure. In discussing several possible explanations for these divergent results, we argue for further research that emphasizes the intergovernmental features of this financing tool.

KEY WORDS: water policy, infrastructure, state revolving funds, public finance, fiscal federalism

Ensuring adequate infrastructure investment in the United States remains a central policy challenge. The nation’s highways, bridges, electrical, and water infrastructure are all underfunded, creating operational vulnerabilities that jeopardize public health and safety (American Society of Civil Engineers [ASCE], 2016; Copeland &
Tiemann, 2010; Gomez, 2013; Morris, 2017; U.S. Environmental Protection Agency [EPA], 2002; U.S. Government Accountability Office [GAO], 2012). By the theory of fiscal federalism, local and state governments are best positioned to develop and implement infrastructure projects that satisfy local preferences and respond to local conditions. Yet subnational governments often underinvest in public goods, particularly environmental infrastructure (ASCE, 2016). The federal government historically has offered grant assistance to supplement state and local spending and to encourage investment in national priorities. Grant programs are costly for a central government to sustain, however. In recent decades, the federal government has shifted some of its funding assistance from direct grant programs to more complex, multilevel policy instruments in order to stretch federal dollars further and respond to political demands for reduced federal government activity.

State-operated revolving loan fund programs are an example of the type of networked governance that has emerged from widespread devolution (O'Toole, 1996). The general state revolving fund (SRF) model is a state-managed fund capitalized from federal grants that offers various forms of financing, typically direct loans at low-interest rates, to local governments and other public and private entities for infrastructure projects. Loan repayment along with interest and fees replenish the funds for future loan recipients. The result is a complex network of multilevel relationships and incentives where states experience the funding as grants with matching requirements while localities, who are making infrastructure investment decisions, experience the funding as loans that must be repaid.

SRFs have attracted attention as a mechanism for using federal dollars to leverage state, local, and private investment in infrastructure improvement (Chen, 2016; Chou, Hammer, & Levine, 2014; Holcombe, 1992; Johnson, 1995; Ryu, 2006, 2007). They are the dominant form of federal assistance for water and wastewater projects, and variations on the SRF model exist in the transportation, clean energy, and brownfields redevelopment sectors and have been proposed for other sectors as well (Booth, Doris, Knutson, & Regenthal, 2011; Coye & Bernstein, 2003; Gouldson et al., 2015; Puentes & Thompson, 2012; Yusuf & Liu, 2008). Yet little evidence exists about the effectiveness of this policy instrument in stimulating higher levels of infrastructure investment by state and local governments. A federally funded SRF program combines features of a categorical matching grant (to the states) and a subsidized loan program (to localities), both of which should lower the effective price of infrastructure investment and therefore promote higher levels of expenditure. However, federal funds dedicated for an intergovernmental loan program may not encourage state and local investment. It may be that the only localities motivated to take advantage of an SRF loan are those that would have pursued financing through other means if the fund were not available. The complex, networked implementation of SRF programs and states’ variable performance in managing their funds also may dampen any stimulus effect on subnational spending.

In this article, we evaluate the effectiveness of SRFs as a policy instrument for stimulating subnational infrastructure spending by examining the two largest such programs, the Clean Water and the Drinking Water SRF Programs. To date, the
funds have provided over $133 billion for projects to improve the quality of the nation’s drinking water and surface water bodies (U.S. GAO, 2015). Combined, they represent the largest expenditure in the U.S. Environmental Protection Agency (EPA) budget, accounting for over 25 percent of EPA expenditures in many years.1 While often described as a successful policy instrument (Copeland, Maguire, & Mallett, 2016; U.S. EPA, 2006, 2010; Water Environment Federation, 2016), there has been limited analysis of SRF programs and their ability to generate subnational investment in water infrastructure. Analyzing 17 years of state-level panel data, we find evidence that the flow of federal funds from the EPA to states under the SRF programs is effective in stimulating new subnational investment in wastewater infrastructure, but not in drinking water infrastructure. To account for the potentially long lag in converting federal contributions to a SRF into new local capital investment, we employ error correction models (ECMs) that allow us to estimate both short-term and long-term effects of federal transfers to SRFs. Our results show that long-run effects dominate: for every dollar that a state receives under the SRF model, wastewater expenditures rise $2.84. In contrast to the results for wastewater, however, our analysis suggests that federal funds designed to support drinking water systems do not consistently generate local investment in drinking water infrastructure. We discuss several possible explanations for these divergent results, which are relevant for understanding the effectiveness of SRFs as a policy tool in a complex multilevel governance setting.

SRFs and Local Investment

"Federal Funding for Local Water Infrastructure"

Localities in the United States typically self-finance the construction and maintenance of water infrastructure, but the federal government has long offered local governments financial assistance to encourage local investment in wastewater treatment (Copeland et al., 2016). Congress first appropriated funds for wastewater construction grants in 1957. The initial goal was to assist smaller, less wealthy communities build treatment facilities, on the assumption that larger localities could finance the infrastructure improvements themselves (Thomas & Luken, 1974). As time went on, federal water quality requirements increased and appropriations grew to support addressing the most severe water quality problems. With enactment of the Clean Water Act (CWA) in 1972, Congress increased construction grant funding considerably and changed the allocation formula to one based on a state’s estimated need.2

Funding for the Construction Grants program dominated the EPA’s budget throughout the 1970s, until the program became the target of budget cuts during the Reagan administration (Morris, 1999; Regens & Rycroft, 1989). Through 1984, Congress had appropriated nearly $41 billion in grants (Copeland, 2012). The nation’s capacity for treating wastewater strengthened considerably over the life of the Construction Grants program; from 1950 to 1988, the population served by secondary treatment facilities increased fourfold (U.S. EPA, 1993). Seeking to phase out the federal role in funding local infrastructure and address local governments’ complaints
about the program’s burdensome procedures, Congress created the Clean Water SRF program when reauthorizing the CWA in 1987 (Copeland, 2012; Morris, 1999, 2017).

The establishment of SRFs represented an important transition in the intergovernmental framework for investment in wastewater infrastructure. The federal government would no longer directly subsidize a portion of a local project but instead would give grants to states that, along with a 20 percent state match, provided seed money to capitalize state loan funds. While Congress developed this funding approach with the intent of providing support to small communities, communities unable to comply with CWA regulations, and lower income communities, states have considerable discretion in managing and distributing loan funds (Morris, 1997). The multilevel context of SRF implementation establishes the importance of state goals in clean water infrastructure investment and emphasizes the working relationship between state and local governments. Communities and other potential borrowers must apply to the state for low- or no-interest loans to support construction and improvement of sewage treatment plants and other water-quality projects. Repayment by local recipients would allow the state-operated loan funds to become self-sustaining, with the eventual goal that federal assistance would end when initial authorizations expired in 1994. Despite this intention, Congress has continued to appropriate funds to the Clean Water SRF program, and in 1996 introduced a similar program for drinking water investment.

Figure 1 shows the sums of federal capitalization grants to the 50 states for both SRF programs through 2008, adjusted to year 2000 dollars. The Clean Water SRF program was phased in beginning in 1989 and fully replaced the Construction Grants program in 1991, which was the peak year for Clean Water SRF funding. Appropriations in real dollars fluctuated over the next 17 years but mostly declined. Although the transfers that states received in 2008 totaled only one-fifth the peak value of SRF capitalization grants, federal support has long outlasted its original authorized end.
date of 1994. Unlike the case with the Clean Water program, the Drinking Water SRF program represented the federal government’s first broad effort to help communities finance infrastructure projects needed to comply with drinking water regulations ushered in under the Safe Drinking Water Act (SDWA). Funding has remained more level in this program after its peak in 1998, even increasing slightly in 2008. In 2009, the American Recovery and Reinvestment Act infused the two programs with a total of $6 billion in emergency appropriations, attaching new allocation and implementation rules to the funds.

Despite this investment, the nation’s water infrastructure remains underfunded: current annual spending falls short of estimated need by tens of billions of dollars (Anderson, 2010; ASCE, 2016; Copeland & Tiemann, 2010; U.S. EPA, 2002). When water infrastructure fails, there is increased risk of large-scale environmental exposure, higher incidence of waterborne diseases, and increased mortality. Each year, thousands of public water systems—typically serving over 25 percent of the U.S. population—report violations of health-based drinking water standards (U.S. EPA, 2015a, 2015b). The Clean Water and Drinking Water SRF Programs represent a substantial federal commitment to addressing these needs, but little evidence exists on whether they stimulate new subnational investment in water infrastructure or substitute for spending that would have occurred through other mechanisms if the programs did not exist.

**SRF Programs as a Policy Instrument for Stimulating Local Investment**

American states and localities are highly reliant on federal government support, receiving approximately a fifth of their revenue from intergovernmental grants. Transfers from the federal to state and local governments serve a variety of purposes, including internalizing spillover benefits from local public goods, promoting more uniform public good provision, sustaining a more efficient and equitable overall tax system, and satisfying the political incentives of elected officials (Fossett, 1987; Inman, 2008; Oates, 1999; Peterson, 1995; Ring, 2008). Grants-in-aid can provide an important set of incentives and coordinating devices in a system of fragmented and multilevel governance, but as implemented they may induce spending patterns that are inconsistent with a grant program’s goals.

Under the SRF programs, federal assistance comes in the form of categorical matching grants to the states. This type of grant should have a stimulating effect on local spending, because it not only increases a community’s income but also reduces the price of the affected good relative to other government activities (Bradford & Oates, 1971a, 1971b; Gramlich & Galper, 1973). The economic rationale for matching grants lies mostly in benefit spillovers; if many of the benefits of a publicly provided good are enjoyed by residents of neighboring jurisdictions, local governments have little incentive to fully consider these external benefits in their decision-making calculus, leading to inadequate investment in infrastructure. The federal government’s matching rate therefore should reflect the proportion of benefits that accrue outside the jurisdiction (Quigley & Rubinfeld, 1986). In practice, federal grant programs for
infrastructure investment often have match rates that far exceed the proportion of benefits that are realized outside of recipient jurisdictions, potentially inducing sub-national governments to overspend, and cap grant values at levels below what the jurisdiction would spend on the function anyway. If a jurisdiction already is spending more than its required contribution under a closed-ended matching grant, the grant's effect is to subsidize the jurisdiction's income rather than to lower the price of the good, and its effect on stimulating capital investment therefore may be minimal (Chernick, 1979, 2014; Gramlich, 1994).

A categorical grant program’s influence on subnational spending therefore depends on program details including match levels, funding ceilings, and restrictions and incentives (Gramlich & Galper, 1973; Moffitt, 1984). Program details are particularly complex in the case of SRFs, where spending outcomes are the product of two levels of decision making. First are decisions at the state level about the design of its loan fund program. States have considerable discretion to use their revolving funds to meet state-specific needs and to fit state political culture and administrative capacity (Daley, Mullin, & Rubado, 2014; Morris, 2010; Travis, Morris, & Morris, 2004). State agencies implementing SRF programs can determine the types of assistance the funds will provide, set loan terms, and target resources toward particular types of communities or environmental challenges. State choices regarding selection criteria for project funding, the importance of fiscal discipline in long-term fund management, and the provision of outreach activities and technical assistance all influence the ability of local communities to access funds for capital investment. State programs also vary in their operation costs and the resulting share of funds that are invested directly into infrastructure projects.

The second level of decision making is in local jurisdictions, where nearly all wastewater and drinking water investment occurs (Copeland & Tiemann, 2010). According to data reported in the U.S. Census Bureau’s Annual Survey of State and Local Government Finances, localities accounted for 97.3 percent of combined 2008 state and local expenditures for wastewater, and 99.3 percent of expenditures on drinking water. Unlike states, the localities making decisions about infrastructure investment experience the federal aid as loans, not grants. SRFs may offer application assistance, technical expertise, and an interest rate advantage over the private bond market that all lower localities’ costs of borrowing, which should stimulate higher levels of infrastructure spending than otherwise would occur. The interest rate on an SRF loan typically is about half that of a market rate municipal bond. The EPA estimates that localities borrowing from an SRF in 2009 saved an average of 22 percent over the life of a typical 20-year loan (U.S. EPA, 2010). An SRF program’s effect on local spending comes in reduced costs of borrowing, such that investment in water infrastructure becomes relatively more attractive than other spending options, especially for smaller communities that have less access to the private bond market. With rare exception, localities still must generate local revenue for the full cost of infrastructure projects. In practice, then, any stimulus effect may be attenuated if loan application processes are more burdensome than those in private bond markets or if states manage their programs not to maximize overall spending but instead
to meet other goals, such as equalizing environmental quality, offering assistance to communities with the greatest financial needs, or responding to political incentives in distributing funds.

To understand if SRF programs are successful in generating subnational investment, it is necessary to explicitly consider the multilevel nature of this policy tool. SRFs’ combined attributes of a categorical grant program to states that gets channeled into a subsidized loan program for localities should stimulate infrastructure spending. However, this stimulus effect may be dampened by high federal match rates, complex program design, and discretion granted to states in managing their loan funds. A further complication is that the targets of these loan programs are large infrastructure projects, for which expenditure patterns are lumpy. A locality’s choice to take on new spending typically will involve commitment to a major new project, not an incremental increase in ongoing outlays, and wide variation over time in infrastructure spending may mask any stimulus effect that might exist.

**Drinking Water and Clean Water SRFs**

The hypothesis we test in this article is that after states receive federal SRF capitalization funds, local infrastructure spending rises by more than the value of the federal grant. We test this hypothesis across two SRF programs and their associated domains of water infrastructure spending. Table 1 compares features of the two programs we analyze. The programs are very similar in their implementation details: both require a 20 percent match from states; both allow states to leverage federal capitalization grants by borrowing against them in the private bond market, an opportunity about half the states have taken under each program; agency leadership over the two programs is the same in over two-thirds of states; and the dominant form of assistance that state loan programs offer is low-interest 20-year loans at an interest
rate two to three points under market rates to local drinking water and wastewater systems for traditional treatment and distribution infrastructure.

The SRF programs differ on four important dimensions, which in varying ways could shape subnational spending response to federal SRF transfers. First are their establishment dates and program histories. The Clean Water program is nine years older than the Drinking Water program, and it replaced an older system of direct grants to local governments to support wastewater infrastructure investment. The Drinking Water program, in contrast, was the federal government’s first large-scale effort to support drinking water investment. Second, the programs use different formulae to allocate federal funds among the states, which we describe in more detail when outlining our estimation approach. Third, problem conditions and the regulatory context of the CWA and the SDWA are distinct. With its emphasis on restoring and maintaining the overall integrity of the nation’s surface water bodies, the CWA is sweeping in scope, encompassing numerous regulatory and incentive-based approaches to address various point and nonpoint sources of pollution. During the period of our study, Clean Water SRF funds were directed overwhelmingly toward controlling one particular point source of pollution—municipal wastewater discharges—but projects to address these discharges may be positioned within broader, multi-stakeholder efforts to manage stormwater runoff or engage in collaborative regional watershed management. In contrast, the SDWA traditionally has been more narrowly construed, focusing on the operations of drinking water utilities. Over time, amendments to the SDWA increased its regulatory force and broadened the scope to address source water quality, yet even with those changes, enforcement and compliance are less complex than under the CWA and may leave more room for incremental responses from regulated local utilities.

A fourth difference between the programs is the nature of the good targeted for investment. Local investment in wastewater treatment has substantial spillover benefits. Despite a long-term regulatory approach under the CWA to minimize and eliminate discharges from wastewater treatment plants, they remain a significant source of water quality impairment and a considerable public health risk (U.S. EPA, 2007, 2015a, 2015b). Investing in wastewater treatment infrastructure directly translates into improved water quality, as harmful pathogens and toxic pollutants are not released into waterways. However, much of the benefit from this improvement spills over to downstream communities (Hoornbeek, 2011; Hunter & Waterman, 1996). In comparison, upgrading drinking water infrastructure offers a contained benefit. Oates (2001) cites drinking water as an example of a purely local public good, in which improved environmental quality has effects solely within the immediate jurisdiction. The community investing in drinking water infrastructure reaps the full reward of improved public health and better drinking water quality (U.S. EPA, 2006). To the extent that a jurisdiction’s willingness to invest in infrastructure from its own revenue sources varies according to the spillover benefits of the infrastructure, federal assistance to stimulate additional spending may have varying effects.
Research Design and Data

Estimation

Most empirical research estimating the stimulus effect of federal grants focuses on government spending from regular income. In contrast, our interest is in a government’s decision to take on debt and make large investments in a capital project. Funds from a federal SRF capitalization grant will move through state loan funds and into the coffers of local loan recipients at varying speeds based on the structure of the state program and the construction plans of the borrower. States often confront delays in allocating federal grant money to local projects and accumulate large backlogs of unspent money—totaling $2.2 billion among state drinking water programs in 2011 (Associated Press, 2015). The projects themselves can take several years to complete, and capital improvements in drinking water and wastewater often produce higher ongoing expenditures to operate and maintain the new facilities. Indeed, ensuring that local loan recipients have adequate personnel and expertise for long-term facility maintenance is a priority of many state fund programs (U.S. EPA, 2003).

For these reasons, we require a dynamic modeling approach that imposes little constraint on the length of time it takes for subnational spending to respond to federal SRF transfers. Our estimation strategy uses single-equation ECMs, which treat the relationships between variables as moving equilibria in which state and local expenditures respond to both short-run changes in federal funding as well as long-run funding levels. First differences models that are commonly used to examine the relationship between federal transfers and subnational expenditures often restrict their analysis to a short time horizon, an unrealistic assumption given the long-term nature of infrastructure capital planning. An ECM allows us to separately estimate the immediate and long-term relationships between $X$ and $Y$ and avoid biasing our results with invalid restrictions (De Boef & Keele, 2008).

An ECM can be expressed in the simplified bivariate case as:

$$
\Delta Y_{i,t} = \alpha_0 + \alpha_1 Y_{i,t-1} + \beta_0 \Delta X_{i,t} + \beta_1 X_{i,t-1} + \epsilon_{i,t}
$$

(1)

where change in combined state and local expenditures for state $i$ between time $t - 1$ and time $t$ ($\Delta Y_{i,t}$) is a function of a constant ($\alpha_0$), state and local expenditures in the previous year ($Y_{i,t-1}$), change in federal funding ($\Delta X_{i,t}$), funding level in the previous year ($X_{i,t-1}$), and an error term ($\epsilon_{i,t}$). Our analysis extends the bivariate case to include a set of control variables that are likely to impact state and local expenditures on water infrastructure, and to allow maximum flexibility we include these variables in both lagged and differenced forms.

Water and wastewater projects are large-scale investments that require significant technical and financial planning. Unlike the federal Construction Grants program that responded to specific project-based requests, SRF capitalization grants seed a fund that can be distributed by states over the long term. Thus, we expect any stimulus effect of federal funds to operate over the long term; short-term effects as represented by $\beta_0$ should be zero. By contrast, we expect $\beta_1$ to be positive. The ECM
allows us to test this hypothesis rather than restrict the dynamics of the model by assumption. An ECM is mathematically equivalent to an autoregressive distributed lag model, but it allows easier interpretation of the long-run multiplier of an independent variable, or the total effect \( X_{i,t} \) has on \( Y_{i,t} \) cumulatively over future time periods, through calculating \( \frac{\beta_1}{\alpha_1} \) in equation (1) above. This cumulative impact is of particular interest for the types of infrastructure investment we examine here. We estimate all models using ordinary least squares (OLS) with panel-corrected standard errors (PCSEs) that help mitigate disturbances that are heteroskedastic and contemporaneously correlated across panels. Although the time span for our analysis is fairly short, we considered longer lags, but ultimately selected a single lag using the Akaike information criterion (Beck & Katz, 2011).

The multilevel structure of SRFs reduces concern about endogeneity in estimating how federal grants stimulate local spending. For a typical direct grant program, higher demand for public goods within a community may predict both grant receipts and government spending. If the analysis does not fully account for community preferences, then omitted variable bias will artificially inflate estimates of the relationship between grants and expenditures. Chernick (1979) notes that grant levels are often a product of negotiation between central and recipient governments and may depend on a recipient’s ability to contribute. Alternatively, federal aid may go to communities most in need of assistance (Stein, 1981). Recent literature on the effects of federal grant programs has attempted to account for endogenous distribution of transfers by using instruments based on a state delegation’s leadership positions in Congress (Knight, 2002), exploiting discontinuities in fund distributions based on demographic data released at decennial censuses (Gordon, 2004), simultaneously modeling grant receipts and state expenditures (Clark & Whitford, 2011), or using grant distribution formulae to identify the models (Brooks & Phillips, 2010).

Under the SRF model, grant recipients are not communities with infrastructure needs, but rather states, and the processes by which the federal government allocates capitalization grants help allay concerns about endogeneity. In the Clean Water SRF program, each state receives a fixed percentage of the total SRF appropriation. State allocations were specified in the 1987 reauthorization of the CWA and have not changed through the life of the program. No public record exists documenting how Congress developed the original allocation (Copeland, 2005), but the outcome did not reflect the distribution of demands for wastewater spending across the states. Population and documented infrastructure needs contributed to proposed formulae in early versions of the legislation, and deference was given to holding harmless states that had received large allocations under the wastewater Construction Grants program, but legislative politics played an important role in defining allocations in the final bill (Copeland, 2005). The correlation with infrastructure demand was weak—the median state received 14 percent of its 20-year infrastructure need as estimated by the EPA, but the range varied from less than 5 percent to over 100 percent (Holcombe, 1992)—and has weakened further over time as demand patterns have changed but allocations remained fixed. Moreover, allocations measured per capita have varied over time as states have experienced different levels of population growth. To account for the state-level need that had a modest influence on initial
fund allocations, we control for the EPA’s 1988 estimates of wastewater investment need (U.S. EPA, 1988). By controlling also for state population and year fixed effects that capture total federal SRF expenditures, we address the sources of variation in a state’s fund receipts over time.

For the Drinking Water SRF program, the EPA recalculates state capitalization grant allocations every four years using a formula based on a state’s relative need as measured in the Drinking Water Infrastructure Needs Surveys. As a check on endogeneity, in a model not presented here we included a control variable capturing each state’s level of need according to those surveys, identifying the model based on a state’s need relative to other states as well as the nature of the formula. We also estimated a two-stage model using surveyed need as an instrumental variable predicting federal allocation to states. Although these estimation approaches do not allow us to fully identify the relationship between federal grants and subnational spending under either SRF program, by controlling for the main factors affecting grant allocation they lessen the bias that may result from endogeneity.

Data

Our dependent variables are combined state and local expenditures on wastewater and drinking water, as reported in the U.S. Census Bureau’s Annual Survey of State and Local Government Finances. This combined measure is the most granular subnational spending measure we can obtain for all states over time. It is appropriate for our analysis because the development of SRF programs purposively reconfigures infrastructure finance to empower state decision making. Although states account for little of the direct spending on water infrastructure, they play an important role in configuring the form and distribution of loan assistance to localities, and therefore the overall state response to the capitalization grant. Clean Water SRF funds can be used for a wide range of water quality projects including nonpoint source pollution control and estuary protection, but wastewater treatment projects account for 95 percent of total assistance that has been awarded (U.S. EPA, 2007). Our data cover the period from 1989, the first year of SRF capitalization transfers, through 2008, the year before the American Recovery and Reinvestment Act made various changes to the SRF programs. For the 2001 and 2003 Annual Surveys, the Census reduced sample sizes in a way that prohibits state-level estimates of local government spending. Because our models measure annual change in spending, our analysis therefore covers the years 1990–2000 and 2005–2008, for a balanced panel of 750 state-year observations.

Data on federal transfers to capitalize the loan funds come from the Clean Water and Drinking Water SRF National Information Management Systems, compiled by the EPA for accountability purposes. The data indicate amounts actually awarded to states, net of adjustments, and rescissions after the appropriation process. All financial variables are per capita and converted to 2000 dollars. Summary statistics appear in Appendix Table A1.
We include a series of control variables designed to account for other factors that may confound the relationship between the disbursement of federal funds to states and spending on drinking water and wastewater infrastructure. Total population and the percentage of population that lives in urban areas both contribute to residential water and wastewater usage, and we include the percentage of a state’s gross domestic product that is attributed to the farming, mining, and manufacturing sectors to capture industry demands on infrastructure. Total federal intergovernmental revenue controls for substitution that may occur among public goods that receive central government assistance. An indicator for gross state product measures the state’s fiscal capacity to provide public goods. No data exist for political control of the thousands of local governments that make water and wastewater spending decisions—many of which are in fact nonpartisan institutions—so we use the party of the state’s governor as a time-varying measure of state partisanship and to absorb any effect from political control of the state’s funding programs. For the models estimating wastewater expenditures, we include a measure of wastewater need reported in 1988 for model estimation reasons as described above, and the population change variable helps account for changes in per capita allocation of capitalization transfers that stem from growth or decline in the state’s population. We also include region and year fixed effects in both models.

Results

Results from our analyses appear in Table 2. The first column shows the relationship between federal Clean Water SRF transfers and subnational spending on wastewater. In this model, the coefficient for the lagged value of SRF capitalization funds (SRF transfers$_{t-1}$) indicates a positive and significant stimulus effect on subnational spending. To estimate the cumulative effect that $X_{it}$ has on $Y_{it}$ over future time periods, we divide the coefficient for the lagged value of SRF transfers by the coefficient on the lagged dependent variable. Controlling for other factors influencing wastewater spending, the estimated total long-run cumulative effect of a dollar increase in federal aid equals $\frac{1}{0.46}$, or $2.84 of subnational spending on wastewater infrastructure over time. The black bars in Figure 2 show how the cumulative effect gets distributed over time. In the short run, a $1 dollar increase in SRF funding is associated with a $0.37 rise in state and local wastewater spending. This change in spending comes from the coefficient on the change in SRF transfers ($\Delta$ SRF transfers), but as predicted the effect estimate is not significant. The remaining $2.47 increase in the long-run multiplier occurs over future time periods at a pace determined by the error correction rate $a_1$. At the estimated rate here of 0.46, as indicated by the coefficient for lagged expenditures (Expenditures$_{t-1}$), we expect after the immediate increase in spending that 46 percent of the remaining difference will be made up in the next year, 46 percent again in the following year, until the total long-run effect of $2.84 gets distributed (ignoring further shocks to funding amounts in the intervening years) and the relationship between federal aid and subnational expenditures returns to equilibrium.
Turning to the result for drinking water expenditures in Table 2, federal aid does not have the same effect. Coefficients showing both the long-term and short-term effects of Drinking Water SRF capitalization funds are small and insignificant. The gray bars in Figure 2 show the estimated cumulative impact distributed over time. This long-run multiplier of 0.09 (0.49)** or $0.86 (discrepancy due to rounding), is not significantly different from 0 and has little predicted influence on spending after the current period. To facilitate comparison with the Clean Water SRF results, the models shown here include multiple years prior to enactment of the Drinking Water SRF program where the federal contribution is zero. The substantive difference in results persists when restricting both analyses to the years after the federal government started awarding funds. Results are consistent across modeling choices: federal transfers to state loan programs have a positive relationship with long-term state and local spending on wastewater infrastructure, but no apparent association with drinking water spending.13

However, various methods of testing the statistical significance of the difference in stimulus effect across the two functions yielded mixed results.

| Table 2. Error Correction Models: Federal Transfers and Subnational Expenditures |
|----------------------------------|----------------------------------|
|                                  | Δ Wastewater Expenditures        | Δ Drinking Water Expenditures   |
| SRF transfers_{t-1}              | 1.30 (0.49)**                    | 0.09 (0.41)                     |
| Δ SRF transfers                   | 0.37 (0.50)                      | 0.36 (0.29)                     |
| Long-run controls                |                                  |                                 |
| Population (log)_{t-1}           | 2.68 (1.17)*                     | 1.66 (1.16)                     |
| Urban_{t-1}                      | 0.27 (0.12)*                     | −0.02 (0.09)                    |
| % GSP farm_{t-1}                 | −0.96 (0.58)                     | −0.79 (0.52)                    |
| % GSP mine_{t-1}                 | −0.90 (0.21)**                   | −0.07 (0.26)                    |
| % GSP manufacturing_{t-1}        | 0.48 (0.16)**                    | −0.26 (0.15)                    |
| Gross state product_{t-1}        | 0.84 (0.24)**                    | −0.02 (0.20)                    |
| Total federal revenue_{t-1}      | 6.84 (3.01)*                     | 1.39 (3.89)                     |
| Democratic governor_{t-1}        | 1.18 (0.82)                      | −0.76 (0.62)                    |
| Short-run controls               |                                  |                                 |
| Δ Population (log)               | −180.08 (114.64)                 | 71.24 (157.77)                  |
| Δ Urban                           | 3.74 (6.77)                      | 2.27 (5.11)                     |
| Δ % GSP farm_{t-1}               | 2.19 (0.93)*                     | −1.08 (1.01)                    |
| Δ % GSP mine_{t-1}               | 0.22 (0.75)                      | −5.42 (1.36)**                  |
| Δ % GSP manufacturing_{t-1}      | 0.62 (0.86)                      | −0.9 (0.66)                     |
| Δ Gross state product_{t-1}      | −0.91 (0.93)                     | 3.27 (0.93)**                   |
| Δ Total federal revenue_{t-1}    | 7.60 (7.18)                      | −4.64 (11.09)                   |
| Δ Democratic governor_{t-1}      | −0.01 (1.03)                     | −2.82 (1.19)*                   |
| Northeast                         | −7.98 (2.29)**                   | −4.73 (1.97)*                   |
| South                             | −1.53 (2.11)                     | −1.52 (2.02)                    |
| West                              | 11.40 (4.36)**                   | 3.34 (3.44)                     |
| Year fixed effects                | Yes                              | Yes                             |
| Wastewater need, 1988             | 0.05 (0.02)*                     |                                 |
| Expenditures_{t-1}               | −0.46 (0.10)**                   | −0.11 (0.03)**                  |
| Constant                          | −47.78 (13.89)**                 | 3.59 (10.07)                    |
| $^2$                              | 0.26                             | 0.19                            |
| N                                | 750                              | 750                             |
| Long-run multiplier for SRF transfers | 2.84 (0.90)**                  | 0.86 (2.64)                     |

Notes: Data are annual, 1990–2000 and 2005–2008. OLS estimates with PCSEs in parentheses. **p < 0.01, *p < 0.05 (two-tailed). Standard errors for the long-run multipliers calculated using the Bewley transformation.
Control variables explain more of the variation in wastewater than drinking water expenditures, and most of their effects operate over the long term. As predicted, higher sewerage spending is associated with larger state populations, although the results also show a negative relationship between recent population growth and wastewater spending. More urban states and those with more manufacturing activity spend more on wastewater—as do those with less mining activity, perhaps capturing another aspect of population distribution. Higher levels of state spending and receipt of federal revenue are both associated with higher wastewater spending. Regional patterns emerge as well, with higher levels of spending in the rapidly growing western United States and lower levels in the northeast. Finally, estimated state wastewater investment needs at the start of the SRF program have a significant correlation with spending. The effect of most control variables is insignificant for drinking water expenditures, although we find evidence for a short-term rise in drinking water spending associated with growth in gross state product, decline in mining activity, and Republican leadership in the governor’s office, as well as lower levels of spending in the northeast.

Explanations for Variable Stimulus Effects

Across a range of policy areas, the federal government increasingly is relying upon SRF programs to stretch federal funds and achieve policy goals. Yet, little is known about the effectiveness of this policy instrument in stimulating additional subnational investment in federal priorities. Our study takes advantage of a rare pair of programs that have similar features including match requirement, program structure, and state implementation that may influence how state and local decision making responds to federal transfers. Our design and estimation strategy takes into

Figure 2. Dynamic Change in Expenditures After a $1 Increase in SRF Transfers. Note: Estimated lag distributions calculated from models shown in Table 2.
account the different allocation formulae that govern distribution of federal grant funds among the states.

What, then, accounts for the difference in our results between programs? Our analysis cannot identify the specific mechanism driving these divergent results, but we can clarify potential explanations to encourage additional research into this important policy area. Prior research indicates that goal conflict between the grantor and grantee can dampen a stimulus effect (Chubb, 1985; Nicholson-Crotty, 2004), but that is an unlikely explanation in this case, because the CWA is more politically controversial than the SDWA. More compelling are four other explanations that stem from the program differences outlined earlier.

First, it may be that prior federal activity accounts for the differences between the SRF programs: whereas the Clean Water SRF program replaced an older system of direct grants to support wastewater pollution control, the Drinking Water SRF program represented the federal government’s first effort to help communities finance infrastructure projects needed to comply with drinking water regulations. In the absence of federal assistance, localities may have become accustomed to self-financing their drinking water systems, so new loan funds simply displaced local borrowing and spending that already was occurring. Because localities had long relied on grants and subsidies to support wastewater investment, federal aid would not have displaced local expenditures in the same way. The impact of these pre-existing spending patterns may eventually dissipate, but changes in budgeting behavior take time. Implementation research indicates that it can take up to a decade or more to observe the impacts of policy change, particularly when implementing complex public policy (Mazmanian & Sabatier, 1989).

Second, the broader regulatory environment could be driving subnational investment decisions in different ways across the two water functions. Regulatory requirements under both the CWA and the SDWA expanded during the period of our analysis, creating demands on many local governments for increased spending. If Clean Water SRF programs directed loans toward costly compliance-oriented projects to a greater degree than did Drinking Water SRF programs, it could appear that those loans stimulated higher levels of spending. Higher overall costs of regulatory compliance under the CWA may explain our results. But, this would mean that compliance costs at the state level were correlated with larger SRF capitalization grants—an unlikely correlation considering the fixed allocation of Clean Water SRF grants. However, without detailed data on local government compliance costs across both infrastructure types for the period of our analysis, we cannot rule out a role for regulatory context.

The third potential explanation is the difference in the nature of wastewater and drinking water infrastructure as public goods. Goods that have high spillover benefits, such as wastewater treatment, are more likely to be undersupplied by local jurisdictions (Oates, 1972). Where such spillovers occur, matching grants from the central government should help stimulate local investment (Jondrow & Levy, 1984; Oates, 1999). Significant interjurisdictional spillovers also create opportunity for jurisdictions to free ride on the collective goods provided by their neighbors and may make it difficult to identify the source providing goods such as pollution prevention or ecological protection. Underinvestment in wastewater treatment infrastructure may
therefore result not only from failure to be compensated for the positive benefits to downstream communities, but also from collective action problems among neighboring jurisdictions in deciding who is responsible for pollution control (Feiock, 2013; Ostrom, Tiebout, & Warren, 1961). For goods like drinking water infrastructure with benefits that are largely contained in the immediate jurisdiction, communities do not face these collective action problems and may be more likely to fund provision up to the point where marginal cost is equal to marginal benefit. Because local expenditures on drinking water accrue almost entirely to the immediate community, produce visible outcomes, and address a problem widely perceived as serious, localities may be more likely to spend at levels that satisfy community demand from their own-source revenue or from funds obtained in the municipal bond market. The new loan funds provided by SRF programs may simply substitute for expenditures that would have occurred otherwise. Aggregated to the state level, these local responses to the availability of new loan funds may produce the divergent patterns we observe between the two programs.

Finally, differences in state-level program management may account for the stimulus patterns we find. Previous research shows that within the Drinking Water SRF program, the agency location of state program management can influence patterns of loan distribution (Daley et al., 2014). States have opportunity to craft SRF programs to meet state needs, and use of this discretion may influence whether the recipients of loans are communities that would have pursued their infrastructure projects without state funds. However, because the two SRF programs within a state are commonly directed by the same state agency, we think this is an unlikely explanation for our divergent results, and find the explanations rooted in local spending behavior that results from the nature of the good or program history to be more compelling.

Conclusion

SRFs have gained attention as a policy instrument for using federal dollars to stimulate states and localities to invest in needed infrastructure. Our results suggest that SRFs indeed have this potential to induce new spending: under the oldest and largest federally capitalized SRF program, we find that an additional dollar from the federal government into a state’s loan fund translates into $2.84 in new spending on wastewater infrastructure. In calculating this stimulus effect, we use a modeling approach appropriate for analyzing infrastructure investment decisions that involve significant advance planning and often lock in increased costs for operating and maintaining the new facilities.

Further research is needed to identify the mechanism that produces this effect and specify the conditions under which a SRF program can substantially increase subnational investment in public goods. The stimulus effect we observe in the Clean Water SRF program is not evident in the Drinking Water SRF program, where federal dollars appear to displace existing spending rather than stimulate new investment. We propose four potential explanations for the difference: history of federal funding assistance prior to SRF program establishment, regulatory context, features of the public good being funded, and differences in state-level programmatic
management. Adjudicating among these explanations will require detailed investigation at the state and local levels, where funding priorities are established and infrastructure decision making takes place. This type of detailed investigation is worthwhile in order to establish the conditions under which the SRF model can be most successful in bolstering local investment that promotes public health and environmental protection.

Stimulating subnational expenditures is not the sole purpose of central government assistance, however. Not all communities are able to invest in water infrastructure at levels needed to maintain compliance with public health and environmental regulations, and federal funds may help equalize the quality of drinking water delivered across communities. It is possible that federal transfers help stimulate local investment among a subset of drinking water systems, even if we cannot detect a significant stimulus effect in the aggregate. For example, the EPA encourages state-managed funds to provide loans to small drinking water systems and systems serving disadvantaged communities, two categories of water systems most likely to be out of compliance with water quality laws. A stimulus effect that exists only among these systems may be too small to detect in the overall data, but would nonetheless have an important impact on the safety of the nation’s drinking water supplies.

A full assessment of the impacts of federal water infrastructure investment is beyond the scope of this analysis. We focus on the effectiveness of SRFs in redirecting spending priorities within local communities. On that question, our evidence is mixed: federal dollars channeled through SRFs have the potential to substantially boost subnational investment in infrastructure, but under some conditions they may simply substitute for local contributions. Where localities struggle to meet the demand of providing adequate water infrastructure, even that substitution may be worthwhile. But as estimated need for infrastructure investment continues to escalate, it becomes ever more important to understand why some SRF programs successfully stimulate higher spending throughout the multilevel governance system, while others do not.

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Notes

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1. EPA budget information is available at http://www2.epa.gov/planandbudget/archive.

2. Need was estimated by a survey of communities seeking assistance. Because results of the needs survey required Congressional approval, the new formula provided opportunity for local and state officials, as well as members of Congress, to overstate their state’s needs in order to win more federal support (Thomas & Luken, 1974).

3. Although ECMs often are used in the presence of cointegration, they also are appropriate for stationary data (De Boef & Keele, 2008; Keele, Linn, & Webb, 2016). Dickey–Fuller tests reject the null hypothesis of a unit root for any of our level measures of federal aid and give borderline results for some measures of state expenditures. Tests reject the null of a unit root for all transfer and expenditure variables after differencing.

4. The Drinking Water Needs Surveys are conducted only every four years, and variation in survey methodology over time and states’ varying capacities and incentives to catalog their needs make the needs surveys an unreliable measure of demand across states or over time. We thus included estimates from the needs survey only as a means to account for allocations of funds, not as an indicator of true infrastructure demand in a state. Results presented here omit the measure of drinking water needs for consistency between drinking water and clean water models. Restricting the analysis to the years after introduction of the drinking water program, the coefficient on estimated needs is insignificant. Using surveyed need as an instrumental variable, need predicts federal allocations to the states but our main result remains unchanged.

5. Notably, although endogeneity concerns are stronger for the drinking water program that recalculated allocations on an ongoing basis, that is, the program where we find null results.

6. We accessed some of these data using the State & Local Finance Data Query System hosted by the Urban Institute-Brookings Institution Tax Policy Center. Wastewater expenditures appear in the finances data as “sewerage” and drinking water as “water supply.”

7. Data on transfers are reported for the federal fiscal year, and state expenditure data are reported for the state fiscal year. Although the federal fiscal year expires (September 30) after the fiscal years for most states (June 30), allotments of SRF transfers are announced early in the year.

8. A small number of state-years in the Drinking Water SRF data are coded as receiving zero federal funds, which may represent inability to meet programmatic or match requirements. Our results are robust to eliminating these observations from the analysis.

9. The urban variable is linearly interpolated from decennial Census data; all other variables are annual data.

10. In models not presented here but available in the replication materials, we also controlled for outstanding obligations awarded through the Construction Grants program after the program’s expiration and funds earmarked by Congress for specific water and wastewater projects. Although these funds should be more responsive to community demand, we found little evidence that they boosted local spending, and their inclusion did not change our findings about SRFs.

11. Data and code for replicating the results discussed here and additional analyses can be found at https://dataverse.harvard.edu/dataverse/meganmullin.

12. Calculation of the standard error on the long-run multiplier using the Bewley transformation is available in the replication material.

13. Results are similar when omitting two observations with extreme values on wastewater expenditures, when using robust standard errors clustered on state, and when replacing year fixed effects with a measure of total U.S. SRF funding.

References


Appendix

Table A1. Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
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<tbody>
<tr>
<td>Wastewater expenditures_{t-1}</td>
<td>COG</td>
<td>93.43</td>
<td>36.55</td>
<td>14.45</td>
<td>477.53</td>
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<td>Δ Wastewater expenditures</td>
<td></td>
<td>1.23</td>
<td>24.53</td>
<td>-398.09</td>
<td>340.86</td>
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<td>Water supply expenditures_{t-1}</td>
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<td>51.80</td>
<td>35.90</td>
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<td>1.04</td>
<td>18.30</td>
<td>-117.81</td>
<td>154.58</td>
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<tr>
<td>CWSRF transfers_{t-1}</td>
<td>CWNIMS</td>
<td>-6.63</td>
<td>4.47</td>
<td>0.73</td>
<td>27.72</td>
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<td>Δ CWSRF transfers</td>
<td></td>
<td>-0.23</td>
<td>3.33</td>
<td>-16.03</td>
<td>13.91</td>
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<tr>
<td>DWSRF transfers_{t-1}</td>
<td>DWNIMS</td>
<td>2.03</td>
<td>4.24</td>
<td>0.00</td>
<td>47.51</td>
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<tr>
<td>Δ DWSRF transfers</td>
<td></td>
<td>0.30</td>
<td>4.96</td>
<td>-43.46</td>
<td>47.51</td>
</tr>
<tr>
<td>Population (log)_{t-1}</td>
<td>Census</td>
<td>8.11</td>
<td>1.01</td>
<td>6.12</td>
<td>10.50</td>
</tr>
<tr>
<td>Δ Population (log)</td>
<td></td>
<td>0.01</td>
<td>0.01</td>
<td>-0.06</td>
<td>0.11</td>
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<tr>
<td>% Urban_{t-1}</td>
<td>Census</td>
<td>71.57</td>
<td>14.51</td>
<td>38.40</td>
<td>94.79</td>
</tr>
<tr>
<td>Δ % Urban</td>
<td></td>
<td>0.11</td>
<td>0.16</td>
<td>-0.24</td>
<td>0.59</td>
</tr>
<tr>
<td>% GSP farm_{t-1}</td>
<td>BEA</td>
<td>1.70</td>
<td>2.05</td>
<td>0.03</td>
<td>11.74</td>
</tr>
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<td>Δ % GSP farm</td>
<td></td>
<td>-0.07</td>
<td>0.69</td>
<td>-5.19</td>
<td>4.27</td>
</tr>
<tr>
<td>% GSP mining_{t-1}</td>
<td>BEA</td>
<td>2.67</td>
<td>5.79</td>
<td>0.01</td>
<td>37.61</td>
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<td>Δ % GSP mining</td>
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<td>-0.04</td>
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<tr>
<td>% GSP manufacturing_{t-1}</td>
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<td>15.71</td>
<td>6.71</td>
<td>1.79</td>
<td>31.47</td>
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<td>Δ % GSP manufacturing</td>
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<td>-0.36</td>
<td>1.11</td>
<td>-7.60</td>
<td>6.87</td>
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<tr>
<td>Gross state product_{t-1}</td>
<td>BEA</td>
<td>31.86</td>
<td>6.53</td>
<td>19.85</td>
<td>60.39</td>
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<td>Δ Gross state product</td>
<td></td>
<td>0.35</td>
<td>1.13</td>
<td>-10.43</td>
<td>8.54</td>
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<tr>
<td>Total federal revenue_{t-1}</td>
<td>COG</td>
<td>1,068.71</td>
<td>406.06</td>
<td>457.57</td>
<td>3,440.04</td>
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<tr>
<td>Δ Total federal revenue</td>
<td></td>
<td>20.70</td>
<td>84.68</td>
<td>-534.98</td>
<td>723.10</td>
</tr>
<tr>
<td>Democratic governor_{t-1}</td>
<td>Klarner</td>
<td>-0.04</td>
<td>0.99</td>
<td>15.71</td>
<td>92.16</td>
</tr>
<tr>
<td>Δ Democratic governor</td>
<td></td>
<td>-0.01</td>
<td>0.58</td>
<td>-1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Wastewater need, 1988</td>
<td>U.S. EPA</td>
<td>135.16</td>
<td>82.64</td>
<td>29.23</td>
<td>533.03</td>
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<td>Drinking water need</td>
<td>DWSNS</td>
<td>682.06</td>
<td>278.44</td>
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<td>2.00</td>
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