TO MUNICIPALIZE OR TO PRIVATIZE?:

WATER COMPANY GOVERNANCE FORM AND SERVICE QUALITY

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ABSTRACT

We explore how changes in governance form affect service quality. We develop hypotheses drawing on political economy and the attention-based view of the firm, and test them using a panel of data on 179,927 water systems in the U.S. from 2006 to 2014. In particular, we study the effect of municipalization and privatization of water systems on their compliance with water quality standards. By combining matching and differences-in-differences methods to construct comparable counterfactual control groups, we present the first large-scale empirical study on the governance form – service quality relationship for US water systems that addresses endogeneity concerns. We also examine how this effect differs for systems of different characteristics and in different socio-economic environments. The results indicate that while privatization does not lead to significant changes in water quality on average, municipalization leads to significant and persistent improvements in performance. These improvements are particularly notable for large systems, systems located in areas with low educational attainment, systems with low poverty levels, and communities with a smaller number of systems. Although privatization has no significant effect on average, it appears to produce an improvement in water quality in the short term, which is reversed within five years.

Keywords:

Water management; environmental economics; privatization; governance

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We would like to express our sincere gratitude to Ms. Stephanie Flaharty of the EPA Office of Ground Water and Drinking Water for her gracious assistance in assembling the data used in this paper.

I. INTRODUCTION

Governance form has implications for multiple dimensions of organizational performance, and has been studied extensively in management (Boyatzis, 1982; Perry and Rainey, 1988; Boyne, 2002; Leiblein, 2003; Moore and Kraatz, 2011) and economics/political science (Chubb and Moe, 1988; Megginson et al. 1994; Hart, Shleifer and Vishny, 1997; Frydman et al., 1999; Megginson and Netter, 2001; Konisky and Teodoro, 2015). Indeed, whether organizations providing crucial public services such as education, energy, health care, telecommunications, and water should be public or private has long been an issue of heated debate (Crocker and Masten, 1996; Newbery and Pollitt, 1997; Koh et al., 1996; Troesken, 2001; Kwoka, 2002, 2005, 2008; Troesken and Geddes, 2003).

In recent years water has emerged into the spotlight. The World Economic Forum 2015 named "water crisis" the biggest global risk, ahead of disease and weapons of mass destruction. In the U.S., water has attracted attention due to the unprecedented drought in California and Texas. In addition, following the Great Recession, many municipal governments, especially those in the Rust Belt, considered privatizing their water systems to cope with fiscal challenges (Food & Water Watch, 2010). Masten (2010) points out that water and sewage systems constitute an anomaly in the U.S., in that they have traditionally been publicly owned while other services have long been provided privately.

Advocates of privatization argue it will drive down costs and increase efficiency, but social activist groups take a very different view. Food & Water Watch (2010) argues that privatization amounts to a very expensive loan, and estimate that privatization added 64%, or $153 per annum, to the water bill of a typical New Jersey household. Detroit's shutoffs of water to over 30,000 households in 2014 led to large-scale demonstrations by crowds with banners and chants repeating "Who's Water? Our Water" and "Who's on our side? United Nations. Who's on their side? Corporations."[1] The shutoffs are rumored to be a precursor to privatization .[2]

As privatization has gained attention, municipalization of water systems has also become more common (Food & Water Watch, 2012). In fact, the number of people served by private systems dropped by 16% between 2007 and 2011 while those served by public systems rose by 8%. Underlying these numbers is the high frequency with which local governments have been acquiring private systems. For example, from 1998 to 2010, 379 privately owned and operated water systems were consolidated with government owned water systems in Georgia. Activists contend that one of the three major reasons why communities take public control of water and sewer systems is to improve water quality and service (Food & Water Watch, 2012).

The governance form for water systems is also a global issue. There was a notable trend towards privatization of water systems around the world, especially in developing countries, in the late 20th century (Bakker, 2010). In England, Ireland, and Wales, when Thatcher's

[1] From the authors' own field observations and data collection.

[2] Lukacs, Martin. (2014). *Detroit's Water War: a tap shut-off that could impact 300,000 people*. The Guardian. http://www.theguardian.com/environment/true-north/2014/jun/25/detroits-water-war-a-tap-shut-off-that-could-impact-300000-people

government privatized the 10 regional water authorities in 1989, controversies arose and the results have been decidedly mixed. Saal and Parker (2000) found that privatization produced no measurable efficiency improvements, but Ogden and Watson (1999) found that shareholder returns were significantly higher in response to improved customer service performance after privatization. In the 2000 Bolivia Water War[3], social movements stopped the company, Aguas de Tunari, a subsidiary of the US corporation Bechtel, from privatizing the Cochabamba public water system.

Despite attracting growing attention in the public arena, water supply is understudied in the management literature, which is lagging behind in studying the business implications of a water-constrained world, and the stakeholder and institutional forces that businesses face around water (Kurland & Zell, 2010). Moreover, there is little research exploring how alternative approaches to managing water, e.g. public vs. private ownership, perform. Although there is a substantial economics literature on privatization, it has focused on cost, pricing and efficiency (Bel and Warner, 2008). Scant attention has been paid to the issue of quality of service, and in particular compliance with quality standards among water systems of different governance forms.

The issue of governance and water quality, even though understudied, is by no means unimportant. It is arguably more important than cost reduction or efficiency if one considers the severe consequences quality problems can generate. For example, the water crisis in Toledo, Ohio, in 2014 caused widespread panic,[4] and the mayor even compared it to 9/11[5]. The cause was algae growth fed by phosphorous, which came mainly from agriculture and the excessive amount of fertilizer and animal manure that many farmers apply to their fields. Water quality problems can also be very costly financially. Toledo spent about $4 million in 2013 on maintaining water quality, but could not prevent the 2014 crisis, and another $300 million in plant renovations is planned. More recently, the water system of Flint, Michigan has had a lead poisoning crisis,[6] evoking memories of the dire impacts of lead poisoning on the Romans two millennia earlier.

In this paper we aim to fill the aforementioned research gap by studying how changes in the governance form of water systems (privatization and municipalization) affect their performance with respect to violations of water quality standards stipulated in Environmental Protection Agency (EPA)'s Safe Drinking Water Act (SDWA). We develop a set of hypotheses drawing from the literatures on political economy (Chubb and Moe, 1988; Megginson et al. 1994; Hart, Shleifer and Vishny, 1997; Frydman et al., 1999; Megginson and Netter, 2001; Konisky and Teodoro, 2015) and the attention-based view of the firm (Barnard and Simon, 1947; March

[3] Wikipedia: "2000 Cochabamba protests." Extracted on 11/14/2015: https://en.wikipedia.org/wiki/2000_Cochabamba_protests

[4] CBS/AP: "Toxic tap water causes state of emergency in Toledo." August 2, 2014. http://www.cbsnews.com/news/toledo-ohio-officials-warn-against-drinking-toxic-tap-water/

[5] The Blade: "Mayor says water crisis is similar to 9/11." 8/19/2014. http://www.toledoblade.com/Politics/2014/08/19/Mayor-says-water-crisis-is-similar-to-9-11.html

[6] USA TODAY: "Michigan health officials scramble to help lead-poisoned Flint." October 25, 2015. http://www.usatoday.com/story/news/nation-now/2015/10/25/lead-poisoning-flint-water/74599112/

and Olsen 1976; Weick, 1979; Ocasio, 1997; Hoffman and Ocasio, 2001; Joseph and Ocasio, 2012). We hypothesize that differential attribution of accountability in the event of privatization vs. municipalization leads water system managers to differentially focus their attention on performance in response, resulting in significant performance improvements post-municipalization and insignificant performance changes post-privatization.

We use a panel of data acquired primarily through two Freedom of Information Act (FOIA) requests to the US EPA Office of Ground Water and Drinking Water to test these hypotheses. This main data set contains system-level information on all water systems in the US and their significant, health-related SDWA violations for each year between 2006 and 2014. Complementing this with a series of other data, including, for example, the Toxic Release Inventory (TRI), the Census of Agriculture by the U.S. Department of Agriculture, and the American Community Survey, we arrive at a panel of 179,927 water systems associated with 1,348,799 system–year observations.

Our main empirical method is differences-in-differences matching. By combining propensity score matching and differences-in-differences to construct comparable counterfactual control groups, we effectively address the endogeneity concern about governance form of water systems that several previous studies on similar issues failed to account for. This is a major strength of our empirical estimation. We also examine how the effect of a governance form change differs when we factor in a series of moderators including system size, the educational attainment rate and poverty rate of the community a system is located in, system count per county, and the share of population served by a system in its county. Our findings suggest that while privatization of water systems results in significant increase in violations for small systems, low poverty level systems, and systems that are both small and associated with low educational attainment level communities, privatization generally doesn't lead to significant changes in service quality performance as estimated by severe health-related violations count. On the other hand, municipalization causes overall improvements in performance. In terms of the subgroups, the effect of municipalization is significant among large systems, systems located in low educational attainment and poverty level communities, communities with a small number of systems, systems that take up a large market share in the local community, and systems that are both small and associated with low educational attainment level communities.

The remainder of the paper is structured as follows: Section II reviews the existing literature. Section III lays out a theory and a set of testable hypotheses. Section IV presents background information on water systems and their monitoring. Section V describes our data sources and presents summary statistics. Section VI reports empirical specifications and estimation results, and Section VII concludes and offers implications for future research.

II. RELATED LITERATURE

Public vs. private governance form

There is a large literature comparing the merits of public and private ownership. The findings indicate that there is no universal domination of one mode of governance over the other; instead, relative performance depends upon a variety of factors such as the complexity of the technology involved, the predictability of the institutional environment, and the relationship between cost and quality.

Theoretical work has come from both transaction cost analysis and formal agency theory. For example, Crocker & Masten (1996) apply a transaction cost approach, starting from the observation that when relationship-specific investments play a crucial role, the potential for opportunism may lead to traditional spot markets being supplanted by more structured governance alternatives. When it comes to a simple market context, the parties may formally assign responsibilities at the very beginning, creating a long-term relationship administered through contracts. With the complexity of the market background growing or the cost of negotiation of future duties accumulating, the parties may choose to implement the exchange through internal administration (public water systems).

Hart, Shleifer & Vishny (1997) derive complementary results using a formal model of incomplete contracting. They show that public ownership should be preferred when cost reductions, which are not contractible, may undermine quality to a large extent, when little emphasis is needed on quality innovations, and when government procurement suffers from severe corruption. In contrast, private firms provide a better outcome when the utilization of contracts or competition can limit the reduction in quality associated with cost reductions, when quality innovations are important, and when the government has trouble dealing with patronage and powerful unions. King and Pitchford (2008) discuss the importance of externalities in a similar model of private vs public governance. They argue that the flat incentive structure of public managers is desirable when negative externalities abound, but is undesirable when externalities are positive.

Within the empirical literature, the bulk of the work has focused on the relative efficiency of the two alternative governance structures. Megginson and Netter (2001) offer an extensive review of the empirical literature on privatization. They focus on the methodology and results of ten prominent recent empirical papers, among which nine find that private enterprises outperform public ones, while the remaining one finds no significant difference. However, the authors note that privatization is likely to perform less well in the presence of serious market failures, and they do not separate out the results for transition economies from results for developed capitalist economies, nor do they treat separately the privatization of traditionally monopolistic firms such as public utilities. Thus it is important to delve more deeply into works that focus on industries with unique characteristics like healthcare, and utilities such as electricity, natural gas, telecommunications, and water and sewage.

Sloan (2000) studies the healthcare industry and documents the impact of governance form on hospital performance in a number of dimensions. In looking through the detailed empirical evidence he observes no systematic efficiency gap between for-profit and not-for-profit hospitals. If we compare public and private ownership of health systems, results are similarly mixed. While some studies find public ownership to be more efficient (Granneman et al., 1986; Koop, 1997), others find exactly the opposite (Breyer et al., 1988; Wilson and Jadlow, 1982), whereas still others find no significant difference (York et al., 1996). In terms of service quality, an important study by Keeler et al. (1992) documented inferior performance by public hospitals. On the other hand, Shortell and Hughes (1988) found no significant difference between public and private hospitals.

The 1990 privatization and liberalization of the British electricity industry is assessed by Newbery and Pollitt (1997), who find significant post-privatization performance improvements. However, they find that almost all of the financial rewards of this improvement were captured by the producers and their shareholders, whereas little benefit went to the government or consumers. Using U.S. data, Koh, Berg, & Kenny (1996) find that municipally owned power plants are more efficient when output is low, probably due to the more effective public cost control generated by higher voter attention when jurisdictions are small. Kwoka (2002, 2005) finds that even though privately-owned electric utilities have an overall cost advantage, publicly-owned utilities offer significantly lower prices, in part because they perform better in the end-user-oriented distribution function due to quality attributes on which it is difficult to contract. Kwoka (2008) reviews ten studies of the restructuring and privatization of the U.S. electric power industry, eight of which give electricity restructuring a generally positive appraisal, though most of these had one or more serious methodological limitations. A key takeaway from these empirical studies is that even though, theoretically speaking private and public governance forms excel at respective performance dimensions, the empirical evidence is quite mixed and inconclusive. Thus, to look at the effect of governance form and governance form change on performance, we must put it in the context of the specific industry under study and the multiple moderators contributing to the heterogeneous outcomes of governance form changes.

Attention-based view of the firm

An underlying assumption of the attention-based view of the firm is bounded rationality. Barnard and Simon (1947) argued that humans have limited attention instead of being completely rational, and organizational structure can affect the distribution of this attention. Ocasio revived the original attention theory in his 1997 paper focusing on attention at the organizational level. He views corporations as systems of structurally distributed attention and corporate strategy as a pattern of organizational attention, i.e. focus of time and effort. This is a perspective that has also been elaborated in economics (Holmstrom and Milgrom, 1991), finance (Hirshleifer et al., 2009), and accounting (Hirshleifer et al., 2003). Hoffman and Ocasio (2001) further articulate and extend these ideas, bringing into the theory the concept of public attention by Hilgartner and Bosk (1988), which is a scarce resource for which potential issues compete. Perhaps most importantly, they extend the notion of organizational attention in Ocasio (1997) to industry-level attention.

Public vs. private water systems

A large empirical literature focuses specifically on water and sewage. However, most of it is focused on efficiency-related aspects of performance instead of service quality, which is arguably at least of equal importance for such a health-related service. Masten (2010) points out that water and sewage are the only public utilities that are predominantly public in the U.S. He lays out several possible causes of the historical municipalization of water, and assesses them using data from the turn of the 19th century. He finds that the simplicity of early water supply systems made them less vulnerable to poor management by government bureaucrats, and that the contentiousness of any attempts to raise water prices made private ownership less attractive. Troesken & Geddes (2003) use a dataset on municipalization of private water companies from 1897 to 1915 to support a transaction cost theory for public acquisition. They conclude that since governments cannot credibly commit to eschew opportunistic expropriation from private companies once the latter have made investments, private companies have weak incentives to make investments and governments accordingly may need to acquire private water systems in order to induce appropriate investments.

As for the consequences of water privatization, Bel & Warner (2008) conduct a review of all published econometric studies of water and waste production since 1970. They do not find much backing for a connection between privatization and cost savings. For example, no evidence of cost savings exists in water delivery, and savings are not systematic in waste. In line with this, Hunt & Lynk (1995) find that the privatization of the UK water industry resulted in significant efficiency losses due to lost economies of scope. In a rare study of the impact of privatization on service quality, Troesken (2001) finds African Americans to be a major beneficiary of water municipalization, for it decreases the spread of waterborne-disease among them. Overall, the existing literature suggests that privatization may have important impacts on costs, productivity, prices, and quality. These impacts, however, may depend in subtle ways on details of the empirical setting, such as scale of operation and demographic factors such as race or consumer attention to service quality.

Three other recent papers study similar questions to ours. Two use U.S. data, and reach substantially different conclusions. Because neither makes any attempt to control for endogeneity of ownership form, however, they are unable to address questions of causality. Wallsten and Kosec (2008) use a system-level panel from 1997 to 2003 to test the effects of ownership and benchmark competition on violations of the SDWA. They conclude that compliance is not affected by system ownership, although the detailed findings indicate a much more complex pattern. Konisky and Teodoro (2015) develop a political theory of the compliance behavior of public vs. private water systems, arguing that regulators may be politically unable to impose penalties on public systems that are as high as those imposed on private systems. However, their theory ignores the fact that private systems have high-powered incentives to cut costs that can undermine quality. They test their theory using water system data on violations from 2010 to 2013, and claim that public systems incur more violations. In both papers, the lack of control for endogeneity of ownership form calls the results into question.

Closest in method to our paper is Galiani et al. (2005), who study water privatization in Argentina in the 1990s. They use a difference-in-differences and difference-in-differences matching methodology and find that privatization of water systems in Argentina led to a significant decrease in child mortality. While our underlying core empirical strategy has much in common with theirs, our paper differs from this previous paper in several aspects. First of all, ours is the first large-scale empirical study on US water systems that addresses the endogeneity of ownership, whereas theirs is based in a quite different developing country context. Second, because of the uniqueness of their context, they study only the effect of privatization, whereas we look at both the effect of privatization and municipalization. Third, we make theoretical contributions that may have broader implication than just water systems whereas the previous paper is a purely empirical work. Fourth, our empirical analysis is at the more detailed level of individual water systems while theirs is at the municipality level.

From a technical perspective, we place more emphasis on differences-in-differences matching than do Galiani et al. (2005), and apply multiple matching algorithms with different parameters (e.g. bandwidth selection), in addition to making the estimation more complete by applying a standardized differences test. We also test for heterogeneous effects with regard to numerous moderators by matching on different subgroups. Furthermore, even though the results are not yet completely pinned down, we have tried using the method discussed in Cattaneo, Drukker and Holland (2012) to decide the specification of our propensity score using the Akaike information criterion and a logit model. We also applied the semiparametric efficient estimators proposed in Cattaneo (2010), i.e., efficient-influence-function (EIF) estimator and inverse-probability weighted (IPW) estimator. Finally, we performed different various robustness checks to support our main results. In short, even though the core empirical technique is similar, we have applied a much broader set of robustness checks. To summarize, in formulating a theory and empirically testing its hypotheses, we contribute to various streams of literature that focus on heterogeneous performance implications of governance form and changes to it.

III. THEORY AND HYPOTHESES

Hart, Shleifer and Vishny (1997) showed that if quality incentives are weak relative to cost incentives, then for-profit firms will put excessive effort into cost reduction at the expense of quality enhancement. Much of the environmental economics literature suggests the financial incentives for quality provision are weak when it comes to environmental protection. (Gray and Shimshack, 2011). In particular, fines are too low to motivate first-best levels of environmental protection. Of course, fines are not the only incentive mechanisms facing firms. There may also exist other, more subtle, incentives to exert abatement effort. Pressure may arise from activist groups, institutional investors, consumers, employees, regulators, and the media. (Short and

Toffel, 2010). Total stakeholder pressure may or may not be equal across privately and publicly-owned firms.

Hypothesis 1*: All other things equal, if fines are below first-best levels then publicly-owned firms will provide higher environmental quality than privately-owned firms.*

However, we argue that there are several ways in which stakeholder pressure differs between public and private firms. Of course, private firms face pressure from investors, which should lead to a greater emphasis on cost reduction as opposed to quality enhancement, as reflected in Hypothesis 1. In addition, we argue that private firms face greater pressure from activist groups and the media. One recent Gallup poll found that 72% of Americans have a great deal or a fair amount of trust in local government,[7] while only 21% have "a great deal" or "quite a lot" of confidence in big business.[8] Thus, poor performance by private firms, especially large ones, may be more salient to the public than poor performance by public firms. If so, then the media will be likely to provide more coverage to stories about environmental violations by private firms than public firms. The impact of media coverage, in turn, depends on the portion of the public that pays attention to the news and is willing to take action based on it. Thus, the impact of private ownership on performance will be moderated by the amount of public attention to quality issues in particular industries. In particular, one would expect that the performance of private firms would be especially sensitive to the level of education and average income in the areas where they provide service.

Hypothesis 2*: The environmental performance of private firms is more sensitive to public attention and activist pressure than is that of public firms.*

The amount of public attention a firm or issue receives varies not just across ownership forms, but also over time. John Elkington (1997) has documented three "waves" of attention to environmental issues that vary across decades. Shifts in attention can also change much more quickly. Media coverage of COP21 surged right after the meeting, but was quickly overtaken by coverage of a mass murder with assault weapons in San Bernadino, California, which turned out to have been conducted by a couple with allegiance to ISIS, a terrorist group. The Republican primary debate that followed on December 17, 2015, focused almost entirely on national security. Climate change had been pushed off of the agenda.

The larger point is that media attention to any issue varies over time depending upon the importance of other events competing for public attention. Hirshleifer et al. (2009) find that investors underreact to earnings news when many firms make announcements at once. A shift in ownership form is likely to prompt greater public attention for a period of time, but that attention

[7] McCarthy, Justin (2014). *Americans Still Trust Local Government More Than State* Gallup: http://www.gallup.com/poll/176846/americans-trust-local-government-state.aspx
[8] Dugan, Andrew (2015). *Americans Still More Confident in Small vs. Big Business*. Gallup: http://www.gallup.com/poll/183989/americans-confident-small-big-business.aspx

will shift towards other issues at some point. Because private firms are more sensitive to stakeholder attention, and because privatization generates a spike in attention, we have

Hypothesis 3: *Privatization will produce short-run improvement in environmental performance, but this will worsen over time.*

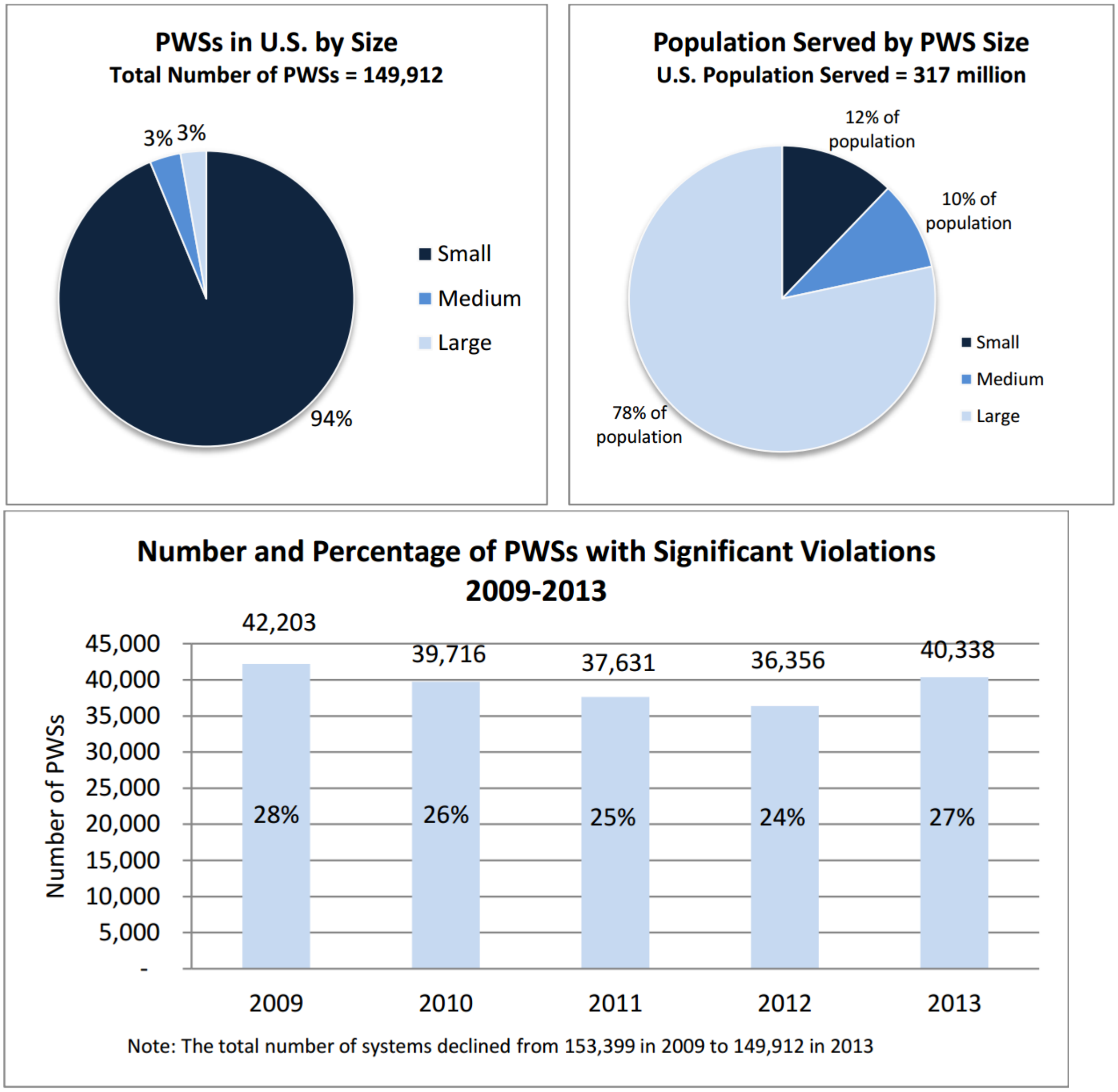
The equilibrium level of private performance relative to public performance will depend upon the long-run level of stakeholder pressure and whether that is enough to overcome the financial incentives of the private firm.

IV. EMPIRICAL CONTEXT - MANAGEMENT OF WATER SYSTEMS IN THE U.S.

According to the 2013 National Public Water Systems (PWSs) Compliance Report by EPA, who is in charge of regulating all water systems in the U.S., there were 149,912 active water systems in the U.S. by the end of 2013. Among these systems, the dominant majority are relatively small systems serving fewer than 10,000 customers. The number of systems with severe violations dropped from 36,536 in 2012 to 40,338 in 2013. Agencies with EPA-delegated enforcement authority, such as state governments, reported that roughly 27% of all systems in the U.S. had one or more severe violation in 2013, whereas 7% of all systems, serving about 26.5 million consumers, had health-related violations, while significant monitoring and reporting violations made up another 18%. In the same year, 9,392 enforcement actions were initiated in response to drinking water violations at water systems. The following graphs are from EPA's 2013 National PWSs Compliance Report.[9]

[9] Note that here "public" means serving the public, not publicly owned.

Figure 1



A public to private spectrum of water management

In light of the existence of a range of governance forms of water provision that entail both public and private participation, it would be tempting (and useful) to view water supply models in terms of a strict dichotomy between public and private. In practice, however, there is a spectrum with purely public on one end and purely private on the other.

These supply models are characterized broadly into 3 categories by Bakker (2003), providing a useful framework for our discussion. The first category is the "public utility" municipal model. This was the dominant form of water provision over the past century. As the name implies, these systems are owned and primarily operated by governments. They are generally of non-profit nature, and often have subsidized rates. The second category is the private sector "commercial" model, under which systems are managed and sometimes owned by private companies. One common type in this category is Private Sector Participation (PSP, also termed Public Private Partnerships). This mode, which has been gaining popularity in recent years, uses private companies to manage infrastructures oftentimes owned by municipal governments. Private systems are typically for-profit and apply a market-oriented pricing scheme. The third model, lying somewhere between the aforementioned two, is the community 'cooperative' model. According to Bakker (2003), a cooperative can be defined as "an enterprise owned and democratically controlled by the users of the goods and services provided." This model often finds its existence in rural areas. According to EPA's Safe Drinking Water Information System, in Fiscal Year 2013, there are 1322 Community Water Systems serving 4,736,882 residents. Of these, 1135 are small or very small (less than 3300 people), and only 7 serve more than 100,000 residents.

Due to the complexities and ambiguity in the categorization of water systems, the EPA has for the case of simplicity categorized almost all water system as either public (federal, state, local) or private, while classifying a negligible portion of systems as mixed and Native American. Even though we will largely adopt this categorization in the empirical analysis below but drop the mixed category since the sample size is too small, it is always important to keep in mind the complications in the categorization of water system governance form and its implications that may be masked under the simplifications of the data in that some public systems empirically recorded as public maybe a private system in disguise. One such example is that due to the stigmatization of private governance form under certain contexts, public systems would rather use management contract instead of direct privatization in order to avoid being seen as private. This is an area where case studies may be a valuable supplement to our quantitative strategy.

Water system treatment practices and their monitoring

An important subject in the treatment of drinking water is the suite of Surface Water Treatment Rules (SWTRs) which stipulates how water systems disinfect and filter surface water sources so as to reduce the harm of microbial pathogens and disinfection byproducts. Numerous ways of treating drinking water are used in the US and the SWTRs have respective regulations for them. Some of these technologies include conventional or direct filtration, slow sand, diatomaceous earth, and alternative filtration. For a complete introduction about the water treatment techniques regulated by the SWTRs, please refer to the EPA webpage.

Similarly, the monitoring process is based upon the Safe Drinking Water Act (SDWA), the primary federal law to ensure the quality of Americans' drinking water. Originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply, the law was later amended in 1986 and 1996. The amended law adds a series of requirements to protect drinking water and its sources: rivers, lakes, springs, reservoirs, and ground water wells. The Act stipulates that U.S. EPA should set drinking water standards that public water systems must meet. 90 contaminants now have standards set by the U.S. EPA. Under SDWA, primary enforcement authority, or primacy may be granted to states that meet certain requirements, including setting regulations that are at least as stringent as US EPA's.

According to the SDWA and EPA, the monitoring process works as follows: water systems submit samples of their water for testing in authorized laboratories to verify that the water they provide to the public meets all federal and state standards. US EPA regulations specify the methods that must be used to analyze drinking water samples whereas states or the US EPA certify the laboratories that conduct the analyses. The frequency and location of the sample taking process vary according to numerous factors. Monitoring schedules differ according to the type of contaminant, the population served by the public water system, and the type of source water used to produce drinking water. It is worthy of noticing here that since the frequency of sample taking is proportional to the size of the water system as represented by population served, the number of violations observed in this process already has a normalized nature in terms of size. This way if we find size to be a factor that affects violation frequency in our empirical estimation, it would be on top of the normalizing process and cannot be simply played down as the exemplification of a mechanic process. Additionally, since the level of detail included in the regulations, specifying procedures for every kind of contaminant and water systems, there is theoretically speaking little flexibility through which water systems can game this system. So even though we cannot observe this directly, we can generally assume a strong tie between the violations detected and the underlying water quality. Here we make a simplification to use the violations detected as a proxy for service quality. However, future research equipped with better data may probe further into this issue and examine, for example, whether private and public systems are treated differently on this matter.

The SDWA provides states or EPA the authority to grant “variances” that allow water systems to use less costly technology, and “exemptions” to allow water systems more time to comply with a new drinking water regulation. More specifically, “variances” allow eligible systems to provide drinking water that does not comply with a National Primary Drinking Water Regulation (NPDWR) on the conditions that the system installs a certain (less expensive) technology and that the quality of the drinking water is still protective of public health. Similarly, “exemptions” allow eligible systems additional time to build capacity in order to achieve and maintain regulatory compliance with newly promulgated NPDWRs, while continuing to provide acceptable levels of public health protection. Exemptions do not release a water system from complying with NPDWRs; rather, they allow water systems additional time to comply with NPDWRs. The takeaway from here is that the exceptions made to systems that are typically small and located in poorly funded areas, together with a series of EPA funding and projects to assist the small systems improve their performance (for example, those documented in the 2012 National Public Water Systems Compliance Report), would work to bias the empirical data in favor of the small and disadvantaged water systems. Consequently, any empirical estimation indicating the poor performance of these systems would be a lower bound.

Violations

Violations are detected by assessment of the above-mentioned sample results or reviews (including on-site visits). Once detected, violations may lead to legal actions or compliance orders. Violations may be remedied by compliance/ enforcement actions, such as improved filtration techniques or changes in procedures. In terms of severity of the nature of violations, violations can be categorized into two large types: significant quality and health related violations, or GPRA violations, or violations that do not pose a real threat to quality of service and health, a typical example of which being rather monitoring and reporting violation. Some examples of violations include: Maximum Contaminant Level (MCL) violations, Treatment Technique (TT) violations, failure to replace lead service lines, monitoring and reporting violations, and procedural violations. Among these, MCL and TT violations, which themselves also include a multitude of subcategories of violations, are the two major types of violations that deserve special notice. Unfortunately, in our dataset the distinction between MCL and TT violations is only made between the years of 2010 and 2014 (with the 2014 data having some consistency issues on this categorization), we decide not to differentiate between MCL and TT violations in the empirical part of this draft. However, since it is in our plan to supplement the main empirical estimation with the subsample of our data that makes a distinction between these types due to the potential implications it will derive according to the following illustration, we still digress a little to introduce these two types of violations below. An MCL denotes the highest level of a contaminant that EPA allows in drinking water so as not to pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible. A TT refers to a required process intended to reduce the level of a contaminant in drinking water. In the two tables below we list the key types of violations and major contaminants in our data set from 2010 to 2013 that is to be explained later on. In Table 2, we can see that coliform, arsenic, and a type of contaminant related to water treatment techniques top the list of major contaminants in our dataset of significant health-related violations between 2010 and 2013. These statistics provide credential for our including information from the Toxic Release Inventory in the empirical part.

Table 1
Key Types of Violations

Abbreviations	Full Name
Arsenic	Arsenic
CCR	Consumer Confidence Report Rule
FBRR	Filter Backwash Recycle Rule
GWR	Ground Water Rule
I_LT1_ESWTR	Interim Enhanced Surface Water Treatment Rule and the LT1 (future) Enhanced SWTR
LCR	Lead and Copper Rule
LT2_ESWTR	LT2 (future) Enhanced SWTR
Misc	Miscellaneous
Nitrates	Nitrates
Other_IOC	Other Inorganic Chemicals
PN_rule	Public Notification Rule
Rads	Radionuclides
SOC	Synthetic Organic Chemicals
St1_DBP	Stage 1 Disinfectants By-Product Rule
St2_DBP	Stage 2 Disinfectants By-Product Rule
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TTHM_pre-St1	TTHM Rule violations, which was replaced by the ST1 DBP Rule
VOC	Other Volatile Organic Chemicals

Table 2
Major Contaminants in Significant Health-related Violations, *2010 - 2013*

Contaminant	Freq.	Percent
Coliform (TCR)	10,541	26.77
Arsenic	5,916	15.02
TTHM (Trihalomethanes)	5,148	13.07
SWTR	2,719	6.9
Total Haloacetic Acids (HAA5) (Stage 1 Disinfectants By-Product Rule)	2,244	5.7
Lead & Copper Rule	1,862	4.73
Combined Radium (-226 & -228)	1,738	4.41
Nitrate	1,516	3.85
Gross Alpha, Excl. Radon & U	1146	2.91
Fluoride	1120	2.85

A number of descriptors are normally used to describe each violation, such as: type, date, description, severity, and recommended corrective actions. It is worth reiterating that even though violations are quite prevalent among systems, many should not be a cause of severe concern since they may not relate directly to water quality and health but are rather monitoring and reporting, and other minor violations. Nevertheless, when a violation is reported, EPA records very detailed information about it throughout its course of life and makes the information publicly available through its Safe Drinking Water Information System (SDWIS) and ECHO (Enforcement and Compliance History Online) website. Below is a screen capture from the ECHO website on compliance monitoring history for Barton Hills Ann Arbor. Additionally, information about the violations and enforcement actions to make the system return to compliance are also recorded.

Figure 2

Compliance Monitoring History (5 years)

Statute	Source ID	System	Inspection Type	Lead Agency	Date	Finding
SDWA	*MI0000430*	*SDWIS*	*Regularly Scheduled*	*State*	*09/21/2012*	
SDWA	*MI0000430*	*SDWIS*	*Regularly Scheduled*	*State*	*03/25/2013*	
SDWA	*MI0000430*	*SDWIS*	*Regularly Scheduled*	*State*	*07/22/2014*	
SDWA	*MI0000430*	*SDWIS*	*Sanitary Survey, Complete*	*State*	*07/22/2014*	
SDWA	*MI0000430*	*SDWIS*	*Regularly Scheduled*	*State*	*01/16/2015*	

SDWA Violations and Enforcement Actions (5 Years)

Violations										Enforcement Actions			
Compliance Period	Violation ID	Federal Rule	Contaminant	Category	Description	Measured Value	State MCL	Federal MCL	Resolved	Date	Category	Description	Agency
SDWA (Source ID: MI0000430)													
09/01/2012 - 09/30/2012	4000310	Total Coliform Rule	Coliform (TCR)	MCL	Maximum Contaminant Level Violation			5% of samples	09/26/2012	10/05/2012	Informal	St Violation/Reminder Notice	State
										09/27/2012	Informal	St Public Notif received	State
										09/26/2012	Resolving	St Compliance achieved	State
										09/17/2012	Informal	St Boil Water Order	State
										09/17/2012	Informal	St Public Notif requested	State

In addition to the SDWIS and ECHO website, there are other ways for EPA to communicate to consumers about the violations and enforcement actions. EPA can have public notifications issue regarding specific violations if they pose a severe threat to public safety. EPA also requires community water systems to deliver annual drinking water quality reports (Consumer Confidence Report) to their customers. This information supplements public notification that water systems must provide to their customers upon discovering any violation of a contaminant standard. Large water systems with more than 10,000 customers must deliver the water quality reports to their customers, and take steps to get the information to people who do not receive water bills. Water systems serving fewer than 10,000 people, on the other hand, may be able to distribute the information through newspapers or by other means. The largest water systems must post their reports on the Internet, in addition to other delivery mechanisms, to make the reports easily accessible to all consumers.

V. DATA

Data construction

The primary source of data used in this study comes from two Freedom of Information Act (FOIA) Requests to the EPA Office of Ground Water and Drinking Water. The water systems in the datasets are classified into seven ownership categories. They are: Federal government, State government, Local government, Mixed public/private, Native American, Private, and not specified. As mentioned in the governance form categorization section, in the regressions we perform in the following section, we only consider the three government and one private ownership categories, leaving out the other types in order to sharpen our empirical analysis since the other governance forms while being too small in quantity to generate significance, may also poses anomaly characteristics we don't really want to deal with. We also take out systems located in tribal areas in our data cleaning process.

The main data sets we are using below contain information regarding the population of all water systems in the U.S. each year from 2006 to 2014 and annual records of Government Performance and Results Act (GPRA) violations occurred through the same period. Violations are counted towards GPRA if they are health-based violations at community water systems that are open[10] during the respective fiscal years they are observed.

Cleaning up and assembling the highly fragmented and inconsistent data sets with severely non-standard geographical information and numerous missing observations took extended effort. Indeed, data construction is one major difficulty and contribution this research is associated with. For one part of the data, we first assemble the yearly violations data and system inventory data respectively. We then append together the violations data and inventory data to arrive at one data set. Separately we have assembled a geographical information data set that utilizes cross matching among various geographical identifiers at different levels so as to achieve maximum matching rate. This crosswalk data set is merged to the data set above. The merged data set with geographical identifiers is then merged with a series of economic, political, and environmental moderators and collapsed by water system ID and fiscal year. In the end, we arrive at a panel with unit of observation as a pair: water system ID# - Fiscal Year. For observations with which violations are associated, we also have the violations count for the systems in the year. For these observations, we have information regarding the ID and name of

[10]Violations are considered open during (some or all of) FY 2014 if the calendar date of the beginning of a monitoring period in which a public water system was determined to be in violation of a primary drinking water regulation is earlier than or equal to 6/30/2014 and the calendar date of the end of a monitoring period in which a public water system was determined to be in violation of a primary drinking water regulation is later than or equal to 7/1/2013. The same is true for FY 2006 to 2013.

the public water system, which state and county the system is in, its source of water (surface or ground), its size as measured by population served, the system's first and last reported date, and its ownership status, among other things.

As for the violation records, we know the violation's ID, violation and contaminant type and name, date a violation was first reported to SDWIS-Fed, its enforcement action date and type, number of system and population in violation, total number of systems and population. However, this information is not available through all the fiscal years. Given that in our final collapsed panel, our focus is on the violation count for a water system in a specific year, we argue that this incompleteness of information does not detract from the effectiveness of our main empirical strategy.

We complement these variables with a series of social, economic, and environmental variables acquired from various sources. Annual county level unemployment rate for each year between 2006 and 2013 from the U.S. Bureau of Labor Statistics is accessed from Missouri Census Data Center. Percent of people with Bachelor's or higher degrees averaged through 2009 and 2013 at the county level from the American Community Survey is obtained from the Missouri Census Data Center. Annual poverty rate for each year between 2006 and 2013 at the county level from the U.S. Bureau of the Census is still acquired from the Missouri Census Data Center. We also use DW-Nominate Scores developed and updated by a group of political scientists. They estimate a random utility model in which a vote is determined by the congressmen's ideological preference and random taste shocks using data on their choices in roll-call votes on bills. There are two dimensions to the DW-Nominate Scores and the first dimension we use here can be interpreted in most periods as government intervention in the economy or liberal-conservative in the modern era. The higher the score, the more conservative the congressman is. In particular, we take the average of congressmen's Nominate Scores within each state and congress for the House and Senate, respectively. We then take the average of that average to come up with the Average Nominate Score for each state and congress.

We also incorporated a series of environment-related variables into our analysis. Utilizing the Toxic Release Inventory, we calculate the total amount of Arsenic, Lead, and Copper released into water at the county level in each year from 2005 to 2014. These three chemicals are chosen because they are the largest three contaminants traceable back to the TRI and we construct the data by adding up multiple raw forms of data. Finally, two types of expenses and one inventory measure associated with farm production are calculated using the 2012 Census of Agriculture by the U.S. Department of Agriculture (USDA) – National Agricultural Statistics Service (NASS). They are total chemicals purchased, fertilizer, lime, and soil conditioners purchased, all in thousands of dollars, and inventory of livestock and poultry in number count, all at the county level. These social, economic, and environmental information from different sources are thus merged with the major data sets on the water systems using FIPS (Federal Information Processing Standards) codes and fiscal year (and also congresses corresponding to the fiscal years duration which they met in the case of Nominate Scores). The rational for the inclusion of all these factors will be discussed in more detail in the empirical estimation section.

Descriptive Statistics

Over the nine years from 2006 to 2014, we have data on 179,927 water systems associated with 1,348,799 system–year observations, and 97,362 violation records. Thus, the vast majority of water systems had zero violations in any given year. In the following Table 3 of the number and proportion of systems with violations by governance form, we can see that only several percent of water systems have had violations in a given fiscal year. More specifically we observe that the proportion of public systems with violations (5~7%) is much higher than that of private systems (about 2 %). However, given the fact that there is a very large number of private systems that are very small and the general size distribution of private versus public systems is different, we should take the descriptive result with a large grain of salt and refrain from jumping to the conclusion that private systems outperform public systems in terms of compliance performance.

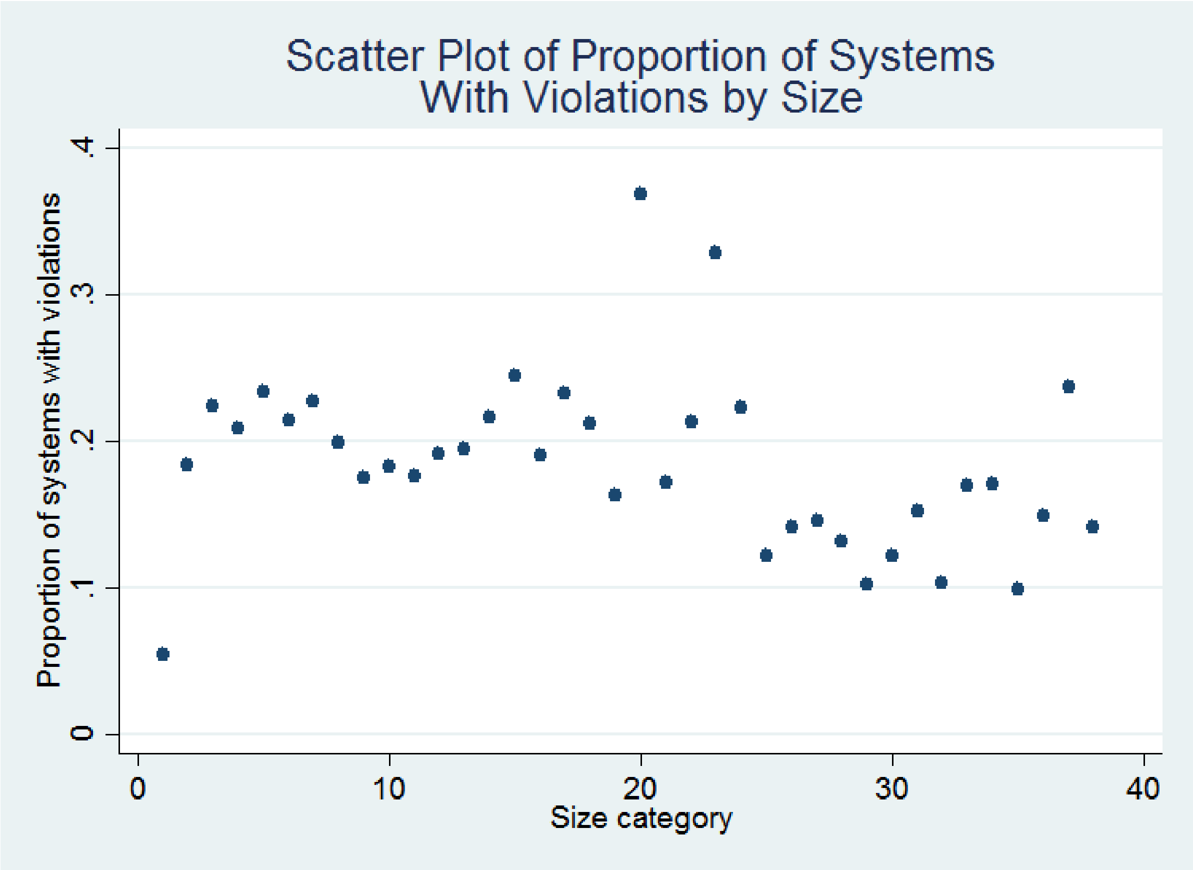
Table 3

Number of Systems with Violations by Governance Form

	Public		
Year	**# Systems with Violations**	**Total # Systems**	**% of Systems with Violations**
2006	2912	41405	7.033
2007	2911	41458	7.022
2008	2978	41857	7.115
2009	2927	41761	7.009
2010	2575	42509	6.058
2011	2376	41935	5.666
2012	2327	41655	5.586
2013	2170	41318	5.252
2014	2336	46430	5.031
	Private		
Year	**# Systems with Violations**	**Total # Systems**	**% of Systems with Violations**
2006	2635	108767	2.423
2007	2790	107801	2.588
2008	2711	106687	2.541
2009	2591	105745	2.450
2010	2499	110353	2.265
2011	2224	108347	2.053
2012	2018	107965	1.869
2013	2059	107176	1.921
2014	2226	105630	2.107

Figure 3 demonstrates the importance of system scale, and shows a trend of decreasing occurrence of violations as systems get larger.

Figure 3



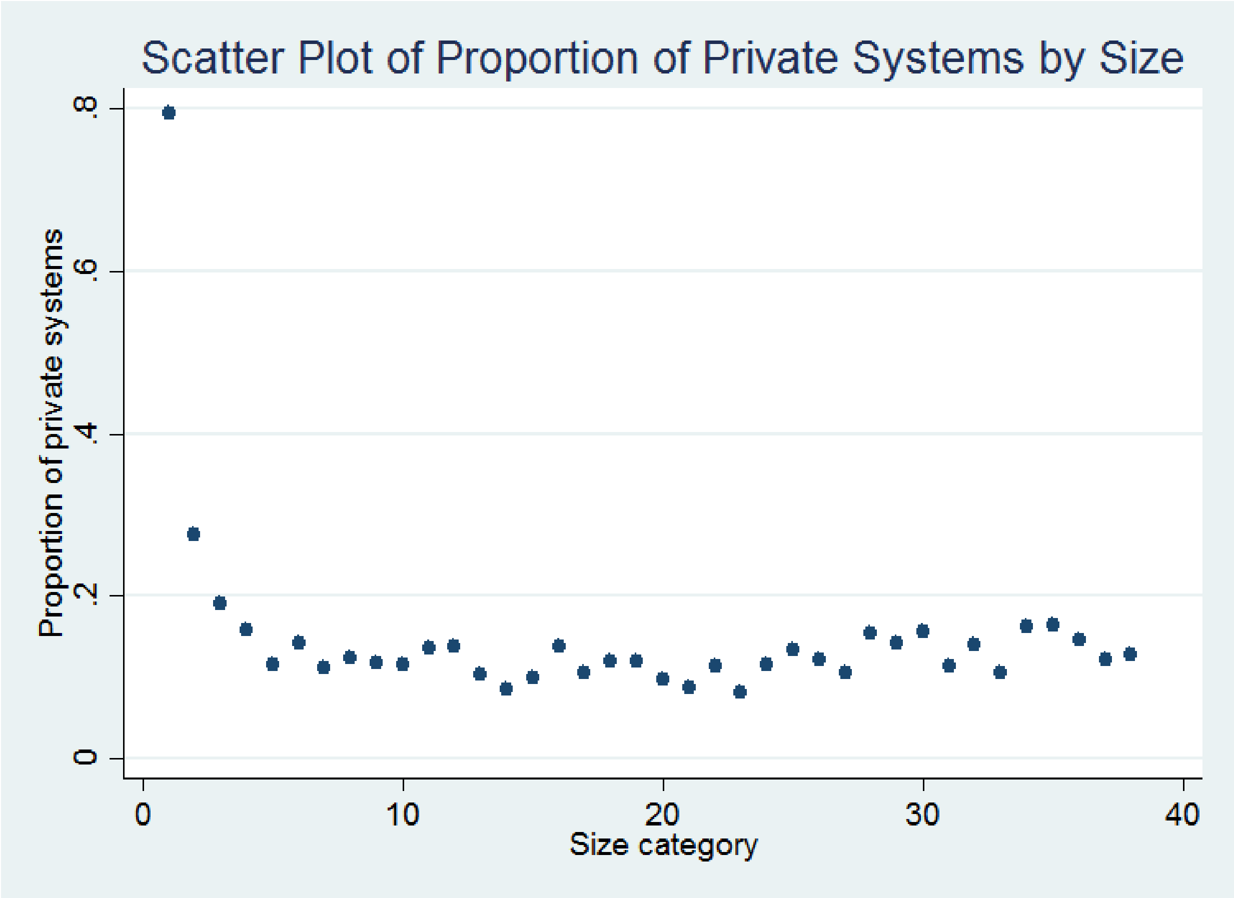
Tables 4 and 5 present some summary statistics on all the public, private, privatized, and municipalized systems. Public systems are on average significantly larger than private systems (in terms of thousands of people served). Actually, public systems are larger by an entire order of magnitude. Also, we can see that private systems are located in areas that have slightly better educated and less poor residents. Indeed, T-tests for equality of means confirm that the percent of people with bachelor's or higher degree and poverty rate for public and private systems are not equal, respectively. Another important observation is that public systems seem to be located in areas with a higher mean amount of arsenic, lead, and copper released to the local water body. Additionally, private systems are located in areas with much lower nominate scores. Since the higher the score, the more conservative the congressman is, it is very interesting to observe that private systems are located in more liberal areas. Private systems also tend to be located in communities with a higher number of water systems. Finally, the communities public and private systems are located in do not seem to differ much in terms of the expenses in chemicals, fertilizer, lime, and soil conditioners used in agriculture, as well as the scale of livestock and poultry output.

Table 4
Characteristics of Public and Private Systems

	Public				*Private*			
	Mean	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Population Served (thousands)	6.18	53.74	0.00	6,552.72	0.49	11.46	0.00	2,360.00
Uses Ground Water	0.76	0.42	0.00	1.00	0.97	0.18	0.00	1.00
Water System Age	24.56	8.03	0.00	33.00	19.45	9.54	0.00	33.00
Unemployment Rate	7.26	2.94	0.80	29.90	7.51	2.91	0.80	29.90
Poverty Rate	14.20	5.36	2.40	48.40	13.06	4.70	2.40	44.80
Percent of People With Bachelor's or Higher Degrees	23.89	9.79	6.50	60.00	25.14	9.52	6.50	60.00
Nominate Score	0.08	0.30	-0.52	0.82	0.01	0.26	-0.52	0.82
System Count Per County	141.89	189.61	1.00	1,475.00	205.91	185.83	1.00	1,475.00
System Share in County	0.05	0.12	0.00	1.00	0.00	0.03	0.00	1.00
Chemicals	8,183.64	23,436.65	0.00	297,669.00	8,182.31	24,468.24	0.00	297,669.00
Inventory of Livestock and poultry (number)	2,785,432.00	12,000,000.00	0.00	174,000,000.00	2,768,402.00	13,200,000.00	0.00	174,000,000.00
Fertilizer, lime, and soil conditioners	11,789.02	20,236.06	0.00	216,341.00	11,585.42	20,529.14	0.00	216,341.00
Arsenic, Lead, & Copper Amt Released to Water	2,545.80	22,176.69	0.00	466,588.30	1,783.10	18,277.76	0.00	466,588.30
Arsenic, Lead, & Copper Amt Released to Water L(1)	3,605.24	34,141.34	0.00	607,310.80	2,419.99	27,096.98	0.00	607,310.80

Figure 4 shows that the vast majority of the very small systems (size category = 1, i.e., serving less than 1,000 people) are private; however, for systems larger than 2,000 people, the proportion of private systems does not exceed 20%.

Figure 4



In Table 5, we observe that municipalized systems seem to be larger on average compared with privatized systems. Some interesting patterns show up if we compare the size of the systems that went through governance form change with the population of all systems. For example, the municipalized systems have an average size that is not only larger than the population of private systems, but also larger than public systems. Whereas for the privatized systems, their size is smaller than the population of public systems, but still march larger than private systems. Assuming size will not change rapidly from year to year, we see a general trend here that the public systems that got privatized are in general, relatively smaller than their peers. On the other hand, the systems that got municipalized are usually the extremely large private systems. This makes controlling for size important in our empirical estimation to follow.

Table 5

Characteristics of Privatized and Municipalized Systems

	Privatized				*Municipalized*			
	Mean	**Std. Dev.**	**Min.**	**Max.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Population Served (thousands)	3.80	38.04	0.00	1,281.00	8.20	76.81	0.00	2,360.00
Uses Ground Water	0.85	0.35	0.00	1.00	0.81	0.39	0.00	1.00
Water System Age	24.83	7.88	1.00	33.00	25.16	7.65	0.00	33.00
Unemployment Rate	7.91	2.80	2.50	29.90	8.65	2.58	2.50	29.90
Poverty Rate	15.89	5.80	3.70	44.80	14.19	4.13	3.70	32.40
Percent of People With Bachelor's or Higher Degrees	23.85	10.07	8.50	58.60	21.93	8.89	8.40	57.90
Nominate Score	0.17	0.31	-0.45	0.75	0.10	0.23	-0.52	0.75
System Count Per County	167.41	280.27	4.00	1,475.00	132.19	185.04	4.00	1,475.00
System Share in County	0.02	0.07	0.00	0.84	0.04	0.10	0.00	0.91
Chemicals	6,481.04	21,886.47	22.00	248,270.00	6,050.84	17,607.23	0.00	248,270.00
Inventory of Livestock and poultry (number)	2,025,453.00	6,432,392.00	357.00	62,700,000.00	1,480,252.00	5,785,562.00	0.00	92,100,000.00
Fertilizer, lime, and soil conditioners	9,312.97	20,464.95	79.00	179,664.00	10,712.61	15,134.98	0.00	179,664.00
Arsenic, Lead, & Copper Amt Released to Water	7,431.51	35,922.18	0.00	351,547.10	2,967.57	22,666.83	0.00	351,547.10
Arsenic, Lead, & Copper Amt Released to Water L(1)	8,846.71	41,726.29	0.00	351,547.10	3,789.72	28,833.69	0.00	351,547.10

Since we have been singling out the "switchers" to look at their characteristics, the following Table 6 presents the number of systems that changed their governance form each year, and the total amount of people served by them. Even though the pattern is a rather mixed one and there is a significant fluctuation in the number of governance form changes from year to year, one thing we can say for sure is that municipalization happens on a much larger scale compared with privatization in the years observed. So the big trend in the past few years has been towards the public governance of water systems instead of private ownership. We have also generated the trends using systems that are divided into several subgroups according to their size and educational attainment level of the local community. Table 7 is an example while the rest are included in the appendix. Figure 5 summarizes the various subgroup results in a graph. From the graph, we observe a peak of privatization in 2010 and that large systems went through the most privatizations.

Table 6

Summary Statistics on Trends of Governance Form Change

			All Systems		
Year	**Systems Privatized**	**Systems Municipalized**	**No. of Private Systems**	**No. of Public Systems**	**Total No. of Systems**
2007	141	261	107801	41458	149,259
2008	85	728	106687	41857	148,544
2009	65	200	105745	41761	147,506
2010	105	131	110353	42509	152,862
2011	74	69	108347	41935	150,282
2012	70	98	107965	41655	149,620
2013	58	77	107176	41318	148,494
2014	60	393	105630	46430	152,060
	Population Privatized	**Population Municipalized**	**Private Population**	**Public Population**	**Total Population**
2007	364.463	906.854	56221.100	244536.800	300757.900
2008	30.757	5388.924	51782.150	254503.400	306285.500
2009	113.379	255.431	51491.430	256668.700	308160.100
2010	1886.609	1100.078	52525.980	260524.400	313050.400
2011	177.028	3958.156	48785.12	263830.6	312615.7
2012	51.181	137.835	48769.39	264912.6	313682
2013	136.947	412.394	48458.74	263959.8	312418.6
2014	113.596	1699.849	47588.11	273497.3	321085.5

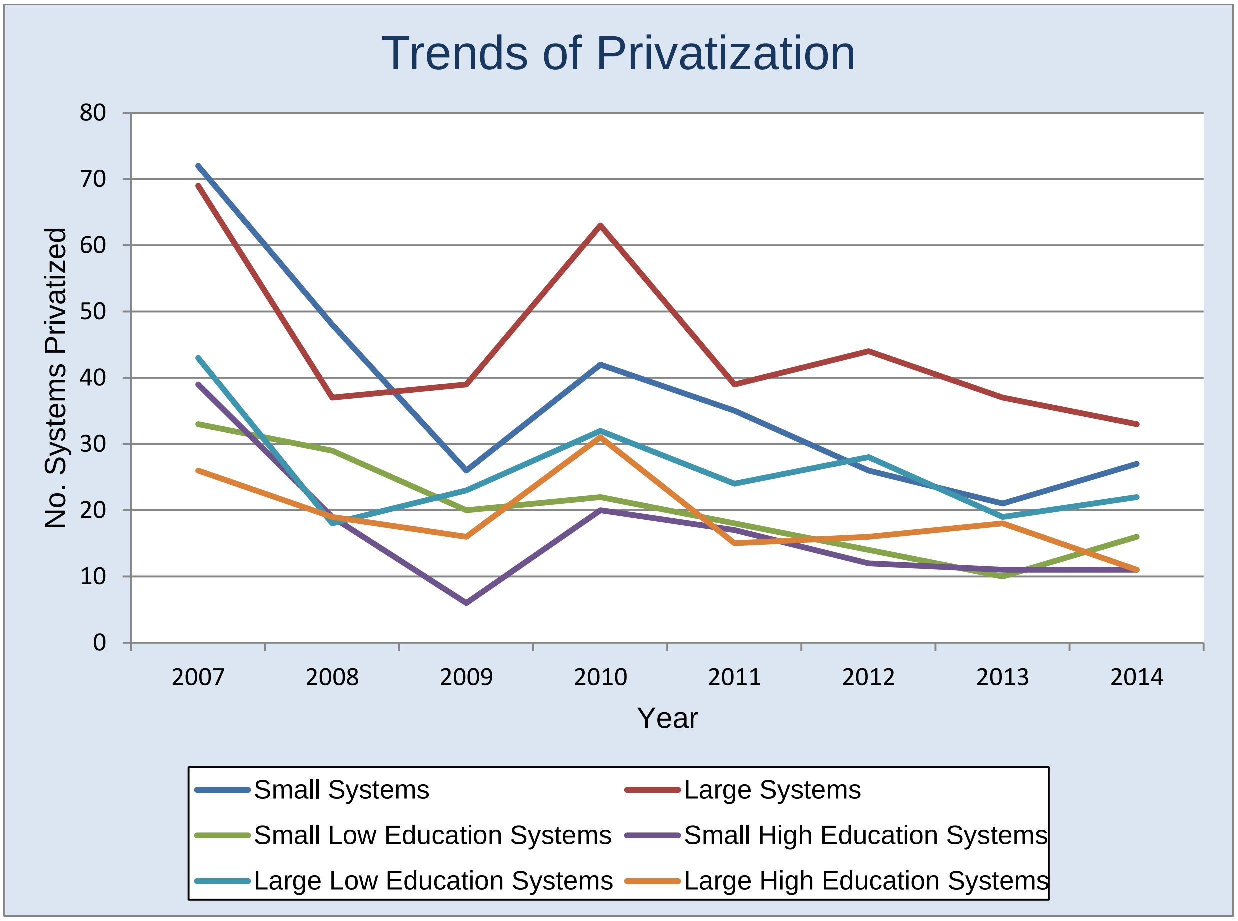
Table 7

Summary Statistics on Trends of Governance Form Change

Small Systems

Year	Systems Privatized	Systems Municipalized	No. of Private Systems	No. of Public Systems	Total No. of Systems
2007	72	93	61343	11275	72,618
2008	48	144	61004	11271	72,275
2009	26	108	60737	11275	72,012
2010	42	58	63489	11495	74,984
2011	35	27	62348	11305	73,653
2012	26	39	62052	11233	73,285
2013	21	25	61554	11023	72,577
2014	27	126	60752	13264	74,016
	Population Privatized	**Population Municipalized**	**Private Population**	**Public Population**	**Total Population**
2007	8.230	6.992	3,121.95	1,219.92	4,341.87
2008	4.438	13.005	3,113.43	1,246.26	4,359.68
2009	1.567	6.402	3,125.36	1,265.96	4,391.32
2010	3.084	3.602	3,169.43	1,203.64	4,373.07
2011	3.777	1.161	3,149.25	1,224.56	4,373.80
2012	1.354	1.945	3,130.48	1,220.28	4,350.76
2013	1.297	1.137	3,124.15	1,220.11	4,344.26
2014	2.593	6.019	3,134.90	1,531.11	4,666.01

Figure 5



VI. EMPIRICAL APPROACH

Our empirical strategy of differences-in-differences matching combines the strategies of differences-in-differences and propensity score matching. In the privatization analysis, we define an observation as being treated if it is associated with the post-privatization periods of a water system that is publicly owned in the first year observed but was later privatized. Thus, the average effect of treatment on the treated (ATET) we are estimating is the average effect of privatization on our dependent variable i.e., number of violations of the privatized water systems. In the municipalization analysis, we define an observation as being treated if it is associated with the post- municipalization periods of a water system that is privately owned in the first year observed but was later municipalized. Thus, the ATET in this case is the average effect of municipalization on the number of violations of the municipalized water systems. A small caveat is that in some cases we see governance change getting reversed; for example, some systems are re-municipalized after privatization (26), still others were re-privatized after municipalization (79), and re-municipalized again after that (36). We deal with each situation accordingly in our coding and summary statistics and estimation results have also been generated for these special cases that are relatively infrequent. They are available upon request.

Matching

We begin with matching using violation count as the dependent variable. The key idea of matching is using non-parametric regression methods to construct counterfactuals under the assumption of selection on observed variables.

As is well known, it would be inadequate to derive the causality effect of treatment implied here using a simple reduced form regression analysis since we cannot observe the counterfactuals of no privatization/municipalization for the treated units, and vice versa. Nevertheless, this is what both previous papers studying a similar, but smaller, data set did. Put another way, we have the classical problem of selection bias due to water systems selecting into privatization or municipalization in ways related to their counterfactual compliance performance. Even if we can minimize the selection bias by adding controls in the reduced form regressions, there are still things that simple regressions cannot do. For example, since matching does not impose a strong linear parametric form, as regression does, its assumptions are more easily satisfied. Matching also sheds light on the common support condition in that in the course of matching, it states explicitly if comparable counterfactuals exist at all. Another advantage matching poses over regression is that in reduced form regressions, all untreated observations are given the same weight in determining the counterfactuals, whereas matching, by definition, gives the untreated observations appropriate weights according to their comparability with the treated observations. Finally, the estimand of matching is the ATET, which has more practical implications than that of simple regressions.

For matching methods to work, however, we need to satisfy the conditional mean independence assumption. This requires that, conditioning on a series of observables, the mean untreated outcome is independent of treatment status. Thus it is crucial that we exclude any variable that might be affected by the treatment when specifying the observables in the following analysis, either ex post or ex ante. Additionally, these observables must include all variables affecting both treatment status and treatment outcome. This shares some flavor with the instrumental variable approach but also has a stark difference: an instrument only influences treatment outcome through its effect on treatment status.

After performing the matchings, we also need to estimate the standardized biases for the variables included in calculating the weights as a specification test. In particular, this is one variant of the balancing test, which works to pick a propensity score specification for a given observable. We will save us from discussing the detailed definition of this test. Even though convergence for a small portion of the tests cannot be achieved and not all variables are completely balanced after matching, they do not constitute a fatal flaw to our knowledge.

All these conditions add to the complexity of adding the conditioning observables used in matching. In our practice, we experimented with tens of specification of the inputs in the matching process and finally came up with what is going to be illustrated below. As one can tell, given the subjective nature of the process of selection of matching variables and the difficulty of satisfying the ideal condition (the conditional mean independence assumption, or its stronger form, the conditional independence assumption (CIA) is impossible to test without experiments or joint nulls tests), the flaw of matching methods is also obvious.

In the matching process, we applied three matching methods. The first two are inexact matching estimators. One is normal Kernel matching. This method constructs the counterfactuals by taking local averages of the comparison group observations near each treated observation. Given the structure of our data, which contains a huge amount of untreated observations compared with the treated ones, yet distributed asymmetrically, Kernel matching is probably an ideal choice. The superiority of Kernel matching is documented in the Monte Carlo analysis of Frölich (2004).The other is local linear matching, which is comparable to Kernel matching but has the advantage of converging faster at the boundary (propensity score of 1 and 0) and adapting better to varying data densities. It is also good at dealing with data with a large number of untreated observations having propensity score close to the boundary. Both of the inexact matching methods entail the use of a distance metric. Here we use propensity score matching, where propensity score is a measure of probability of treatment defined below. Even though it is theoretically possible to perform non-parametric estimation of propensity score, we estimate the propensity scores using a probit model to avoid the curse of dimensionality. According to Smith (2014), Monte Carlo experiments and sensitivity analyses have shown that estimating propensity scores using parametric methods like the probit model will have very small impact on the results. The third matching technology is a kind of exact matching with discretized observables. It is coarsened exact matching. This method calculates a mean difference in each cell and then takes a weighted average of the mean differences using the fraction of treated observations in each cell as the weights. According to Iacus et al. (2008), this method has multiple advantages, including saving the need for bandwidth selection, dealing with common support, and being robust to measurement error. But most important of all, it is much faster. In our analysis below, we will mainly be focusing on the coarsened exact matching while leaving kernel and local linear matching for the robustness checks.

One thing worthy of noticing is that for both kernel and local linear matching, we experiment with bandwidth of 0.02, 0.2, and 2, respectively. As one can tell, this selection of bandwidth is a little bit arbitrary. A better way might be to perform cross-validation to choose bandwidths in order to minimize a mean squared error (MSE) criterion using subsets of the data. However, we decide that approach is probably too computationally intensive for now. For both matching methods, we also impose a common support condition both by dropping treatment observations whose propensity score is higher than the maximum or less than the minimum propensity score of the controls and trimming 1 percent of the treatment observations for which the propensity score density of the control observations is the lowest. The latter approach, though, does very little change to results but undermines balancing. So the first approach is reported onwards. This is useful in insuring that we have an observation similar to the one we are constructing the counterfactual in the matching process. However, imposing this condition may have a negative impact on our estimation because in deleting some treatment observations, we are in practice changing the estimand. Nonetheless, as pointed out by Crump, Hotz, Imbens and Mitnik (2009), this is not necessarily a bad thing. That being said, the way we are using to ensure common support is among the simplest and least attractive in literature. There is a number of other more sophisticated and better approaches to this that might be used.

In the case coarsened exact matching, we set the matching observables to be a dummy variable for "large" systems serving over 10,000 people, indicator variable for systems using groundwater, indicator variable "old" for systems first reported on or before 1981[11]. It does not seem too difficult to argue that all the afore-mentioned covariates affect both the ownership status of a system and also the likelihood that a violation is to be reported. I complement these variables with a series of social economic and environmental variables acquired from various sources documented above. They are county unemployment rate, percent of people with Bachelor's or higher degrees at the county level, county level poverty rate, and state level average DW-Nominate Scores. Similarly, one may make an argument that these social economic variables have an impact on both the governance form of a system and its compliance with Safe Drinking Water Act Standards (as well as the monitoring and enforcement associated with the reporting of a violation). In the following table, we present the standardized differences in these variables before and after matching. We can see that matching has indeed reduced standardized differences sufficiently. For all but one variable (poverty rate), the null hypothesis that the matched sample has equal mean between treated and control observations cannot be rejected. For every variable, the reduction in bias is also very significant.

[11] We observe clustering in 1979, 1980, and 1981 for the first reporting year of systems in our data. 1979 is the first year systems are required to report to the EPA.

Table 8
Coarsened Exact Matching Standardized Difference

Variables	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct abs(bias)	t-test t	t-test p>abs(t)	V(T)/ V(C)
Large System (over 10000 people)	U	0.04	0.03	7.30		4.47	0.00	.
	M	0.04	0.04	2.90	60.40	1.56	0.12	.
Uses Ground Water	U	0.85	0.91	-17.70		-10.91	0.00	.
	M	0.85	0.85	-1.60	90.90	-0.82	0.41	.
Old Systems	U	0.55	0.44	21.80		12.02	0.00	.
	M	0.55	0.56	-1.10	94.80	-0.62	0.54	.
Unemployment Rate	U	8.10	7.49	20.40		8.80	0.00	0.93*
	M	8.10	8.05	1.70	91.80	0.75	0.45	1.00
% People With Bachelor's or Higher Degrees	U	23.02	24.34	-13.50		-7.52	0.00	1.08*
	M	23.02	23.17	-1.50	88.90	-0.80	0.42	1.00
Poverty Rate	U	16.72	13.91	47.80		29.89	0.00	1.60*
	M	16.72	16.53	3.30	93.00	1.74	0.08	1.12*
Nominate Score	U	0.16	0.05	36.40		21.33	0.00	1.29*
	M	0.16	0.16	0.30	99.30	0.13	0.89	0.99

Differences-in-differences

We begin with a simple differences-in-differences estimation to provide a benchmark for the DID matching analysis. Note that all the dependent variables in the following estimations are still violations count. Before going forward with this, though, we performed a test for equality of pre-switching time trends in the same style as Galiani et al (2005). However in the F-test, we cannot reject the null of equality. Another minor note is that in order for matching (and difference-in-differences) to work, general equilibrium effects cannot be too strong (i.e. we must have Stable Unit Treatment Value Assumption). It is not too unimaginable to assume here that the privatized/municipalized systems are not having a big effect on the performance of the controlled systems given the lack of ex post competition in the industry due to the nature of its none-overlapping geographical distribution.

Our empirical specification is:

$$y_{it} = \alpha\, G_i + \beta\, T_t + \gamma\, I_{it} + \lambda\, X_{it} + \epsilon_{it}$$

Here y_{it} is the number of violations for system i in year t, $G_i$is a treatment group dummy, T_t is a vector of fiscal year dummies, I_{it} is a treated status dummy that is equal to one for treated groups in the post -treatment period, and X_{it} is a vector of control variables to be expanded below. Finally, ϵ_{it} is clustered at the state-year level. For the control variables, we include retail population served and its square; an indicator variable for systems serving over 10,000 people; an indicator variable for systems using groundwater; system age; and an indicator variable for old systems (first reported on or before 1981). We include system count per county and proportion of the county population served by the water system under consideration (System Share in County) to account for the possible effect of market power and bargaining power with regulators. We also include county unemployment rate, county level percentage of people with bachelor's or higher degrees, county poverty rate, and state level DW-Nominate Scores. In addition to these, the amount of arsenic, lead, and copper released to both surface and ground water, as well as this number lagged by 1 year is included. These three chemicals are chosen because they are the largest three contaminants traceable back to the TRI. Finally, the following three types of expenses associated with farm production are acquired from 2012 Census of Agriculture by the U.S. Department of Agriculture (USDA) – National Agricultural Statistics Service (NASS), respectively. They represent the local expenses on chemicals, fertilizer, lime, and soil conditioners, as well as the inventory of livestock and poultry counted in numbers. Water system age is calculated by deducting the year a system first reported to EPA from the year it was observed. State fixed effects are included to control for unobserved state specific characteristics such as regulatory background that might affect ownership status. In Table 9 below, it is quite obvious that the average treatment effect on the treated for privatization is insignificant for each of the three models.

Table 9

Difference in Differences Regressions on Number of Violations

VARIABLES	(1) Privatization	(2) Privatization (2)	(3) Privatization (3)
ATET (Privatize)	0.0317	-0.0225	-0.00735
	(0.0368)	(0.0405)	(0.0344)
Population Served (thousands)		-0.000229***	-0.000530***
		(3.24e-05)	(5.20e-05)
Square of Population (thousands)		3.30e-08***	1.00e-07***
		(6.16e-09)	(1.79e-08)
Large System (over 10000 people)		-0.00421	-0.0398***
		(0.0126)	(0.0145)
Uses Ground Water		-0.154***	-0.132***
		(0.0121)	(0.00978)
Water System Age		0.000823***	0.000819***
		(0.000182)	(0.000180)
Old System (first reported on or before 1981)		0.0493***	0.0395***
		(0.00458)	(0.00386)
Unemployment Rate		-0.00305**	-0.00100
		(0.00126)	(0.000667)
Percent of People With Bachelor's or Higher Degrees		-0.00116***	-0.000552***
		(0.000239)	(0.000156)
Poverty Rate		0.00201***	0.000384
		(0.000418)	(0.000307)
Nominate Score		-0.0218	-0.0220
		(0.0150)	(0.0148)
System Count Per County			-1.09e-05
			(1.02e-05)
System Share in County			0.316***
			(0.0377)
Chemicals			9.20e-07***
			(3.19e-07)
Inventory of Livestock and poultry (number)			-7.32e-11
			(9.12e-11)
Fertilizer, lime, and soil conditioners			-2.68e-07
			(2.49e-07)
Arsenic, Lead, & Copper Amt Released to Water			-2.14e-07***
			(3.87e-08)
Arsenic, Lead, & Copper Amt Released to Water L(1)			-1.16e-07***
			(2.85e-08)
Constant	0.0820***	0.215	0.116***

	(0.0127)	(2.533)	(0.0153)
Observations	1,348,799	1,009,829	889,842
R-squared	0.000	0.025	0.024

Robust standard errors clustered at the state-year level in parentheses
***** p<0.01, ** p<0.05, * p<0.1*

The DID results show a variety of reasonable relationships between violations and various control variables. Violations decrease with system size, but at a decreasing rate. However, they show no significant effect of privatization on the number of water quality violations. Large systems, which must provide customers with written water quality reports each year, have fewer violations than small systems. Systems using ground water have fewer violations than systems using surface water, and older systems have more violations than new ones. Systems in areas that purchase more agricultural chemicals have more violations. Surprisingly, systems in areas with more TRI emissions actually have fewer violations. Political factors have no significant impact on violations. On average, privatization has no significant effect on violations.

In order to test both the effect of privatization and municipalization, we apply the DID approach twice, once for privatization and once for municipalization. For each application, we repeat the analysis on 15 subgroups. The subgroups are, in order of appearance: all systems, small systems, large systems, systems in poorly educated communities, systems in highly educated communities, small systems in poorly educated communities, large systems in poorly educated communities, small systems in highly educated communities, large systems in highly educated communities. Note that for each subgroup, each pair of subgroup is divided using the state median. For example, large and small systems here are divided by the state median size, instead of the absolutely fixed cutoff of 10,000 defined above. We find this approach to be more appropriate given the heterogeneous conditions systems face in different states. This way we have 30 iterations in total, as illustrated below in Table 10. All the subgroup results correspond to model (3) in the previous table, with the most comprehensive controls. We see that municipalization consistently leads to a reduction in violations, although the effect is not significant for small systems or systems in poorly educated communities. In contrast, privatization never leads to a significant change in violations.

Table 10

Difference in Differences Regressions on Number of Violations, Subgroups

GPRA Violations

Privatization

	# Violations	Robust Std. Err.
All Systems	-0.00735	(0.0344)
Small Systems	0.0102	(0.0439)
Large Systems	-0.0206	(0.0387)
Low Education Systems	0.0354	(0.0405)
High Education Systems	-0.0672	(0.0430)
Low Poverty Systems	0.0114	(0.0290)
High Poverty Systems	-0.0184	(0.0477)
Low System Count Per County Systems	0.0165	(0.0415)
High System Count Per County Systems	-0.0372	(0.0408)
Low System Share in County Systems	0.0118	(0.0298)
High System Share in County Systems	-0.0196	(0.0500)
Small Low Education Systems	0.0642	(0.0606)
Large Low Education Systems	0.00966	(0.0421)
Small High Education Systems	-0.0670	(0.0499)
Large High Education Systems	-0.0622	(0.0559)

Municipalization

	# Violations	Robust Std. Err.
All Systems	-0.0743***	(0.0182)
Small Systems	-0.0635	(0.0386)
Large Systems	-0.0712***	(0.0165)
Low Education Systems	-0.0478	(0.0318)
High Education Systems	-0.100***	(0.0324)
Low Poverty Systems	-0.107***	(0.0269)
High Poverty Systems	-0.0440**	(0.0207)
Low System Count Per County Systems	-0.0528***	(0.0187)
High System Count Per County Systems	-0.0928***	(0.0279)
Low System Share in County Systems	-0.136***	(0.0356)
High System Share in County Systems	-0.0407**	(0.0179)
Small Low Education Systems	0.0565	(0.0469)
Large Low Education Systems	-0.0846**	(0.0375)
Small High Education Systems	-0.195***	(0.0637)
Large High Education Systems	-0.0536*	(0.0291)

Finally, we carry out the DID matching estimation by estimating the simplest DID with state fixed effects using weighted least squares (absolute value of the residuals used) with the weights derived above in the matching section. This is our preferred set of estimates. The results, shown in Table 11, suggest that privatization has no significant effect of violations overall, but that it does appear to weakly increase violations for small systems, particularly in poorly educated areas. It also appears to weakly increase violations in areas with low poverty rates. In contrast, municipalization generally leads to improvements in water quality. These improvements are particularly notable for large systems, systems located in areas with low educational attainment, systems with low poverty levels, and communities with a smaller number of systems.

Table 11

Diff-in-Diff Matching (ATET): Coarsened Exact Matching

GPRA Violations

Privatization

	# Violations	Robust Std. Err.	p-value
All Systems	0.021	0.019	0.273
Small Systems	0.049	0.029	0.095
Large Systems	-0.005	0.027	0.849
Low Education Systems	0.041	0.027	0.126
High Education Systems	-0.030	0.030	0.313
Low Poverty Systems	0.043	0.023	0.059
High Poverty Systems	-0.007	0.031	0.830
Low System Count Per County Systems	0.029	0.026	0.255
High System Count Per County Systems	-0.017	0.032	0.594
Low System Share in County Systems	0.030	0.024	0.218
High System Share in County Systems	0.000	0.030	0.999
Small Low Education Systems	0.076	0.039	0.052
Large Low Education Systems	0.027	0.037	0.461
Small High Education Systems	-0.004	0.044	0.933
Large High Education Systems	-0.044	0.040	0.261

Municipalization

	# Violations	Robust Std. Err.	p-value
All Systems	-0.060	0.017	0.000
Small Systems	-0.046	0.035	0.197
Large Systems	-0.062	0.018	0.001
Low Education Systems	-0.099	0.026	0.000
High Education Systems	-0.010	0.021	0.616
Low Poverty Systems	-0.111	0.023	0.000
High Poverty Systems	-0.009	0.025	0.704
Low System Count Per County Systems	-0.121	0.025	0.000
High System Count Per County Systems	0.012	0.022	0.587
Low System Share in County Systems	-0.006	0.029	0.823
High System Share in County Systems	-0.083	0.021	0.000
Small Low Education Systems	-0.094	0.048	0.048
Large Low Education Systems	-0.010	0.057	0.858
Small High Education Systems	0.005	0.054	0.931
Large High Education Systems	-0.260	0.262	0.322

It is puzzling that municipalization is associated with a significant decrease in violations but privatization is not associated with a symmetrical increase in violations. Figures 6 and 7 provide some preliminary insights into this question. We see that the number of violations per 1000 people served for municipalized systems falls and remains less than that of their control group, but that the pattern for privatized systems is much messier. Privatized systems initially provide a drop in violations per 1000 people served, but this reverses after a couple years and then rises above that of the control group. As a result, the average effect of privatization is insignificant, but its long-run impact on water quality may be quite negative. Obviously, further research is warranted on this issue.

Figure 6

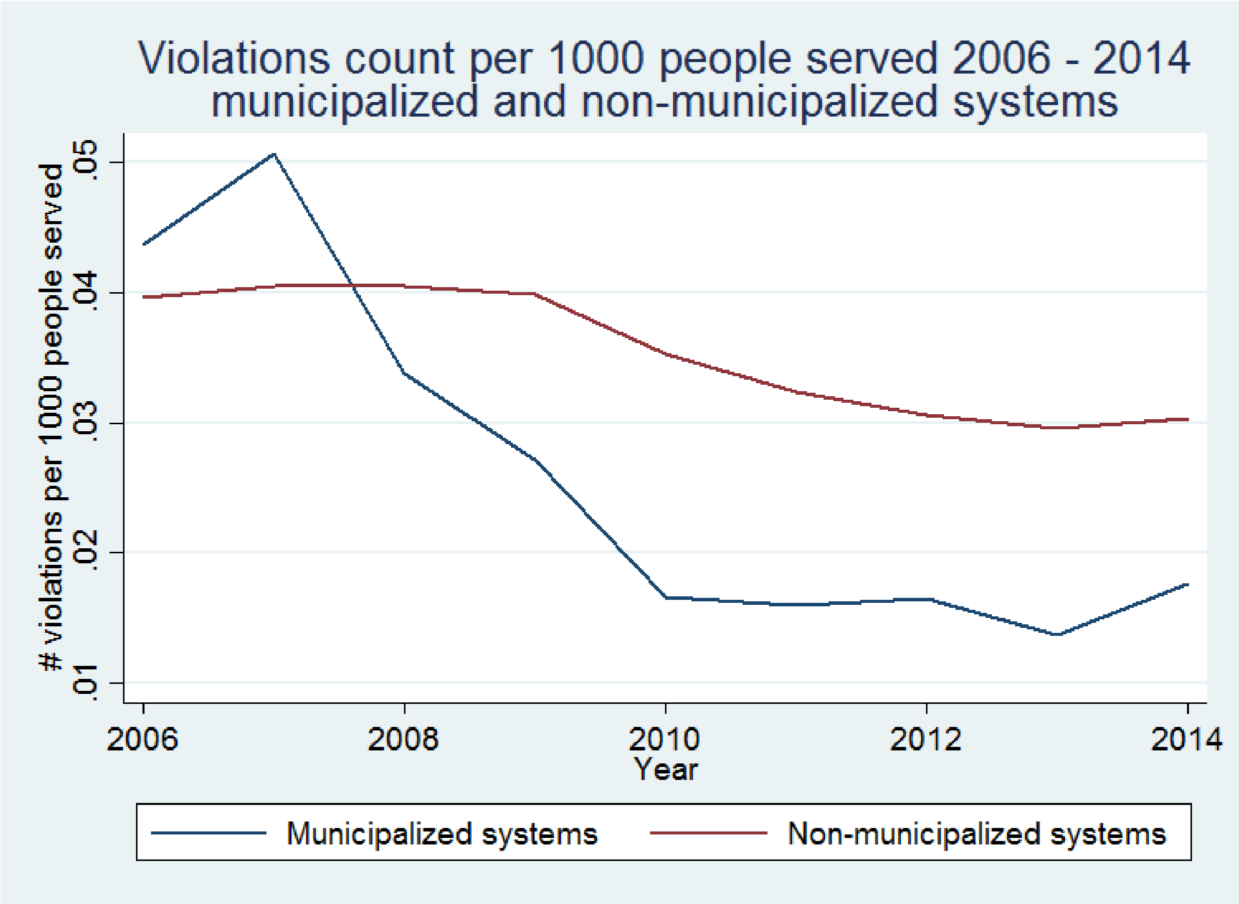
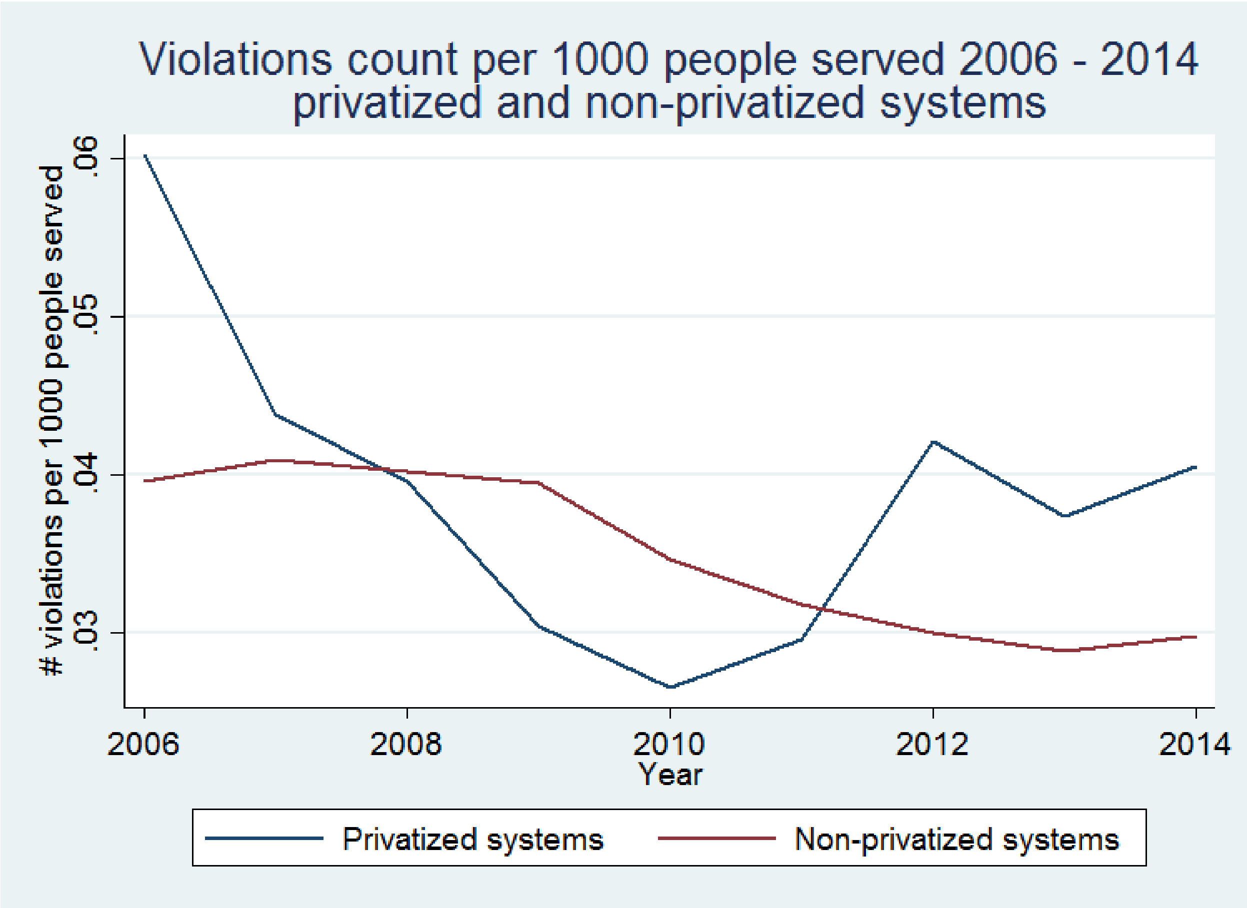


Figure 7



Robustness Checks

Finally, we carry out a series of robustness checks. First of all, we repeated the estimation using not just coarsened exact matching but also kernel matching and local linear matching. The results are very similar and in Table 12 below we present a snapshot of them. Similarly, using the 1% trimmed common support condition generates results that are very similar. Secondly, since the violations count may be related to system size, even with the monitoring system favoring the small systems, one might argue that it would be unfair to compare a simple violations count between large and small systems. Thus, we tried normalizing the violations count by system size in terms of population served. This still generates very similar results. Thirdly, considering the possibility that there may be a time lag between the treatment of a governance form change and the resulting effect on water quality, we repeated our analysis using different lags of the treated dummy. This, however, does not have too much impact on our results.

Table 12

Differences in Differences Matching (ATET)

	Privatization		
	# Violations	Robust Std. Err.	p-value
Coarsened Exact Matching	0.021	0.019	0.273
Kernel Matching (3 Bandwidths)	0.007	0.021	0.747
Local Linear Matching (3 Bandwidths)	0.007	0.021	0.750
	Municipalization		
	# Violations	Robust Std. Err.	p-value
Coarsened Exact Matching	-0.060	0.017	0.000
Kernel Matching (3 Bandwidths)	-0.062	0.017	0.000
Local Linear Matching (3 Bandwidths)	-0.062	0.017	0.000

Finally, we used the method described in Cattaneo, Drukker and Holland (2012) to choose specifications for the propensity score and come up with a rich propensity score. Based on the Akaike information criterion and logit, a fully interacted, 2nd-order polynomial for the generalized propensity score is recommended. However, overlap plots show not all predicted probabilities are sufficiently far away from 0 and 1, meaning that parameters are not identifiable. As a result, we settled for a not fully interacted polynomial after numerous trials and errors. This method is very computationally intensive and takes an immense amount of time to converge, if it ever does. Additionally, it does not always outperform user-chosen specifications. So this coarse propensity score should be taken with a grain of salt. The results turn out to be less significant. We also tried implementing the semiparametric efficient estimator proposed in Cattaneo (2010) i.e., efficient-influence-function (EIF) estimator. While the mean effects are less significant, the quantiles estimation cannot achieve convergence. These tables are available upon request.

VII. DISCUSSION AND CONCLUSIONS

Our empirical results show that while privatization of water supply does not lead to significant changes in service quality, municipalization leads to significant and persistent improvements in service quality. These improvements are particularly notable for large systems, systems located in areas with low educational attainment, systems with low poverty levels, and communities with a smaller number of systems. Although privatization has no significant effect on average, it appears to produce an improvement in water quality in the short term, which is reversed within five years. Our findings have potential implications for the optimal governance form of many other organizations and services in addition to the important service of drinking water.

Our results present a number of puzzles for theory. First, the effects of privatization and municipalization are asymmetrical. Municipalization reduces violations, especially for large systems or systems in areas with low education. However, privatization has no significant effect on violations on average. Static economic theories of contracting and regulation would imply symmetric (and opposing) effects from the two governance changes. Second, the effect of privatization on violations has a very distinct dynamic pattern, with violations falling in the first two to three years after privatization, but reverting again to the pre-privatization level within five years.

To some extent these puzzles can be explained with reference to our results for specific subgroups of systems. Our DID matching results suggest that privatization leads to significantly worse quality results for small systems in low education areas, and municipalization leads to significantly better water quality for small systems in low education areas. Thus for this subgroup at least, the results for the two governance form changes are symmetrical and persistent, and of similar magnitudes. More generally, however, the effects are asymmetrical. Moreover, municipalization is beneficial for large systems and for low-education systems, but not for systems that are both large and located in low-education areas.

Finally, municipalization is beneficial for systems that represent a large share of the systems in a given country and that are located in counties with a small number of systems. This suggests that privately owned systems in such areas have substantial market power, and that municipalization offers particular benefits there.

Further research is needed to understand the financial impacts of privatization and municipalization. Anecdotal evidence suggests that fiscal issues provide the impetus for many changes of governance form, and it would be very interesting to know how privatization and municipalization affect water rates. Unfortunately, data on water rates are not collected systematically for the universe of water supply systems, so answering this question will be a long-term project. It would also be of interest to understand better the role of specific contaminants in violations, especially toxic chemicals such as arsenic, emissions of which can be tracked using the Toxic Release Inventory. Finally, additional research into the dynamics of governance form transition would be valuable. This is an understudied area in regulatory economics, and our results suggest that more systematic inquiry into this area would be worthwhile.

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APPENDIX

Table 13

Summary Statistics on Trends of Governance Form Change

Large Systems

Year	Systems Privatized	Systems Municipalized	No. of Private Systems	No. of Public Systems	Total No. of Systems
2007	69	168	46458	30183	76,641
2008	37	584	45683	30586	76,269
2009	39	92	45008	30486	75,494
2010	63	73	46864	31014	77,878
2011	39	42	45999	30630	76,629
2012	44	59	45913	30422	76,335
2013	37	52	45622	30295	75,917
2014	33	267	44878	33166	78,044
	Population Privatized	**Population Municipalized**	**Private Population**	**Public Population**	**Total Population**
2007	356.233	899.862	53,099.15	243,316.90	296,416.00
2008	26.319	5375.919	48,668.73	253,257.10	301,925.80
2009	111.812	249.029	48,366.08	255,402.70	303,768.80
2010	1883.525	1096.476	49,356.55	259,320.80	308,677.30
2011	173.251	3956.995	45,635.88	262,606.00	308,241.90
2012	49.827	135.89	45,638.91	263,692.30	309,331.20
2013	135.65	411.257	45,334.59	262,739.70	308,074.30
2014	111.003	1693.83	44,453.21	271,966.30	316,419.40

Table 14

Summary Statistics on Trends of Governance Form Change

Small High Education Systems

Year	Systems Privatized	Systems Municipalized	No. of Private Systems	No. of Public Systems	Total No. of Systems
2007	39	61	31165	5325	36,490
2008	19	91	30980	5333	36,313
2009	6	70	30366	5246	35,612
2010	20	27	32398	5426	37,824
2011	17	14	31766	5260	37,026
2012	12	20	31668	5242	36,910
2013	11	10	31236	5132	36,368
2014	11	41	30632	6144	36,776

Table 15

Summary Statistics on Trends of Governance Form Change

Large Low Education Systems

Year	Systems Privatized	Systems Municipalized	No. of Private Systems	No. of Public Systems	Total No. of Systems
2007	43	82	21065	16259	37,324
2008	18	304	20618	16599	37,217
2009	23	34	20661	16676	37,337
2010	32	33	21086	16564	37,650
2011	24	15	20717	16403	37,120
2012	28	30	20704	16306	37,010
2013	19	27	20680	16359	37,039
2014	22	176	20446	17962	38,408

Table 16

Summary Statistics on Trends of Governance Form Change

Large High Education Systems

Year	Systems Privatized	Systems Municipalized	No. of Private Systems	No. of Public Systems	Total No. of Systems
2007	26	86	25393	13924	39,317
2008	19	280	25065	13987	39,052
2009	16	58	24347	13810	38,157
2010	31	40	25778	14450	40,228
2011	15	27	25282	14227	39,509
2012	16	29	25209	14116	39,325
2013	18	25	24942	13936	38,878
2014	11	91	24432	15204	39,636