

# The Buck Stops Where? Federalism, Uncertainty, and Investment in the Brazilian Water and Sanitation Sector<sup>†</sup>

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*This paper documents how regulatory uncertainty may undermine public service when different levels of government share a mandate on public service provision. I examine the Brazilian water and sanitation sector, which presents a natural experiment of shared provision between state and municipal companies. Using a difference-in-differences framework, I study a legal reform that clarified the relationship between municipal and state providers and eliminated any takeover threat by state companies. I find that after the reform, municipal companies almost doubled their total system investment, leading to significant increases in system access and decreases in child mortality. (JEL H77, L95, O13, O18, Q53)*

In many countries, multiple levels of government share responsibility in the provision of public goods (see Table 1). There exists a large debate on the proper role of these levels of government (Acemoglu, García-Jimeno, and Robinson 2015; Bardhan and Mookherjee 2006; Besley and Coate 2003; Galiani, Gertler, and Schargrotsky 2008; Hulten and Schwab 1997; Oates 1999, 2005). Some papers argue for centralized provision of services, citing efficiency gains from economies of scale and internalization of cross-jurisdictional spillovers (Dur and Staal 2008, Inman and Rubinfeld 1996, Lipscomb and Mobarak 2016, Oates 1972). Others argue for a more decentralized framework, as local governments may be more knowledgeable and responsive to local conditions (Faguet 2004, Rubinchik-Pessach 2005).

However, this debate assumes that the shared mandate between levels of government is clearly defined; less is known about situations in which there is uncertainty about which level is the ultimate authority for provision. This can arise when regulatory frameworks do not clearly delineate the jurisdictional management of the

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TABLE 1—SHARED GOVERNMENT RESPONSIBILITY OF THREE PUBLIC GOODS IN SELECT COUNTRIES

Country	Water			Electricity			Airports		
	Local	State	Federal	Local	State	Federal	Local	State	Federal
Bangladesh	X			X		X			X
Ghana	X		X			X			X
Honduras	X		X		X	X		X	X
Uganda	X	X	X			X			X
Brazil	X	X			X	X	X	X	X
Indonesia	X	X	X			X	X		X
Iran		X		X		X			X
Vietnam	X	X				X			X
Germany	X			X	X		X	X	
Japan	X		X		X		X	X	X
Netherlands	X	X		X			X		X
USA	X			X	X		X	X	X

*Notes:* This table reports the overlapping responsibilities of various levels of government for three public goods in select countries. Each good displays three columns that correspond to the typical structure of federal governments. Entries with an “X” denote the particular level of government that is responsible for some share of service provision in a given country.

public service. This situation is particularly relevant in developing countries with lower state capacity and weaker mechanisms for political accountability (Ashraf, Glaeser, and Ponzetto 2016; Bardhan 2002).

This paper examines how uncertainty in the shared mandate of provision may lead to a threat of takeover between different levels of government, and how this risk can lead to suboptimal investment by the current provider. Consequently, any reform that strengthens the rights of the current provider would lead to increased investment in service provision.

To study this, I consider a Brazilian legal reform that clarified the relationship between municipal and state governments in the water and sanitation (WS) sector. Prior to the legislation, the WS sector was a patchwork of overlapping providers. More developed municipalities elected to self-provide service through municipal companies while other municipalities contracted these services out to their respective state company. This arrangement was legally tenuous, with multiple attempts in the late 1990s and early 2000s by state governments to take over municipal-run companies. To address this, Congress proposed legislation that established municipal governments as ultimate authority in this sector (if they had not already contracted these services to the state), thereby ending any legal grounds for state takeover. This bill was ratified as National Water Law 11.447 in January 2007.

In order to causally identify the impact of this legislation on investment, I exploit the variation in company type across municipalities in a difference-in-differences framework. I utilize a municipal-level panel dataset of the Brazilian WS sector before and after the legislative change to compare municipalities that provide service via self-run companies against those municipalities that contract these services to the state. Crucial for identification, the decision to provide service via a self-run or state-run company was made in the early 1970s, with virtually no changes in company type thereafter. Thus, any comparison between self-run and state-run

municipalities is driven by the change in takeover risk and not by endogenous “switching” of company type as a result of the reform.

I find the elimination of the takeover threat by state companies led to increased investment in self-run municipal systems, nearly doubling the level of total investment after 2005. This investment was primarily funded by two sources: debt-driven finance (e.g., loans from development banks) and self-financing. Post-legislation, self-run companies saw positive growth—relative to municipalities that contracted with state companies—in their water and sanitation networks as well as in miscellaneous network resources (e.g., office buildings, vehicles, computer systems).

To further identify the threat of state takeover as an underlying mechanism driving these results, I run multiple extensions of the main result based on the pre-reform probability of expropriation. Those self-run municipalities that were relatively richer and in metropolitan areas were more likely targets of state takeover. I stratify the results by whether a self-run municipality was a more likely target for state takeover, and find that these municipalities have larger increases in investment post-reform.

Moreover, this increase in investment led to increases in system access for residents. Two years after the reform, self-run municipalities saw a significant increase in the number of connections as well as increases in the average total network length of 6 and 16 percent for water and sanitation, respectively. I also find evidence of significant decreases in child mortality from this network improvement; coinciding with the increase in system access, self-run municipalities achieved an average decrease of 7 percent in under-1 infant mortality. This significant reduction in mortality provides evidence for the large welfare implications of reducing uncertainty when mandates for public service delivery are shared between different levels of government.

The water and sanitation sector—like many public utilities—is an ideal setting for the analysis; it is significantly capital-intensive with large up-front costs in network infrastructure that is long-lived (Hanemann 2006). Moreover, investment in the WS sector in developing countries trails dramatically those of developed ones (Duflo, Galiani, and Mobarak 2012). A large increase in network infrastructure can lead to significant increases in health and other important socioeconomic outcomes.

While this paper focuses on Brazil, the threat of takeover from different levels of government is not unique to this setting. The phenomena of well-off communities sequestering tax revenues and services from neighboring communities is a common occurrence in many settings, including homeowners associations (Cheung and Meltzer 2014) and school districts (see *Serrano v. Priest* in Goldstein 1972). Briffault (2005) provides an overview of the tension between local school boards and state governments in the United States, where matters of autonomy and legal status are often resolved in federal court.<sup>1</sup> Uncertainty and tension between federal and state governments also exist concerning the use of eminent domain of publicly-owned state land for federal purposes (Schill 1988).

<sup>1</sup>Galiani, Gertler, and Schargrodsky (2008) present evidence of school decentralization in Argentina. They find that a complete decentralization of secondary schools to provincial oversight from a previous shared mandate between the federal and provincial governments led to an increase in test scores. These gains were not universal, though, as test scores in poorer municipalities did not improve. It is important to note that this setting differs from the one in Brazil in that the previous mandate—while shared—was clearly delineated between the levels of government.

Moreover, the disparity in resources across communities creates incentives for government entities to “capture” smaller communities and drives significant urban policy in the United States—for example, the separation of the city of St. Louis from St. Louis county in 1876 (Cassella 1959) and recent efforts by state legislators to consolidate St. Louis city and county into Missouri’s first “metropolitan city” (Better Together 2019). County-city mergers—and the opposition to them by wealthy suburbs—is an active area of urban policy, with recent consolidations in large cities like Toronto (1998) and Louisville (2003).

This paper contributes to the literature on fiscal and environmental federalism. Whereas much of the literature has focused on competition and coordination between the same level of government on issues such as taxation (Epple and Zelenitz 1981; Keen and Kotsogiannis 2002; Rauscher 1998; Sitkoff and Schanzenbach 2005), education (Alesina, Baqir, and Hoxby 2004; Brasington 1999; Hoxby 2000), and environmental resources (Kunce and Shogren 2005; Lipscomb and Mobarak 2016; Sigman 2005; Woods 2006),<sup>2</sup> this paper analyzes the shared mandate between *vertical* levels of government. While some papers do consider issues surrounding the shared mandate across vertical levels of government (Brollo and Nannicini 2012; Estache, Garsous, and da Motta 2016; Joanis 2014; Solé-Ollé and Sorribas-Navarro 2008), they primarily focus on the electoral and policy impacts of political alignment.<sup>3</sup> This is the first paper—to the best of my knowledge—that studies the role that uncertainty in the shared mandate can have on decisions made under the threat of takeover by another level of government.

Insight into the intragovernmental threat of takeover contributes to the literature on incomplete contracts, property rights, and the residual rights of control that follows in the tradition of Coase (1960), Grossman-Hart-Moore (Grossman and Hart 1986; Hart and Moore 1990), and Shleifer (1994). This literature provides evidence on the positive impacts of the strengthening of property rights on investment decisions, such as at the household level (Besley 1995; Field 2005; Galiani and Schargrodsky 2010). Most of the papers on incomplete contracts and investment decisions that include government entities usually model the government’s interaction with fully private firms or via “public-private partnerships” (Besley and Ghatak 2001; Hart, Shleifer, and Vishny 1997; Hoppe and Schmitz 2010; Martimort and Pouyet 2008). This is similarly true for papers that look at investment decisions under the threat of government expropriation, such as Chen and Yeh (2013) and Shleifer (1994). This paper departs from the literature in that the takeover threat takes place *within* different levels of government as opposed to outside firms.

Finally, this paper contributes to our understanding of the role that weak institutions has on development.<sup>4</sup> Much of the previous work highlights the role that

<sup>2</sup>Lipscomb and Mobarak (2016) analyze how decentralization can negatively impact water quality in the presence of negative externalities, and this comparison is done on the same government level across Brazilian municipalities.

<sup>3</sup>The paper most closely related to this one is Estache, Garsous, and da Motta (2016). In that paper, they study the role that electoral outcomes and political alignment between the governor and mayors of municipalities in Sao Paulo has on sanitation services in the state. Their framework derives from the principal-agent model and relies on the split mandate in sanitation authority, with municipalities in charge of sanitation provision and the state in charge of surface water pollution control.

<sup>4</sup>Mookherjee (2015) provides a synthesis of the recent literature concerning political decentralization and economic development.

weak institutions play in undermining economic development through corruption (Banerjee et al. 2014; Ferraz and Finan 2011; Olken 2007) and low state capacity (Acemoglu 2005; Ashraf, Glaeser, and Ponzetto 2016; Besley and Persson 2009; Dell, Lane, and Querubin 2018). However, few papers have studied the role that weak institutions have on intragovernmental dynamics—the notable (and partial) exception being Acemoglu, García-Jimeno, and Robinson (2015), which studies the network effects of state capacity building between local and national governments in Colombia. My analysis of intragovernmental takeover risk documents a novel way in which a weak institutional environment can undermine the ability of well-intentioned governments to provide important public goods and services.

This paper is organized as follows. Section I provides background on the institutional structure of the Brazilian water and sanitation sector and briefly describes the proposed sector reforms of the early 2000s. Section II describes the data, and Section III discusses the empirical strategy. Estimation results, robustness checks, and extensions of the main empirical findings are presented in Section IV, and Section V concludes.

## I. Background

### A. Brazilian Water and Sanitation Sector

The water and sanitation sector in Brazil is characterized by the existence of both municipal- and state-level entities responsible for service provision. While a structure of shared provision is not particularly unique across public utilities (see Table 1), this shared responsibility is not observed in other utilities in Brazil, such as electricity and telecommunications (Tupper and Resende 2004).

The structure of the Brazilian WS sector has its origins in the federal policy mandates of the late 1960s. Before this, water and sanitation services (where available) were provided locally by municipal governments under the supervision of the National Health Foundation (*Fundação Nacional de Saude*—FUNASA). This arrangement was acknowledged in the 1967 Federal Constitution, which endowed responsibility for water and sanitation provision to municipal governments. In the early 1970s, Brazil's military government attempted to centralize operations in this sector (Heller 2007) through the creation of the National Sanitation Plan (*Plano Nacional de Saneamento*—PLANASA), which created a WS company in each state (*Companhias Estaduais de Saneamento Basico*—CESB) that would be responsible for providing basic water and sanitation services.

The argument for the creation of state companies as a replacement for municipal service provision involved concerns over scale and efficiency. Proponents of PLANASA argued that WS service exhibits a cost structure of a natural monopoly, with small-scale municipal companies not efficiently providing service at low costs (Heller 2007). Additionally, mandating at the state level would make it possible for cross-subsidization from wealthier municipalities to finance infrastructure and service in poorer parts of the state.

While PLANASA created state companies, it could not abolish municipal companies due to legal concerns surrounding the 1967 Constitution with regards to the



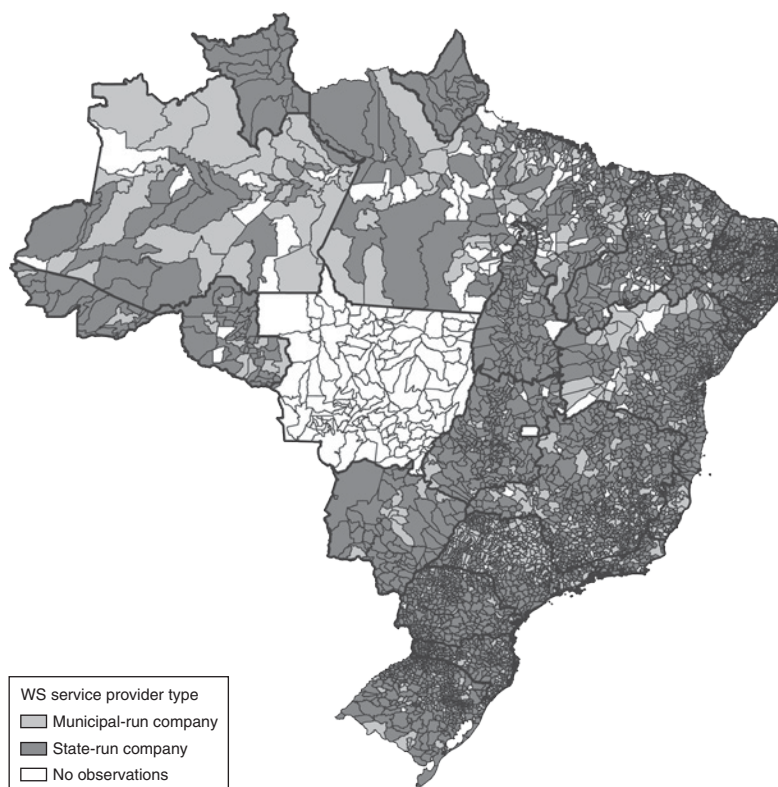


FIGURE 1. WS PROVIDER TYPE BY MUNICIPALITY

*Notes:* This figure shows the breakdown of Brazilian municipalities by type of WS provider. Municipalities for which there are no observations are shaded in white. Non-white regions indicate municipalities for which there is at least one observation in the study period 2001–2012. Note that since no municipality switched provider type during the study period, this map is unchanged for all 12 years. Bold lines indicate the division of Brazilian states. The state of Mato Grosso (in central-west Brazil) eliminated its state WS company in 1998 and thus is not included in the analysis. The Brasilia Federal District is also excluded from the analysis. Data on WS company type are provided by the Ministry of Cities, and the administrative boundary map is provided by IBGE.

municipal government's role in the sector. Rather, federal and state governments encouraged municipalities to enter into concession contracts ceding operational control to state companies.<sup>5</sup> While many municipalities contracted with these state companies, a significant number did not and kept provision through municipality-run companies. Approximately 60 percent of all municipalities joined PLANASA, with the remaining 40 percent providing service via local companies. Figure 1 shows the breakdown of Brazilian municipalities by type of provider.<sup>6</sup>

<sup>5</sup>One of the stated benefits to help induce municipalities to enter into agreements with state companies is the fact that only CESBs had authorization to obtain financing via the National Housing Bank (Portuguese: *Banco Nacional de Habitacao*). See Sabbioni (2008).

<sup>6</sup>The state of Mato Grosso had a state WS company (SANEMAT) that was created in 1966; however, it was dissolved in 1998 and all operations were given back to the municipalities. For that reason, Mato Grosso has no state company observations, and is removed from this paper's analysis. For more information, see <http://www.cosama.am.gov.br/>.

Those municipalities that decided to create self-run companies in response to PLANASA were generally larger, richer, and more developed. Castro and Heller (2009) observe that richer municipalities with higher levels of HDI were more likely to choose to provide their own service and not cede these operations to the state companies. Additionally, Rezende (2005) found that these municipalities were also more politically autonomous than those that contracted service to the state. Table 2 compares various characteristics in 1970 of municipalities that created a self-run company against those that contracted service to the state. Across multiple dimensions, municipalities that retained their right to WS provision by creating self-run companies had higher levels of welfare and development.

The decision of wealthier municipalities to create self-run companies undermined one of the main objectives of PLANASA to cross-subsidize poorer areas of the state. In line with the seventh Millennium Development Goal, water and sanitation in Brazil places an emphasis on “basic sanitation” as a human right, with a primary objective of providers to attain universal access and adequate service (Heller 2007). Despite the reluctance of the sector to privatize and explicitly set profit-maximizing targets, the regulatory framework requires financial sustainability of service providers with a traditional rate of return (Tupper and Resende 2004). The inability of state-run companies to subsidize resources across jurisdictions provided strong incentive by state governments to expropriate authority from self-run municipalities. Likewise, due to the historical inability by the sector to secure significant loans and the mandate to be financially stable, self-run companies with a threat of state takeover had a strong incentive to not undertake long-term investments with large fixed costs. This insight drives the main result of the paper: a self-run company will optimally underinvest when there exists a threat of takeover by the state company, and investment levels should increase once this threat is removed.

### B. *Water and Sanitation Sector, 1971–2005*

The inability of PLANASA to universally mandate state provision created an environment of uncertainty and tension between state and municipal providers. With no clear regulatory framework, questions arose regarding jurisdictional management and which level of government ultimately held authority in the sector. Even among municipalities that ceded authority to the state companies, there was ambiguity on the relationship between levels of government as many concession contracts between municipalities and state companies were informal or never explicitly signed. Despite this, once municipalities chose to cede authority to the state, legal and logistical hurdles made it exceedingly rare to switch to self-run provision.

Frictions between state and municipal governments led to a climate of uncertainty for municipal-run companies and created an ever-present threat of takeover by the state provider.<sup>7</sup> This threat led to the creation of the National Association of Municipal Sanitation (ASSEMAE) in 1984, comprising over 1,800 municipal-run companies. The stated mission of the organization is to protect the authority of

<sup>7</sup>See Britto and Silva (2006) for a more detailed discussion of the conflict between municipality-run and state-run WS companies, particularly in urban areas.

TABLE 2—MUNICIPALITY CHARACTERISTICS IN 1970 BY WS PROVIDER TYPE

	Variable mean		Difference	<i>p</i> -value
	Municipal-run	State-run		
<i>Panel A. Geographic</i>				
Total area	2,418.296	1,780.746	637.550	0.054
Transport cost to state capital	696.174	625.091	71.084	<0.0001
<i>Panel B. Population</i>				
Total population	26,639.978	2,3101.410	3,538.568	0.499
log population	9.546	9.371	0.176	<0.0001
Fraction population urban	0.417	0.305	0.112	<0.0001
<i>Panel C. Education</i>				
Illiterate and >15 years old	36.902	45.335	-8.433	<0.0001
>11 years of schooling	0.742	0.384	0.358	<0.0001
<8 years of schooling	96.089	97.793	-1.703	<0.0001
<4 years of schooling	80.858	86.080	-5.221	<0.0001
Not in school, ages 7-14	34.206	41.079	-6.874	<0.0001
Not in school, ages 10-14	13.996	16.401	-2.405	<0.0001
<i>Panel D. Housing</i>				
Has electricity	2,874.010	1,984.754	889.256	0.400
Has >2 bedrooms	48.128	53.446	-5.318	<0.0001
Has toilets	1,348.926	416.410	932.516	0.009
Has piped water	2,256.380	1,297.314	959.066	0.222
Has potable water	45.878	29.661	16.218	<0.0001
<i>Panel E. Human development</i>				
Life expectancy	52.514	50.956	1.557	<0.0001
Infant mortality	106.921	127.943	-21.022	<0.0001
Human development index	0.405	0.344	0.061	<0.0001
<i>Panel F. Income</i>				
Median HH income	0.448	0.323	0.125	<0.0001
Farming wages	1,057.550	558.141	499.409	<0.0001
Theil inequality index	0.372	0.347	0.026	<0.0001
<i>Panel G. GDP</i>				
GDP	103,837.215	73,361.692	30,475.523	0.527
log GDP	10.004	9.420	0.584	<0.0001
log GDP per capita	1.027	0.790	0.237	<0.0001
log GDP—agriculture	8.786	8.430	0.356	<0.0001
log GDP—construction	6.526	5.631	0.895	<0.0001
log GDP—industrial	7.978	6.979	0.999	<0.0001
log GDP—services	8.981	8.376	0.605	<0.0001
Observations	3,833			

Notes: This table reports municipal characteristics in 1970 by WS company type. Columns 1 and 2 present municipality averages and column 3 reports the difference. GDP variables are measured in year 2000 reals (R\$).

municipalities in the sector, as in the case of the attempted takeover of Campinas' municipal company (SANASA) by the state of Sao Paulo (da Costa et al. 2006).

Even with the abolition of PLANASA in 1992, the ambiguity inherent to the shared mandate persisted. Additionally, the Public Concession Act of 1995 created more legal uncertainty by contesting the long-term concession contracts that were inherited from PLANASA. This resulted in multiple lawsuits and an increased call for reform to the institutional framework of the sector (Sabbioni 2008).



Two such lawsuits occurred in the late 1990s, as both the states of Bahia and Rio de Janeiro attempted controversial reforms that would have ceded universal authority to their state providers (McNallen 2006). In 1999, the state legislature of Bahia attempted to alter a substantial number of articles in its state constitution. Among these alterations, the legislature attempted to fully transfer ownership of all WS services from municipalities to the state company. Similarly, the state legislature of Rio de Janeiro passed Complementary State Law No. 87 in 1997, which created the Rio de Janeiro metropolitan region and Lagos microregion and granted the state company (CEDAE) complete authority of operations in these newly defined areas, thereby expropriating the services of all self-run companies.

Both of these legislations faced stiff opposition from pro-labor organizations—the Workers' Union in Bahia and the Democratic Workers' Party in Rio de Janeiro. In both cases, the opposition filed suit in the Federal Supreme Court, claiming that the laws were unconstitutional and that Article 30 of the 1988 Federal Constitution granted the authority of service provision to municipalities.<sup>8</sup> Due to the backlog of cases awaiting decisions from the court, neither case was decided. Even if timely decisions had been rendered, however, neither decision by the court would have set precedent nor fundamentally altered the legal architecture of the WS sector, as the Brazilian legal code is based in the civil law tradition (McNallen 2006). Rather, any far-reaching attempt to clarify the roles of government in the sector would have to come from the legislative branch.

### *C. 2005 Legal Reform*

Following a landslide victory in the 2002 national election, the administration of the newly elected President Lula da Silva made improvement to the WS sector a high priority (Heller 2007). This is from a retrospective letter in the 2006 Human Development Report (UNDP 2006):

In Brazil we have been attempting to address the water and sanitation problem as part of our broader drive to create a more just, less divided and more humane society. We have been making progress. ... new legislation will make the utilities that provide water service more accountable to the people they serve.

... Clean, accessible and affordable water is a human right. It is also one of the foundations for economic and social development. Strengthening these foundations is not always easy: it takes political leadership and it costs money. But failing to invest political and financial capital today will carry the high price of lost opportunities for social progress and economic growth tomorrow.

<sup>8</sup>The 1988 Constitution provided contradictory support for municipal authority in the WS sector: Article 21 provides the federal government the authority to set directives in sanitation; Article 23 outlines the shared responsibilities across the three levels of government to promote the construction of basic sanitation systems; Article 30 gives the municipality authority over all public services “of the local interest”; and Article 200 defines sanitation as a component of health policy, which is shared between the three levels of government.

The administration submitted a reform to the Brazilian legislature with the goal of strengthening the sector's regulatory framework. The drafted proposal—Bill 5.296—entered Congress in 2005 as an attempt to resolve the conflicts of jurisdiction between state and municipal companies, as well as to define the role of the federal government in the sector.

While Bill 5.296/2005 contained many proposed changes to the WS sector, there are two reforms that directly altered the shared power structure of the previous systems (da Motta and Moreira 2006). First, it explicitly and unambiguously designated the municipal government as the conceding authority in the areas of water provision, sewerage treatment, and solid waste collection. In this, Bill 5.296 was an affirmation and clarification of Article 30 of the 1988 Brazilian Constitution. By explicitly defining water and sanitation issues as inherently of “local interest,” the bill effectively removed the threat of takeover by state-run companies.

Second, the bill clarified the status of those municipalities that ceded service to state companies. While municipalities were the ultimate authority in the WS sector, they could cede this authority to the state, with the bill providing a legal structure for the relationship (i.e., concessions contracts) between the municipalities and state governments.<sup>9</sup>

The bill was approved by Congress in January 2007 as National Water Law 11.447 and was the first ever federal law to address the WS sector (Castro and Heller 2009).

## II. Data

Information on the water and sanitation sector comes from the *Sistema Nacional de Informações sobre Saneamento* (SNIS) dataset provided by the Brazilian Ministry of Cities. The municipality is the level of observation; for those municipalities that contract service to state companies, the dataset provides information for the parts of the system that operate within the municipal boundary. The Ministry of Cities provides the data in some form annually starting in 1995, however the earliest rounds are not standardized nor compatible with later years, and I restrict the period of analysis to the years 2001 to 2012.

The main outcome of interest is yearly investment at the municipal level. The dataset contains seven categories based on the nature of the investment: total investment, three origin categories, and three destination categories.

Total investment is the total investments made by the service provider in a given year and can be calculated as either the sum of the “origin” investment or the sum of the “destination” investments, as these two quantities are necessarily equal.<sup>10</sup>

Investments can originate through (i) self-financing, (ii) loans and debt, or (iii) government grants. Self-financing is defined as all investment made by the

<sup>9</sup>It is important to note that any existing concessions made by municipalities to state companies were still legally valid and were not superceded by this reform.

<sup>10</sup>There is an additional term—capital expenditure—that is defined as expenses incurred by the service provider in a given year for capitalizing the costs of projects that have not yet been incorporated into the appropriate investment classification. It does not have a significant economic interpretation and is primarily an accounting term that is used so that the sum of the destination classifications plus capital expenditure equals total investment.

WS company from its own resources—through service collections, non-operating income, sale of stock to shareholders, etc.

Loans and debt are those resources the company services through paid loans that are returnable through depreciation or interest. These loans generally come from agreements with the large Brazilian bank *Caixa Economica Federal* (CEF), the Brazilian Development Bank (BNDES), or external financial institutions such as the IMF and World Bank.

The last source of investment comes in the form of nonrepayable government grants. The majority of these grants are earmarked from the Federal Budget (OGU), with a small share coming from state and municipal sources. The data are not disaggregated by government source however, and I treat this investment category as being primarily a function of the federal level of government.

Investment destinations are defined by the final use of resources. Investment in water is investment taken by the company for all equipment and facilities that are directly involved in the service of water provision (e.g., water lines, treatment facilities). Similarly, investment in sewer is defined as the value of all investments in equipment and facilities built for the collection and treatment of wastewater.

A third category exists—investment in other—for all investments that are general use and not directly related to either the water or sewer systems. Examples of investments in this category include office buildings, computer systems, general tolls and machinery, and maintenance vehicles. Importantly, assets in this category are generally less fixed in nature as compared to the water and sewer facilities and could therefore be more easily redistributed by a state company in the event of a takeover.

Additional information on municipal characteristics comes from annual surveys conducted by the *Instituto Brasileiro de Geografia e Estatística* (IBGE). These data comprise various socioeconomic indicators for all of Brazil's municipalities on a yearly basis. Indicators include information on municipal finances, populations, water-intensive industries, climate, and political characteristics.

### III. Empirical Strategy

To see how the legal reform affected investment levels, I estimate the following difference-in-differences (DID) specification:

$$(1) y_{mt} = \alpha + \gamma_m + \lambda_t + \delta Reform_{mt} + \beta \mathbf{X}_{mt} + \theta InitialInvest_m \times timetrend + \varepsilon_{mt}$$

where  $y_{mt}$  is the investment level of municipality  $m$  in year  $t$ , and  $Reform_{mt}$  is an indicator that is equal to 1 for all observations of self-run municipalities after the proposed reform. The specification is run separately for the seven investment categories described in Section II. The data are disaggregated at the municipality level—even for state-run companies—making it possible to run this analysis with the municipality as the unit of observation.

I include fixed effects for municipality ( $\gamma_m$ ) and year ( $\lambda_t$ ). To address the heterogeneity in investment levels across municipalities before the study period, I also

include a time trend interacted with the initial level of investment.<sup>11</sup> The set of controls,  $\mathbf{X}_{mt}$ , comprises time-variant municipality characteristics, including municipality  $m$ 's population, municipal finances (e.g., municipal GDP, taxes), water-intensive industries (e.g., agriculture, livestock production), and annual temperature and rainfall measures. To correct for issues that arise due to general autocorrelations in the DID setting (Bertrand, Duflo and Mullainathan 2004), the error term— $\varepsilon_{mt}$ —is estimated with robust standard errors that are clustered at the WS company level. I cluster at the company level to address that fact that investment decisions are to some extent determined at this level, as would arise if a state-run company were required to have a minimum investment level in each municipality, for instance.

The main coefficient of interest ( $\delta$ ) is interpreted as the increase in investment by self-run municipalities after the introduction of the congressional reform. As municipalities with self-run companies were targets of takeover by the states, any policy reform that eliminates the takeover risk should lead to an increase in investment for self-run companies. Since one stated goal of the legislation was to reduce ambiguity in WS provision between state and local governments, one would expect this coefficient to be positive and significant.

The greatest threat to a causal interpretation of the DID estimator is if the passage of Bill 5.296 induced municipalities to switch their WS provider. That is, after the law municipalities that previously had state-run provision decided to create a self-run company instead. Due to the long-lived (often 99-year) contracts signed with state companies in the 1970s, informal pressure to maintain service, or logistic and bureaucratic hurdles in switching service, no municipalities in the study period switch service providers from state-run to municipal-run companies, or vice versa. The absence of “switchers” from comparison to treatment group mitigates the concern of any omitted variable bias on the decision of provider-type that could potentially be driving the difference in investment decisions. Moreover, the parallel trends across provider-type in Figures 2, 3, and 4 allay additional concerns of differential omitted variables driving the difference in WS investment.

Another potential concern is the presence of confounders that could bias the estimate of  $\delta$ . The most salient of these is if there were changes in the transfers of resources to municipalities during the study period. Any additional reforms that caused self-run municipalities to invest more than state governments would overstate the effect of the legal reform. Additionally, the reform itself could have created a differential impact, where resources used to protect the property rights of self-run municipalities could be now deployed in other areas, for example. While I control for the time-invariant aspects of a municipality, it could potentially be the case that those municipalities that happen to operate their own WS companies might also have differential increases in other expenditures over time.

To the best of my knowledge, there were no other reforms enacted during the study period that differentially impacted municipalities in any relevant dimension. However, I present a further check to address the presence of potential confounders by analyzing other municipal expenditures during this time. Figure 5 presents

<sup>11</sup> An alternative specification omitting the time trend is presented in online Appendix A.III, with regression estimates being similar to the main specification.

average municipal expenditures in five sectors by company type. The most striking feature of Figure 5 is the common trends in each sector by self-run and state-run municipalities. There is no significant break in expenditure by self-run municipalities after the WS reform, which would be expected if the reform led to a significant redistribution of municipal resources across sectors. Moreover, it does not appear that self-run municipalities had increasingly differential expenditures over time (although it should be noted that self-run companies *do* have higher levels of expenditure, in line with the intuition of Section I). The absence of differential expenditures by municipalities across company type over time supports the identifying assumption and increases confidence that the DID specification is estimating the causal effect of the reform on investment.

An important point in running the DID specification is the validity of state-run municipalities as a comparison group. Municipalities with state-run service would not be a valid comparison group if they were “treated” by the reform. Therefore, the causal interpretation of  $\delta$  would only be valid if state-run municipalities were not affected by the reform’s elimination of takeover risk. The fact that these municipalities are serviced by state companies implies that they already ceded their authority in this sector—either through formal contracts or *de facto* by operations on the ground—to the states. Thus, even before the reform, these municipalities had a probability of state takeover of zero and any legal reform that decreases risk of state takeover should not affect this group. Therefore as a first-order effect, the legal reform differentially affected the self-run and state-run municipalities.<sup>12</sup>

I use the year of the proposal of Bill 5.296 as the measure of the “pre-” and “post-” treatment periods, rather than approval because the reform of the WS sector was a primary policy concern for the administration of the widely popular President Lula da Silva.<sup>13</sup> Given the administration’s support of the initiative, the bill’s passage was likely. This is further evidenced by the fact that the bill eventually did pass Congress to become National Water Law 11.447 in January 2007. Moreover, since WS systems require large and lengthy investment schedules, confidence in the bill’s passage and a future elimination of takeover risk would spur investment by the municipal companies at the time of the bill’s proposal. Online Appendix A.II discusses this issue in more detail, and finds that an alternative specification using 2007 as the “post-” treatment period provides similar estimates to the preferred specification.

The estimation covers the period for which I have available data (2001–2012). The paper also restricts the empirical specification to municipalities that have observations in both “pre-” and “post-” periods, although the findings in Section IV are robust to the use of the unbalanced panel. This is discussed in greater detail in online Appendix A.I.

<sup>12</sup>Some may consider the reform to strengthen the rights for *all* municipalities. However, if that was the case, then the DID coefficient would provide an *underestimate* of the effect of the reform.

<sup>13</sup>President Lula da Silva’s 61.3 percent vote share in the second round of the 2002 presidential election made him the second-most voted for president in the world at that time.

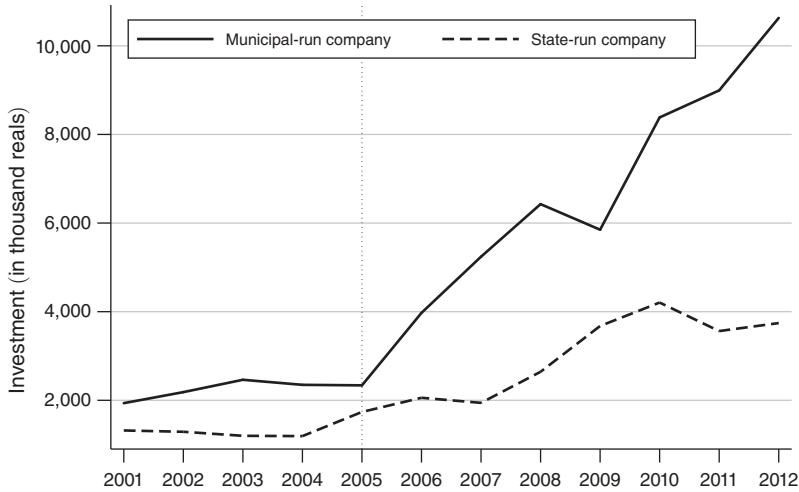


FIGURE 2. TOTAL INVESTMENT

*Notes:* This figure shows the municipal average total investment level for both types of WS companies in a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed.

## IV. Results

This section presents results from the empirical specification estimating how the investment strategies for municipal-run companies changed as a result of the proposal and subsequent passage of National Water Law 11.447. I present the main finding of the paper: once the risk of expropriation by state companies was eliminated, municipal companies significantly increased the level of investment in their WS networks. I provide additional evidence that the elimination of takeover risk is the primary mechanism driving the results by studying the heterogeneity in investment decisions by self-run municipalities. This section concludes with an extension of the analysis to observe if there was any change to service provision and associated health improvements as a result of the increased investments.

### A. Investment Decisions

*Graphical Results.*—I first present the graphical results of the impact of the congressional reform. Figure 2 through Figure 4 show the raw investment data of the WS companies disaggregated at the municipality level for the period 2001–2012.

Figure 2 shows the annual average total investment for municipalities by company type. There are two important features of Figure 2. First, pre-reform trends for the two types of companies are fairly comparable. The annual investment by self-run municipalities is on average higher than state-run municipalities in the pre-reform period. This corroborates a key insight from Section I that richer and more developed municipalities chose to create their own self-run companies and



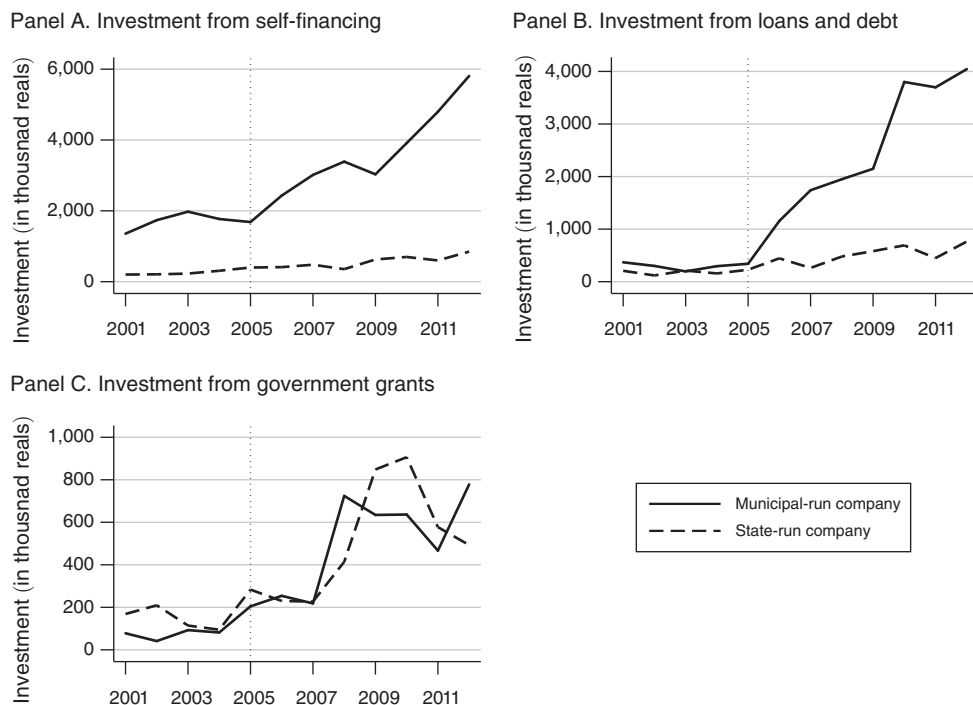


FIGURE 3. INVESTMENT BY SOURCE

*Notes:* This figure shows the municipal average investment for both types of WS companies in a given year. Panel A shows investment derived from self-financing; panel B shows investment derived from loans and debt; and panel C shows investment derived from government grants. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed.

maintain higher levels of investment. Crucially for the DID framework, the parallel trends assumption appears to hold.

The second key feature of Figure 2 is the sharp increase in investments made by self-run municipalities after the proposal of Bill 5.296 in 2005. This increase in total investment by is large, with the level in 2012 being approximately five times the pre-reform level.

I decompose the increase in total investment by its source and destination. Figure 3 shows the yearly investment levels for the investment sources—self-financing, loans and debt, and government grants. As with total investment, self-run municipalities have a large and dramatic increase in investment from both self-financing and loans and debt after the introduction of the reform.<sup>14</sup> For both investment sources, the parallel trends assumption is even more strikingly satisfied, and there is little discernible post-reform increase in investment for state-run counterparts. As both sources of investment are costly to the WS company—either by forgoing service

<sup>14</sup>As shown in online Appendix A.V, the increase in self-financing is not being driven by an increase in the average tariff rate charged to consumers.

expenditure in the current period or servicing the debt in a later one—this pattern is consistent with the prediction that investment levels would rise if the takeover threat from state companies was eliminated.

Moreover, the increase in loans and debt may also indicate a greater willingness by financial institutions to make loans to self-run municipalities without fear that the loans would not be repaid in the event of a takeover by the state company.<sup>15</sup> As there was no federal regulation of the sector until this reform, there was no clear precedent on how loans to third parties would be handled in the event of state takeover. The closest regulation on government concessions (Law No. 8.987, art. 36) outlines that *the termination of the concession entails the payment/indemnity for assets that were not amortized or depreciated yet*. While a simple interpretation of the federal legislation would extend to loans—implying lenders should be repaid by the state that takes over the services—it is likely that lenders would have to expend time and resources in the court system to get their payment back.

A similar increase does not appear in investments that come from government grants (Figure 3, panel C). Rather, the amount of yearly federal grants appear to be distributed equally to both types of companies, with their levels comoving throughout the study period. There is a large increase in investment for both company types starting in 2007, and this is likely due to a new federal initiative—Program for the Acceleration of Growth (PAC)—that was pushed as a policy priority by the administration of President Lula da Silva in 2007. This program called for large increases in federal funding for major visible infrastructure projects (e.g., ports, highways, energy, water and sanitation) throughout Brazil. This new program may also explain the slight increase in total investment for state-run municipalities after 2007 observed in Figure 2.

Figure 4 shows the average annual investment for municipalities by company type and investment destination. There are significant post-reform increases for self-run municipalities in all aspects of the WS network: water (Figure 4, panel A), sewer (Figure 4, panel B), and miscellaneous investments (Figure 4, panel C). In all three figures, both company types display parallel trends in the pre-reform period.

The effect in both the water and sewer networks are attenuated by the fact that investment in state-run municipalities increases after 2007 as a result of the federal PAC program. Consistent with this explanation is the lack of increased miscellaneous investments by state-run companies. These types of investments (e.g., computers systems, office space) are not related to the visible infrastructure of WS provision and were not a priority for the federal grants via PAC. Moreover, the sharp increases in miscellaneous investment by self-run municipalities between 2005 and 2007 cannot be explained by the introduction of PAC and is strong evidence for causal impact of the 2005 legislation that eliminated takeover risk.

*Empirical Results.*—Table 3 presents the regression results using the difference-in-differences specification outlined in Section III. Each column of the table corresponds to Figures 2 through 4, respectively.

<sup>15</sup> Unfortunately I am unable to distinguish to what degree the increase came from the intensive margin (banks making larger loans than before) or the extensive margin (new financial institutions making loans).

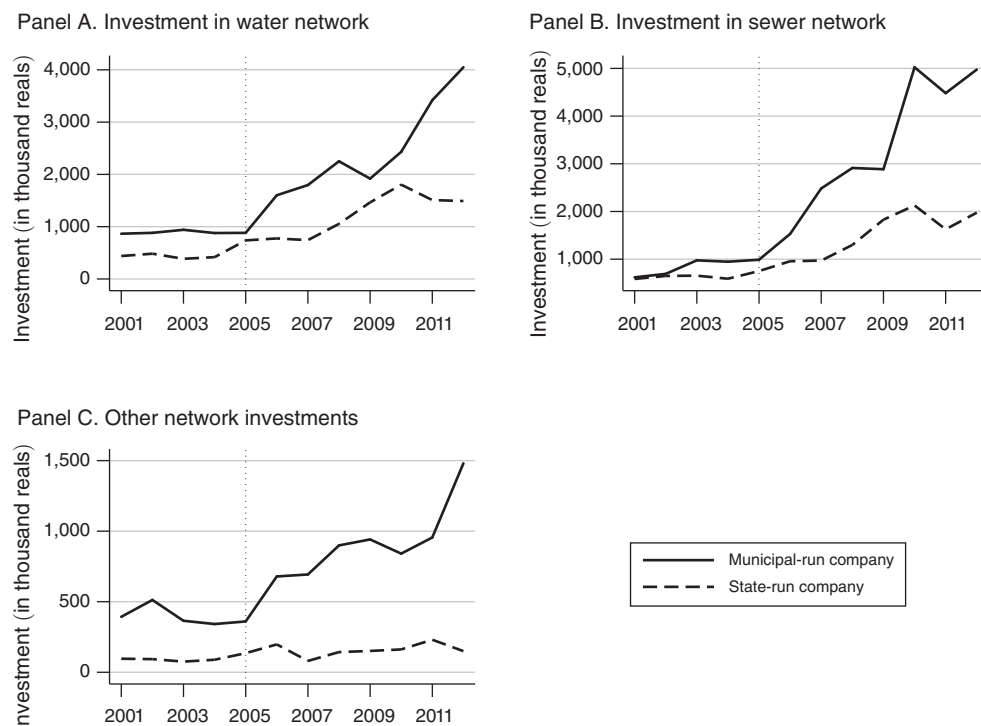


FIGURE 4. INVESTMENT BY DESTINATION

*Notes:* This figure shows the municipal average investment by destination for both types of WS companies in a given year. Panel A shows investment in the water network; panel B shows investment in the sewer network; and panel C shows miscellaneous network investments. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed.

TABLE 3—WS INVESTMENT

	Total investment	Source of investments			Destination of investments		
		Self-financing	Loans and debt	Government grants	Investment in water	Investment in sewer	Other investments
Self-run company, post-reform	2,868 (1,319)	1,798 (490.3)	2,124 (921.1)	-92.68 (298.0)	521.3 (599.2)	1,869 (856.4)	431.2 (147.5)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,460	14,460	14,460	14,460	14,460	14,460	14,460
Adjusted within $R^2$	0.299	0.0324	0.0215	0.0493	0.258	0.196	0.0238
Mean dependent variable	2,731	717	535	395	1,074	1,321	192

*Notes:* This table shows the effect of Bill 5.296 on WS system investment levels. Cluster robust standard errors in parentheses. All specifications include municipality and year fixed effects. Standard errors are clustered at the WS company level, with a total of 149 clusters. Investment levels are measured in thousand reals. All specifications include additional controls for municipal population, finances (GDP and taxes), agriculture and livestock production, annual temperature and rainfall measures, and a time trend interacted with the initial investment level.

Estimates from Table 3 show that the empirical specification closely matches the plots of the raw investment data. The causal impact on investment from the introduction of Bill 5.926/2005 is positive and significant for all investment types save government grants and investment in water. The yearly average of total investment by self-run companies was approximately R\$2.3 million from 2001 to 2005, which implies a greater than 100 percent increase in total investment for self-run companies after the elimination of takeover risk. Changes in both self-financing and loans and debt show increases of an order of magnitude. The increase in total investment as a result of the legal reform is split roughly 40/60 in increases from self-financing and loans and debt.

The three right-most columns of the table display the coefficient of interest for the investment destinations and correspond to Figure 4. After the proposed reform, there were large and significant increases in sewer and miscellaneous investments for self-run companies. The estimated coefficient on investment in the water network, while positive, is not statistically significant and is likely attenuated by the introduction of PAC in 2007, which increased investment in the water network for state-run municipalities as well.

Investment in sewer networks is the primary driver of the increase in total investment after the reform. There are two plausible explanations for why sewer investment primarily drives the effect. First, sanitation coverage lags that of water in Brazil, with coverage rates of 73 percent and 94 percent in 2000, respectively (UNICEF and WHO 2017). These numbers mask heterogeneities along several relevant dimensions: the share of rural population with access to a basic sanitation system in 2000 was 36 percent, and only 20 percent of the total population were connected to systems that received at least secondary treatment (UNICEF and WHO 2017). This relative lack of connection to sanitation systems implies a higher return to access per investment, which is discussed later in this section. Second, sewer networks incur a higher costs of construction and operation than water systems.<sup>16</sup> Thus, self-run municipalities that faced a risk of takeover may have been less willing to take on large sanitation projects for which they may not have seen a return.

*Heterogeneity in Investment Decisions.*—The previous two sections provided evidence of a causal link between the 2005 reform that eliminated the threat of takeover by state companies and subsequent increases in network investment. In this section, I provide additional evidence that takeover risk is the primary mechanism driving these results. I study the heterogeneity across two dimensions that would a priori make some self-run municipalities more desirable for state takeover: whether a municipality was in a metropolitan area and a municipality's relative income per capita.

First, I split the analysis by whether a self-run municipality is within an IBGE-designated metropolitan area. The (often wealthier) self-run municipalities

<sup>16</sup>The most pronounced difference between water and sanitation is how water is handled through the system. Drinking water flows through pressurized pipes, which can be made of flexible material and can be placed both uphill and at shallow depths below ground. On the other hand, waste water must flow by gravity, adding additional complexity (and cost) to a system that must flow downhill and often deep below ground.

TABLE 4—WS INVESTMENT BY METROPOLITAN AREA

	Total investment	Source of investments			Destination of investments		
		Self-financing	Loans and debt	Government grants	Investment in water	Investment in sewer	Other investments
Self-run company in metro area, post-reform	4,594 (2,261)	2,534 (933.3)	3,149 (1,572)	103.6 (430.8)	901.8 (887.8)	3,147 (1,631)	447.7 (230.1)
Self-run company not in metro area, post-reform	1,548 (1,169)	1,235 (446.1)	1,340 (1,012)	-242.9 (265.5)	230.0 (570.0)	890.4 (728.0)	418.5 (181.9)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,460	14,460	14,460	14,460	14,460	14,460	14,460
Adjusted within $R^2$	0.300	0.0341	0.0227	0.0493	0.258	0.197	0.0237
Mean dependent variable	2,731	717	535	395	1,074	1,321	192

*Notes:* This specification is identical to the one in Table 3, except that the regressor of interest is interacted with whether a municipality is in an IBGE-designated metropolitan area. All specifications include municipality and year fixed effects. Standard errors are clustered at the WS company level, with a total of 149 clusters. Investment levels are measured in thousand reals. All specifications include additional controls for municipal population, finances (GDP and taxes), agriculture and livestock production, annual temperature and rainfall measures, and a time trend interacted with the initial investment level.

in metropolitan areas were much more desirable takeover targets for state companies due to the efficiency gains of complete metro-area service, the ease of combining services in areas that already shared services in other sectors, and the stronger argument for regional planning in large conurbations.<sup>17</sup> A proposed 2001 congressional bill<sup>18</sup> that would have conceded authority to the state companies would only have extended to municipalities within metropolitan areas (GWI 2001). While this bill did not pass Congress, its proposal along with pushes toward consolidation of services in metropolitan areas implies that those self-run municipalities within metropolitan areas faced a higher and more enduring takeover threat from the state. Table 4 presents the post-reform investment decisions by whether a self-run municipality belongs to a metropolitan area. The table confirms the predication that across all investment types, municipal companies in metropolitan areas have larger and more significant increases in investment after the elimination of the threat of takeover.

Within the set of richer municipalities that decided to create self-run companies, those municipalities with high GDPs relative to other municipalities in the state would be more attractive for takeover, as the state company could then redistribute these large resources to other municipalities in its jurisdiction. Likewise, municipalities that are more “politically autonomous” from the state would allow the state to redistribute the municipality’s resources to localities that are more aligned with state control (Rezende 2005). Both of these observations imply that municipalities with high relative income would be the more likely candidates for expropriation, and would thus have larger post-reform increases in network investment.

<sup>17</sup> Similar arguments drive the movement for greater county-city consolidation in the United States, with recent proposals in St. Louis, Cleveland, and Pittsburgh (Rusk 2013).

<sup>18</sup> Bill 4.147/2001.

TABLE 5—WS INVESTMENT BY SHARE OF STATE GDP

	Total investment	Source of investments			Destination of investments		
		Self-financing	Loans and debt	Government grants	Investment in water	Investment in sewer	Other investments
Self-run company with high share of state GDP, post-reform	5,708 (3,320)	2,889 (1,152)	5,076 (2,345)	-318.2 (620.4)	740.7 (1,510)	4,356 (2,211)	558.9 (308.0)
Self-run company with low share of state GDP, post-reform	1,241 (557.8)	1,173 (368.4)	432.8 (306.2)	36.54 (166.7)	395.6 (226.5)	443.9 (308.9)	358.0 (146.4)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,460	14,460	14,460	14,460	14,460	14,460	14,460
Adjusted within $R^2$	0.300	0.0353	0.0294	0.0493	0.258	0.199	0.0239
Mean dependent variable	2,731	717	535	395	1,074	1,321	192

*Notes:* This specification is identical to the one in Table 3, except that the regressor of interest is interacted with whether a municipality comprises a large share of state GDP in 2001. Cluster robust standard errors in parentheses. All specifications include municipality and year fixed effects. Standard errors are clustered at the WS company level, with a total of 149 clusters. Investment levels are measured in thousand reals. All specifications include additional controls for municipal population, finances (GDP and taxes), agriculture and livestock production, annual temperature and rainfall measures, and a time trend interacted with the initial investment level.

To test this prediction, I split the empirical analysis into municipalities with “high” and “low” shares of state GDP.<sup>19</sup> Table 5 presents the results of the main specification by share of state GDP. Consistent with the above intuition, after controlling for income level, those municipalities that comprise a high share of state GDP have larger and more significant post-reform increases across all investment categories.

Both tables provide evidence that the elimination of takeover risk by the state was an underlying mechanism for the observed post-reform increases in investment. On average, municipalities with self-run companies increased investment in their WS networks after the reform, and those municipalities that faced higher uncertainty over takeover risk had the largest impact.

### B. Access to Water and Sanitation Systems

I also study whether the increase in investment by self-run municipalities had any effect on access to the water and sanitation system. I employ a modified version of the difference-in-differences specification outlined in Section III, with the “post” variable defined as two years after the proposal of Bill 5.296/2005 in Congress. A two year lag is taken to account for the time needed for investment projects begun after the reform to enter into network use.

Table 6 displays the results for access to the water and sewer network. Access to the water network is measured by several variables presumed to have a direct impact on the number of potential users of the water system, including information on the

<sup>19</sup> All self-run municipalities with a share of their respective state’s GDP greater than 1 percent (constituting approximately 30 percent of the sample) are classified as having a high share of GDP, while all others are classified as low GDP share municipalities.



TABLE 6—WS SYSTEM ACCESS

	Number of water connections— total	Number of water connections— active	Number of water connections— metered	Number of households with water connection	Water network length
<i>Panel A. Water network</i>					
Self-run company, two years post-reform	2,701 (779.7)	2,064 (766.5)	2,517 (719.0)	2,765 (973.6)	33.50 (7.917)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	14,260	14,372	14,366	14,363	14,369
Adjusted within $R^2$	0.647	0.605	0.653	0.701	0.293
Mean dependent variable	20,432	18,516	16,764	24,937	224
	Number of sewer connections— total	Number of sewer connections— active	Number of sewer connections— metered	Number of households with sewer connection	Sewer network length
<i>Panel B. Sewer network</i>					
Self-run company, two years post-reform	3,659 (996.8)	3,283 (953.3)	4,600 (1,295)	3,954 (1,197)	59.87 (24.44)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	13,593	13,668	13,676	13,692	13,614
Adjusted within $R^2$	0.671	0.670	0.656	0.665	0.00214
Mean dependent variable	11,358	10,718	15,894	14,270	116

*Notes:* This table reports the impact on access to the water and sanitation system two years after the reform. Cluster robust standard errors in parentheses. All specifications include municipality and year fixed effects. Standard errors are clustered at the WS company level, with a total of 149 clusters. Length of water network is measured in kilometers. All specifications include additional controls for municipal population, finances (GDP and taxes), agriculture and livestock production, annual temperature and rainfall measures, and a time trend interacted with the initial investment level.

number (and type) of connections to the system, as well as the overall length of the water pipe network.

The increase in investment by self-run municipalities resulted in significant increases in the number of several types of water connections, with strong significance in metered connections (columns 3 and 5). The increased investment levels also lead to a significant increase to the length of the water network, although the magnitude of this increase represents a modest growth of approximately 6 percent compared to the pre-reform average.

The bottom panel of Table 6 shows corresponding results for variables related to sewer system access. This table displays a similar pattern to that of water access, with significant increases across all types of sewer system connections. The increase in sewer network length represents a larger 16 percent increase from pre-reform levels.

### C. Impact on Mortality

In this section, I investigate whether the increases in investment and access led to health improvements. As children under five years of age are especially susceptible

TABLE 7—MORTALITY

	Less than one year	1–4 years	5–9 years	9–14 years	15–19 years	20–29 years
Self-run company, two years post-reform	–2.930 (1.459)	–0.545 (0.251)	–0.131 (0.145)	–0.246 (0.180)	–0.824 (1.295)	0.0963 (2.691)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,459	14,459	14,459	14,459	14,459	14,459
Adjusted within $R^2$	0.503	0.401	0.221	0.191	0.393	0.463

*Notes:* This table reports the impact on mortality two years after the reform. Mortality data come from Brazilian Ministry of Health. Cluster robust standard errors in parentheses. All specifications include municipality and year fixed effects. Standard errors are clustered at the WS company level, with a total of 149 clusters. All specifications include additional controls for municipal population, finances (GDP and taxes), agriculture and livestock production, annual temperature and rainfall measures, and a time trend interacted with the initial investment level.

to waterborne diseases—due both to a less developed immune system and less knowledge of avoidance behavior tactics—one would expect that increased access to improved water (Currie et al. 2013; Galiani, Gertler, and Schargrodsky 2005; He and Perloff 2016) and sanitation (Geruso and Spears 2018; Hathi et al. 2017; Kresch, Lipscomb, and Schechter 2019) would greatly reduce the number of annual child deaths.

Using mortality data from the Brazilian Ministry of Health’s *Departamento de Informática do Sistema Único de Saúde* (DATASUS) database, I run a regression similar to the previous section with yearly deaths as the dependent variable. I run this regression separately for various age groups ranging from newborns to adults.<sup>20</sup> The regression results are provided in Table 7. As expected, self-run municipalities that saw significant increases in investment also had significant decreases in child mortality. This finding is in line with Gamper-Rabindran, Khan, and Timmins’s (2010) study that found increased access to piped water in Brazil caused a significant decline in infant mortality since 1970.

The decrease in mortality is statistically significant for the two youngest age cohorts—less than one year and under five years old—with the largest decline for children under one year of age. The estimated impact for the under-1 age group is an order of magnitude larger than the other cohorts, with the nearly three less child deaths per year translating to an approximately 7 percent drop in mortality from the pre-reform period. No other age group older than five years had a statistically significant decrease in mortality during this period.

A potential explanation for the observed decrease in mortality in young children—especially infants under one year—is the short duration of breast-feeding in Brazil (Sastry and Burgard 2005). Infants are particularly susceptible to waterborne illness when they are exposed to formula and other supplemental liquids that use untreated water (Anttila-Hughes et al. 2018). The link between (the lack of)

<sup>20</sup>Summary statistics for mortality data across age cohorts are presented in online Appendix A.VI.

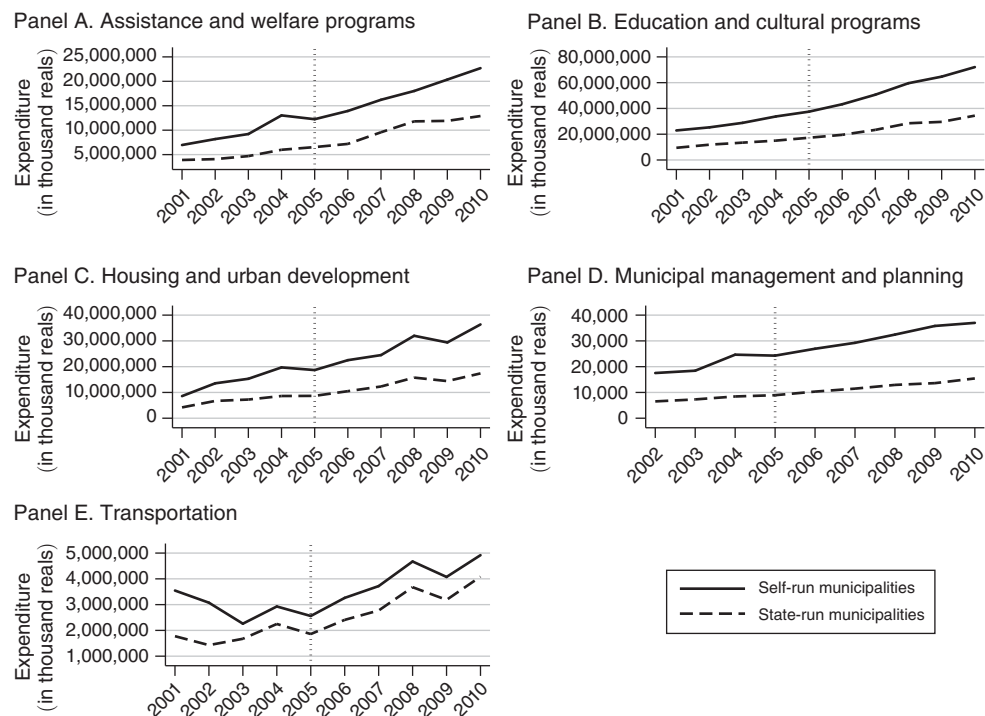


FIGURE 5. MUNICIPAL EXPENDITURES, 2001–2010

*Notes:* This figure shows municipal expenditures in five categories for both types of WS companies in a given year. Data on municipal expenditures come from the National Treasury Secretariat of Brazil. The solid line represents the average annual expenditure for all municipalities that self-provide WS service. The dashed line represents the annual expenditure across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed.

breast-feeding and infant mortality has been observed across developing countries including India (Geruso and Spears 2018; Jayachandran and Kuziemko 2011). Keskin, Shastry, and Willis (2017) find significant impacts on infant mortality for children under one year in Bangladesh, with the effect diminishing with age. Given that only one-third of Brazilian women exclusively breast-feed after six months (Boccolini et al. 2017), the increased access to improved water and sanitation likely explains the large impact of infant mortality.

One may be concerned with the interpretation of Table 7 if there were other reforms during the period that would also have affected children's health. To the best of my knowledge, there was not a health-related reform of similar magnitude and scope during the study period. Additionally, the lack of significance for other age cohorts adds support to the idea that the decrease in child mortality was a result of improved WS services, as opposed to a general improvement in the health environment for self-run municipalities over this period. Figure 5 provides further evidence that the health effects are not driven by an overall increase in investment by municipalities that also happen to have their own sanitation companies, as it does not appear that self-run municipalities had increasingly differential expenditures over time compared to their state-run counterparts.

## V. Conclusion

This paper generates insights in the role that ambiguity in intragovernmental relations can have on the provision of public goods. Using an administrative panel dataset on the Brazilian water and sanitation sector, I find that a legal reform that eliminated the risk of takeover between the various levels of government had a large impact on investment in this sector. Results suggest that post-reform, municipalities with self-run water and sanitation companies nearly doubled their network investment. I find evidence that this increase in investment led to an increase in access to the WS system. Additionally, I document a 7 percent decrease in under-1 child mortality from pre-reform levels due to the increase in access, providing suggestive evidence of the large welfare impacts of this type of reform.

In this paper, I argue that the reform in question—the proposal and subsequent passage of National Water Law 11.447—primarily drove the increase in investment through more secure property rights for municipalities running their own WS companies. However, an alternative explanation is that the reform made salient to voters that mayors were responsible for the delivery of water and sanitation, with this increased accountability causing the increase in investment. This argument is in line with papers that have found a significant relationship between the accountability for mayors and electoral outcomes (Ashworth 2012; Ferraz and Finan 2008, 2011). While I cannot definitively rule out this mechanism having a role in the observed effect of the reform (or directly measure a change in perceived accountability over time), I provide evidence in online Appendix A.VII that points to this not being the primary mechanism. I use an insight from Ferraz and Finan (2011) that increased accountability would have a larger impact on incumbent mayors who are up for reelection; I find that the investment levels for self-run municipalities are not substantially different for incumbents and nonincumbents. This, in addition to the fact that self-run companies are not directly answerable to the mayor, makes it more likely that the decision-making of WS companies for long-term investments was motivated more by the operation of the system than on political considerations.

By incorporating insights from investment under uncertainty into the literature on federalism and decentralization, this paper sheds light on an alternative policy tool that can be used to increase investment in public goods provision. The evidence in this paper suggests that, rather than large-scale, capital-intensive investment campaigns by federal governments and international agencies, countries can focus on passing legal reforms to clearly delineate responsibilities among governmental stakeholders. Moreover, a strong institutional framework would help maintain the large-scale investments from conventional sources, as any investment without the accompanying decrease in uncertainty of takeover risk would result in suboptimal maintenance strategies by the service providers.

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