The Buck Stops Where? Federalism and Investment in the Brazilian Water and Sanitation Sector

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Abstract

This paper shows how weak institutions can undermine public goods service when multiple levels of government share responsibility of provision. In particular, I study how legal ambiguities regarding degrees of governmental authority can lead to systematic underinvestment in public utilities. I examine the Brazilian water and sanitation (WS) sector, which presents an natural experiment of shared provision between state and municipality entities. I look at a legal reform that clarified the relationship between municipalities and states in a quasi-experimental, difference-in-differences framework, using an administrative, municipality-level panel dataset from 2001-2012. I find that when expropriation risk by state companies diminished - self-run municipalities almost doubled their WS network investment. This increase in investment led to a significant increase in access to the WS system in these municipalities. The analysis provides strong evidence that reforms that strengthen residual control rights and eliminate the threat of intra-governmental expropriation can lead to large increases in public goods investment.

Keywords: Fiscal & Environmental Federalism; Water & Sewerage; Public Utilities; Development; Natural Resources; Residual Control Rights.

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1 Introduction

In many countries, multiple levels of government share responsibility in the provision of public goods. There exists a large debate on the proper role of these various levels of government (Bardhan & Mookherjee, 2006; Besley & Coate, 2003; Hulten & Schwab, 1997; Oates, 1999, 2005). Some papers argue for central government provision of such services, citing efficiency gains from economies of scale and internalization of cross-jurisdictional spillovers (Dur & Staal, 2008; Inman & Rubinfeld, 1996; Oates, 1972). Others argue for a more decentralized framework, pointing out that local governments may be more knowledgeable of and responsive to local conditions (Faguet, 2004; Oates, 1994; Rubinchik-Pessach, 2005).

However, this debate assumes that the level of government in charge of provision is clearly defined; little is known about situations when there is ambiguity regarding which level holds the ultimate authority for service provision. More precisely, there have been few studies on instances when it is unclear which level of government holds the residual rights of control and authority in the sector. One way this can occur is if the legal infrastructure is sufficiently vague in delineating the roles of government. This situation can arise in the weak institutional environment of some developing countries, where the legal infrastructure is not as developed (Acemoglu, Johnson & Robinson, 2002; Bardhan, 2002; Gray, 1997).

This paper examines how legal ambiguity in the role of different levels of government can lead to systematic underinvestment in public utilities. I study how this institutional uncertainty may lead to a threat of expropriation of operational authority between different levels of government. I find that expropriation risk can cause sub-optimal investment into public goods provision. Consequently, any reform that strengthen residual control rights would lead to an increase public sector investment.

To study this, I consider a 2005 legal reform in Brazil 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, with some municipalities electing to self-provide service through municipal companies, while other municipalities

contracted these services out to their respective state WS company. This arrangement was legally tenuous, with multiple attempts in the late 1990s and early 2000s by state governments to takeover municipal WS services. Bill 5.296 was introduced to the Brazilian Congress in 2005 and established the local municipality governments as the ultimate authority in WS provision within their jurisdictions. This bill was approved by Congress and became National Water Law 11.447 in January 2007.

In order to causally identify the impact of this legislation on investment in the WS sector, I exploit the variation in municipalities' WS provider type in a difference-in-differences (DID) framework. While some municipalities provided their own WS services through self-owned utility companies, others contracted these services to their respective state service provider. I utilize an administrative, municipality-level panel dataset of the Brazilian WS sector (2001-2012) to compare municipalities that self-provide WS services with those that contract these services to the state-run companies before and after the legislative change.

I find that legal reform that eliminated the threat of expropriation by state companies led to an increase in investment in the WS networks of municipality-run companies, 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 company self-financing. Post-legislation, municipality-run companies saw significant growth - relative to municipalities that contracted for these services to state companies - in their WS systems, as well as in miscellaneous network resources (e.g. office buildings, vehicles, computer systems). All of these increases are statistically significant.

In order to more distinctly identify the removal of expropriation 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, more politically autonomous, and in metropolitan areas were more likely targets of a state takeover of WS services. I stratify the results by whether a self-run municipality was a more likely target for state expropriation, and I find that these municipalities showed a larger

post-reform increases than other self-run companies.

I also run robustness checks to address potential concerns over time-varying unobservables, timing of the legislation, and existence of spatial interdependence. The results of the paper are robust to inclusion of state-specific time trends and definition of the reform year. The results are also robust to two methods to control for spatial correlation: the "buffer zone" approach and the use of a spatial error model.

Moreover, this increase in investment by municipality-run companies 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 to the WS network, as well as increases in the average total length of both networks. The increase in average network length represents a 6.3% and 16.3% growth, respectively, for municipality-run WS companies.

The water and sanitation sector is an ideal setting for the analysis, as it is significantly more capital-intensive than other public utilities, with large up-front fixed 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 & Mobarak, 2012). A large increase into the infrastructure of WS networks can lead to significant increases in health and other important socio-economic outcomes.

This paper contributes to the literature on fiscal and environmental federalism. Whereas much of this work has focused on competition and coordination between the same level of government on issues such as taxation (Epple & Zelenitz, 1981; Keen & Kotsogiannis, 2002; Rauscher, 1998; Sitkoff & Schanzenbach, 2005), education (Alesina, Baqir & Hoxby, 2004; Brasington, 1999; Hoxby, 2000), and environmental resources (Hatfield & Kosec, 2014; Kunce & Shogren, 2005; Sigman, 2005; Woods, 2006), this paper analyzes the vertical competition between higher and lower levels of government. While some papers do consider the vertical competition aspect of federalism (notably (Berry, 2008), (Breton, 2006), and (Hooghe & Marks, 2003)), this is the first paper - to the best of my knowledge - that studies the role that incomplete property rights can have on the dynamics between the various levels of

government.[1] This paper points to the importance that unambiguous delineation of the level of government authority has on public goods provision.

This paper also contributes to the literature on incomplete contracts, property rights, and the residual rights of control that follows in the tradition of (Coase, 1960) and Grossman-Hart-Moore (Grossman & Hart, 1986; Hart & Moore, 1990). This broad literature provides evidence on the positive impacts of the strengthening of property rights on investment decisions, for example from the household unit (Besley, 1995; Field, 2005; Galiani & Schargrodsky, 2010). Most of the papers on incomplete contracts and investment decisions that include the government usually model the government's interaction with fully private firms or via "public-private partnerships" (Besley & Ghatak, 2001; Hart, Shleifer & Vishny, 1997; Hoppe & Schmitz, 2010; Martimort & Pouyet, 2005). This is similarly true for those papers that look at investment decisions under the threat of government expropriation, such as (Chen & Yeh, 2013; Shleifer, 1995). This paper departs from this literature in that the government expropriation takes place *within* the different levels of government, as opposed to with outside firms. This paper likewise departs from the general literature on firm investment under uncertainty (Bloom, Bond & Van Reenen, 2007; Vatiero, 2015) as public utility companies are likely to differ from their private counterparts in their underlying objective function and may not be purely profit-maximizers.

Finally, this paper contributes to our understanding of the role of weak institutions on development. Much of the previous work highlights the role that weak institutions play in undermining economic development through corruption (Banerjee et al., 2014; Ferraz & Finan, 2011; Olken, 2007), historically extractive policies (Acemoglu, Johnson & Robinson, 2001; Dell, 2010), and so-called "weak" state capacity (Acemoglu, 2005; Besley & Persson,

[1]The paper most closely related to this one is (Estache, Garsous & Seroa da Motta, 2015). In that paper, they study the role that electoral outcomes and political alignment between the governor and mayors of municipalities in Sao Paolo 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. (Lipscomb & Mobarak, 2014) 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.

2009; Dell, Lane & Querubin, 2015). However, few papers have studied the mechanism by which weak institutions has on intra-governmental dynamics - the notable (and partial) exception being the paper by (Acemoglu, Garca-Jimeno & Robinson, 2015) that study the network effects of state capacity building between the local and national governments in Colombia. My analysis of intra-governmental expropriation 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 2 provides background on the institutional structure of the Brazilian WS sector and briefly describes the proposed sector reforms of the early 2000s. A theoretical framework to motivate the empirical findings of the paper is presented in Section 3. Section 4 describes the data and Section 5 discusses the empirical identification strategy. Estimation results, robustness checks, and extensions of the main empirical findings are presented in Section 6, and Section 7 concludes.

2 Background

2.1 Brazilian WS Sector

The water and sanitation (WS) sector in Brazil is characterized by the existence of both municipal- and state-level entities responsible for service provision. This shared responsibilities by different levels of government is not observed in other utilities in Brazil, such as electricity and telecommunications.[2] Even across the WS sector, this type of power-sharing arrangement between different levels of government public companies is not observed in comparable developing country settings.

The distinctive structure of Brazil's WS sector has its origins in the Federal policy mandates of the late-1960s and early-1970s. In the middle of the 20th century, water and sewerage services (where available) were provided locally by municipal-level governments - a fact that

[2]See (Tupper & Resende, 2004)

was acknowledged in the 1967 Federal Constitution, which endowed responsibility for water and sewerage provision to the municipalities.

However, Brazil's military government in the late-1960s attempted to centralize operational authority to state-level administrations[3]. This policy culminated in the creation in 1971 of a national plan for WS provision known as PLANASA (*Plano Nacional de Saneamento*). PLANASA created 27 state companies (Portuguese: *Companhias Estaduais de Saneamento Basico*, aka CESBs) - one for each state - that would be responsible for providing basic water and sanitation services.

The underlying argument for the creation of the CESBs as a replacement for local, municipal service provision involves concerns over efficiency in the sector. Many proponents of PLANASA pointed to the fact that WS service exhibits a cost structure of a natural monopoly, and municipal companies of a small scale could not efficiently provide service at low costs. Also, having the operational authority held at the state-level would make it possible for cross-subsidization from wealthier municipalities to finance infrastructure and service in poorer areas of the state.

While PLANASA created the state WS companies, it could not abolish municipal-level companies, due mainly to the ambiguous language in the 1967 Constitution with regards to the ultimate holder of operational authority in the sector. Rather, federal and state governments pressed municipalities to enter into concession contracts with the CESBs, and cede operational control in the sector to state companies.[4] While many municipalities signed on with the state companies, a significant number did not, deciding to keep WS provision through municipality-run companies. Figure 1 shows the break-down of Brazilian municipalities by type of provider.[5] Approximately 60% of all municipalities joined PLANASA,

[3]See (Heller, 2007)

[4]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)

[5]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/

with the remaining 40% providing service via local companies.

The resulting institutional structure created legal ambiguities and debate over which level of government should be the ultimate holder of the residual control rights in WS provision. Compounding this informal situation was the fact that many concession contracts that municipalities had with the state companies were informal and or never explicitly signed. Frictions between state- and municipal- governments led to a climate of uncertainty for municipal-run companies with an ever-present threat of expropriation by the CESBs.[6] This friction between state and municipal providers led to the creation in 1984 of the National Association of Municipal Sanitation (ASSEMAE). This organization consists of over 1,800 municipal WS companies whose mission is to protect the operational authority of municipalities in the sector, as in the case of the attempted expropriation of the municipality of Campinass WS company (Sanasa) by the state of Sao Paulo (da Costa et al., 2006).

Even with the abolition of PLANASA in 1992 and a new Federal Constitution in 1988 that provided language in support of municipal authority, the environment of legal ambiguity between the roles of state and municipality persisted. Additionally, the Public Concession Act of 1995 created more legal uncertainty in the area of public service provision by contesting the long-term concession contracts with the CESBs that were inherited from PLANASA. This resulted in multiple lawsuits and an increased call for reform to the institutional framework of the sector.[7]

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 authority to their respective state WS companies (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 the municipalities to the state company. Similarly, the state legislature of Rio de Janeiro passed Complementary

[6]See (Britto & Silva, 2006) for a more detailed discussion of the conflict between municipality-run and state-run WS companies, particularly in urban areas.

[7]See (Sabbioni, 2008).

State Law No. 87 in 1997, which created the Rio de Janeiro metropolitan region and Lagos micro-region. Furthermore, it granted the state company (CEDAE) complete authority of WS operations in these newly-defined areas, and attempted to expropriate the services of all self-run municipalities therein.

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 that laws were unconstitutional and that the 1988 Constitution granted the authority of service provision to municipalities. Due to the backlog of cases awaiting decisions from the Court, neither of the above cases have been decided. Even if timely decisions were rendered, however, as the Brazilian legal code is based in the "civil law" tradition, neither decision by the court would have set precedent and fundamentally altered the legal architecture of the WS sector (McNallen, 2006). Rather, any far-reaching attempt reform the property rights institutions of the sector would have to come from the legislative branch.

2.2 2005 Legal Reform

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

The administration submitted a reform to the Brazilian legislature with the goal of strengthening the WS 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-level WS 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 relate to and altered the shared power-structure of the previous systems.[8] First, the bill explicitly and unambiguously designates the municipal government as the conceding authority in the sectors of water provision, sewerage treatment, and solid waste collection. In this, Bill 5.296 was seen as a reaffirmation and clarification of Article 30 of the 1988 Brazilian Constitution, and for the first time explicitly stated in legal terms that water and sanitation issues were inherently those of a "local interest" (Brazil, 1988).

Second, the bill provided a legal structure for the relationship (i.e. concessions contracts) between the municipal- and state-level governments in this sector, in the case of those municipalities that do not provide these services themselves and rather cede this operation to state companies.

The bill was approved by Congress in January 2007 as National Water Law 11.447/2007, and was the first ever federal law that addresses the WS sector (Castro & Heller, 2004).

3 Theoretical Framework

This section provides a simple framework to conceptualize the relationship between municipal and state companies in the WS sector. The purpose of this section is two-fold. First, it highlights the fact that some municipalities would be better off self-providing WS services instead of contracting them out to the state company. Furthermore, it provides conditions and intuition on which municipalities would chose to self-run WS service. Second, it informs the key empirical observation of the paper: in the presence of a threat of expropriation by

[8] See (Seroa da Motta & Moreira, 2006)

the state company, municipality-run companies will find it optimal to under-invest in their WS systems. It follows that once the risk of expropriation is eliminated, there will be an increase in investment by these self-run municipal WS companies.

3.1 Basic Set-up of the Framework

At the center of the framework is the difference in optimizing decisions by the state and municipal WS companies. The basic framework has two main components:

- The objective of the municipal company is to maximize the utility of a representative citizen, and the objective of the state company is to maximize the weighted utility of the representative citizens in each of the municipalities in its jurisdiction.[9,10] The citizen's utility depends on the amount (W) of services provided in the WS sector.[11]

- The model has 2 periods, with the respective company choosing W in both periods. The company also chooses a network investment level (I) that is deducted from Period 1's discretionary budget and reduces the per-unit cost of providing W in Period 2.

In the next sections, I solve the optimization problem faced by the municipal-level and state-level companies, respectively. I then compare the service and investment decisions for the two companies and derive conditions under which certain municipalities would be better off providing these services themselves. The conditions that make these municipalities better off via self-provision will also make them attractive to expropriation by the state company. Therefore, I then look at the investment decision of these municipalities under the risk of service expropriation by the state-level companies in period 2. By comparing

[9]There is evidence that social welfare is a large component of the WS sector in Brazil and it is not purely motivated by profit maximization. For example, Sao Paulo's state WS company (SABESP) has a Code of Ethics and Conduct established in its company charter that defines sustainable development, social responsibility, and welfare improvement as guiding principles of its operations.

[10]As another example of non-profit-maximizing behavior of Brazilian WS companies, many companies, such as the provider for Pôrto Alegre implement so-called "social tariffs" that heavily discount initial amounts of water consumption for low-income households, schools, and other charitable organizations. See (Viero & Cordeiro, 2003)

[11]One can think of W in "quality-quantity" units

investment levels of municipality-run WS companies in the first-best case and in the case with expropriation risk, I am be able to make a prediction on the effect that a ambiguity-reducing legal reform will have on investment decisions.

3.2 Service and Investment Decisions

3.2.1 Municipal WS Company

The municipal company chooses the level of service in the WS sector in each period (W_1, W_2) to maximize the utility of a representative citizen. It also chooses a level of investment (I) to devote to the network in the first period that reduces the per-unit cost of providing W_2. Let the citizen's utility have the functional form $U(\cdot) = log(\cdot)$.[12] Mathematically, the optimization problem faced by the municipal company is:

$$\max_{W_1, W_2, I} log(W_1) + \delta \; log(W_2) \quad \text{s.t.} \quad cW_1 + I \leq Y_1 \; , \; \left(\frac{c}{I}\right) W_2 \leq Y_2$$

where Y_1 and Y_2 are the discretionary budgets for the municipal company in the two periods. The cost of providing these services is represented by a generic cost level, c. This per-unit cost in period 2 is decreasing in the level of investment (I) that was chosen in period 1. Period 2 utility is weighted by a discount factor $\delta \leq 1$.

Solving this constrained optimization problem results in the optimal level of investment in the WS sector by the municipal company given by:

$$I^M = \frac{Y_1}{\left[1 + \frac{1}{\delta}\right]}$$

This investment level is increasing in the size of the Period 1 discretionary budget and decreasing in the size of the inter-temporal discount factor.

[12] This functional form allows the framework to be more tractable, however the implications of the model holds under greater generality.

3.2.2 State WS Company

Like its municipal-level counterpart, the state company's objective is to maximize the utility of its representative citizens by choosing the optimal level of services and investment for the 2 periods. The state-level problem differs, however, in that the state company maximizes the *weighted* utility of the representative citizen in each of the n municipalities in its jurisdiction. For a state with $j = 1, \ldots, n$ municipalities, the optimization problem is:

$$\max_{\{W_{1j}, W_{2j}, I_j\}} \sum_{j=1}^{n} \mu_j \left[log(W_{1j}) + \delta \; log(W_{2j}) \right] \quad \text{s.t.} \; \sum_{j=1}^{n} (cW_{1j} + I_j) \leq \bar{Y}_1 \, , \; \sum_{j=1}^{n} \left(\frac{c}{I_j} \right) W_{2j} \leq \bar{Y}_2$$

Where (W_j, I_j) are the levels of services and investment devoted to municipality j by the state company. The coefficients μ_j are the pareto weights that the state assigns to each municipality in its jurisdiction, with $\sum_{j=1}^{n} \mu_j = 1$. The state company's total discretionary budget $(\bar{Y})$ is composed of the total of the respective municipality budgets: $\bar{Y}_1 = \sum_{j=1}^{n} Y_{1j}$ and $\bar{Y}_2 = \sum_{j=1}^{n} Y_{2j}$.

Equating the first-order conditions for two different municipalities i and j and combining these conditions with the budget feasibility condition in period 1 yields the optimal level of investment (I_i^S) in the network that the state company devotes to a given municipality i:

$$I_i^S = \frac{Y_{1i}}{\left[1 + \frac{1}{\delta}\right]} \frac{\sum_{j=1}^{n} \frac{Y_{1j}}{Y_{1i}}}{\sum_{j=1}^{n} \frac{\mu_j}{\mu_i}}$$

Where Y_{1i} is municipality i's component to the state company's first period budget, and is equivalent to Y_1 in the municipal company case of Section 3.2.1. Note that the level of investment that the state company devotes to municipality i is a function of not only the municipality's own budget and discount rate, but it is also dependent on the municipality's budget and pareto weight in relation to all of the other municipalities in the state. This point will be discussed further in the next section.

3.2.3 Comparing Investment Decisions by Municipal and State WS Companies

I now compare the optimal investment decisions made by the municipal-level and state-level companies to derive conditions under which a municipality would investment more into its WS network if it ran it, rather than ceding the residual rights of control of this system to the state.

For a given municipality i, the individual municipal investment in the WS network would be larger than the analogous investment level chosen by its state-level company if:

$$I^M \geq I_i^S \Leftrightarrow \frac{Y_1}{\left[1+\frac{1}{\delta}\right]} \geq \frac{Y_{1i}}{\left[1+\frac{1}{\delta}\right]} \frac{\sum_{j=1}^{n} \frac{Y_{1j}}{Y_{1i}}}{\sum_{j=1}^{n} \frac{\mu_j}{\mu_i}} \Leftrightarrow \sum_{j=1}^{n} \frac{\mu_j}{\mu_i} \geq \sum_{j=1}^{n} \frac{Y_{1j}}{Y_{1i}}$$

This indicates that municipality i would receive less investment in its network from the state if the sum of the relative pareto weights of the other municipalities in the state is greater than the sum of the other municipalities' relative budget components to the state company's first period discretionary budget. This condition is likely to be satisfied when μ_i is small and Y_{1i} is large - that is, municipalities that have very little weight when the state company optimizes its citizen's utility, but has a large amount of resources that contribute to the state budget. This implication supports the observation by (Castro & Heller, 2004) that it was the richer, higher HDI municipalities that were more likely to choose in the late 1960's to provide their own WS services and not cede these operations to the state water companies. Further evidence is provided by (Rezende, 2005), who finds that these municipalities were also more politically autonomous than those that contracted service to the state.

The above comparison provides an interesting insight in the relationship between state and municipal companies; it suggests that *the direction of expropriation is upward*. That is, any move toward expropriation would come from a state company, as it could then take the larger resources from the rich municipalities and redistribute it to other municipalities in which it places a higher pareto weight. Furthermore, self-run municipalities would fear the loss of authority in their WS networks, as any expropriation would decrease citizen welfare.

3.2.4 Municipal Level Investment Under Threat of Expropriation

Lastly, I study the decision of those municipalities that satisfy the condition found in Section 3.2.3, which are better off by self-providing WS services and are attractive to state companies for expropriation. In this case, however, I'll introduce the threat of expropriation, wherein the municipal system can be taken over and incorporated into the state company's operations in period 2. I'll analyze how the introduction of this uncertainty affects the investment decision (I) of the municipal WS company in first period.

The optimization problem is analogous to the one in Section 3.2.1, except that in this scenario there is a probability, p, that the state company can expropriate the municipality's WS services (and all of its residual control rights) in period 2. If the state expropriates the municipal system, then it will only allocate an investment level $\bar{I}_S^i < I_M$ to the municipality.[13] It will also provide a level of service $\bar{W}_{2,S}^i \leq W_{2,M}$, with the remaining part of municipality i's period 2 budget being redistributed to other municipalities within the state. In this scenario, the municipal company will choose (W_1, W_2,I) to maximize the expected utility:

$$\max_{W_1,W_2,I} log(W_1) + \delta \left\{ (1-p) \left[log(W_2) \right] + p \left[log(\hat{W}_2) \right] \right\} \quad \text{s.t. } cW_1 + I \leq Y_1 \ , \ \left(\frac{c}{I} \right) W_2 \leq Y_2$$

Solving for the optimal level of investment under uncertainty yields:

$$\tilde{I}^M = \frac{Y_1}{\left[1 + \frac{1}{(1-p)\delta} \right]}$$

In this scenario, the municipality's optimal choice of investment in its WS system is a function of the probability of expropriation. Moreover, since $p \in (0,1)$, we have two results of interest:

1. $\tilde{I}^M < I^M$: A municipality's optimal investment level is lower than the first-best case

[13] For example, it can take many of the investments that municipality i made in the previous period (such as automobiles, computer systems, etc.) and physically reallocate these to other municipalities within the state's jurisdiction. The state company could also link the municipality's WS network to the larger state network in order to use its water and sewerage facilities for water that would be used by other municipalities.

2. $\frac{\partial \tilde{I}^M}{\partial p} < 0$: A municipality's optimal investment level is a decreasing function of the probability of expropriation

Intuitively, a municipal company under a threat of expropriation would choose a lower investment level and would prefer to defer these resources to first period utility, as it cannot fully benefit from the investment that pays off in the later period.

The above framework presents the main result of the paper: *a municipality will optimally under invest in it's WS system when there exists a fear of expropriation by the state company, and investment levels in these systems should increase once this expropriation threat is removed.*

4 Data

I use three administrative datasets that have the municipality as the unit of observation and are linked through the unique, 7-digit administrative code.

Information on the water and sanitation sector comes from a dataset provided by the Brazilian Ministry of Cities (Portuguese: *Ministrio das Cidades*). This dataset provides basic information and performance indicators on water and sewerage service at the municipality level. Thus for those municipalities that contract out these services to state companies, the dataset provides information for those parts of the system that operate within the municipality boundary.

The Ministry of Cities provides this data on a yearly basis starting from 1995, however the earliest rounds of the data are not standardized and compatible with later years, and I therefore restrict the period of analysis to the years 2001 to 2012.

The main dataset includes data collected on the investments in the WS sector according to either the destination or the origin of these resources. All of the data on investments is disaggregated to the municipality level, which is the unit of observation. This means that the investments recorded for a municipality whose service is provided by a state company

includes only those investments made by the company that are used in the service of residents within the given municipality boundaries.

The categories for the origin of yearly investment are investment financed by *"Own" Resources*, so called *"Onerous" Resources*, and *"Nononerous" Resources*. *"Own" Resources* investment is defined to be all investment made by the WS utility from it's own resources - through service collections, non-operating income, sale of stock to shareholders, etc. *"Onerous" Resources* are those resources for which the service provider services through paid loans which are returnable through depreciation or interest. Those loans generally come from agreements with Brazilian federal banks, external development banks (such as the World Bank), and other financial institutions.[14] All other investments that come in the form of non-repayable government funds and grants are categorized as *"Nononerous" Resources*.

The destination of the investment can be one of three types, depending on the final use of the resources. *Investment in Water* are all investments taken by the service provider 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 held by the service provider in equipment and facilities built into the sewerage system. A third category exists - *Investment in Other* - for all investments of the service provider that are of general use and not directly related to either the water or sewerage systems.[15]

The final category for investment included in the dataset is *Total investment*. This category is the total of all of the investments made by the service provider in a given year. It 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.[16]

[14]Examples of Brazilian federal banks include BNDES, CAIXA, and CEF

[15]Examples include office buildings, computer systems, maintenance vehicles, etc.

[16]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 such that the sum of the destination classifications plus capital expenditure equals total investment.

Additional information on municipality characteristics comes from a dataset derived from annual surveys conducted by the Instituto Brasileiro de Geografia e Estatstica (IBGE). This dataset comprises various socioeconomic indicators for all of Brazil's municipalities on yearly basis. Indicators include information on municipal finances (e.g. municipal GDP, taxes, gross value added) and resident populations for every year of the study period, 2000-2012.

One of the robustness checks presented in Section 6.2 exploits the spatial variation of the municipalities throughout Brazil. To run this analysis, I utilize a geospatial mapping of Brazil's municipality administrative boundaries, which comes from the IBGE's BCIM v304 mapping library. This library contains a GIS file of all of Brazil's municipalities with 2000 as the reference year. Along with the coordinates of the municipalities, it also provides the 7-digit administrative code that allows me to link this spatial dataset to the other datasets provided by the Ministry of Cities and the IBGE.

5 Empirical Strategy

The primary objective of this paper is to determine what effects the strengthening of the residual rights of control has on investment in public goods. The framework in Section 3 predicts that any policy reform that eliminates expropriation risk by state WS companies should lead to an increase in investment in the WS sector for those municipalities that provide their own services.

To estimate this causal effect, I employ a difference-in-differences (DID) strategy - comparing the investment levels of municipalities that provide WS services themselves against

those municipalities that contract them out to a state company.[17,18] I compare these investment levels for the years before the proposed policy reform and for the subsequent years. By differencing out the pre- and post-reform investment levels of the state-run municipalities, I am able to identify and estimate any increase in investment for self-run municipalities that is due to the decrease in legal ambiguity and expropriation risk between different levels of government.

The estimating equation I run is:

$$y_{mt} = \alpha + \gamma_m + \lambda_t + \delta Reform_{mt} + \mathbf{X}'_{mt}\beta + \varepsilon_{mt}$$

The dependent variable, y_{mt}, are the various investments in the WS system of municipality m in year t. There are seven investment levels used in the dataset and are described in greater detail in Section 4.

I use the timing of the proposal of Bill 5.296 as the measure of the "pre-" and "post-" treatment periods. The variable $Reform_{mt}$ is an indicator variable that is equal to 1 for all observations in which the WS system of municipality m is run by a municipal company for all years t after the proposal of Bill 5.296 in Congress. The associated coefficient ($delta$) is the main coefficient of interest and is interpreted as the increase in investment by self-run municipalities after the introduction of the congressional reform. As the goal of this legislation was to reduce ambiguity between state and local governments in WS provision, Section 3.2.4 predicts that this coefficient should be positive and significant.

I use the year of proposal rather than approval because the reform of the WS sector

[17]An important point in running the DID strategy is the validity of the state-run municipalities as a "control" group. In the empirical setting, the control group must not be "treated" by the reform, so the state-run municipalities should not be affected by the reform's elimination of the expropriation risk. The fact that these state-run municipalities are already serviced by the state companies implies that they ceded the operational authority in this sector - either through formal contracts or *de facto* by the daily operations on the ground - to these state companies. Thus even before the reform, the state-run municipalities' probability of expropriation was zero and any legal reform that decreases risk of state takeover should not effect this group. Therefore as a first-order effect, the legal reform differentially affected the self-run and state-run municipalities.

[18]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.

was a primary policy concern for the administration of the widely-elected President Lula da Silva. Given the administration's support of the initiative, the bill's passage was very 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 expropriation risk would spur investment by the self-run municipalities at the time of the Bill's proposal.

To increase the precision of the estimate, I use municipality and year fixed effects - γ_m and λ_t, respectively - instead of the "treatment" and "post" dummy variables found in the standard difference-in-differences regression.

For added controls in the estimating equation, I include a vector of municipality characteristics, $\mathbf{X}_{mt}$. This vector comprises information for each year t on municipality m's population and geographical characteristics (e.g. latitude, longitude, total area). To address the fact that some municipalities started with higher levels of network investment at the beginning of the study period, I control for the base levels of investment in municipality m's WS network in the year 2001. Likewise, to control for the fact that municipalities differ in income, I include variables on municipal finances for the base-year 2001, such as municipal gdp, taxes, gross value added (gva). The specification also contains municipality and year fixed effects.

To correct for issues that arise due to general autocorrelations in the DID setting, as discussed in (Bertrand, Duflo & Mullainathan, 2004), the error term - ε_{mt} - is estimated with robust standard errors that are clustered at the municipality level.

The estimation covers the period for which I have available data, 2001-2012. The paper also restricts the empirical specification to observations for which there are observations in the "pre-" and "post-" periods, although the findings in Section 6 are robust to the inclusion of the unbalanced municipalities, as can be seen in the Appendix.

6 Results

This section investigates how the investment strategies for different types of WS companies changed as a result of the 2005 reform that strengthened the residual rights of control for self-run municipal companies and eliminated the threat of expropriation by the state company. In particular, this section displays the main finding of the paper: once the risk of expropriation by state companies was eliminated, municipality-run WS companies significantly increased the level of investment into their networks. I further provide evidence of the strengthening of the residual rights of control as an underlying mechanism by studying the heterogeneity in investment decisions by self-run municipalities. This section will present robustness checks of the main result, taking into account the possible spatial component of the WS sector. Lastly, I extend the analysis to observe if there was any change to service provision as a result of the increased investments.

6.1 Investment Decisions

6.1.1 Graphical Results

We will first look at the graphical results of the impact of the legislative change, and Figure 2 through Figure 8 show the raw data on the investment decisions of the WS companies by type for the period 2001-2012.

Figure 2 presents the yearly means of total investment in the entire WS system for the two types of companies (i.e. municipality- and state-run companies). There are two important features of Figure 2. First, the yearly trend of pre-reform investment levels by the two types of companies are fairly comparable. The average yearly investment of municipality-run companies is higher than state-run ones in the period 2001-2004, which corroborates a key insight from the theoretical framework in Section 3: those municipalities that are richer and more developed would choose to self-provide and have higher levels of network expenditure. Crucially for the DID framework, the parallel trends assumption appears to hold, in that

although municipality-run investment levels are higher, both types of companies display the same trend prior to 2005, with investment levels staying generally steady from year-to-year.

The second key feature of Figure 2 is the sharp increase in investments made by municipality-run companies after the proposal of Bill 5.296 in 2005. This increase in total investment by municipality-run companies is large, with the 2012 investment level being approximately 5x the pre-reform investment levels.

I decompose this increase in total investment by both its source and destination. Figures 3-5 show the yearly investment levels for "own", "onerous", and "nononerous" sources, respectively. As with Total Investment, municipality-run companies have a large and dramatic increase in investment from own and onerous resources after the introduction of the reform. For both of these types of sources, the parallel trends assumption is even more strikingly satisfied, and there is little discernible post-reform increase in investment for their state-run counterparts. As both types of investment sources are costly to the WS company - either by forgoing service expenditure in the current period or servicing the debt in a later one - this pattern is consistent with the prediction made in theoretical framework that investment levels would rise if the expropriation threat from state companies was eliminated.

A similar post-reform increase in investment for self-run municipalities does not appear in investments that comes from "nononerous" government grants, as seen in Figure 5. Rather, the amount of yearly government grants seems to be distributed equally for both types of municipalities, as their investment levels co-move throughout the period of analysis. However, there is a large increase in investment for both types of municipalities starting in 2007. This is likely due to a new federal initiative called the "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 infrastructure projects (e.g. ports, highways, energy, WS networks) throughout Brazil. This new program also explains the slight increase in Total Investment for state-run municipalities after 2007 that is observed in Figure 2.

Figures 6 through 8 show the average yearly investment for municipalities by company type for the possible investment destinations. There are significant increases in investment for self-run municipalities after the reform in all aspects of the WS network: in water (Figure 6), sewer (Figure 7), and miscellaneous network investments. In these three investment categories, both self-run and state-run municipalities display parallel trends in pre-reform investment levels.

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

6.1.2 Empirical Results

Table 1 presents the regression results using the differences-in-differences specification outlined in Section 5. Each column of the table correspond to Figures 2 to 8, respectively.

Estimates from the table show that the empirical specification closely matches the plots of the raw investment data. The causal impact on investment in the WS networks from the introduction of Bill 5.926/2005 is positive and significant for investment types save those of Nononerous Investment. The yearly average of Total Investment by municipality-run companies was approximately 2.3 million Reals from 2001-2005, which implies a causal impact of over 100% increase in total investment for these companies after expropriation risk was eliminated. Similar comparisons of the change in Own Investment and Onerous Investment show an increase of by 72% and over 550%, respectively. As Total Investment

can be decomposed into its various sources, one can determine that the increase in Total Investment as a result of the legal reform is split roughly 40-60 in increase from Own and Onerous sources.

The right-most three columns of the table display the coefficient of interest for the investment destinations, and correspond to Figures 6 through 8. After the proposed reform, there were large and significant increases in investment across all aspects of the WS network for municipality-run companies. The coefficients on investment in the water and sewer networks are less statistically significant and are likely attenuated due to the introduction of PAC in 2007, which increased investment in these network for state-run municipalities as well.

The largest investment increases occurred in the sewer network. This result is reasonable, as the sewer network incurs high fixed costs of operation, and sewer coverage lags behind water coverage across Brazil, implying higher rates of return to investment in this sector. Post-reform increases in the water, sewer, and miscellaneous network investments by municipality-run companies correspond to an approximately 80%, 170%, and 100% increase, respectively, from pre-reform yearly averages.

6.1.3 Heterogeneity in Investment Decisions

The previous two sections showed evidence of a link between the 2005 reform that strengthened residual control rights for self-run municipalities and subsequent increases in their network investment. In this section I provide additional evidence of the strengthening of control rights and elimination of expropriation risk as an underlying mechanism of the reform. To do this, I study the heterogeneity in investment decisions by self-run municipalities across three dimensions that differentially affect a municipality's optimal investment decision, as shown in the theoretical framework in Section 3. These dimensions are the a priori probability of expropriation by a state company, a municipality's relative income, and its political autonomy from the state government.

The theoretical framework predicts that, under threat of expropriation, self-run munici-

palities with a higher probability of being expropriated by the state company would invest less in their WS network. Moreover, once this expropriation risk is eliminated, these municipalities would have a larger increase in investment than their counterparts.

To test this prediction, I split the analysis by whether a self-run municipality is within IBGE-designated metropolitan areas. An earlier bill[19] was proposed in Congress in 2001 with the aim of clarifying the roles of the different levels of government in the sector. The bill would have given the conceding authority for WS provision to the state companies, but this reform would only have extended to municipalities within metropolitan areas (GWI, 2001). While this bill did not pass Congress, its proposal along with pushes towards metropolitan consolidation of services implies that those self-run municipalities within metro areas faced a higher and more enduring expropriation risk from the state. Table 2 presents the post-reform investment decisions by whether a self-run municipality belongs to a metropolitan area or not. The table confirms the predication that across all investment types, those self-run municipalities in metropolitan areas have larger and more significant increases in investment after the removal of the expropriation risk.

Section 3.2.2 derived the optimal investment that a state company would allocate to municipality i, which is a function of the municipality's income relative to other municipalities in the state, as well as its relative pareto weight μ_i. The relative size of these two values would determine how attractive a given municipality would be to a state company in expropriating its operational authority. Thus municipalities with high relative GDP would be more attractive 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 (i.e. low μ_i) 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 and political autonomy would be the more likely candidates for expropriation, and would thus have larger

[19]Bill 4.147/2001

post-reform increases in WS network investment.

To test the prediction on municipality GDP, I split the empirical analysis into municipalities with "High" and "Low" shares of state GDP. All self-run municipalities with a share of their respective state's GDP greater than 1% (constituting $\approx$ 30% of the sample) are classified as having a high share of GDP, while all others are classified as low GDP share municipalities. Table 3 presents the results of the main specification by share of state GDP. Consistent with the above intuition, those municipalities that comprise a high share of state GDP have larger and more significant post-reform increases across all types of WS investment than the low share municipalities, even after controlling for income level.

I use the results from the 2004 municipal elections to study the heterogeneity in post-reform investment by political autonomy. As municipal and state elections alternate every two years, voters in the 2004 election made their decision for mayor with full knowledge of the political party of both the state legislature and governor. Also, the 2004 election occurred a full year before the proposal of Bill 5.926, and it is unlikely that voters would have taken this future legislation into account when voting for mayor. Thus the result of the 2004 municipal election and whether the party of the mayor aligned with the governor or not is arguably a quasi-exogenous indicator of a municipality's autonomy from the state government.

I use this result to look at the decisions of self-run municipalities whose election resulted in a mayor of the same party of the governor against those where there was not political alignment. The results are presented in Table 4. Self-run municipalities in which the mayor was not aligned with the governor's party as a result of the election had larger and more significant increases to their WS networks after the reform. This finding supports the notion that municipalities that were more autonomous from the state government - and thus more likely to have reduced investment if under the control of the state WS company - had a larger impact on investment decisions once the expropriation risk was removed.

All three of the previous tables provide evidence that the elimination of expropriation

risk by the state company was an underlying mechanism that resulted from the reform. On average, self-run municipalities increased the investment into their WS networks after the reform, and it is those municipalities that faced the higher uncertainty over expropriation risk that had the largest causal impact of the reform.

6.2 Robustness Checks of Main Result

In this section, I perform robustness checks to the main results from Table 1. These robustness checks address possible concerns over the preferred specification presented in this paper.

One concern is that the use of municipality and year fixed effects may not be capturing any *time varying* changes in characteristics of the state and municipalities. To address this, I run an alternative specification using municipality fixed effects and a state-specific time trend, shown in Appendix Table A3. The regression results in this specification are similar to those in Table 1, both in magnitude and significance for the non-attenuated investment categories. The investments that had the largest attenuation - *water* and *sewer* decrease in magnitude and lose their marginal statistical significance. I ran a similar regression employing municipality specific time trends, however these results are very non-significant. I attribute this to the fact that with a large number of municipalities, imposing a specific time-trend for each "soaks up" nearly all of the meaningful variation between the self-run and state-run municipalities.

Another potential concern is the timing of the legislation. While the bill was proposed in Congress in 2005, it was finally ratified as National Water Law 11.447 in January 2007. While there is a clear increase in investment from self-run municipalities starting in 2005 (and argued earlier in the paper as significant policy push by the Lula administration), one may think that the threat of expropriation was not fully removed until the bill became law. I run another DID specification in which $Reform_{mt}$ is equal to 1 for all years t after the passage of the law in 2007. Results of this specification are shown in Appendix Table A4.

The coefficients are comparable in magnitude and significance to the coefficients from the main specification. The coefficient for *Investment in Water* and *Investment in Sewer* are smaller in magnitude, with the water coeffcient losing its statistical significance. This result matches the observation that the federal PAC program, which targeted these highly visible infrastructure projects, was also introduced in 2007, and thus attenuated the difference in investment levels between self-run and state-run municipalities.

While the main specification's use of robust, clustered standard errors, year fixed effects, and controlling for base year conditions help to mitigate issues regarding serial autocorrelation, the largest concern to the causal estimates presented so far is the presence of spatial correlations.

The presence of potential spatial correlations is particularly relevant in this setting, as the construction and operation of water and sewerage networks can be greatly affected by geographic conditions. For example, the type and presence of different water sources (e.g. surface water, groundwater, under river flow) will dictate the amount and type of investment needed in the local water system. Soil and ground conditions will also affect the method and cost of installation of water/sewer pipes and other underground facilities. These examples and others suggest that the amount and types of investments made by WS companies could be clustered in certain geographic regions.

Moreover, the interconnected nature of a water and sewer network give further support to the increased possibility of spatial correlation among municipalities within a small geographic cluster.

While the empirical specification in Section 5 includes spatial fixed effects and standard errors clustered at the municipality level, this may not be enough to remove the spatial dependence (Anselin & Arribas-Bel, 2013). In order to address the possible spatial correlation more directly, I employ two different empirical strategies: creating buffer regions and using the spatial error model (SEM).

The first strategy to control for spatial correlation is to only compare those municipality

with state-run WS companies that are geographically near municipalities that provide their own WS service. This strategy is similar to (Heckert & Mennis, 2012) and should compare only those treatment and control groups that have similar (and unobserved) geospatial characteristics.

To run this approach, I calculate an exterior boundary buffer for all self-run municipalities using an 3rd-level administrative map provided by the IBGE. These buffer regions are of varying distances which are defined to be all areas within the designated distance from any point along the municipality's geographic boundary. For each given buffer distance, I then only include those state-run municipalty's that are (weakly) within the buffer zone.[20] Once the control group of CESB municipalities is generated, I run the same estimating question as before.

Table 5 shows the estimation results for four buffer distances: 10km, 25km, 50km, and 100km. The results are very similar to the coefficient estimates in Table 1 in both magnitude and significance. Moreover, these estimates become larger and more similar to the main result as the buffer zone increases.

The second approach I take is to explicitly structure the error relationship using the spatial error model (SEM).[21] In this model, I construct a error weighting matrix E using the inverse-distance rule of spatial dependence. That is, municipalities that are closer to each other will have great spatial dependence, and this dependence decays at a rate of the inverse of the distance between the two. Formally, the estimating equation is:

$$y_{mt} = \alpha + \beta MuniCo_m + \delta Reform_{mt} + \gamma_s + \lambda_t + \mathbf{Z}'_{mt}\theta + \varepsilon_{mt},$$
$$\nu_{mt} = \lambda E\nu_{mt} + \epsilon_{mt}$$

[20]Note that a municipality with CESB service may be in multiple buffer zones, and the control group is then the set of all state-run municipalities that are in at least one buffer region.

[21]This approach is similar to the one employed by (Dubé, Thériault & Des Rosiers, 2014)

where λ is the spatial error coefficient, ϵ_{mt} is a vector of uncorrelated error terms, and E is the spatial weighting matrix, with the property that for municipality i and municipality j with associated distance between them of $dist_{ij}$, the ij entry of E is given by $E_{ij} = 1/dist_{ij}$.

As in the main specification, δ is the coefficient of interest, with its interpretation identical to that in Section 5. Due to limitations in the non-linear estimation, this specification includes state fixed effects (γ_s) and thus requires the dummy variable $MuniCo_m$ that is equal to 1 is municipality m's WS network is run by a municipal-level company.[22] The vector of controls, $\mathbf{Z}_{mt}$, includes base year levels of WS investment, as well as population of GDP measures.

Table 6 shows the estimates of the result of the legislative reform on investments using the SEM specification. We see that the main findings of the paper are robust to the use of a spatial error structure, with the estimates of the effect of Bill 5.296 on the investment decision of municipality-run companies to be of similar magnitude and significance.

6.3 Access to WS System

I also study whether this increase in invest by municipality-run WS companies had any effect on network service or access. I employ a modified version of the difference-in-differences empirical strategy outlined in Section 5, with the year indicator variable being defined as two years after the proposal of Bill 5.296/2005 in Congress. This two year lag is taken to account for the time needed for investment projects begun after the reform to become active and enter into network use.

Table 7 displays the results for access to the water and sewer network. Access to the water network is measured by several variables available in the dataset that is presumed to have a direct impact on the number of potential users of the water system. The variables include information on the number (and type) of connections to the system, as well as the overall length of the water pipe network.

[22]The sem regressions were run using the SPMLREG program in Stata12. See (Jeanty, 2013).

We see from the table that the increase in investment by municipality-run WS companies resulted in significant increases in the number of water connections across all types, 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 networks pipes, although the magnitude of this increase represents a modest growth of approximately 6.3% compared to pre-reform average water network length for self-run municipalities.

The bottom panel of Table 7 shows corresponding results for variables related to access of the sewer system. 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 16.3% increase from average pre-reform levels.

7 Conclusion

This paper generates significant insight in the role that ambiguity in intra-governmental relations can have in public resource provision. Using an administrative panel dataset on the Brazilian water and sanitation sector, I find that legal reforms which strengthen residual property rights and decrease expropriation risk between the various levels of government have large impacts on investment in public utilities. Results suggest that post-reform, municipalities with self-run, local WS companies almost doubled their network investment. Moreover, this increased investment was funded by both debt and self-financing. I find evidence that this increase in investment led to an increase in access to the WS system in these municipalities. I also find evidence that this increased investment resulted in increased access to both the water and sewerage networks.

By incorporating the literature on incomplete property rights into the work on federalism and public goods provision, this paper provides insight on an alternative policy tool that can be used to increase investment in this crucial welfare sector. The evidence in this paper suggests that, rather than large scale, capital-intensive investment campaigns by fed-

eral governments and international agencies, countries can focus on passing legal reforms to strengthen property rights among governmental stakeholders. This institutional reform can achieve similar increases in investment in public goods. Moreover, a strong institutional framework would help maintain the large scale investments from conventional outside sources, as any large-scale investment without the accompanying decrease in intra-governmental expropriation risk would have sub-optimal maintenance strategies by the operating authorities.

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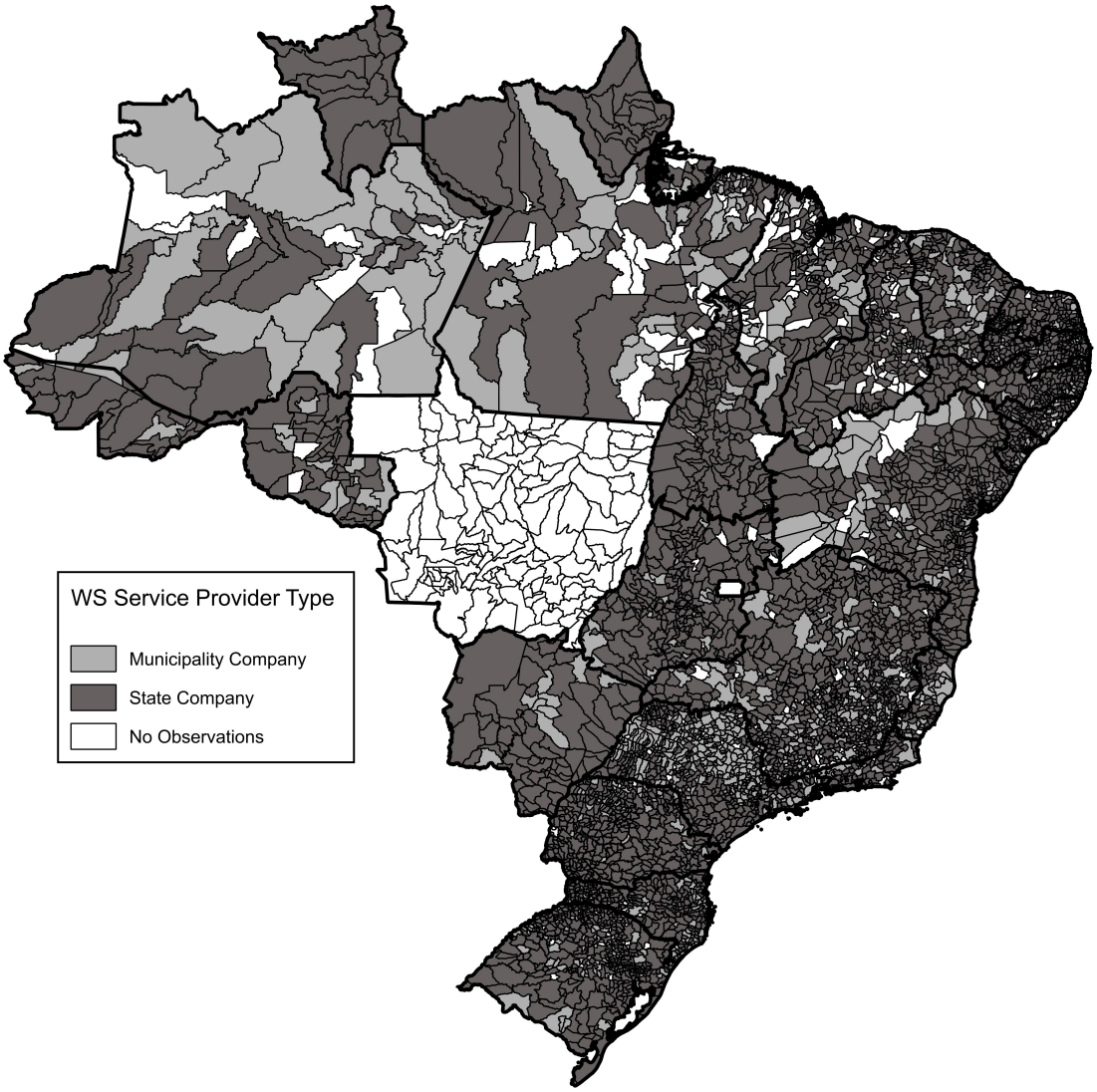
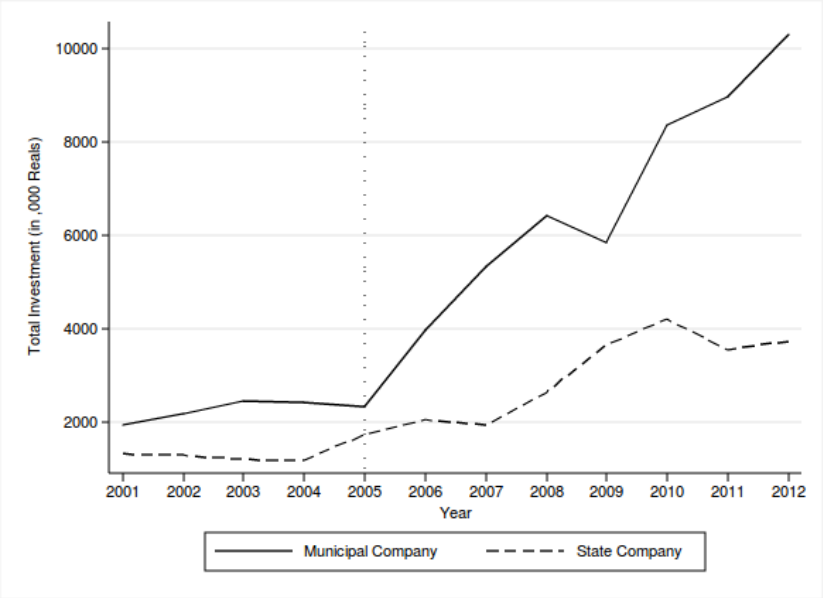
Figure 1: WS Provider Type by Municipality



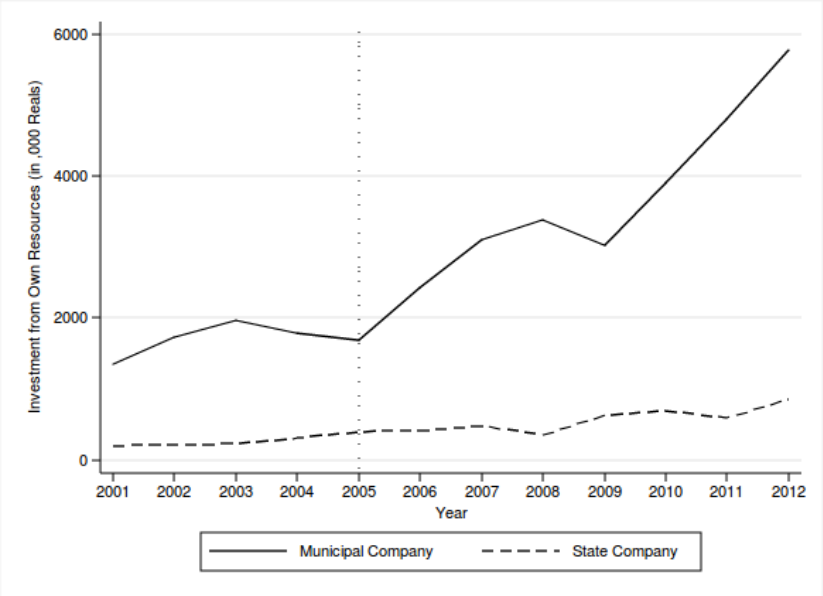
Notes: This map shows the breakdown of Brazilian municipalities by type of WS provider. Municipalities for which there are no observations are shaded in white. Bold lines indicate the division Brazilian states. The state of Mato Grosso (in central-west Brazil) eliminated its state WS company in 1998 and thus is not included in the analysis. The Brasilia Federal District is also excluded from the analysis. Data on WS company type is provided by the Ministry of Cities, and the administrative boundary map is provided by IBGE.

Figure 2: Total Investment



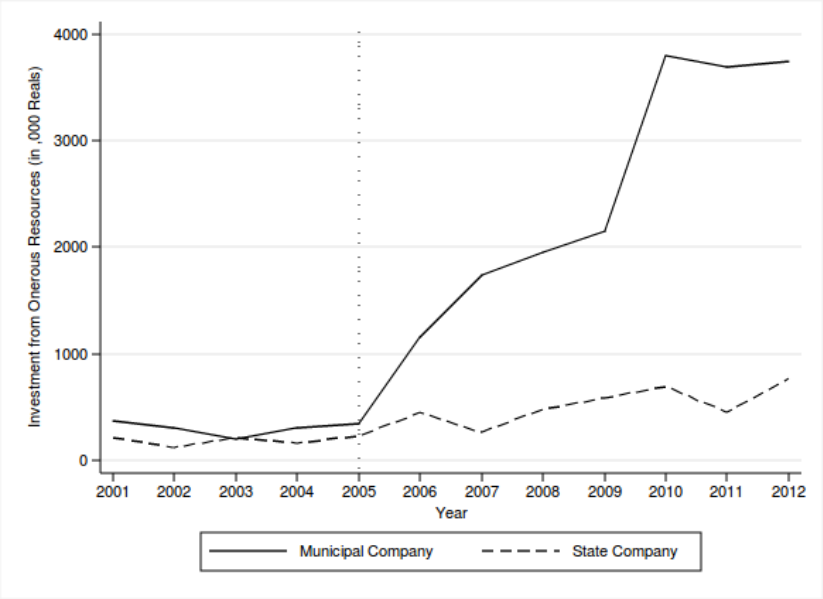
Notes: This graph shows the average total investment level in the municipality by each type of WS company for a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities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

Figure 3: Investment from Own Resources



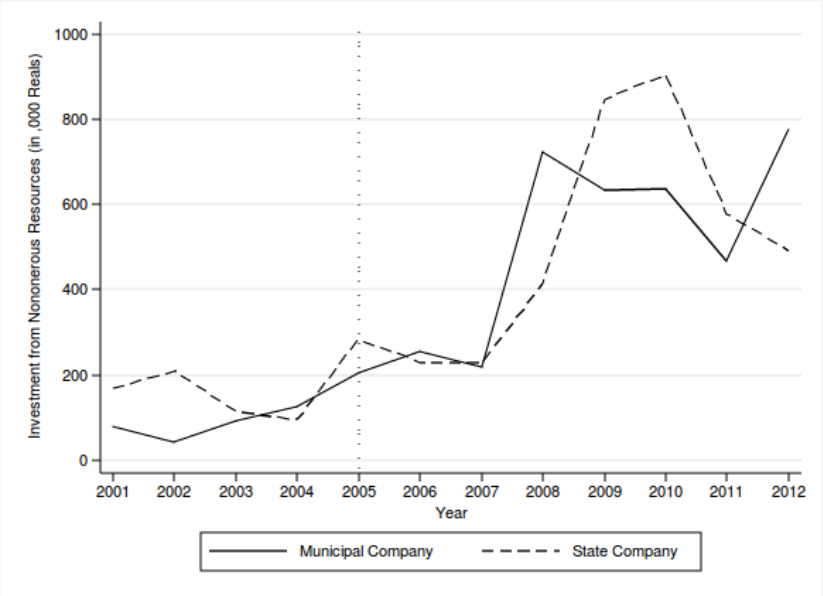
Notes: This graph shows the average investment via own resources in the municipality by each type of WS company for a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed

Figure 4: Investment from Onerous Resources



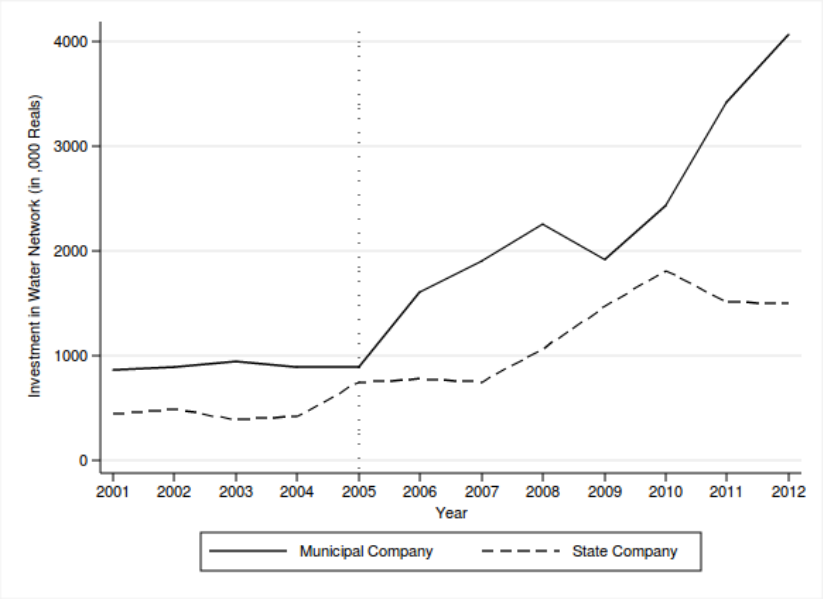
Notes: This graph shows the average investment via onerous resources in the municipality by each type of WS company for a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed

Figure 5: Investment from Nononerous Resources



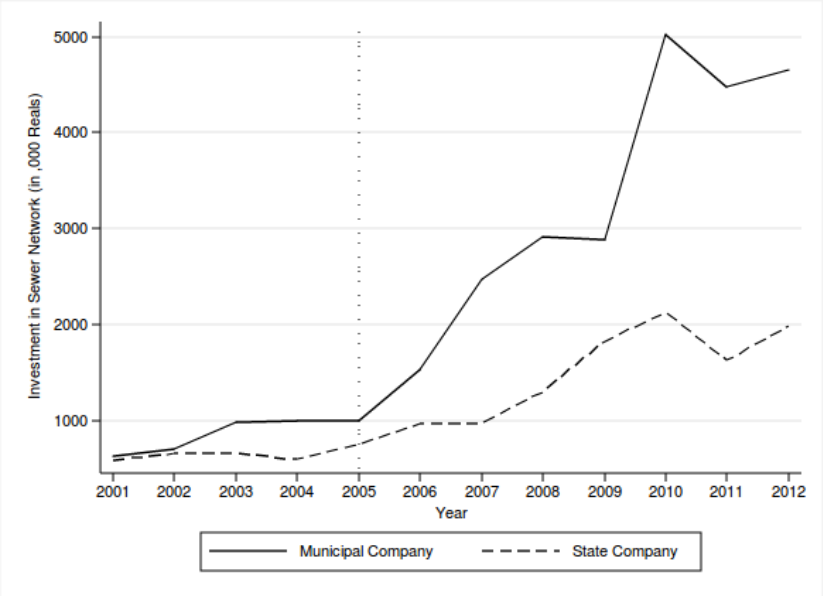
Notes: This graph shows the average investment via nononerous resources in the municipality by each type of WS company for a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average 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

Figure 6: Investment in Water Network



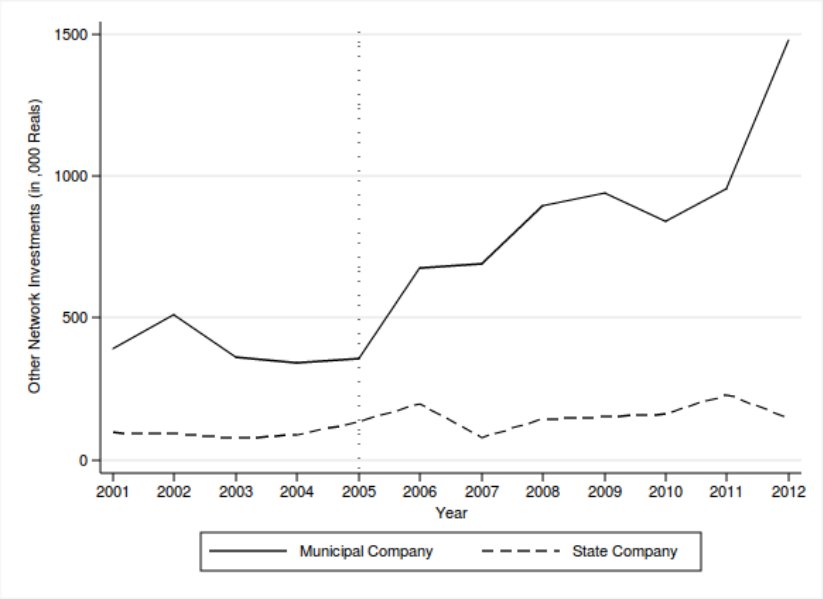
Notes: This graph shows the average investment in the water network in the municipality by each type of WS company for a given year. The solid line represents the average yearly value of investment for all municipalities that self-provide WS service. The dashed line represents the yearly average across all municipalities that have WS services provided by state companies. The vertical dotted line depicts the year the Bill 5.296/2005 was proposed

Figure 7: Investment in Sewer Network



Notes: This graph shows the average investment in the sewer network in the municipality by each type of WS company for 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

Figure 8: Other Network Investments



Notes: This graph shows the average investment in the general WS network in the municipality by each type of WS company for 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

Table 1: WS Investment

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,970**	1,775***	1,973**	10.60	818.0*	1,683**	467.6***
	(1,225)	(459.8)	(823.8)	(164.7)	(439.8)	(852.0)	(140.5)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.609	0.439	0.462	0.612	0.652	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes), and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 2: WS Investment by Metropolitan Area

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company in	4,573**	2,397***	2,770**	236.1	1,241*	2,786*	510.3**
Metro area, Post-reform	(2,236)	(877.2)	(1,386)	(261.6)	(730.5)	(1,626)	(226.1)
Self-run company not in	1,653	1,264***	1,319	-174.5	471.0	778.0	432.6**
Metro area, Post-reform	(1,142)	(413.6)	(960.5)	(146.9)	(418.0)	(752.8)	(173.8)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.610	0.440	0.462	0.612	0.652	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes), and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 3: WS Investment by Share of State GDP

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company with	7,800**	3,085***	5,331**	194.0	2,366**	4,837**	670.0**
High share of State GDP, Post-reform	(3,184)	(1,148)	(2,276)	(320.0)	(996.0)	(2,349)	(295.0)
Self-run company with	478.8	1,099***	241.4	-83.98	19.93	57.45	363.3**
Low share of State GDP, Post-reform	(612.1)	(342.1)	(244.4)	(147.1)	(305.5)	(293.3)	(145.8)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.611	0.445	0.462	0.613	0.653	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes), and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 4: WS Investment by 2004 Municipal Election Result

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company with	3,271**	1,899***	2,218**	-86.85	682.7*	2,065*	480.1***
Different Party, Post-reform	(1,506)	(586.3)	(1,044)	(170.1)	(397.2)	(1,126)	(177.5)
Self-run company with	2,137	1,432**	1,295	280.1	1,192	627.5	433.1**
Same Party, Post-reform	(1,760)	(595.9)	(1,104)	(298.3)	(1,088)	(672.6)	(190.1)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.610	0.440	0.462	0.612	0.652	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes), and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 5: WS Investment with Buffer Zones

		10km Buffer Zone					
		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,795*	1,755***	1,859**	-720.1	432.8	2,052**	491.0***
	(1,436)	(480.8)	(883.0)	(522.2)	(768.7)	(896.2)	(142.6)
Observations	4,412	4,412	4,412	4,412	4,412	4,412	4,412
R-squared	0.465	0.602	0.353	0.389	0.386	0.373	0.344
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		25km Buffer Zone					
		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,772**	1,661***	1,575*	-512.1	534.6	1,773**	461.4***
	(1,377)	(479.6)	(920.4)	(372.4)	(622.8)	(898.8)	(148.8)
Observations	5,756	5,756	5,756	5,756	5,756	5,756	5,756
R-squared	0.545	0.646	0.442	0.393	0.413	0.463	0.438
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		50km Buffer Zone					
		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	3,011**	1,726***	1,735**	-346.1	790.2	1,689*	484.0***
	(1,279)	(467.9)	(878.9)	(291.0)	(501.8)	(882.1)	(145.8)
Observations	7,735	7,735	7,735	7,735	7,735	7,735	7,735
R-squared	0.571	0.643	0.439	0.463	0.413	0.529	0.431
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		100km Buffer Zone					
		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,476*	1,734***	1,935**	-105.5	581.1	1,439*	456.1***
	(1,287)	(463.4)	(834.2)	(198.5)	(505.9)	(866.7)	(142.6)
Observations	11,987	11,987	11,987	11,987	11,987	11,987	11,987
R-squared	0.736	0.617	0.435	0.459	0.611	0.653	0.520
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Panels A, B, C, and D include as the control group those municipalities with state-run WS service which are within 10km, 25km, 50km, and 100km of a self-run municipality's boundary, respectively.
Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes), and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 6: WS Investment (Spatial Error Model)

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,955***	1,799***	1,996***	8.706	784.3**	1,707***	474.6***
	(584.0)	(146.6)	(233.4)	(203.3)	(357.9)	(323.6)	(67.89)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
Adj. R-squared	0.690	0.450	0.268	0.310	0.532	0.599	0.446
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Investment levels are measured in ,000s Reals. Control variables include data on population, municipal gdp in the base-year 2001, and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. SEM standard errors are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table 7: WS System Access

	Water Network				
	Number of Water Connections - Total	Number of Water Connections - Active	Number of Water Connections - Metered	Number of Households with Water Connection	Water Network Length
Self-run company,	2,854**	2,243**	2,770***	3,114**	34.30***
2 years post-reform	(1,176)	(1,092)	(910.1)	(1,477)	(10.50)
Observations	15,169	15,256	15,262	15,283	15,192
R-squared	0.986	0.987	0.990	0.989	0.316
Muni FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

	Sewer Network				
	Number of Sewer Connections - Total	Number of Sewer Connections - Active	Number of Sewer Connections - Metered	Number of Households with Sewer Connection	Sewer Network Length
Self-run company,	4,191***	3,748***	5,206***	4,552***	60.08***
2 years post-reform	(1,132)	(1,064)	(1,527)	(1,413)	(19.90)
Observations	15,169	15,256	15,262	15,283	15,192
R-squared	0.986	0.987	0.990	0.989	0.316
Muni FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

This table reports the results of six OLS regressions. Length of water network is measured in km. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes) in the base-year 2001, and base-year 2001 investment levels. Panel is balanced for the period 2001-2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Appendix Tables

Table A1: WS Investment - No Controls

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	2,970**	1,775***	1,973**	10.60	818.0*	1,683**	467.6***
	(1,225)	(459.8)	(823.8)	(164.7)	(439.8)	(852.0)	(140.5)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.609	0.439	0.462	0.612	0.652	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No	No	No

This table reports the results of eight OLS regressions. Each column corresponds to a different dependent variable relating to type of WS investment in a given municipality. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table A2: WS Investment - Unbalanced Panel

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	1,426**	984.9***	918.8**	32.70	391.7*	795.2*	255.5***
	(626.3)	(249.7)	(393.3)	(116.8)	(234.6)	(425.9)	(69.44)
Observations	43,290	43,290	43,290	43,290	43,290	43,290	43,290
R-squared	0.733	0.595	0.435	0.445	0.611	0.644	0.520
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes) in the base-year 2001, and base-year 2001 investment levels. Panel is unbalanced and includes all municipalities that enter the dataset in any year between 2001 and 2012. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table A3: WS Investment - State Specific Time Trend

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-reform	1,838	1,688***	2,083**	94.66	363.6	1,014	396.4***
	(1,485)	(450.1)	(848.2)	(149.8)	(647.9)	(923.3)	(130.2)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.741	0.614	0.444	0.472	0.618	0.655	0.522
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes) in the base-year 2001, and base-year 2001 investment levels. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.

Table A4: WS Investment - Legislation Passage Date

		Source of Investments			Destination of Investments		
	Total Investment	Own Investment	Onerous Investment	Nononerous Investment	Investment in Water	Investment in Sewer	Other Investments
Self-run company, Post-Legislation	3,029**	1,891***	2,100**	8.187	777.0	1,797*	491.0***
	(1,426)	(496.2)	(932.1)	(209.1)	(557.3)	(1,052)	(164.3)
Observations	16,152	16,152	16,152	16,152	16,152	16,152	16,152
R-squared	0.737	0.610	0.440	0.462	0.612	0.652	0.519
Muni FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Investment levels are measured in ,000s Reals. Control variables include data on population, geographic characteristics (latitude, longitude, area), municipal finances (gdp, gva, taxes) in the base-year 2001, and base-year 2001 investment levels. Robust standard errors clustered at the municipality level are shown in parentheses.
*** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.