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Water Nationalization and Service Quality

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Abstract

The objective of this paper is to explore the impact of Uruguay's privatization and subsequent nationalization of water services on network access and water quality. The results suggest that although the early privatization of water services had little impact on access to the sanitation network, the subsequent nationalization led to an increase in network access at the bottom of the income distribution as well as an improvement in water quality.

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Water Nationalization and Service Quality

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In the 1970s, the government's role as the provider of basic services in sectors with a natural monopoly component, such as the water supply and sanitation, was rarely questioned. Indeed, it was thought that private firms were likely to abuse their monopoly power in this type of market because they would concentrate their supply on rich households, leaving poor households without access to basic services. However, public companies would have incentives to ensure access to the maximum number of potential voters (at least in democracies).

By the late 1980s, the weak economic performance and low productivity of many public companies around the world changed this view (World Bank, 2004). Poor management practices due to political agendas rather than profit-oriented motives shed light on the substantial inefficiencies and poor service quality provided by these public companies. In the 1990s, the privatization of water services was perceived by some as a potential solution to the poor performance of publicly owned water monopolies that left more than one billion people in developing countries without access to clean and safe water and 40 percent of the world's population without access to safe and clean sanitation services (Segeredt 2005). In its Human Development Report of 2006, the UNDP notes, "not having access to water and sanitation is a polite euphemism for a form of deprivation that threatens life." Additionally, Galiani *et al.* (2005) provide empirical evidence that a transition toward privatized water services in Argentina in the 1990s led to a rapid decline in child mortality.

France was an early example of a country with privately provided water services. Throughout the 1990s, many countries privatized water services, beginning with England in 1989 and followed by Eastern European and Latin American countries. A few Asian and African countries followed in the mid- and late 1990s (Hall, Lobina, and Corral 2010). Nevertheless, the share of public water companies is still very large.[1] This share has increased over the last 10 years as negative reactions to privatization occurred in many countries.

Uruguay is a recent example of this reversal. Until 1993, all water services in Uruguay were publicly owned, with the exception of a few small, community-based private companies that operated in the Department of Canelones since the 1940s in areas that the public company did not serve.[2] In 1993, the initial wave of privatization was implemented in the Department of Maldonado, affecting approximately 3,000 customers. A second, larger wave of privatization followed in the same department, affecting over 20,000 customers, including some in the capital of Maldonado. The privatization was reversed in 2004 when an amendment to the Uruguayan constitution was passed declaring water "part of the public domain." The private provision of water was made illegal.[3]

The apparent reasons for Uruguay's renationalization of water companies were no different from those observed in other Latin American countries in the last decade (e.g., Bolivia, Argentina, Brazil). The privatization of water services did not achieve the promised results.[4] Private companies became deeply unpopular due to perceptions of low or declining water quality as well as the high prices charged by private companies. A series of highly publicized episodes of low quality water supplied by Uragua and Aguas de la Costa (subsidiaries of the Spanish water companies Aguas de Barcelona and Aguas de Bilbao) led (as early as 2003, in the middle of a financial crisis) to the well-publicized request by the then-Minister of Economics and Finance, Alejandro Atchugarry, for Uragua to leave the country.

Whether public or private water provision leads to better access and quality is an empirical question. The objective of this paper is to explore the impact of the privatization and subsequent nationalization of water services on water quality (microbiological and inorganic tests) and access to sanitation networks (the percentage of households with water-sealed toilets connected to sewer lines) in Uruguay.

Studying Uruguay's water services is interesting because household access to Uruguay's piped sewerage network is particularly low compared to countries at similar levels of development. With an access rate below 50 percent, Uruguay performs poorly relative to other Latin American countries, such as Chile, Colombia, Mexico, and some comparable Brazilian states, in terms of income per capita. Additionally, as in many other Latin American countries, issues regarding the quality of water provided by private companies were part of the reason for nationalization.

The existing empirical evidence on the impact of privatization on water quality and access is relatively small and tends to suggest that privatization either has a positive impact or no impact. Barrera-Osorio, Olivera, and Ospino (2009) use a difference-in-difference methodology to assess the impact of water privatization in Colombia on several outcomes, such as coverage (the percentage of households connected to water services) and water quality (the frequency of the service and characteristics of the water, such as its color). They find that in urban areas, water access increases and water quality improves as a result of privatization, whereas negative effects on access are detected in rural areas. This finding is consistent with the notion that as water services are privatized, the poorest consumers may be left behind.

In a developed country context, Wallsten and Kosec (2005) analyze the effects of water ownership on water quality, measured as the number of violations of the Safe Drinking Water Act in the United States between 1997 and 2003. Using panel data at the community level and controlling for community fixed effects, they find that ownership is irrelevant with respect to compliance with the Safe Drinking Water Act. This result may have been observed be because the study was conducted in a developed country with high income levels and a strong demand for high quality water.[5]

Moreover, an important body of literature examines the impact of the privatization of water services on child mortality in developing countries. Child mortality is an indirect measure of water quality, but increases in water access and quality have been demonstrated to be negatively associated with child mortality (Lee, Rosenzweig, and Pitt 1997; Shi 2000; Galdo and Bertha 2005). Using a panel data framework, Galiani, Gertler and Schargrodsky (2005) provide convincing evidence that in

Argentinean municipalities where water services were privatized, the incidence of child mortality from water-related diseases declined significantly (whereas the incidence of child mortality for other reasons remained stagnant). They therefore provide indirect evidence of improvements in water quality and access.[6]

The empirical methodology that we followed is similar to that employed in Galiani, Gertler, and Schargrodosky (2005). Using panel data for the periods surrounding the episodes of privatization and nationalization, we identify differences in sanitation rates between regions that first privatized their water suppliers and later nationalized them and those that did not using a difference-in-difference estimator.[7] Our study has at least two important differences from Galiani, Gertler and Schargrodosky (2005). First, as explained above, we focus on the nationalization of water services, not only on their privatization. Second, our dependent variables are direct measures of the quality of service provided by water companies (access to and quality of water). Health outcomes are important, particularly child mortality, but they tend to be determined by many external factors other than water services. In a middle-income country such as Uruguay, child mortality is rarer than in low-income countries. Therefore, water quality may improve dramatically without any observable change in child mortality.[8] Direct measures of the quality of water services seem more appropriate in such a context.

Our results suggest that although the earlier privatization period had little impact in terms of access to the sanitation network, the nationalization of water services had a positive and statistically significant impact on access, particularly among households in the bottom 25 percent of the income distribution. Nationalization also seems to have led to improved water quality. Indeed, the impact of nationalization on the detection of abnormal levels in microbiological and inorganic water tests is consistently negative and has a relatively large coefficient.

It is important to note that although it may be tempting to conclude from our results that the public sector can provide water services as well as or better than the private sector, this conclusion cannot be supported on the basis of our empirical evidence. Indeed, the control group in our difference-in-difference strategy includes cities that were consistently served by public companies, making it impossible to answer such a question.[9] What the results suggest is that the privatization of water companies had little impact in terms of network access, confirming the public opinion that privatization did not deliver the promised results. However, the subsequent nationalization of the water companies delivered progress in terms of both network access and water quality relative to those companies that were consistently publicly owned. This finding contradicts most of the existing evidence for developing countries, which generally shows that water privatization leads to improved service quality.

The reminder of the paper is organized as follows. The next section describes the water system in Uruguay. Section II discusses the empirical methodology, and section III presents the data and some descriptive statistics. Section IV presents the results, and section V concludes.

<<A>>*I. THE WATER SYSTEM IN URUGUAY*

Until the early 1990s, water and sewage services in most of the country were exclusively provided by a publicly owned company, called Obras Sanitarias del Estado (OSE), except for a series of small, community-based providers that were created in the 1940s by residents with the objective of fostering land sales in the area of El Pinar in the Department of Canelones. The largest of these community-based providers was Aguas Corrientes El Pinar, which served fewer than 1,000 clients in the 1990s and only had 12 full-time staff.

In 1993, the first privatization of water services previously provided by OSE occurred in the Department of Maldonado. The new company, Aguas de la Costa, supplied water and sewage in the wealthier areas of La Barra, Manantiales, and José Ignacio, which are to the east of the internationally known resort of Punta del Este. This was a joint venture between a local company, S.T.A. Ingenieros and Benecio S.A., which had approximately 10 percent ownership, and the Spanish company Aguas de

Barcelona, a subsidiary of Suez Lyonaisse des Eaux, which owned the rest of the company. Aguas de la Costa signed a 25-year concession in 1993. The company had approximately 3,100 customers.

A second water service privatization occurred in 2000. Uragua began providing water and sewage services in urban and suburban areas of Maldonado. Maldonado has 150,000 of the 3,300,000 inhabitants of Uruguay. Uragua served the area west of the Maldonado stream, with the exception of the city of Aiguá. Specifically, Uragua served the capital of Maldonado (50,417 inhabitants), San Carlos (23,878), Pan de Azúcar (6,969), Piriápolis (7,579), Cerros Azules, Nueva Carrara, Pueblo Gerona, West of River Solís, Silver River, Highway 9 North, and Punta del Este (7,298 inhabitants).[10] Uragua was owned by Aguas de Bilbao, a Spanish water provider.

Thus, by 2000, only the city of Aiguá in Maldonado was served by OSE, and all other jurisdictions in Maldonado were served by two private companies, Uragua and Aguas de la Costa. OSE had an exclusive monopoly in the rest of the country, except for the area of El Pinar, which was served by small, community-based providers. OSE accounted for over 90 percent of all connections.

In 2004, Uragua began litigation with OSE because of a breach of contract following some well-publicized episodes of colored water in Maldonado. This led to a referendum, which declared water to be part of the public domain, and an amendment to the Uruguayan constitution. Uragua and the Uruguayan government reached an agreement, and all of Uragua's assets were transferred to OSE by the end of 2005. After the agreement with the government, the company left the country in 2005. Aguas de la Costa's assets were transferred to OSE in 2005. Aguas Corrientes el Pinar was nationalized in December 2006, and its assets were also transferred to OSE.

Maldonado was particularly affected by the return to nationalization. At the turn of the century, the only city in Maldonado served by the publicly owned OSE was Aiguá, with 2,676 inhabitants. By 2006, OSE was the only provider of water services in Maldonado.

Our empirical analysis will therefore focus on the change of ownership in the Department of Maldonado because we do not have data at the city level for the small, community-based providers in the Department of Canelones. As discussed in the data section, when examining the impact of the privatization and subsequent nationalization of water services on network access, our treated group is restricted to three cities due to data availability, Maldonado, Pan de Azúcar, and San Carlos. We use 32 cities as a control group, including the 19 departmental capitals (except Maldonado) and other large cities. In our examination of the impact on water quality, we use six treated cities in the Department of Maldonado: Maldonado, Pan de Azúcar, Piriápolis, Punta Ballena, Punta del Este, and San Carlos. The control group has 26 cities, including all departments' capitals except Maldonado.

Table 1 presents the evolution of some indicators for the public company OSE before and after nationalization. Note that the number of employees did not change substantially following nationalization. This is important because we do not wish to attribute any change in the performance of the water companies to a change in the composition of the workforce due to layoffs at the time of nationalization. The absence of layoffs was confirmed through interviews with the managers of the water company, which indicated that only the top managers of the nationalized companies were removed by OSE. As expected, the volume of water produced increased following nationalization because the water service coverage increased. Moreover, the population served with sewerage rose from 531,300 in 2004 to 729,100 in 2006. Total gross fixed assets (including work in progress) increased sharply (by approximately 38 percent) between 2004 and 2006. This increase was partly due to the acquisitions of the private companies and partly the result of new infrastructure investments made through a sanitation project supported by the World Bank following nationalization. Finally, OSE's prices increased sharply in 2003 during the privatization period and then remained stable following nationalization. Note that these are the prices of the public company, but during the privatization period, there were no major differences between the prices of public or private companies because the prices were controlled by the Uruguay Energy and Water Services regulator (URSEA).

<<place table 1 about here>>

<<**A**>>*II. METHODOLOGY*

The identification strategy we followed is similar to that employed by Galiani *et al.* (2005), who searched for systematic differences in changes in child mortality rates between regions that have privatized and those that have not changed the ownership structure of water companies using a difference-in-difference approach.[11] We followed their approach but used a double treatment that included the privatization of water providers in some cities and their subsequent renationalization.

Selection bias due to cherry picking at the moment of privatization is an issue in this framework. Governments may decide to privatize companies in cities that are more profitable and have better prospects to maximize the short-run financial benefits of privatization. If profitability positively affects performance over time (i.e., performance is serially correlated), we will observe that nationalization will lead to a better-performing water company, but this effect will simply be due to the trend in the performance of water companies in that region. In this context, even if nationalization adversely affected performance, the estimation might not identify this effect because the treatment group includes a disproportionate number of utilities that perform well.

We address this issue, as we discuss in the data section below, using parallel trend tests for the outcome variables (access to sewage network and water quality) before privatization. In the absence of any difference in trends before privatization, there would be little evidence of cherry picking along these dimensions, and time fixed effects in our difference-in-difference specification can therefore control for these common trends.

Our econometric model is given by

(1) $$y_{it} = \phi N_{it} + \gamma P_{it} + x_{it}'\beta + \alpha_t + \alpha_i + u_{it},$$

where y_{it} is the outcome variable in city i in year t. We consider two different outcome variables: sanitation rates and water quality. The units of observation i are cities. The parameter N_{it} is a dummy variable that is equal to one after the renationalization in the three cities that were previously privatized. The parameter P_{it} is a dummy variable indicating that the water company in city i in period t is privately owned; x_{it}' is a vector of control variables; β is the corresponding vector of coefficients, α_t is a year effect; α_i is a city-specific fixed effect; and u_{it} is a city time-varying error (distributed independently across departments and time).

The parameters of interest are ϕ and γ, which measure the impact of the dual treatment of the privatization and the subsequent nationalization of water services. When the sanitation rate is the outcome variable, a positive value for ϕ or γ indicates that the nationalization or privatization of private companies led to higher sanitation rates relative to companies that were consistently publicly owned.

The water quality sample does not cover the preprivatization period, as discussed in the next section. Thus, when considering water quality tests (abnormal levels of microbiological and organoleptic elements) as the dependent variable, we only have one treatment, N_{it}. A positive coefficient implies that nationalization led to a higher number of tests with abnormal results relative to companies that were consistently publicly owned.

An important issue in panel data models is that observations tend to be correlated across time within individual cities. One possible solution to the serial correlation problem is to use robust standard errors clustered at the city level. In this context, asymptotic statistical inference depends on the number of clusters and time periods. A small number of clusters may result in biased (clustered) standard errors, tending to underestimate inference precision.

Bertrand, Duflo, and Mullainthan (2004) analyze the performance of the following alternative solutions to the serial correlation problem: 1) using parametric methods, that is, specifying an autocorrelation structure; 2) using the block bootstrap; 3) ignoring time series information, that is, averaging the data before and after treatment; and 4) using an empirical variance-covariance matrix. Bertrand, Duflo and Mullainthan (2004) find that the empirical variance-covariance matrix outperforms the others, but it does not work properly with small samples. Cameron, Gelbach, and Miller (2008) state that the block bootstrap works properly with small numbers of groups.[12]

In our case, bootstrapped, clustered standard errors are similar to clustered standard errors. In most cases, the latter method reports greater standard errors, and in some cases, conventional standard errors are larger than the latter method. As a conservative criterion, we decided to report the method with the largest standard errors in each case. Depending on the nature of the outcome variable, continuous, count, or fractional, we use different estimators that will be discussed in the results section.

<<**A**>>*III. DATA SOURCES AND VARIABLE CONSTRUCTION*

We begin by describing the data sources and variable construction for the analysis of the impact of nationalization on access to water sanitation networks. We then turn to the data sources and variable construction for the analysis of the impact of nationalization on water quality.

<<**B**>>*Access to sanitation networks*

The data regarding the percentage of households with water-sealed toilets connected to sewer lines are obtained from the annual Uruguayan national household survey, Encuesta Continua de Hogares (ECH), conducted by the National Statistical Office of Uruguay, Instituto Nacional de Estadística. The ECH is the main source of socioeconomic information on Uruguayan households and their members at the national level. The surveys were conducted throughout the year with the objective of generating a description of the socioeconomic situation of the entire population.

The ECH also includes questions about household living conditions. In particular, the survey asks whether water-sealed toilets are connected to sewer lines. Therefore, we generate a dummy variable that takes the value one if the household is connected to sewer lines and zero otherwise. Then, we aggregate the data by city to obtain the percentage of households with sanitation access in each city. We therefore consider panel data by city from 1986 to 2009. The time span includes the preprivatization period in the case of Maldonado because the two privatizations in Maldonado occurred in 1993 and 2000, as discussed above.

The ECH survey is only representative at the department level or at the city level for the largest cities in terms of population. Therefore, and to ensure a representative sample, we only retain the capital cities of the different departments and other large cities in our sample. We have a total of 35 cities, three in the treatment group (Maldonado, Pan de Azúcar, and San Carlos) and 32 in the control group (Artigas, Bella Unión, Canelones, Carmelo, Colonia, Dolores, Durazno, Florida, Fray Bentos, Lascano, Libertad, Melo, Mercedes, Minas, Montevideo, Paso de los Toros, Paysandú, Periferia Canelones, Rivera, Rocha, Rosario, Río Branco, Salto, San José de Mayo, San Ramón, Santa Lucía, Sarandí del Yí, Sarandí Grande, Tacuarembó, Tranqueras, Treinta y Tres, Trinidad, and Young).[13]

Because some of the selected cities were not surveyed in certain years (primarily in the older edition of the ECH), we have an unbalanced panel that may imply panel attrition bias. For instance, of the 24 time periods in the treatment group, Pan de Azúcar appears 15 times, and San Carlos appears 18 times. In the control group, we have observations for Lascano in 10 of the 24 time periods; for Bella Unión, Libertad, and Rosario in 12 of the years; for Santa Lucía in 15 of the years; for Carmelo, Dolores, Paso de los Toros, Río Branco, San Ramón, Sarandí del Yí, and Sarandí Grande in 17 of the years; and for Young in 18 of the years. Therefore, we have a total of 735 observations.[14] Some cities began to appear in the ECH because of their rapid population growth; therefore, we checked the robustness of results to a smaller subsample in terms of the time span from 1993 to 2009.

Two observations must be made. First, there are far more control cities than treatment cities; hence, we also estimate our model restricting the number of controls to capital cities alone. The sanitation data for each capital city are available in every year of the full period; hence, in this instance, the panel attrition problems may be solved. Second, because we lose observations as we drop cities, small sample bias is a potential issue. Thus, a tradeoff exists between small sample bias and the potential for panel attrition bias, which provides some robustness checks for our results.

The top panel of table 2 provides descriptive statistics by treatment and control groups for the network access sample before and after privatization and nationalization. Overall, the treatment and control groups present similar characteristics with relatively small differences, on average, although they tend to be statistically significant. It will therefore be important to control for these characteristics in our econometric analysis.[15] More important, the network access rates are not significantly different between treated and control cities before privatization and before nationalization. However, treated cities have a statistically larger network access rate following nationalization. Whether this larger network access rate can be attributed to a causal effect will be addressed using the difference-in-difference method described in the previous section.

<<place table 2 about here>>

As discussed above, a concern one may have with our methodology is that although, on average, network access rates in control and treated cities did not differ before privatization (and nationalization), they may have had different trends, which would bias our estimates of the impacts of privatization and nationalization. To address this issue, we performed a test of parallel trends for the period before the privatization. Thus, we introduce a time trend in the specification of equation (1) and check for its statistical significance. The results of the different specifications and samples are reported in table 3. In all columns except D, the coefficient on the time trend for treated cities is statistically insignificant, suggesting that treated and control cities had common trends before and after privatization.[16] In column D, where we only use departmental capitals as treated and control cities, the coefficient is negative and statistically significant. This result would be a concern if we were to find that the nationalization or privatization of water services led to a decline in network access, which could be explained by its trend before the change of ownership. However, as discussed in the results section, we find that network access increased before nationalization; therefore, the differences in trends could only downward bias the estimated positive impact of the nationalization.

<<place table 3 about here>>

<<B>>*Water quality tests*

The data on water quality come from URSEA. In 2004, URSEA created a water quality unit, in partnership with the chemistry department of University of La República, which was charged with monitoring the water supply system nationwide according to the guidelines of the World Health Organization. This unit conducts a number of water tests (in the distribution network) to measure the quality of the water provided to consumers.

Our units of observation are cities from Uruguay’s 19 departments. We use data for the 2004–2009 period, but some observations are missing for some of the cities. As treatment cities, we use Maldonado, Pan de Azúcar, Piriápolis, Punta Ballena, Punta del Este, and San Carlos. We use the following control cities: Artigas, Canelones, Colonia, Dolores, Durazno, Florida, Fray Bentos, La Paloma, La Paz, Las Piedras, Melo, Mercedes, Minas, Montevideo, Pando, Paysandú, Progreso, Rivera, Rocha, Salto, San José, Atlántida, Tacuarembó, Toledo, Treinta y Tres, and Trinidad.[17]

We use data for two different microbiological tests and two organoleptic tests that we will use as outcome variables because of their importance in terms of direct and indirect negative effects on health. The two microbiological tests are for fecal coliforms and pseudomonas aeruginosa. The two organoleptic tests are pH and cloudiness tests.

The first test indicates whether the fecal coliforms exceed the accepted maximum value. The second test indicates whether pseudomonas aeruginosa is present. In the case of organoleptic tests, the water quality unit reports the observed value. In the case of pH tests, the upper limit is 8 mg/L, and higher levels are considered abnormal. The upper limit in the cloudiness test is five; hence, a result greater than or equal to this value represents a high level of cloudiness in the water, which could indirectly affect health via a higher likelihood of bacteria formation and a reduction in the quantity of water consumed.

The outcome variable that captures abnormal levels of microbiological or organoleptic substances is constructed as follows. For each test, we generate a dummy variable that takes the value one if the test is above the accepted limit and zero otherwise. We then sum these four binary variables to create a count variable that measures the number of tests that showed abnormal levels in each city.

A potential drawback of these data is that the tests have improved and become more precise over time, making it possible to detect abnormal levels of substances more frequently. Thus, our estimates may be biased because we would observe a deterioration of the water quality throughout the period as a result of the improved testing techniques rather than the poor water quality. This issue is addressed in our econometric framework through the use of year fixed effects as control variables.

In the bottom panel of table 2, we provide descriptive statistics by treatment and control groups. It is important to note that there was no statistically significant difference in the count of abnormal results between treated and control cities before nationalization, whereas after nationalization, the count of abnormal results was significantly lower in treated cities.[18] This result seems to be driven by a lower count of abnormal levels of cloudiness and pseudomonas aeruginosa. Note that we cannot perform a test of parallel trends because we only have two periods (2004 and 2005) before nationalization in the water quality sample. The nationalization dummy therefore takes the value one in treated cities between 2006 and 2009 and zero otherwise. Note also that we do not have data for the preprivatization period. We therefore cannot control for privatization in treated cities because the privatization and nationalization of water services would be perfectly collinear with the city fixed effects.

<<**A**>>*IV. RESULTS*

We begin by discussing the results of the estimation of equation (1) when access to sanitation rates is the outcome variable. We then turn to the estimates obtained when water quality is the outcome variable.

<<**B**>>*Access to sanitation networks*

We estimate equation (1) for different subsamples, with and without control variables. Because the left-hand variable is a fractional variable (percentage of households with water-sealed toilets connected to sewer lines), we use a Papke and Wooldridge (2008) estimator. Control variables include average completed years of education of the head of the household and average real per capita household income at the city level as well as accumulated precipitation at the department level. We expect the three control variables to be positively correlated with the sanitation rate.

Table 4 presents the results. There is a positive and statistically significant impact of nationalization on sanitation rates in all subsamples and specifications. A positive effect means that cities in which water services were nationalized experienced an increase in access to sanitation networks. The coefficient that captures the causal impact is 0.15, on average, which means that nationalization led to a 15 percent increase in access to sanitation networks. However, the impact of privatization is never statistically significant, except in column D, where the coefficient is negative and statistically significant. This result suggests that in cities where sewer services were privatized, there was no increase in sanitation access rates relative to the preprivatization period.[19] Note that these results need to be interpreted with caution because we only have three treated cities in columns A and B and only one treated city in columns C and D because of the data constraints discussed in section III. However, the low number of treated cities makes it more difficult to identify a statistically significant coefficient, as discussed in McKenzie (2012), which is not the case for the impact of nationalization in the results reported in table 4.[20]

<<place table 4 about here>>

To determine whether the increase in access to sanitation networks occurred where we expect (i.e., among poor households), we aggregate the data at the city level using only the lower 25th household income percentile in one case and the higher 25th in the other.[21] We then append these data and introduce a dummy variable that indicates that the observation corresponds to the bottom 25 percent of the income distribution as well as interaction variables between this dummy and the nationalization and privatization dummies. A positive coefficient of the interaction of the bottom 25 percent income dummy and the nationalization dummy would indicate that poor households experienced a larger increase in their network access rate after nationalization. Table 5 presents the results for the four different samples with and without using the education level of the head of the household, household per capita income, and accumulated precipitation. Without these controls, the interaction of the bottom 25 percent income dummy with nationalization is always positive and statistically significant, but after introducing the control variables, the interaction is only significant for sample D. The interaction of the bottom 25 percent dummy with the privatization dummy is negative and statistically significant when using the control variables, but not in the specifications without them. If we combine these results, across all samples we find that the bottom 25 percent has greater access to the network during the nationalization period than during the privatization period.[22]

<<place table 5 about here>>

Because serial correlation may be an issue in this difference-in-difference framework, we parametrically model the serial correlation of the error term as a first-order autoregressive process. We use different estimation methods that imply different assumptions. The results are reported in table 6. In the first column, we report feasible generalized least squares estimates, allowing the error term to be correlated across cities (i.e., we allow for error correlation across panels, or what is typically termed spatial correlation). In the second column, the correlation of errors across individuals is assumed to be identically and independently distributed. In the third column, we use a within estimator with city fixed effects, and in the last column, we provide estimates using the Driscoll and Kraay (1998) method to obtain Newey-West standard errors, which allow error autocorrelation of the general form. We use the subsample, which only includes capital cities other than Montevideo. Again, in all cases, nationalization has a positive impact on access to the sanitation network.

<<place table 6 about here>>

This increase in sanitation access is consistent with the fact that a USD 50 million loan was obtained from the World Bank for an OSE project on sanitation and residual treatment after the nationalization of private companies. However, the external funding the World Bank provided to Uruguay's water company was not unusual. Three loans have been granted for the improvement of water services in Uruguay since 1999 that covered the preprivatization period, the privatization period, and the nationalization period.[23] Thus, there is no systematic bias toward the nationalization period. More important, we could not find any indication in the official documents that the last loan should be used primarily for improvements in treated cities (those that were nationalized). Thus, one should not expect that this last loan is the reason for the improvement in water services in treated cities. We obviously cannot exclude the possibility that the loan contributed to improved access and water quality in cities where nationalization took place, but this seems to have been driven by something deeper than the simple availability of funds. On its website, OSE reports that following nationalization, work related to sanitation improvements, which had ceased in 2002, was restarted. Sanitation projects in Ciudad de la Costa, Punta del Este, and Maldonado, where private companies were located, apparently became a priority in OSE's agenda regardless of the availability of funding from external sources.

<<B>>*Water quality tests*

The outcome variable is the number of tests that reported an abnormal level of microbiological or organoleptic substances. This type of right-hand variable requires an appropriate estimator. We will use Poisson and negative binomial estimators to account for overdispersion in the water tests (a nonconstant ratio of variance over a conditional mean). Because there is a large number of zeros in the data (see table 2), we also performed a Vuong test, which indicated that the zero-inflated Poisson was the appropriate model.[24]

For control variables, we used accumulated precipitation and the minimum and average temperatures at the department level. We expect precipitation to be positively correlated with the number of abnormal quality tests because a high level of precipitation is likely to negatively affect the functioning of the water network, making water tests more likely to detect higher levels of undesired substances. Low temperatures may increase the likelihood of failures in the distribution network, and a high average temperature may contribute to the reproduction of bacteria, such as coliforms. Hence, we expect a negative coefficient on the former and a positive coefficient on the latter.

Table 7 reports the estimates with and without control variables. The first two columns present the zero-inflated Poisson estimates, and the last two columns present the zero-inflated negative binomial estimates. The control variables have the expected signs in both specifications, but none of the variables are statistically significant. The nationalization of water services is always negatively associated with abnormal levels of undesirable substances in water quality tests, and the impact is statistically significant at the 10 percent level. It is also very large, with a reduction of 0.7 tests per city exhibiting abnormal levels after nationalization. Thus, the results suggest that water quality improved with nationalization. As discussed above, note that because of the small number of treated cities, the results should be interpreted with caution even though we have a larger number of treated cities in the water quality sample than in the network access sample. Moreover, because the water quality sample does not cover the preprivatization period, we cannot control for the determinants of privatization, which leaves us with a weaker identification strategy than for the network access sample.[25]

<<place table 7 about here>>

<<**A**>>*V. CONCLUSIONS*

The question of market versus government failures in the provision of water services is complex and unlikely to be answered without empirical evidence. In this paper, we examine the impacts of the privatization and nationalization of water services on service quality. Thus, in contrast to most of the existing literature, we identify the impact not only through the privatization of public firms but also through the nationalization of private firms. Another important aspect of the study is the focus on direct measures of service quality (access to the network and water quality) rather than on indirect measures, such as health outcomes.

Using difference-in-difference estimators, we find that Uruguay's privatization of water companies in 1993 and 2000 yielded little progress in terms of access to sanitation networks. However, the nationalization of all private companies in 2006 led to an improvement in access to the sewage network as well as an improvement in water quality. The improvement in access following the nationalization of water services tended to favor of the poor because greater increases in access were observed for poor households.

These results are in contrast to existing evidence on the privatization of water services in other Latin American countries, which finds that privatization led to a decline in child mortality and an increase in water access and quality.

Future research should attempt to disentangle the determinants of these two outcomes to improve understandings of why privatization and nationalization had different impacts in Uruguay. Private and public companies have different objectives: private firms tend to maximize profits, whereas the objectives of public companies are more varied and may include motives ranging from political consideration to corruption or social objectives. These differences in objectives frequently motivate calls for both privatization and nationalization (see Chong and Lopes-de-Silanes 2005) and may explain part of our empirical findings for Uruguay. However, other potential explanations may also be important. For example, the type of regulations at the time of privatization or nationalization such as required investment or the requirement to provide universal access, the functioning of regulatory bodies, or poorly designed contracts and bidding processes may help to reconcile the results found here and in the rest of the literature. A detailed examination of these differences will improve understandings of what works and what does not with respect to water privatization. Additionally, differences in the functioning of public companies (e.g., external funding, the composition of the board of directors) may help to explain differences at the time of the privatization or nationalization of water services.

Finally, the results of this paper suggest that the focus on private versus public ownership of natural monopolies such as water providers may be misleading. The institutional environment within which the natural monopoly operates may be much more important.

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TABLE 1. Indicators of the Public Company: OSE

	Units	2002	2003	2004	2005	2006
Service area						
Total population - water supply	'000 inhabitants	3,158.4	3,178.2	3,100.7	3,245.0	3,253.7
Total population - wastewater	'000 inhabitants	1,791.6	1,805.9	1,541.2	1,919.0	1,935.7
Total number of staff	# FTE	4.816	4.508	4.362	4.174	4.280
Water service						
Population served - water	'000 inhabitants	3,041.6	3,063.8	2,833.5	2,980.9	3,055.3
Water connections year end	'000 connections	735.1	732.9	737.7	799.9	822.5
Volume of water produced	Million m3/year	282.7	275.1	288.1	309.4	320.0
Total volume of water sold	Million m3/year	135.3	131.0	132.3	142.0	147.1
Sewerage Service						
Population served - sewerage	'000 inhabitants	467.8	479.7	531.3	633.8	729.1
Sewerage connections year end	'000 connections	162.2	166.1	169.5	195.6	205.9
Length of sewers	Km	1,683.0	1,759.6	1,872.5	2,410.8	2,494.5
Financial information						
Total operating revenues	Million URY of 2010	3,951.3	6,015.2	6,036.5	627.3	6,848.2
Total billings to residential customers	Million URY of 2010	2,252.1	3,417.8	3,537.0	3,718.0	4,070.0
Total billings to industrial customers	Million URY of 2010	840.9	12,19.0	1,269.5	1,340.1	1,499.5
Total water and wastewater operational expenses	Million URY of 2010	2,499.8	3,736.6	3,733.9	3,689.6	4,010.7
Labor costs	Million URY of 2010	1,342.1	1,851.9	1,842.9	1,688.4	1,848.8
Total gross fixed assets including work in progress	Million URY of 2010	17,907.5	24,051.4	2,356.2	24,330.8	2,4604.8
Tariff information						
Fixed charge per month for water and wastewater services for residential customers	URY of 2010 per month	86.4	140.7	144.5	145.7	145.0
Connection charges - water	URY of 2010	1,414.1	1,814.4	1,803.5	1,891.0	1,957.6
Connection charges - sewers	URY of 2010	567.3	726.7	722.3	757.1	784.3

Source: OSE.

TABLE 2. Descriptive Statistics for Treatment and Control Groups

	Publicly owned period (1986–2000)			Privately owned period (2001–2005)			Publicly owned period (2006–2009)		
	Treated (1)	Control (2)	Difference (1) − (2)	Treated (1)	Control (2)	Difference (1) − (2)	Treated (1)	Control (2)	Difference (1) − (2)
Access to sewage network sample									
Network evacuation rate	0.47 (0.10)	0.44 (0.19)	0.03	0.53 (0.07)	0.49 (0.21)	0.04	0.69 (0.10)	0.54 (0.22)	0.15**
Education (head of household)	6.78 (0.42)	6.58 (0.77)	0.20*	7.22 (0.55)	7.18 (0.73)	0.04	7.82 (0.38)	7.77 (0.75)	0.05
(log) Household per capita income	7.90 (0.10)	7.58 (0.25)	0.32***	7.52 (0.14)	7.43 (0.22)	0.09*	7.83 (0.18)	7.63 (0.21)	0.20***
(log) Accumulated precipitations	6.95 (0.17)	7.11 (0.23)	−0.16***	7.09 (0.20)	7.24 (0.27)	0.15**	6.97 (0.17)	7.07 (0.31)	−0.10
Observations	31	385		15	165		11	128	
Water quality sample									
Fecal coliforms	NA	NA	NA	0.00 (0.00)	0.00 (0.00)	0.00	0.00 (0.00)	0.65 (6.19)	−0.65
Pseudomonas aeroginosa	NA	NA	NA	0.00 (0.00)	0.04 (0.19)	−0.04	0.00 (0.00)	0.14 (0.35)	−0.14**
pH	NA	NA	NA	7.11 (0.48)	7.35 (0.47)	−0.24*	6.94 (0.39)	7.31 (0.48)	0.37***
Cloudiness	NA	NA	NA	1.57 (1.86)	1.73 (1.93)	−0.16	0.64 (0.63)	1.37 (1.74)	−0.73**
Count of noncompliance tests	NA	NA	NA	0.33 (0.49)	0.46 (0.79)	−0.13	0.05 (0.21)	0.45 (0.78)	−0.40***
Minimum temperature (°C)	NA	NA	NA	9.02 (0.30)	4.70 (1.11)	4.32***	8.62 (0.44)	4.86 (1.15)	3.76***
Average temperature (°C)	NA	NA	NA	16.96 (0.06)	17.50 (0.94)	0.54**	16.74 (0.15)	17.55 (0.99)	0.80***
(log) Accumulated precipitations	NA	NA	NA	4.18 (0.05)	4.33 (0.19)	0.15***	4.20 (0.24)	4.29 (0.27)	0.09*
Observations				12	54		22	94	

Source: URSEA, ECH, and the National Meteorology Office.
Note: Figures in parentheses are standard deviations.
*, **, and *** indicate statistical significance at the 10 percent level, 5 percent level, and 1 percent level, respectively.

TABLE 3. Test of Parallel Trends before Privatization in the Network Access Sample

Variables	A[a]		B[a]		C[b]		D[c]	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Time trend	0.002	−0.003	0.010**	0.008*	0.003	−0.002	0.006**	0.001
	(0.002)	(0.003)	(0.004)	(0.005)	(0.002)	(0.003)	(0.002)	(0.004)
Time trend by treatment status	0.004	0.004	0.004	0.004	−0.000	−0.005	−0.007**	−0.010**
	(0.004)	(0.006)	(0.004)	(0.006)	(0.003)	(0.005)	(0.003)	(0.005)
Education		0.030		0.038		0.037		0.041***
		(0.027)		(0.033)		(0.027)		(0.015)
(log) Household per capita income		0.205*		0.234**		0.185*		0.098
		(0.105)		(0.107)		(0.106)		(0.104)
(log) Accumulated precipitation		0.052**		0.050		0.046**		0.053***
		(0.021)		(0.043)		(0.021)		(0.020)
Year effects	No	Yes	No	Yes	No	Yes	No	Yes
Observations	416	416	261	261	400	400	270	270
Log likelihood	−199.18	−184.35	−126.12	−116.78	−191.76	−176.84	−124.75	−122.75
Sample period	1986–2005		1993–2005		1986–2005		1986–2005	

Source: Authors' estimation using ECH and National Meteorology Office data.
Note: Estimates are obtained using a Papke & Wooldridge Fractional Logit Model. Marginal effects are reported, and robust standard errors clustered at the city level are reported in parentheses. All models include city fixed effects.
*, **, and *** indicate statistical significance at the 10 percent level, 5 percent level, and 1 percent level, respectively.
[a] Treatment Units (three cities): Maldonado, San Carlos, and Pan de Azúcar; Control Units (32 cities): Artigas, Bella Unión, Canelones, Carmelo, Colonia, Dolores, Durazno, Florida, Fray Bentos, Lascano, Libertad, Melo, Mercedes, Minas, Montevideo, Paso de los Toros, Paysandú, Periferia Canelones, Rivera, Rocha, Rosario, Río Branco, Salto, San José de Mayo, San Ramón, Santa Lucía, Sarandí del Yí, Sarandí Grande, Tacuarembó, Tranqueras, Treinta y Tres, Trinidad, and Young.
[b] Treatment Unit (one city): Maldonado; same Control Units as in A.
[c] Treatment Unit (one city): Maldonado; Control Units (17 cities): Artigas, Canelones, Colonia, Durazno, Florida, Fray Bentos, Melo, Mercedes, Minas, Paysandú, Rivera, Rocha, Salto, San José de Mayo, Tacuarembó, Treinta y Tres, and Trinidad.

TABLE 4. Impact of Privatization & Nationalization on Network Evacuation Rate in Maldonado

Variables	A[a]		B[a]		C[b]		D[c]	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Private provision	0.037	0.055	0.037	0.053	−0.003	−0.035	−0.086***	−0.081
	(0.042)	(0.066)	(0.042)	(0.067)	(0.036)	(0.054)	(0.031)	(0.049)
Renationalized provision	0.163***	0.143**	0.163***	0.140**	0.244***	0.173***	0.154***	0.139**
	(0.053)	(0.058)	(0.053)	(0.061)	(0.036)	(0.056)	(0.037)	(0.055)
Education		0.041		0.049		0.045		0.025**
		(0.028)		(0.031)		(0.029)		(0.012)
(log) Household per capita income		0.210***		0.221***		0.191***		0.169***
		(0.063)		(0.085)		(0.062)		(0.060)
(log) Accumulated precipitation		0.075**		0.072*		0.072**		0.063***
		(0.030)		(0.043)		(0.030)		(0.022)
Observations	735	735	580	580	702	702	432	432
Log likelihood	−355.21	−331.55	−282.16	−263.89	−340.11	−316.54	−198.54	−195.19
Sample period	1986–2009		1993–2009		1986–2009		1986–2009	

Source: Authors' estimation using ECH and National Meteorology Office data.
Note: Estimates are obtained using a Papke & Wooldridge Fractional Logit Model. Marginal effects are reported, and robust standard errors clustered at the city level are reported in parentheses. All models include city fixed effects.
*, **, and *** indicate statistical significance at the 10 percent level, 5 percent level, and 1 percent level, respectively.
[a] Treatment Units (three cities): Maldonado, San Carlos, and Pan de Azúcar; Control Units (32 cities): Artigas, Bella Unión, Canelones, Carmelo, Colonia, Dolores, Durazno, Florida, Fray Bentos, Lascano, Libertad, Melo, Mercedes, Minas, Montevideo, Paso de los Toros, Paysandú, Periferia Canelones, Rivera, Rocha, Rosario, Río Branco, Salto, San José de Mayo, San Ramón, Santa Lucía, Sarandí del Yí, Sarandí Grande, Tacuarembó, Tranqueras, Treinta y Tres, Trinidad, and Young.
[b] Treatment Unit (one city): Maldonado; same Control Units as in A.
[c] Treatment Unit (one city): Maldonado; Control Units (17 cities): Artigas, Canelones, Colonia, Durazno, Florida, Fray Bentos, Melo, Mercedes, Minas, Paysandú, Rivera, Rocha, Salto, San José de Mayo, Tacuarembó, Treinta y Tres, and Trinidad.

TABLE 5. Impact of Nationalization on Access to Sewage Network in Maldonado at the Bottom and Top 25 percent of the Income Distribution

	A[a]		**B**[a]		**C**[b]		**D**[c]	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Private provision	0.013	0.083	0.022	0.084	−0.030	−0.005	−0.152***	−0.119**
	(0.046)	(0.089)	(0.047)	(0.091)	(0.043)	(0.053)	(0.030)	(0.048)
Renationalized provision	0.093*	0.143**	0.105*	0.146**	0.158***	0.164***	0.016	0.044
	(0.056)	(0.063)	(0.056)	(0.066)	(0.045)	(0.053)	(0.035)	(0.052)
Private provision by Bottom 25 percent	0.032	−0.134*	0.013	−0.139*	0.025	−0.112***	0.101***	0.013
	(0.024)	(0.070)	(0.024)	(0.072)	(0.023)	(0.033)	(0.015)	(0.043)
Renationalized provision by Bottom 25 percent	0.109***	−0.047	0.091**	−0.049	0.108***	−0.028	0.177***	0.094**
	(0.036)	(0.041)	(0.037)	(0.043)	(0.022)	(0.033)	(0.013)	(0.042)
Bottom 25 percent	−0.362***	0.111	−0.348***	0.103	−0.364***	0.128	−0.415***	−0.185*
	(0.018)	(0.086)	(0.018)	(0.093)	(0.018)	(0.089)	(0.009)	(0.110)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	1470	1470	1160	1160	1404	1404	864	864
Log likelihood	−653.93	−597.64	−524.11	−482.46	−625.26	−568.37	−341.32	−338.75
Sample period	1986–2009		1993–2009		1986–2009		1986–2009	

Source: Authors' estimation using ECH and National Meteorology Office data.

Note: Estimates are obtained using a Papke & Wooldridge Fractional Logit Model. Marginal effects are reported, and robust standard errors clustered at the city level are reported in parentheses. All models include city fixed effects.

*, **, and *** indicate statistical significance at the 10 percent level, 5 percent level, and 1 percent level, respectively.

[a] Treatment Units (three cities): Maldonado, San Carlos, and Pan de Azúcar; Control Units (32 cities): Artigas, Bella Unión, Canelones, Carmelo, Colonia, Dolores, Durazno, Florida, Fray Bentos, Lascano, Libertad, Melo, Mercedes, Minas, Montevideo, Paso de los Toros, Paysandú, Periferia Canelones, Rivera, Rocha, Rosario, Río Branco, Salto, San José de Mayo, San Ramón, Santa Lucía, Sarandí del Yí, Sarandí Grande, Tacuarembó, Tranqueras, Treinta y Tres, Trinidad, and Young.

[b] Treatment Unit (one city): Maldonado; same Control Units as in A.

[c] Treatment Unit (one city): Maldonado; Control Units (17 cities): Artigas, Canelones, Colonia, Durazno, Florida, Fray Bentos, Melo, Mercedes, Minas, Paysandú, Rivera, Rocha, Salto, San José de Mayo, Tacuarembó, Treinta y Tres, and Trinidad.

TABLE 6. Impact of Nationalization on Network Access Controlling for First-order Autoregressive Disturbances

Variables	Pooled FGLS	Pooled OLS	Within Estimator	Within Estimator D-K
Private provision	−0.003	−0.019	−0.007	−0.024
	(0.019)	(0.037)	(0.048)	(0.038)
Renationalized provision	0.163***	0.159***	0.168***	0.168***
	(0.026)	(0.048)	(0.066)	(0.059)
Education	0.024***	0.023***	0.019**	0.032**
	(0.003)	(0.008)	(0.008)	(0.011)
(log) Household per capita income	0.159***	0.157***	0.164***	0.137***
	(0.013)	(0.035)	(0.035)	(0.037)
(log) Accumulated precipitation	0.017***	0.029	0.023	0.042*
	(0.007)	(0.018)	(0.016)	(0.021)
Observations	432	432	414	432
AR(1)	0.329	0.270	0.209	0.06
Sample period	1986–2009			

Source: Authors' estimation using ECH and National Meteorology Office data.

Note: All columns report estimates using panel data estimators controlling for first-order autoregressive (AR(1)) disturbances. Marginal effects are reported, and robust standard errors clustered at the city level are reported in parentheses. All models include individual effects, year effects, and time trends by city. Treatment Unit (one city): Maldonado; Control Units (17 cities): Artigas, Canelones, Colonia, Durazno, Florida, Fray Bentos, Melo, Mercedes, Minas, Paysandú, Rivera, Rocha, Salto, San José de Mayo, Tacuarembó, Treinta y Tres, and Trinidad.

*, **, and *** indicate statistical significance at the 10 percent level, 5 percent level, and 1 percent level, respectively.

TABLE 7. Impact of Nationalization on Water Quality

(count of abnormal tests of levels of microbiological elements)

	Poisson		Negative Binomial	
Variables	(1)	(2)	(3)	(4)
Renationalized provision	−0.651*	−0.642*	−0.650*	−0.665*
	(0.357)	(0.371)	(0.355)	(0.390)
Education		0.367		0.466
		(0.247)		(0.306)
(log) Household per capita income		−0.016		−0.145
		(0.865)		(0.848)
Precipitation		0.423		0.611
		(0.330)		(0.385)
Minimum temperature		−0.146		−0.235
		(0.118)		(0.165)
Average temperature		0.014		0.002
		(0.146)		(0.149)
Individual effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	182	182	182	182
Log likelihood	−101	−100	−101	−100
Sample	2004–2009			

Source: Authors' estimation using URSEA, ECH and National Meteorology Office data.
Note: All columns report estimates using a zero inflated model. Marginal effects are reported, and robust standard errors clustered at the city level are reported in parentheses. All models include city and year fixed effects. Vuong tests indicate that the zero inflated models are appropriate. Treatment Units (six cities): Maldonado, Pan de Azúcar, Piriápolis, Punta del Este, Punta Ballena, and San Carlos. Control units (26 cities): Artigas, Canelones, Colonia, Dolores, Durazno, Florida, Fray Bentos, La Paloma, La Paz, Las Piedras, Melo, Mercedes, Minas, Montevideo, Pando, Paysandú, Progreso, Rivera, Rocha, Salto, San José, Atlántida, Tacuarembó, Toledo, Treinta y Tres, and Trinidad.
* indicates statistical significance at the 10 percent level.

Notes

[1] According to Hall, Lobina, and Corral (2010), water services are owned and run by the public sector in 90 percent of the 400 largest cities in the world. This figure should be compared to the share of formal employment in public companies across all sectors, which is 5 percent, on average, according to Kikeri (1999).

[2] For an assessment of the performance of community-driven water providers in developing countries, see

Whittington *et al.* (2009).

[3] Water privatization was also made illegal in the Netherlands.

[4] The reason for the failure of privatization is not necessarily inherent to privatization but may also be explained by poorly designed contracts (in terms of required investments) or inadequate regulatory bodies. These are often associated with problems due to corruption (see Chong and Lopez-de-Silanes, 2005).

[5] In their review of the literature, Nauges and Whittington (2009) suggest that income elasticities of demand oscillate between 0.1 and 0.4.

[6] Note that the same critiques of private water suppliers that were present in Uruguay in the late 1990s and early 2000s were also made in the Argentinean press at the time (high prices, water provided by private companies being unfit for human consumption, or the fact that these private companies only honor half of their investment commitments).

[7] Because the data on water quality only span the nationalization period, we cannot measure the impact of the privatization of water services.

[8] Over the last decade, the average number of child deaths in Uruguay was 10 per jurisdiction. Of those, less than 10 percent were water related. See Borraz and Olarreaga (2011). The reason the effect of privatization on child mortality was estimated as being relatively large in Argentina, which is also a middle-income country, is that although the two countries have similar levels of income per capita, Uruguay is much more homogenous than Argentina in terms of both income and race.

[9] We are grateful to a referee for this clarification.

[10] We consider all year-round residents and not the tourist population, which can reach hundreds of thousands during the summer.

[11] Lee, Rosenzweig, and Pitt (1997) show that this reduced form approach may downward bias the effects of the treatment because households adjust their behavior to the new environment and provide an alternative structural approach to estimate the impact of improved quality on health outcomes.

[12] An alternative solution is to use the method proposed by Bell and McCaffrey (2002), “bias correction of clustered standard errors,” but this approach unfortunately cannot be applied in a difference-in-difference framework.

[13] Of these 35 cities, only 19 are capital cities.

[14] There are 35 cities. We have 21 cities times 24 years (1986–2009 period), yielding 504 observations. In addition, we have $1 \times 10 + 3 \times 12 + 2 \times 15 + 7 \times 17 + 2 \times 18 = 231$ observations.

[15] These differences reflect that only a few cities’ water services were privatized and subsequently nationalized.

[16] We obtain qualitatively identical results from a parallel test in the trends for the period before the nationalization, which are available upon request.

[17] Note that we have six treated cities in the water sample instead of the three in the network access sample. This is still a relatively small number of treated cities, which suggests that the results should be interpreted with caution.

[18] Note that some of the control variables present relatively large differences between treated and control cities, which again reflects that only a few cities’ water companies were privatized and subsequently nationalized.

[19] We also tested whether network access was higher during periods with the public provision of water services (i.e., the preprivatization period and postnationalization period) and found a statistically significant coefficient for most specifications (available upon request). However, the coefficients are 50 percent smaller when using this alternative definition, which confirms that most of the positive impact is due to the nationalization of water services and not to the preprivatization period.

[20] This may explain the statistically insignificant results for privatization.

[21] Unfortunately, the ECH data do not follow households over time. Therefore, we cannot implement our difference-in-difference methodology at the household level.

[22] We also run these regressions for households above and below the poverty line. The results, which are available upon request, suggest that nationalization increased the network access rate of poor households.

[23] The World Bank provided Uruguay with financial support to develop water and sanitation services through three investment loans at different time periods: 1) Water Supply Rehabilitation project (1988–1999), USD 22.3 million; 2) OSE Modernization and Systems Rehabilitation project, APL-1 (2000–2007), USD 27 million; 3) OSE Modernization and Systems Rehabilitation project, APL-2 (ongoing since 2007), USD 50 million. Other loans focused on technical support, such as the Public Services Modernization Technical Assistance project (2001–2008) for USD six million. The objective of these loans was to help Uruguay make investments in the water infrastructure, improving the efficiency and coverage of the water supply and sanitation services. See The World Bank (2010) for additional details.

[24] When testing the negative binomial estimator, the Vuong test takes the value 5.79 in the specification without controls and 6.45 in the specification with controls. When testing the Poisson estimator, the Vuong test takes the value 1.81 without controls and the value 1.87 with controls. They all reject that the ordinary Poisson or negative binomial models should be preferred to the zero-inflated estimators at the 5 percent level, which is unsurprising given the large number of zeroes.

[25] Note that when using a public provider dummy that takes a value of one when the city is served by a publicly owned water company in lieu of a nationalization dummy, we obtain qualitatively and quantitatively similar results to those reported in table 7.