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ABSTRACT

Water Nationalization: network access, water quality, and health outcomes*

In the case of natural monopolies there tends to be a trade-off between a higher quality of output provided by private firms, and a better access for poor consumers provided by public firms. This is partly the reflection of differences in objectives by private and public firms. The former tend to be profit-driven, whereas the latter tend to base decisions on political agendas (Chong and Lopez de Silanes, 2005). The objective of this paper is to explore the impact on network access, water quality, and health outcomes of Uruguay's nationalization of water services. An important advantage of focusing on nationalization rather than privatization is that it avoids selection bias due to cherry-picking by firms or governments at the time of privatization. Indeed, nationalization in Uruguay affected all private firms, as water was declared "part of the public domain". Results suggest that the change in ownership led to an increase in the sanitation rate, as well as improvements in water quality. It was also accompanied by a decline in water-related child mortality, although this latter effect tends not to be statistically significant across most specifications.

JEL Classification: D60, F10, H51, I10, L33 and O12
Keywords: access to sanitation, child mortality, nationalization and water quality

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1 Introduction

Back in the 1970s the role of the government as provider of basic services in sectors with a natural monopoly component, such as water supply and sanitation, was hardly questioned. Indeed, it was thought that private firms were likely to abuse their monopoly power in this type of markets, and concentrate their service supply on rich households, leaving poor households without access to a basic service.[1] On the other hand, public companies, because they often tend to be partly driven by a political agenda, would have incentives to ensure access to a maximum 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). Bad management practices, due to political agendas rather than profit-oriented motives, shed light on large inefficiencies and poor quality of services being provided by these public companies. In the 1990s, privatization of water services was seen by some as a potential solution to the poor performance of publicly owned water monopolies that left more than 1 billion people in developing countries without any access to clean and safe water, and 40 percent of the world's population without access to safe and clean sanitation services (Segerfledt, 2005). UNDP in its Human Development Report of 2006 notes that "not having access to water and sanitation is a polite euphemism for a form of deprivation that threatens life."And Galiani *et al.* (2005) provide empirical evidence that a move towards privatization of water services in Argentina in the 1990s led to a faster decline in child mortality.

France was an early example of a country with privately provided water services. And throughout the 1990s many countries engaged in privatization of water services, starting with England in 1989, followed by Eastern European and Latin American countries. A few Asian and African countries followed them in the mid and late 1990s (Hall *et al.* 2010). Nevertheless, the share of public water companies is still very large.[2] Moreover, it has

[1] In September 2010, the United Nation's Human Rights' Council adopted Resolution 64/292 which declares access to water and sanitation a human right.

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

increased in the last ten years as backlashes to privatization occurred in many countries.

Uruguay is a recent example of this reversal. An amendment to the Uruguayan constitution was passed in 2004 declaring water as "part of the public domain". The private provision of water was made illegal.[3] This led to the nationalization of two water and sewage suppliers in the Department of Maldonado that were privatized in 1993 and 2000. The private water companies that operated in the Department of Canelones since the 1940s also came under the control of the public monopoly.

The apparent reasons for Uruguay's nationalization of water companies were no different from the ones observed in other Latin American countries in the last decade (Bolivia, Argentina, Brazil, etc). Privatization of water services did not deliver on its promises.[4] Private companies became deeply unpopular due to perceptions, at least, of low or falling quality of water, as well as the high prices private companies charged. 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 Aquas de Bilbao) led as early as 2003 (in the middle of a financial crisis) to an also well publicized request by the then Minister of Economics and Finance, Alejandro Atchugarry, for Uragua to leave the country.

Whether public or private provision of water leads to better access, quality and health outcomes is an empirical question. The objective of this paper is to explore the impact that the nationalization of water services had on the quality of water (microbiological and inorganic tests) and access to sanitation networks (percentage of households with water-sealed toilets connected to sewer lines) in Uruguay, as well as on an important health outcome: child mortality. The study of Uruguay's nationalization episode is interesting because it avoids the inherently selection bias associated with cherry-picking when looking at privatization. Indeed, nationalization affected all companies as private provision of water was made illegal. Thus, as long as the determinants of the decision to privatize are not serially correlated we would have a reliable identification strategy. Second, household access

[3]In the Netherlands water privatization was also made illegal.

[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 non-adequate regulatory bodies. These are also often associated with problems of corruption (see Chong and Lopez-de-Silanes, 2005).

to Uruguay's piped sewerage network remains particularly low for countries at similar levels of development. The access rate below 50 percent compares badly with other Latin American countries such as Chile, Colombia, Mexico and some comparable Brazilian states in terms of income per capita.

The existing empirical evidence on the impact of privatization on water quality, access and child mortality tends to suggest a positive impact, although there are a few studies suggesting otherwise. Wallsten and Kosec (2005) analyze the effect of water ownership on water quality, measured as the number of violations of the Safe Drinking Water Act (SDWA) in the US between 1997 and 2003. Using panel data at the community level, and controlling for community fixed effects, they find that ownership does not matter in terms of compliance with the SDWA. This may be due to the fact that the study is undertaken in a developed country with high levels of income and therefore a strong demand for high quality water.[5]

In a developing country study, Barrera-Osorio *et al.* (2009) using a difference-in-difference methodology assess the impact of water privatization in Colombia on several outcomes like coverage (percentage of households connected to water service) and water quality (frequency of the service and aspect of water, such as its color). They find that, in urban areas, water access increases and that water quality improves as a result of privatization, while negative effects on access where detected in rural areas. This is consistent with the idea that as water services are privatized the poorest consumers may be the ones left behind.

Regarding the impact on child mortality, Shi (2000) finds a positive effect of private provision of water on child mortality using a cross city model. However, problems of selection bias and endogeneity were difficult to address in a cross section setup. Using a panel data setup, 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. Note, however, that the same critiques towards private water suppliers that were present in Uruguay in the late 1990s and early 2000s were

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

present also 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). Galdo and Bertha (2005) also found that water access had positive effects on child mortality in Brazil and Ecuador.

The empirical methodology we followed is similar to the one in Galiani, Gertler, and Schargrodosky (2005). Using panel data around the nationalization episode, we identify differences in sanitation rate, water quality indicators and water-related child mortality between regions that first privatized their water suppliers, and later nationalized them, and those that did not using a difference-in-difference estimator.

Our results suggest that the nationalization of water services had a positive and statistically significant impact on access to the sanitation network, in particular among household in the bottom 25 percent of the income distribution. At the top of the income distribution, only households in Maldonado seemed to experience an increase in access to the sanitation network. But even in Maldonado the impact of nationalization is clearly pro-poor with a larger impact on poor households (coefficients tend to be 2 times larger and statistically different from the coefficient in the rich household sub-sample).

Nationalization seemed to have led to higher quality of water as well. Indeed, the impact of nationalization on the detection of abnormal levels in microbiological and inorganic water tests is always negative and has a relatively large coefficient, suggesting that nationalization led to an improvement of water quality.

Finally, our different specifications tend to suggest that water nationalization had little impact on child mortality, even when we disentangle water and non-water related diseases. Indeed, in most cases the coefficients on nationalization of water services is not statistically different from zero, even though in most cases it has a negative sign, suggesting that child mortality declined after nationalization.

To summarize, the nationalization of water services in Uruguay suggests that the public sector can do it as well or better than the private sector. This goes against most of the existing evidence for developing countries that generally shows that privatization leads to higher levels of sewerage access and water quality, as well as lower levels of child mortality.

This could be partly explained by a badly implemented privatization in Uruguay that was not accompanied by adequate regulation and institutions. Also, it is possible that Uruguay's public company is more efficient in terms of access, water quality and public health objectives than public water companies in other countries. Overall, the empirical results in this paper suggest that privatization is not the silver bullet that could lead the way towards better access to clean and safe water.[6]

The reminder of the paper is organized as follows. Section 2 describes the functioning of the water system in Uruguay. Section 3 discuses the empirical methodology, and Section 4 presents the data and some descriptive statistics. Section 5 presents the results, and section 6 concludes.

2 The Water System in Uruguay

At the turn of this century water and sewage service in Uruguay were provided by fifteen private companies and a publicly-owned company called OSE (Obras Sanitarias del Estado). OSE had an exclusive monopoly in water provision in Montevideo (Uruguay's capital city) and almost all of the national territory accounting for more than 90% of the connections. The private sector was basically composed of three big companies (Uragua, Aguas Corrientes El Pinar, and Aguas de la Costa) and approximately twelve water providers with less than 500 connections each. These small providers were cooperatives founded by residents to provide water services in areas that OSE was not reaching or was reaching with poor quality water.

Uragua started to provide water and sewage service in urban and sub-urban areas of Maldonado in 2000. Maldonado has 150,000 inhabitants of a total of 3,300,000 in Uruguay. Uragua served the west of the Maldonado stream with the exception of the city of Aiguá. More 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 the international well-known

[6] Note that our result could also be explained by an initial euphoria and push to better management immediately after the nationalization that could eventually vanish as time goes by.

resort of Punta del Este (7,298 inhabitants)[7].

Uragua was owned by Aguas de Bilbao, a Spanish water provider. In 2004 Uragua entered in litigation with OSE because of a breach of contract, following some well publicized episodes of colored water in Maldonado. Following the 2004 amendment to the Uruguayan constitution,[8] Urugua reached a deal with the Uruguayan government and all Uragua assets were transferred to OSE by the end of 2005.

Aguas Corrientes El Pinar was created in 1946, six years before the creation of OSE, with the objectives of fostering land sales in El Pinar area which legally required connections to water and sewage services. It served less than 1,000 clients until the 1990s, but by the time of the nationalization it had reached around 5,000 clients due to the rapid development of the area over the last decade. Interestingly, only 12 persons worked full time in Aguas Corrientes El Pinar. The connection fee was around USD 200 and the average consumption was USD 10.

Aguas Corrientes el Pinar provided services in El Pinar, but also the adjacent areas of San Cristóbal, El Palmar, Médanos de Solymar, Lomas de Solymar, Autodromo, and Colinas de Solymar in the department of Canelones. Canelones is the second Department in Uruguay in terms of population size with 500,000 inhabitants. The population in El Pinar and Lomás de Solymar is around 33,000. Aguas Corrientes el Pinar was nationalized in December 2006 and its assets were also transferred to OSE.

The third biggest private company in Uruguay was Aguas de la Costa. It was a joint-venture between a local company, S.T.A Ingenerios and Benecio S.A., which had around 10% 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 the concession in 1993 for twenty five years. The company supplied water and sewage in the wealthier areas of La Barra, Manantiales and José Ignacio, which is next to Punta del Este. This area is to the east of the Maldonado stream. The company had around 3,100 customers and the connection fee for water and sewage was USD 2,000 and USD 1,000 for water only. A special rate for

[7] We take all year around population and not the tourist population, which can reach hundreds of thousands during the summer.

[8] The amendment that went through a referendum declared water as being part of the public domain.

low income households was available. The average water consumption ranged between USD 40 and USD 100. After an agreement with the government, the company left the country in 2005. Aguas de la Costa assets were transferred to OSE in 2005.

Figure 1 provides a map of Uruguay and Figure 2 provides maps of Canelones and Maldonado to better understand the location of the privately-owned water companies. The left panel of Figure 2 shows the department of Canelones by judicial section. The judicial section 19 in Canelones was served principally by Aguas Corrientes el Pinar. The rest of the judicial sections of Canelones were operated by the publicly-owned OSE. The right panel of Figure 2 shows the map of the Department of Maldonado by judicial section. The judicial sections 1,2, 3 and 5 were served by Uragua. The judicial section 6 was operated by Aguas de la Costa. Finally, judicial section 4, which contains the city of Aigua, was not privatized and was controlled by the public company OSE.

It is clear that Maldonado was particularly hit by the nationalization reversal. At the turn of the century, the only city in Maldonado served by the publicly-owned OSE was Aigua with 2,676 inhabitants. By 2006, OSE was the only provider of water services in Maldonado.

Table 1 shows the evolution of some indicators of the public company OSE between 2002 and 2006. For instance, the number of employees did not suffer a substantial modification after nationalization. As it is expected, the volume of water produced grew after nationalization since 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 (around 38%) between 2004 and 2006. This partly includes acquisitions of the private companies, but also new infrastructure investments through a sanitation project supported by the World Bank after nationalization. Finally, contrary to what could have been expected, average prices charged by OSE increased after nationalization. The fixed charge per month for water and wastewater services for residential customers increased by approximately USD 1 after nationalization. Connection fees also increased.

3 Methodology

The ideal methodology to assess the impact of privatization (nationalization) on different outcomes would be an experiment involving a random assignments to treated and non-treated individuals. That is, we would have cities which are randomly chosen to be privatized, usually called the "treatment group" and other which are not (the "control group"). In our case privatization was not carried out at random and therefore we need to find out an alternative methodology which mimics as best as possible a natural experiment. We followed the existing literature and adopt a quasi-experimental difference-in-difference methodology.[9]

The identification strategy we followed is similar to the one in Galiani *et al.* (2005) in where they search 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.[10]

Selection bias due to cherry-picking at the moment of privatization is an issue in this setup, that they address through different methods. In our case, given that the nationalization was imposed on all private firms allows us to circumvent this problem, as long as the determinants of privatization are not serially correlated. In the case of Uruguay's nationalization of water companies in 2005-2006, the condition seems to be satisfied as some of the private companies in Canelones were funded as early as 1946, and it is therefore unlikely that the determinants of "privatization" at that time are correlated with the decision to nationalize all water companies in 2005-2006.

On the other hand, in Maldonado the privatization episode was more recent. Aguas de la Costa and Uragua were originally privatized in 1993 and 2000 respectively. In that sense, one can argue that there was selection in the privatization decision at the time. If this latter argument applies, these endogenous determinants of privatization may also be biasing the estimates of the impact of nationalization on the outcome variable.

[9] For a randomized experiment of spring water cleaning in rural Kenya, see Kremer, Leino, Miguel and Zane, (2009).

[10] Lee *et al.* (1997) show that this reduced form approach may downward bias the effects of treatment as households adjust their behavior to the new environment, and provide an alternative structural approach to estimate the impact of better quality on health outcomes.

For example, suppose that the government decide to privatize companies in judicial districts that were more profitable and had better prospects in order to maximize the short-run financial benefits from the privatization. If profitability positively affects performance over time (i.e., performance is serially correlated) we will observe that nationalization had led to a better performing water company, but this was just due to the trend in the performance of water companies in that region. In this context, even if nationalization adversely affected performance, estimation might not identify this effect because the treatment group includes a disproportionate number of utilities that perform well.

There are two answers to this. First, as observed in the Data section, privatized and public water companies in Maldonado had similar trends in performance before the nationalization of water companies. And in some of the difference-in-difference specification we control for general trends using year fixed effects, as well as jurisdiction-specific trends. Second, the decision to nationalize water companies was mainly politically as illustrated in Table 2 which shows data from the Electoral Court regarding the water referendum and the national election of 2004, as well as the department elections in 2005. There is a strong correlation between support for the water referendum and support for the left wing party. For example, if we considered the Department of Maldonado, which had two private water providers, we observe that the referendum was defeated only in cities where the national or department elections went for right wing parties (Pan de Azúcar, Punta del Este and Aigua). One therefore suspects that the decision to privatize in the 1990s was also politically and not performance driven.

Our general econometric model is given by:

$$(1) \quad y_{it} = \phi D_{it} + x'_{it}\beta + \lambda_t + \alpha_i + u_{it}$$

where y_{it} is the outcome variable in city (or judicial section) i in year t. We consider three different outcome variables: sanitation rates, water quality, and child mortality. The unit of observation i are cities in the case of sanitation and water quality analysis, and judicial sections in the case of child mortality. D_{it} is a dummy variable indicating that the water company in city (or judicial section) i in period t is publicly-owned, α_i is a city (or judicial section) specific fixed effect, λ_t is a year effect, x_{it} is a vector of control variables and u_{it} is a city (or judicial section) time-varying error (distributed independently across department and time). The regression is structured to capture the effects of aggregate factors and department specific responses to aggregate factors.

The parameter of interest is ϕ which measures the casual impact of the type of ownership (public vs. private) of the water company on water quality. When sanitation rate is the outcome variable, a positive coefficient will indicate that nationalization of private companies led to larger sanitation rates conditional on year and city fixed effects, as well as control variables at the city level. On the other hand, when considering water quality tests (abnormal levels of microbiological and organoleptic elements) or child mortality rates as the dependent variable, a positive coefficient implies that nationalization led to a higher number of tests with abnormal results and more child mortality, again conditional on year and city (or judicial section) fixed effects, and other control variables at the city (or judicial section) level.

In order to address the problem that different departments may have been following different trends before nationalization, we include a city (or judicial section) specific time trend. This will correct for the fact that nationalization may be correlated across time with other determinants of our outcome variables that are unrelated to the change in ownership of water companies. If we do not control for this city (or judicial section) specific time trends, our estimates may be biased due to a spurious correlation between nationalization of water companies and the three different outcome variables. Formally,

$$(2) \quad y_{it} = \phi D_{it} + x'_{it}\beta + \lambda_t + \gamma_i trend + \alpha_i + u_{it}$$

where γ_i trend is a city (judicial section) specific time trend.

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

Bertrand, Duflo and Mullainthan (2004) analyzed the performance of different alternative solutions to the serial correlation problem: 1) parametric methods, that is, specifying an autocorrelation structure; 2) 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, *et al.* find that the latter perform better than the others, but it does not work properly with small sample size. Moreover, Cameron, Gelbach and Miller (2008) states that block bootstrap work properly with small number of groups.[11]

In our case, bootstrap clustered standard errors are similar to clustered standard errors and in most cases the latter method report greater standard errors and in some cases conventional standard error are larger than the latter. 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 will use different estimators that will be discussed in the results section.

4 Data sources and variable construction

We start describing data sources and variable construction for the analysis of the impact of nationalization on access to water sanitation networks. We then turn to data sources and variable construction for the study of the impact of nationalization on water quality, and we finally discuss data sources when we use child mortality as the outcome variable.

4.1 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*

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

Continua de Hogares (ECH) conducted by the National Statistical Office of Uruguay, *Instituto Nacional de Estadística* (INE). The ECH is the main source of socio-economic information about Uruguayan households and their members at the national level. The surveys were carried out throughout the year with the objective of generating a proper description of the socio-economic 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. Hence, we generate a dummy variable that takes the value 1 if the household is connected to sewer lines and 0 otherwise. Then, we aggregate the data by city in order to obtain the percentage of households with sanitation access in each city. We therefore work with panel data by city from 1986 to 2009. The time-span includes the pre-privatization period in the case of Maldonado, as the two privatizations in Maldonado occured in 1993 and 2000 as discussed earlier.

The ECH survey is only representative at the Department level or at the city level for largest cities in terms of population. Therefore, and to have a representative sample, we keep only capital cities of the different Departments and other big 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.

Due to the fact that there are some selected cities which were not surveyed in some years (mainly in the ECH older edition), we have an unbalanced panel which could possibly imply panel attrition bias. For instance, in the treatment group, of the total 24 time periods, Pan de Azúcar appears 15 times and San Carlos 18 times. In the control group, we have observations for Lascano in 10 of the 24 time periods, and for Bella Unión, Libertad and Rosario in 12 years, Santa Lucía in 15 years, Carmelo, Dolores, Paso de los Toros, Río Branco, San Ramón, Sarandí del Yí and Sarandí Grande in 17 years, and Young in 18 years.

So, we have a total of 735 observations[12]. Some cities started to appear in the ECH because of their rapid growth in terms of population and therefore we checked the robustness of results to a smaller sub-sample in terms of time-span: 1993-2009.

The are two observations that need to be made. First, control cities largely exceed treatment cities and hence we will also estimate our model reducing the number of controls to only capital cities. The sanitation data of each capital city are available in every year of the whole period, so in this case panel attrition problems are potentially solved. Second, since we lose observation as we drop cities, small sample bias could arise. Thus, this could be seen as a trade-off between small sample bias and possible panel attrition bias, which provides some robustness checks to our results.

In Figure 3, we present the evolution of the average sanitation rate of the 35 cities. Overall, we can see that it has an upward trend and in recent years it grows at a faster pace which leaves sanitation above its trend level. In the econometric analysis we will include general trends in network evacuation rates to control for this. Note that the water utilities of Maldonado, Pan de Azúcar and San Carlos belonged to the private company Uragua between 2000 and 2005. Thus, we have for those cities a pre-privatized period 1986-1999, in where water utilities were serviced by OSE the public company, and the period after nationalization, 2006-2009, when the water utilities returned to OSE.

Figure 4 illustrates the evolution of the average sanitation rate for treated (solid line) and non-treated cities (dash line). There seems to be a higher variance for the treatment group, but before privatization the trend in network evacuation rates across the treatment group and the control group were similar, especially between 1997 and 2000, the period immediately before privatization. During the privatization period between 2000 and 2006, the rate of growth in sanitation access in treated cities seemed to accelerate relative to non-treated cities. And this trend accelerates again after nationalization in 2006.

Figure 5 plots the evolution of sanitation rates for each city belonging to the treatment group (Maldonado, Pan de Azúcar and San Carlos), as well as Ciudad de la Costa, which used to be provided by the private-owned company Aguas Corrientes El Pinar. We observe

[12]There are 35 cities. We have 21 cities times 24 (1986-2009 period) which represent 504 observations. In addition, we have 1 x 10 + 3 x 12 + 2 x 15 + 7 x 17 + 2 x 18 = 231 observations.

some interesting variability in this indicator of performance. Access to the sanitation network in Ciudad de la Costa was nearly zero until 2005, when the nationalization process begun and after that, we observe an upward trend. Ciudad de la Costa was not included in the sample because, as we can see in Figure 5, its sanitation rate is far from the average of the rest of the cities of the treatment group (and from the overall average) and thus it could interfere in the estimation of a reliable counterfactual.

Table 3 provides some descriptive statistics by treatment and control groups. Overall, the treatment and control group present similar characteristics on average. Nevertheless, the treatment group has a smaller proportion of poor and extremely poor inhabitants, which should be captured by our city specific effects in the econometric analysis. Indeed, using a difference-in-difference method, we will try to answer whether the higher level of access to the sanitation network observed in the treatment group after nationalization can be attributable to a causal effect. This evolution could be following a trend and thus in some specifications we include time trend by city as a way to check if our results are robust.

4.2 Water quality tests

Data on water quality tests comes from the energy and water services regulator (URSEA). In 2004, URSEA jointly with the chemistry department of University of La República created a water quality unit (UAA) which is in charge of monitoring the water supply system in the whole country, according to the guidelines of the World Health Organization. This unit carries out several water tests (in the distribution network) to measure the water quality provided to consumers.

Our units of observation are cities from Uruguay's 19 Departments. We have data for the period 2004-2009 but some observations are missing for some of the cities. As treatment cities we have Maldonado, Pan de Azúcar, Piriápolis, Punta Ballena, Punta del Este and San Carlos. And as 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, Atlantida, Tacuarembó, Toledo, Treinta y Tres and Trinidad.

We have data for two different microbiological tests and two organoleptic tests, which 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 limit value. The second test indicates whether pseudomononas aeruginosa is present. In the case of organolpetic tests, the UAA reports the observed value. In the case of ph tests, the upper limit is 8 mg/Land, and higher levels are considered abnormal. The upper limit in the cloudiness test is 5, so a result greater 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 consumed of water.

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 1 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.

One possible drawback of this data is that tests have become better and more precise over time, allowing to detect more often abnormal levels of substances. This could bias our estimates, as we would observe a deterioration of the water quality throughout the period due to better testing techniques, rather than water quality. This is addressed in our econometric framework by the use of year fixed effects as control variables.

Figure 6 plots the evolution of the average of this count variable for treatment and control groups. We actually observe initially a downward trend in both treated and control groups until nationalization. And the average of the treated group declines faster. After nationalization, the treatment group experience almost no detection in abnormal levels until 2008, whereas the control group had a slight increase in the detection of abnormal levels. From 2008 there is an increase in the detection in both the treatment and the control group. This could be explained by the increase in the detection capacity as mentioned above.

In Table 4, we provide some descriptive statistics by treatment and control group.

Overall, and as we previously observed in the figures, the treatment group presents a better level of quality if we consider the entire period.

4.3 Child mortality

The data on child mortality by judicial section and cause of death come from the Ministry of Public Health (Dirección General de la Salud-Departamento de Información Poblacional-Estadísticas Vitales). An important characteristic of Uruguay's health infrastructure is that it tends to be concentrated in its capital: Montevideo. Children's health is no exception, and when children from all over the country need serious care, they are sent to the Pereira Rossell in Montevideo, which is the largest children hospital in Uruguay. If the child eventually dies in the Pereira Rossell, public mortality statistics will report this death as occurring in Montevideo. In order to avoid this bias we asked the Ministry of Public Health to provide us with information regarding the mother's residence by judicial section, rather than the location of the child's death.

Another interesting aspect of the dataset is that it contains detailed information on the causes of death. Galiani *et al.* (2005) lump together all death caused by infectious and parasite diseases and perinatal death as being water-related. Our dataset includes information taken from the death certificate signed by the Judicial Officer, which identifies the cause of death in great detail. This allows us to more precisely identify whether the type of infectious disease and exclude child deaths which were caused by infectious diseases that are not water-related.[13] This could be done with relatively more precision in the case of non-perinatal deaths, i.e., those that occur between 5 weeks and 1 year old. In the case of perinatal deaths, which occur within the first 4 weeks it is often difficult to identify the exact cause of death.

The evolution of total, perinatal, and non-perinatal child mortality in Uruguay around

[13] We include the following causes of death as being water-related: myotonic disorders, bacterial sepsis of newborn, unspecified, necrotizing enterocolitis fetus and necrotizing enterocolitis of the new birth septicemia, unspecified, meningitis, unspecified encephalitis, myelitis and encephalomyelitis, unspecified, bacterial meningitis, unspecified, congenital viral hepatitis, sepsis of new birth by other staphylococcus, and other unspecified, septicemia due to candida.

the nationalization period is shown in Figure 7.[14] Child mortality experienced a downward trend between 2003 and 2006, with an important increase in 2007, followed by a decline in 2008 and 2009, which leaves child mortality below its trend level. It is interesting to note that during all this period the average GDP growth was 6.3% and ranged from 2.2% in 2003 to 11.8% in 2004.

Figure 8 shows the evolution of child mortality rates by water-related diseases for treated and control groups separating the regions affected by the privatization in Canelones and Maldonado of Lavalleja and Rocha (and we also include the part of Canelones which always belonged to the public company). In both cases, we observe a downward trend through most of the period. But there are some interesting differences before and after nationalization: 1) before nationalization water-related child mortality has a similar trend across the treatment and control Departments, but the treatment group tends to have a higher level of water-related child mortality; 2) after nationalization water-related child mortality declines faster in the treatment group at least until 2009, and the level of child mortality in the treatment group is generally below the level of water-related child mortality in the control group. This fact could be attributable to a causal effect.

In the econometric analysis we work with a panel data at the judicial section level. Our control group are the neighboring judicial districts in Canelones and Maldonado. More precisely, the judicial sections with private water companies located in Maldonado are judicial sections 1 to 3, 5 and 6. We merge judicial sections 3 and 5 because of representativeness of judicial section 3 in terms of population. In Canelones judicial section 19 is subject to treatment. As control groups we will use neighboring judicial sections that did not privatize: judicial section 4 in Maldonado, and judicial sections 1 to 7, 10, 11, 13, 14, 16, 17 and 18 in Canelones. We also use as control judicial section 1 in Maldonado's neighboring Department of Lavalleja and judicial sections 1, 3, 4 and 5 in Maldonado's neighboring Department of Rocha. In total, we have 25 judicial sections in our analysis from 2003 to 2009. Therefore, the total number of observation is 175. In Table 5, we present descriptive statistics.

[14] Figures for Uruguay are approximated by figures for the departments of Canelones, Lavalleja, Maldonado and Rocha, which represent our choice of treatment and control groups.

5 Results

We start discussing the results of the estimation of equations (1) and (2) when access to sanitation rates is the outcome variable. We then turn to the estimates obtained when water quality is the outcome variable, and we conclude this section with the results obtained when child mortality is used as the outcome variable.

5.1 Access to sanitation networks

We estimate equations (1) and (2) for different subsamples, with and without control variables. Because the left-hand-side variable is a fractional variable (percent of households with water-sealed toilets connected to sewer lines) we used a Papke and Wooldridge (2006) estimator. Control variables include average completed years of education of the household head and average real per capita household income at the city level, as well as accumulated precipitations at the department level. We expect the three control variables to be positively correlated with network evacuation rates.

Table 6 presents the results. In almost all subsamples, there is a positive and statistically significant impact of public ownership on sanitation rates. A positive effect means that the presence of a public provider (i.e., nationalization) led to a higher access to sanitation networks. The coefficient which captures the causal impact is on average 0.08, which means that nationalization led to an 8% increase in access to sanitation networks.

In order to check whether the increase in access to sanitation networks occurred where we expect it, 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. Table 7 and Table 8 provide estimates for these two sub-samples. As expected, in the first case we found a positive, large and statistically significant impact of private ownership on sanitation rate for all sub-samples. The point estimate is larger than the one reported in Table 6. Access to sanitation networks for those at the bottom of the income distribution increased by 15% on average as a result of nationalization. In the case of rich households, we found a positive and statistically significant effects but only for some specific sub-samples. Moreover, the coefficient is always statistically smaller than the coefficient for poor households. In sum, nationalization has a positive impact on access to sanitation networks, and this effect is stronger for poor households.[15]

Because serial correlation may be an issue in this difference-in-difference setup, we parametrically model the serial correlation of the error term as a first autoregressive process AR(1). We use different estimation methods which imply different assumptions. Results are reported in Table 9. In the first column, we report pool feasible generalized least squares estimates, allowing the error term to be correlated over cities, i.e., we allow for error correlation across panels or usually called "spatial correlation". In the second column, error correlation across individuals is assumed to be identically and independently distributed. In the third column, we use the within estimator to estimate fixed effects, and in the last column we provide estimates using Driscoll and Kraay method to obtain Newey West type standard errors, which allow error autocorrelation of the general form. We use the sub-sample, which only includes capital cities apart from Montevideo. Again, in all cases there is a positive impact of nationalization on access to network sanitation.

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 nationalization of the private companies.[16] In addition, OSE has published on its website that after nationalization work related to sanitation improvements, which has been stopped since 2002, restarted again. Sanitation projects in Ciudad de la Costa, Punta del Este and Maldonado, where private companies were located became priority in OSE's agenda.

[15]We also tried these regression for households above and below the poverty line. The results, which are available upon request, are similar.

[16]The World Bank has financially supported Uruguay in the development of the water and sanitation services with 3 investment loans in 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. Additionally, there were other loans which focus on technical support: Public Services Modernization Technical Assistance project (2001-2008) – USD 6 million. These objective of these loans were to help Uruguay carry out investments in the water sector infrastructure, improving efficiency and coverage of the water supply and sanitation service.

5.2 Water quality tests

The outcome variable is the count of tests that reported an abnormal level of microbiological or organolpectic substances. This type of right-hand-side variables requires an appropriate estimator. We will use a Poisson and a Negative Binomial estimator to take into account over-dispersion in water tests (a non-constant ratio of variance over conditional mean). Because there is a large number of zeros in the data (see Table 4) we also perform a Vuong test which indicated that the zero-inflated Poisson was the appropriate model.

We used as control variables accumulated precipitations, minimum temperature and average temperature at the department level. We expect precipitation to be positively correlated with the number of abnormal quality tests, since a high level of precipitations is likely to negatively affect the functioning of the water network, making water tests more prone to detecting higher levels of undesired substances. Low temperature could increase the likelihood of failure of the network distribution system and a high average temperature could contribute to the reproduction of bacterium like coliforms, so we expect a negative coefficient on the former and a positive coefficient on the latter.

Table 10 reports the estimates with and without control variables. The first two columns provide the zero-inflated Poisson estimates, and the last two columns the zero-inflated Negative Binomial estimates. Control variables have the expected signs across both specifications, but none of the variables is statistically significant. The public provision of water services is always negatively associated with abnormal levels of undesired 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 showing abnormal levels after nationalization. Thus, results suggests that water quality improved with nationalization.

5.3 Child mortality

Because child mortality by water-related diseases is a count variable, we address the count nature of the data using either a Poisson, or a Negative Binomial estimator to control for over-dispersion in child mortality (a non-constant ratio of variance over conditional mean), when measurement error is likely to be different in judicial districts with different levels of child mortality. There is also a large number of judicial districts that report no child mortality throughout the period and therefore we used a Vuong test to see whether a Poisson or a zero-inflated Poisson model is the appropriate estimator. The results of the Vuong tests suggest that the standard Poisson model is the adequate estimator in spite of the large presence of zeroes. We also provide estimates using child mortality rates as the dependent variable (instead of the count in child mortality). Because child mortality rates (child mortality over the number of births) are a fractional variable we used Papke and Wooldrige (1996) correction.[17]

We used as control variables average completed years of education, average household income per capita and the unemployment rate at the judicial section level, as well as annual accumulated precipitations and average minimum temperatures at the department level. The first three variables are expected to be correlated with child mortality. Higher income and education will be negatively correlated with child mortality, as they will help households avoid diseases that may lead to the death of a child. On the other hand, higher levels of unemployment (conditional on income and education) may tend to positively affect child mortality through the additional stress and tension it imposes on households. A high level of accumulated precipitation is associated with floods which affect children's health, and therefore is expected to be positively correlated with child morality. The variable average minimum temperature is expected to be negatively correlated with child mortality since higher minimum temperatures could be linked with a less risky environment in terms of illnesses.

The results of different panel estimation with and without control variables are provided in Table 11. The first six columns present results using Canelones and Maldonado as the treatment group, and the last six columns results are for Maldonado only. In each case, results are first given for the Poisson estimator, then the negative Binomial estimator and finally for the Papke and Wooldridge (1996) fractional response estimator.

The estimated coefficients capturing the impact of having a public water provider on child mortality are generally negative, but they are statistically significant only for the Papke and

[17]Note that in the Poisson and Negative Binomial estimation we also control for the total number of births in each judicial district, and impose a coefficient equal to 1.

Wooldridge estimates, and only when we do not use control variables. There are no major differences between the estimates obtained when using only Maldonado as the treatment group, and Maldonado and Canelones judicial districts as the treatment group.

In sum, the nationalization of water services does not seem to have had an important impact on water-related child mortality. But, if anything, nationalization has led to a reduction, not an increase, in child mortality, as could have been expected from earlier papers. Note that the lack of statistical significance of some of the results on water-related child mortality could be partly explained by the low numbers of water-related child deaths in Uruguay as reported in Table 5.

6 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 impact of nationalization of water services on access to network and quality of water, as well as a health outcome: child mortality. Contrary to most of the existing literature we identify the impact not through the privatization of public firms, but rather through the nationalization of private firms. This is an interesting advantage of our case study because nationalization suffers less than privatization from selection bias, i.e., the fact that governments and private firms select the public companies that should be privatized. In the case of the nationalization of water services in Uruguay, all existing private companies were nationalized, which help us identify the impact of the reform on the quality of the service provided without having to worry about firms or governments choosing the best (or the worst) firms for privatization.

Several outcomes variables were used: access to sewage network, water quality and water-related child mortality. Using difference-in-difference estimators, we found that Uruguay's nationalization of water services in 2006 led to an improvement in access to the sewage network, as well as an improvement in water quality. We also found evidence of a decline in water-related child mortality, but this latter effect tends not to be statistically significant.

These results contrast with existing evidence for privatization of water services in other Latin American countries, which tend to find that privatization led to a decline in child mortality, and an increase in water access and quality. Future research should try to disentangle the determinants of these two different outcomes to help understand why privatization did not have the expected impact in Uruguay.

Potential explanations for these differences may lay on the type of regulations at the time of privatization or nationalization (investment requested, universal services), the functioning of regulatory bodies, or badly designed contracts and bidding processes, etc. A detailed examination of these differences can help understand what works and what does not work in terms of water privatization. Also differences in the functioning of public companies (external funding, composition of the board of directors, etc) could help explain why in some countries public providers of water services seem to do better than in other countries.

Finally, the results in this paper suggest that the focus on private versus public ownership of natural monopolies such as water providers may be misleading. The institutional environment under which the natural monopoly operates may be much more important. In Uruguay, at least, the public operator provided a service of equal if not better quality than the one previously provided by private firms.

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Figure 1
Map of Uruguay and treated jurisdictions

Figure 2
Map of treated jurisdictions

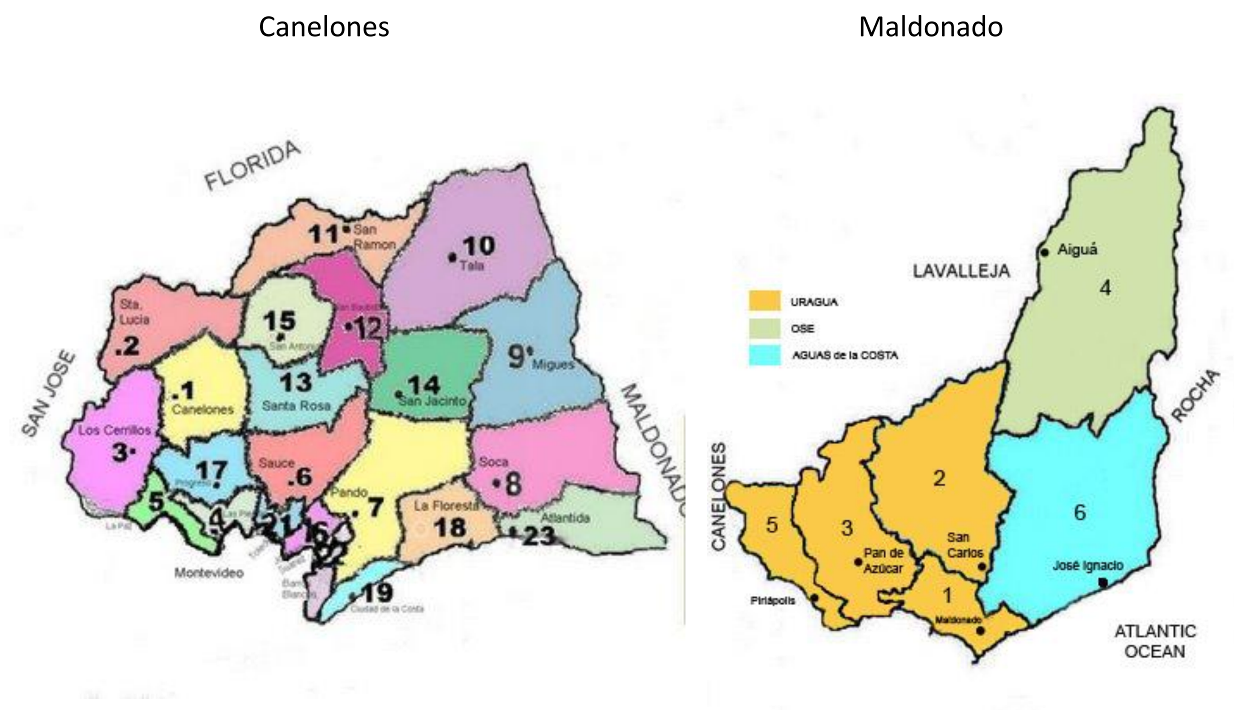
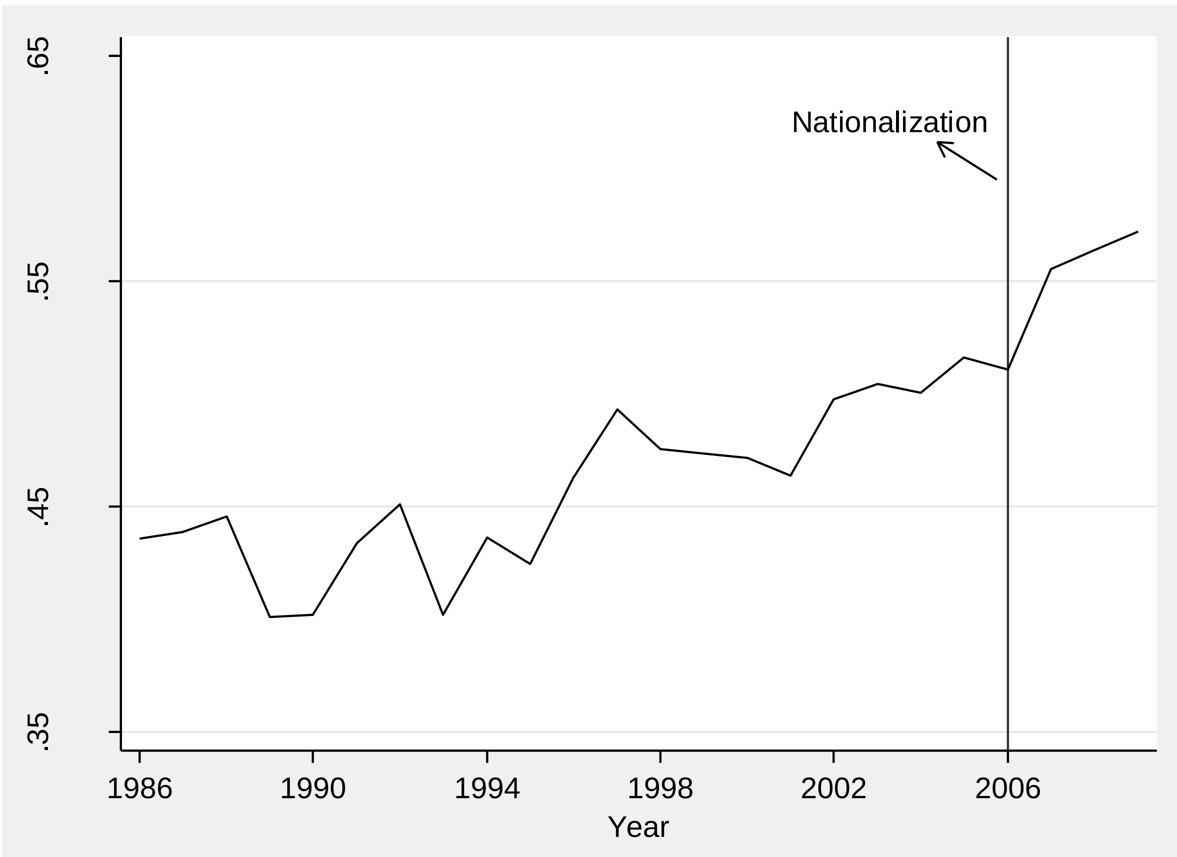
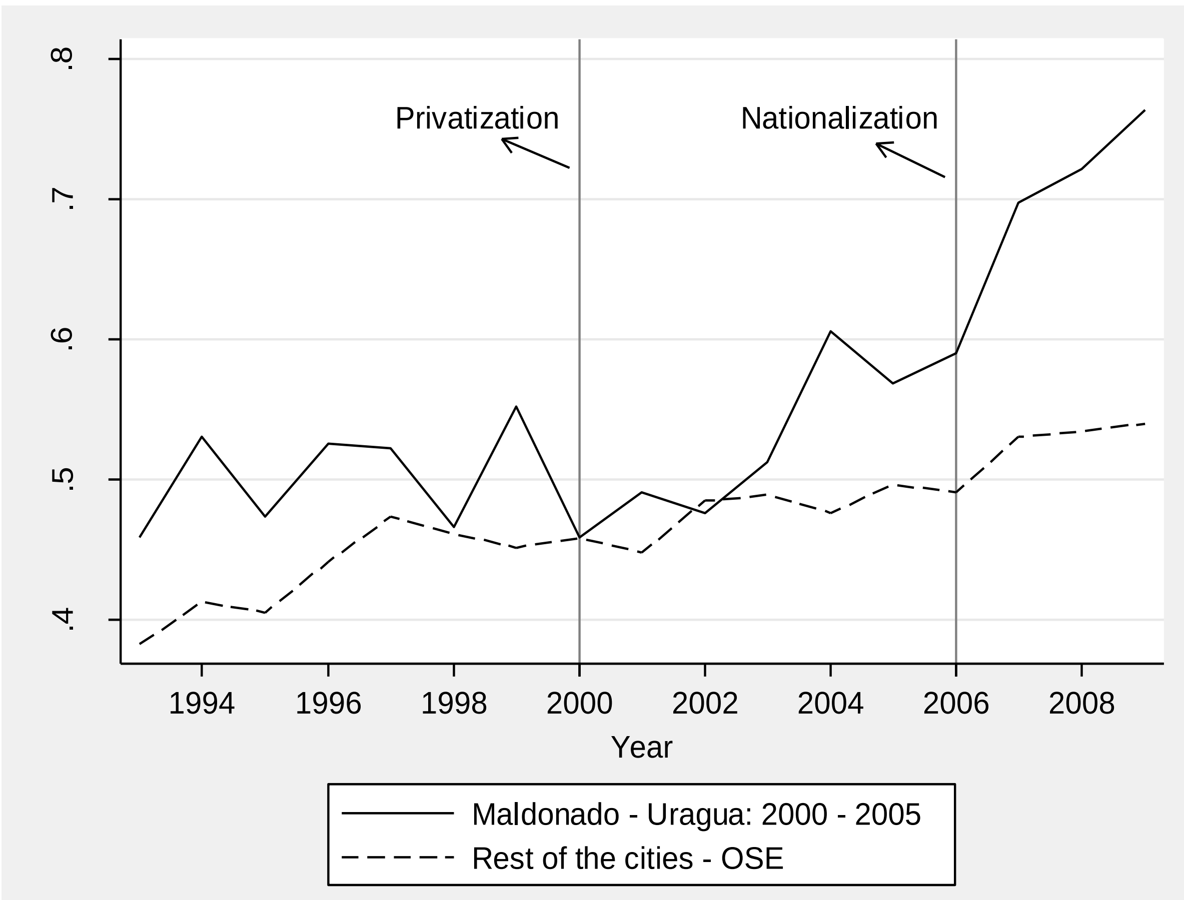


Figure 3
Average sanitation rate of main cities



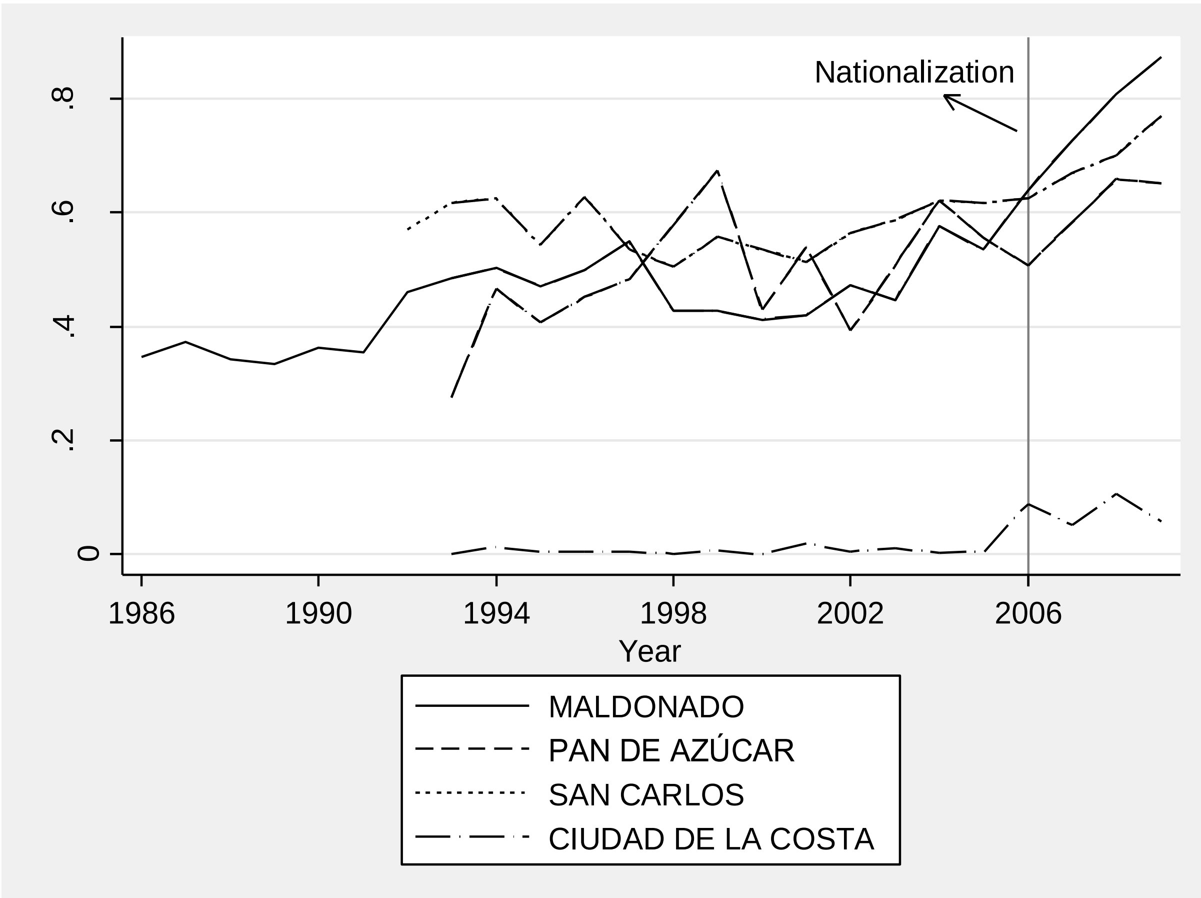
Source: ECH and authors' compilations.

Figure 4
Average sanitation rate in treatment and control cities



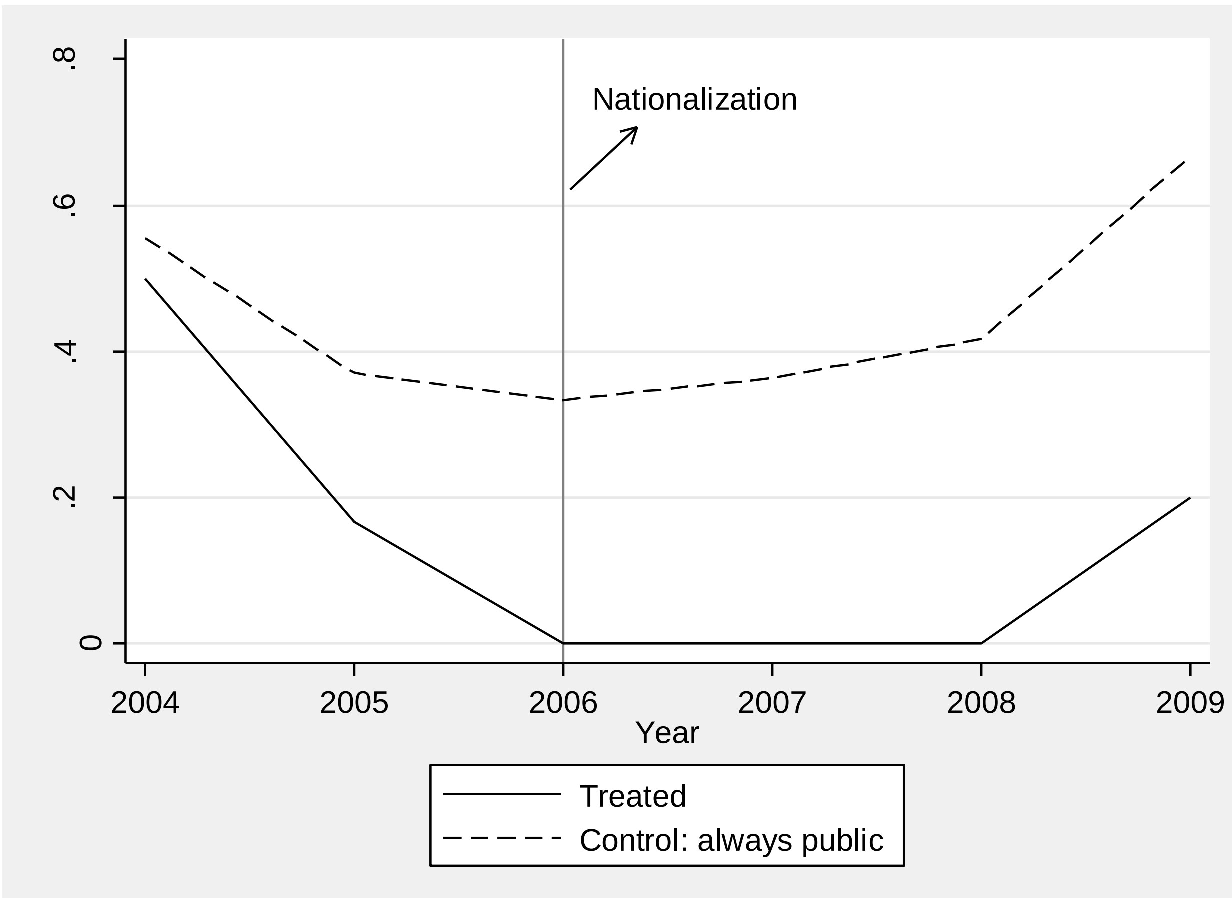
Source: ECH and authors' compilations.

Figure 5
Sanitation rate in cities with privatized water companies – treatment group



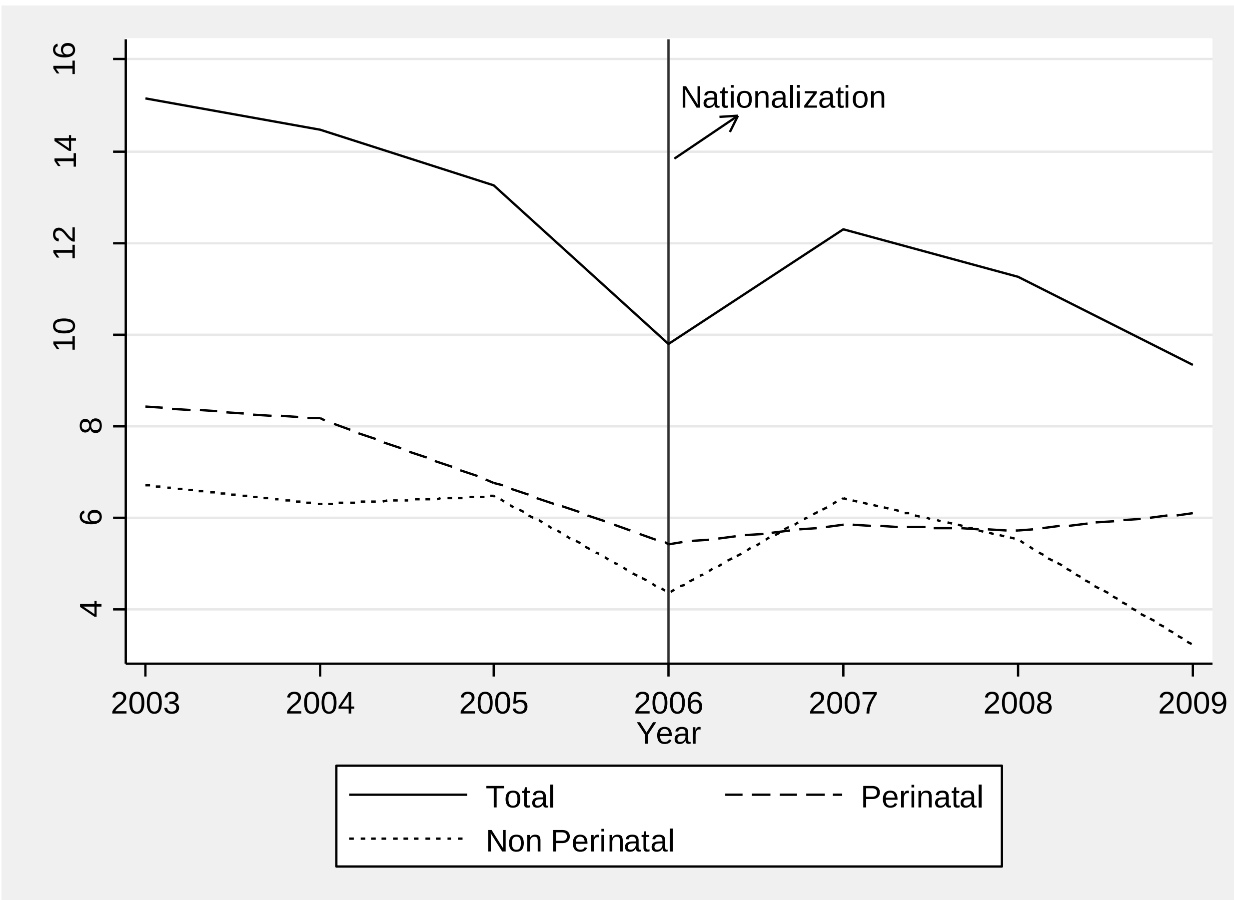
Source: ECH and authors' compilations.

Figure 6
Average count of abnormal levels in treatment and control cities



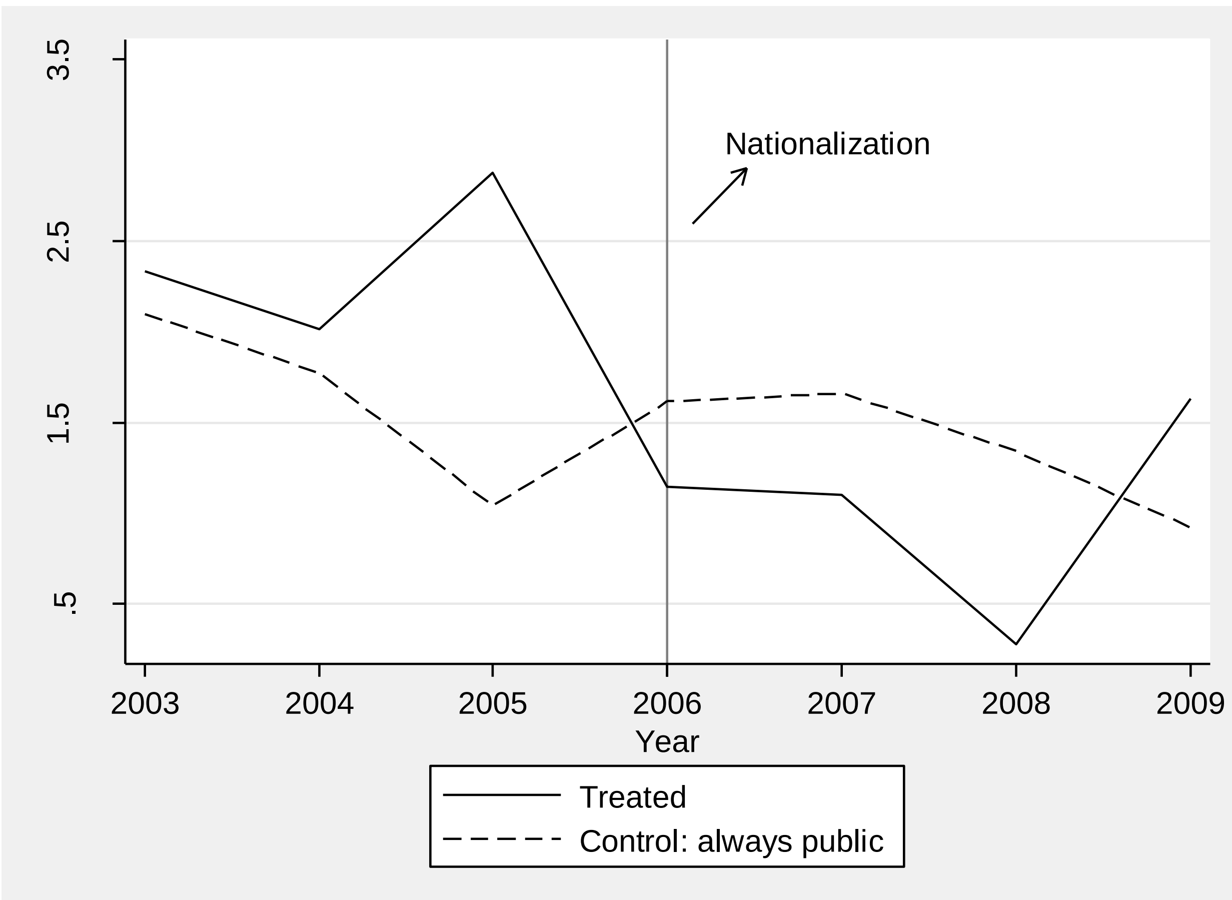
Source: URSEA and authors' compilations.

Figure 7
Child mortality rate in Uruguay per 1,000 births



Source: Ministry of Public Health and authors' compilations.

Figure 8
Child mortality rate by water related diseases in Uruguay per 1,000 births by treatment and control group



Source: Ministry of Public Health and authors' compilations.

Table 1
Indicators of the public water 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 USD	137.2	128.3	137.9	176.6	207.8
Total billings to residential customers	Million USD	78.2	72.9	80.8	104.6	123.5
Total billings to industrial customers	Million USD	29.2	26.0	29.0	37.7	45.5
Total water and wastewater operational expenses	Million USD	86.8	79.7	85.3	103.8	121.7
Labor costs	Million USD	46.6	39.5	42.1	47.5	56.1
Total gross fixed assets including work in progress	Million USD	621.8	513.0	542.7	684.5	746.6
Tariff Information						
Fixed charge per month for water and wastewater	USD per month	3.0	3.0	3.3	4.1	4.4
services for residential customers	USD per month					
Connection charges - water	USD	49.1	38.7	41.2	53.2	59.4
Connection charges - sewers	USD	19.7	15.5	16.5	21.3	23.8

Source: OSE

Table 2
Relationship between elections & the water referendum 2004 (in percentage)

		National elections & Water referendum 2004			**Council Elections 2005**	
Department	**City**	In favor of Nationalization	Left Wing Main Party	Right Wing Main Parties	Left Wing Main Party	Right Wing Main Parties
Canelones	Canelones	69	54	40	68	26
Canelones	Santa Lucia	75	57	38	65	28
Canelones	Las Piedras	73	58	36	67	27
Canelones	Soca	58	34	61	42	52
Canelones	Pando	68	52	43	57	35
Canelones	Atlantida	65	48	46	58	36
Canelones	Ciudad de la Costa	75	64	29	72	22
Canelones	San José de Carrasco	75	65	28	74	21
Canelones	El Pinar	80	72	21	79	16
Maldonado	Maldonado	54	51	42	48	46
Maldonado	Punta del Este	41	35	56	36	58
Maldonado	San Carlos	56	53	41	55	40
Maldonado	Pan de Azúcar	42	39	55	43	53
Maldonado	Piripolis	52	47	46	47	49
Maldonado	La Barra -Manantiales	55	45	51	41	57
Maldonado	Aiguá	27	22	73	24	72
Rocha	Rocha	74	46	48	50	45
Rocha	La Paloma	76	58	38	63	33
Rocha	Castillos	72	40	53	43	48
Rocha	Lascano	51	34	61	44	51
Rocha	El Chuy	74	55	39	60	34
Lavalleja	Minas	51	36	58	24	72
Lavalleja	Pueblo Solś	36	27	67	16	79
Lavalleja	Pueblo Mariscala	23	18	75	6	86
Lavalleja	José Pedro Varela	47	34	62	22	73
Lavalleja	José Batlle y Ordonez	32	27	70	17	79

Source: Uruguayan Electoral Court.

Table 3

Descriptive statistics for treatment and control groups in the access to sewage network sample

	Treated					Control				
Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
Network Evacuation Rate	57	0.53	0.12	0.28	0.87	678	0.47	0.20	0.00	0.96
Water Supply Rate	57	0.99	0.01	0.96	1.00	678	0.96	0.06	0.50	1.00
Education (Head of Household)	57	7.10	0.60	6.12	8.31	678	6.95	0.89	3.71	9.89
(log) Household per Capita Income	57	7.78	0.21	7.31	8.09	678	7.55	0.25	6.65	8.25
Unemployment Rate	57	0.13	0.06	0.04	0.25	678	0.11	0.05	0.00	0.32
Poverty Rate	57	0.16	0.09	0.02	0.40	678	0.28	0.13	0.00	0.82
Extreme Poverty Rate	57	0.01	0.01	0.00	0.04	678	0.02	0.03	0.00	0.30
% of Occuppied Households	57	0.16	0.06	0.07	0.31	678	0.14	0.06	0.01	0.33
(log) Accumulated Precipitations	57	6.99	0.19	6.64	7.32	678	7.13	0.27	6.17	7.94

Sources: ECH and the National Meteorology Office.

Table 4
Descriptive statistics by treatment and control group for the water quality sample

	Treated					Control				
Variables	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
Fecal coliforms	34	0.00	0.00	0.00	0.00	148	0.41	4.93	0.00	60.00
Pseudomonas aeroginosa	34	0.00	0.00	0.00	0.00	148	0.10	0.30	0.00	1.00
ph	34	7.00	0.42	6.10	8.10	148	7.33	0.48	6.20	8.90
Cloudiness	34	0.97	1.27	0.10	6.06	148	1.50	1.81	0.00	12.60
Count of non-compliance tests	34	0.15	0.36	0.00	1.00	148	0.45	0.79	0.00	4.00
Minimum temperature (°c)	34	8.76	0.44	7.83	9.30	148	4.80	1.13	2.48	7.38
Average temperature (°c)	34	16.82	0.16	16.57	17.02	148	17.53	0.97	16.07	20.51
Maximum Temperature (°c)	34	22.18	0.68	20.95	23.05	148	24.06	1.38	21.95	27.35
(log) Accumulated precipitations	34	4.19	0.19	3.82	4.36	148	4.30	0.24	3.50	4.78

Sources: URSEA, ECH and the National Meteorology Office.

Table 5
Descriptive statistics by treatment and control group for the child mortality sample

	Treated					Control				
Variables	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
Perinatal	35	6.22	8.92	0.00	51.28	140	6.21	6.80	0.00	31.25
Non Perinatal	35	3.43	3.16	0.00	9.55	140	5.59	6.36	0.00	28.99
Total Child Mortality Rate	35	9.65	9.26	0.00	51.28	140	11.80	9.19	0.00	43.69
Child Mortality Rate by Water	35	1.14	1.33	0.00	4.58	140	1.38	2.59	0.00	14.49
Education	35	8.49	0.98	6.99	10.76	140	7.61	1.01	5.70	10.67
Unemployment Rate	35	0.13	0.05	0.05	0.25	140	0.13	0.04	0.05	0.22
(log) Household per Capita Income	35	8.14	0.27	7.72	8.74	140	7.89	0.26	7.13	8.52
(log) Accumulated Precipitations	35	6.98	0.17	6.58	7.22	140	7.05	0.21	6.58	7.29
Minimum Temperature	35	2.23	2.19	-3.10	5.00	140	-0.97	1.77	-4.00	5.00

Sources: Ministry of Public Health, ECH & the National Meteorology Office.

Table 6

Impact of nationalization on access to sewage network in Maldonado[a]

Variables	A[b]			B[c]			C[d]			D[e]		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Public Water Provider	0.041**	0.068**	0.041	0.051**	0.067**	0.039	0.059***	0.126***	0.099***	0.059***	0.134***	0.114***
	(0.016)	(0.027)	(0.027)	(0.022)	(0.027)	(0.028)	(0.012)	(0.008)	(0.009)	(0.014)	(0.008)	(0.007)
Education			0.032***			0.030***			0.033***			0.029***
			(0.009)			(0.010)			(0.009)			(0.010)
(log) Household per capita income			0.166***			0.185***			0.156***			0.127***
			(0.028)			(0.035)			(0.028)			(0.040)
(log) Accumulated precipitations			0.051***			0.052***			0.045***			0.041**
			(0.015)			(0.019)			(0.015)			(0.019)
Time trend by city	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Observations	735	735	735	580	580	580	702	702	702	432	432	432
Adjusted R2	0.846	0.899	0.911	0.851	0.892	0.906	0.849	0.903	0.915	0.775	0.869	0.881
Sample Period		1986-2009			1993-2009			1986-2009			1986-2009	

[a]Estimates are obtained using Papke & Wooldridge Fractional Logit Model. Marginal effects reported and robust standard errors clustered at city level reported in parentheses. All models include individual and year effects. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.

[b]Treatment Units: Maldonado, San Carlos and Pan de Azúcar; Control Units: 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.

[c]Same as in **A**.

[d]Only Maldonado as Treatment Unit and the same Control Units as in A and B.

[e]Treatment Units: Maldonado; Control Units: 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 7

Impact of nationalization on access to sewage network in Maldonado in the bottom 25% of the income distribution[a]

Variables		A[b]			B[c]			C[d]			D[e]	
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Public water provider	0.076***	0.092***	0.073***	0.080***	0.095***	0.076***	0.109***	0.150***	0.128***	0.118***	0.159***	0.137***
	(0.019)	(0.026)	(0.025)	(0.022)	(0.027)	(0.026)	(0.011)	(0.008)	(0.010)	(0.013)	(0.010)	(0.014)
Education			0.017**			0.018**			0.016**			0.012
			(0.007)			(0.009)			(0.008)			(0.011)
(log) Household per capita income			0.113***			0.115***			0.090***			0.101***
			(0.031)			(0.038)			(0.028)			(0.033)
(log) Accumulated Precipitations			0.041			0.033			0.028			0.042
			(0.034)			(0.036)			(0.034)			(0.040)
Time trend by city	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Observations	735	735	735	580	580	580	702	702	702	432	432	432
Adjusted R2	0.649	0.732	0.740	0.659	0.713	0.721	0.657	0.742	0.748	0.641	0.751	0.758
Sample Period		1986-2009			1993-2009			1986-2009			1986-2009	

[a]Estimates are obtained using Papke & Wooldridge Fractional Logit Model. Marginal effects reported and robust standard errors clustered at city level reported in parentheses. All models include individual and year effects. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.

[b]Treatment Units: Maldonado, San Carlos and Pan de Azúcar; Control Units: 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.

[c]Same as in **A**.

[d]Only Maldonado as Treatment Unit and the same Control Units as in A and B.

[e]Treatment Units: Maldonado; Control Units: 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 8

Impact of nationalization on access to sewage network in Maldonado in the top 25% of the income distribution[a]

Variables		**A**[b]			**B**[c]			**C**[d]			**D**[e]	
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Public water provider	-0.002	0.025	0.001	0.012	0.023	-0.001	0.013	0.081***	0.054***	0.009	0.079***	0.064***
	(0.028)	(0.034)	(0.036)	(0.033)	(0.033)	(0.036)	(0.015)	(0.011)	(0.010)	(0.012)	(0.007)	(0.006)
Education			0.007			0.004			0.008			0.014**
			(0.006)			(0.007)			(0.006)			(0.006)
(log) Household per capita income			0.214***			0.232***			0.220***			0.151***
			(0.037)			(0.042)			(0.037)			(0.046)
(log) Accumulated precipitations			0.052**			0.055*			0.052**			0.043***
			(0.024)			(0.031)			(0.024)			(0.009)
Time trend by city	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Observations	735	735	735	580	580	580	702	702	702	432	432	432
Adjusted R2	0.873	0.901	0.912	0.871	0.894	0.907	0.876	0.905	0.917	0.719	0.794	0.816
Sample Period		1986-2009			1993-2009			1986-2009			1986-2009	

[a]Estimates are obtained using Papke & Wooldridge Fractional Logit Model. Marginal effects reported and robust standard errors clustered at city level reported in parentheses. All models include individual and year effects. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.

[b]Treatment Units: Maldonado, San Carlos and Pan de Azúcar; Control Units: 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.

[c]Same as in **A**.

[d]Only Maldonado as Treatment Unit and the same Control Units as in A and B.

[e]Treatment Units: Maldonado; Control Units: 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 9
Impact of nationalization on access to sewage network controlling for AR(1) disturbances[a]

Variables	Pooled FGLS	Pooled OLS	Within Estimator	Within Estimator D-K
Public Water Provider	0.067***	0.104***	0.097***	0.115***
	(0.019)	(0.032)	(0.033)	(0.030)
Education	0.024***	0.021***	0.019**	0.031**
	(0.003)	(0.008)	(0.008)	(0.011)
(log) Household per Capita Income	0.154***	0.156***	0.161***	0.133***
	(0.013)	(0.035)	(0.035)	(0.038)
(log) Accumulated Precipitations	0.012*	0.029	0.023	0.043*
	(0.007)	(0.019)	(0.016)	(0.022)
Observations	432	432	414	432
AR(1)	0.366	0.270	0.397	-
Sample Period		1986-2009		

[a]All columns report estimates using panel data estimators controlling for AR(1) disturbances. Marginal effects reported and robust standard errors clustered at city level reported in parentheses. All models include individual and year effects, as well as time trends by city. Treatment Units: Maldonado; Control Units: Artigas, Canelones, Colonia, Durazno, Florida, Fray Bentos, Melo, Mercedes, Minas, Paysandú, Rivera, Rocha, Salto, San José de Mayo, Tacuarembó, Treinta y Tres and Trinidad. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.

Table 10
Impact of nationalization on water quality[a] (abnormal levels of microbiological elements)

	Poisson		Negative Binomial	
Variables	(1)	(2)	(1)	(2)
Public water provider	-0.650*	-0.693*	-0.650*	-0.694*
	(0.358)	(0.367)	(0.355)	(0.384)
Precipitations		0.381		0.381
		(0.381)		(0.386)
Minimum temperature		-0.098		-0.098
		(0.121)		(0.122)
Average temperature		0.001		0.001
		(0.152)		(0.152)
Individual Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
Observations	182	182	182	182
Log Likelihood	-101.316	-100.954	-101.316	-100.954
Sample	2004 - 2009			

[a]All columns report estimates using a zero inflated model. Marginal effects reported and robust standard errors clustered at city level reported in parentheses. All models include individual and year effects. Vuong tests indicated that the zero inflated models are appropriate. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.

Table 11
Impact of nationalization on child mortality by water-related diseases[a]

	All						Maldonado					
Variables	Poisson		Negative Binomial		Papke & Wooldridge		Poisson		Negative Binomial		Papke & Wooldridge	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Public water provider	-0.632	-0.031	-0.632	-0.031	-0.001**	-0.000	-0.636	0.061	-0.636	0.061	- 0.001**	-0.000
	(0.403)	(0.581)	(0.403)	(0.581)	(0.000)	(0.001)	(0.440)	(0.680)	(0.440)	(0.680)	(0.000)	(0.001)
Education		-0.158		-0.158		0.000		0.008		0.008		0.000
		(0.431)		(0.431)		(0.001)		(0.477)		(0.477)		(0.001)
Unemployment rate		11.649*		11.649*		0.014		11.371		11.371		0.015
		(6.972)		(6.972)		(0.009)		(7.161)		(7.161)		(0.009)
(log) Household per capita income		0.677		0.677		0.001		0.323		0.323		0.001
		(1.343)		(1.343)		(0.002)		(1.507)		(1.507)		(0.002)
(log) Accumulated precipitations		-1.915		-1.916		-0.001		-1.934		-1.934		-0.001
		(2.349)		(2.349)		(0.004)		(2.379)		(2.379)		(0.004)
Minimum temperature		0.047		0.047		-0.000		0.020		0.020		-0.000
		(0.247)		(0.247)		(0.000)		(0.248)		(0.248)		(0.000)
Observations	133	133	133	133	175	175	126	126	126	126	168	168
Log Likelihood	-96.314	-93.978	-96.314	-93.978	-1.445	-1.438	-88.902	-86.856	-88.902	-86.856	-1.395	-1.388

[a]Marginal effects reported. All models include year effects & judicial section fixed effects. The data are for the period 2003-2009. The Poisson and negative binomial estimates report conventional standard errors in parenthesis, while the Papke & Wooldridge estimates report robust standard errors clustered at the city level in parenthesis. The Vuong test suggest that the standard poisson model, and not the zero-inflated poisson model is appropriate in this sample. * stands for significance at the 10% level; ** stands for significance at the 5% level; *** stands for significance at 1% level.