Water for Life: The Impact of the Privatization of Water Services on Child Mortality

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Abstract: While most countries are committed to increasing access to safe water and thereby reducing child mortality, there is little consensus on how to actually improve access to water. One important proposal under discussion is whether to privatize water provision. In the 1990s Argentina embarked on one of the largest privatization campaigns in the world including the privatization of local water companies covering approximately 30 percent of the country's municipalities. Using the variation in ownership of water provision across time and space generated by the privatization process, we find that child mortality fell 8 percent in areas that privatized their water services overall; and that the effect was largest (26 percent) in the poorest areas. We check the robustness of these estimates using cause specific mortality. While privatization is associated with significant reductions in deaths from infectious and parasitic diseases, it was uncorrelated with deaths from causes unrelated to water conditions.

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At the 2000 Millennium Summit, member countries of the United Nations unanimously agreed on a set of eight goals to reduce poverty by 2015; among them are reducing child mortality by two-thirds and cutting in half the number of households that do not have access to safe water. These goals are interrelated in that clean water is critical to containing the spread of infectious and parasitic diseases. Indeed, each year more than 3 million children die from preventable water-related diseases (World Bank, 2002a), and a number of studies have found that access to safe water is associated with better child health (Merrick 1985, Behrman and Wolfe 1987, the Cebu Team 1991, Esrey et al 1991, Lavy et al 1996, Lee et al 1997, Jalan and Ravalion 2002, inter alia).

While most countries have committed to increasing access to safe water, there is little consensus on how to actually achieve this goal. One increasingly popular proposal is to turn water provision over to the private sector. Governments who privatize water systems are typically motivated by potential efficiency gains. They hope that these efficiency gains will be translated into expanded access and enhanced service quality, and thereby improve health outcomes. While there has been little privatization of water services (World Bank, 2002a), a number of authors have reported large gains in productivity and profitability associated with privatization in other sectors (Megginson et al, 1994; Barberis et al, 1996; Frydman et al, 1999; and La Porta and Lopez-de-Silanes, 1999, inter alia).

In the water sector, however, it is not clear whether any efficiency gains from privatization would necessarily be translated into improved health outcomes or help to alleviate poverty. Indeed, recent public opinion polls and press articles report widespread discontent with privatization in general in Latin America (Finnegan, 2002; McKenzie and Mookerjee, 2002; Tagliabue, 2002; IDB, 2002). Private water companies may provide sub-optimal service quality levels because they fail to take into account the significant health externalities that are present in this industry (Shirley, 2000). In this case, privatization of water services may affect health outcomes negatively. In addition, privatization may hurt the poor through price increases, service

payment enforcement, and investment only in lucrative high-income areas (Estache et al, 2001; Birdsall and Nellis, 2002). In this case, efficiency gains from privatization might be obtained at the cost of excluding the poor from access to water services, and thus health outcomes of the poor may actually deteriorate under privatization.

In this paper, we examine the impact of the privatization of water services on child mortality in Argentina. Our study focuses on young children because they are particularly vulnerable to water-related diseases due to weak body defenses, higher susceptibility, and greater exposure from inadequate knowledge of how to avoid risks (WHO, 2002a). There are two main disease transmission mechanisms generated by the lack of appropriate water systems: waterborne diseases that occur by drinking contaminated water, and water-washed diseases that occur when there is a lack of water and sanitation for household hygiene. Young children worldwide suffer from several deadly diseases that could easily be prevented through the interruption of these transmission mechanisms by access to safe and sufficient water supply and provision for the hygienic removal of sewage (WHO, 2000). For example, diarrhea alone accounts for approximately 15 percent of all child deaths worldwide (UNICEF, 2001). In Argentina, diarrhea, septicemia, and gastrointestinal infections are three of the top ten causes of death for children under five (Ministerio de Salud, 1999).

Our analysis takes advantage of the fact that local governments are responsible for delivering water services and only some municipalities privatized those services. Between 1991 and 1999, about 30 percent of water companies covering approximately 60 percent of the population were privatized. This variation in ownership across time and space provides a potential instrument to identify the causal effect of privatization on child mortality.

A major methodological concern, however, is that local governments choose to privatize water services, and that choice may not be orthogonal to unobservable factors that also affect mortality. We address this concern in a number of ways that lead us to believe that the link between the privatization of water systems and child mortality is causal.

In the end, despite the concerns about potential negative health effects, we find that the privatization of water services is actually associated with a reduction in child mortality of 8 percent. Moreover, we find that most of the reduction in mortality occurred in low-income areas (26 percent), where the network expansion was greatest. Finally, we check the robustness of these estimates using cause specific mortality. While privatization is associated with significant reductions in deaths from infectious and parasitic diseases, it was uncorrelated with deaths from causes unrelated to water conditions.

1. THE ECONOMICS OF WATER SERVICE DELIVERY

Water systems include both the supply of clean water and the treatment and removal of sewage. These services are a natural monopoly involving large fixed costs and significant economies of scale (Noll et al, 2000).[1] There is typically little competition to a well functioning water system from alternative sources (Foster, 1999; Estache et al, 2001). The main alternative is household self-provision through pumped wells, rainwater catchments, cesspools, and septic tanks. Self-provision suffers from low quality and high cost (Abdala and Spiller, 1999). Similarly, the sale of drinkable water from private vendors is substantially more costly and therefore does not present serious competition either. Finally, the average asset life of water systems' physical plants is very long and therefore impedes any potential dynamic competition.

The water sector is also characterized by the presence of significant externalities. Most water-related diseases are contagious. This generates positive externalities in the provision of clean water across society. Similarly, the proper elimination of sanitation residuals and treated industrial waste prevents negative externalities through the pollution of natural bodies of water and other natural resources.

[1] For example, fixed costs represent more than 80% of water service costs in the United Kingdom (Armstrong et al, 1994).

Another special feature of water supply is that, as human life depends on access to drinkable water, the demand for water is perfectly price inelastic at survival levels. Of course, demand exhibits some price elasticity at levels for which water is used for other non-survival household and productive uses.

These features, natural monopoly, the presence of significant externalities, and the inelasticity of demand, have historically justified public intervention in the water sector. Most countries supply water services through the public sector, and private entry into water provision has been limited. However, there are growing calls to consider allowing a regulated private sector to deliver water services (World Bank, 2002a).

Private supply has the advantage of providing strong incentives for cost reductions and other productivity enhancements. In contrast, these incentives are weak under public ownership, where typically agents cannot reap the results of their effort and innovation. In fact, empirical evidence from several sectors strongly suggests that service quality, productivity and profitability rise significantly following privatization (Megginson et al, 1994; Barberis et al, 1996; Frydman et al, 1999; La Porta and Lopez-de-Silanes, 1999).

Nonetheless, the weak efficiency incentives in public firms might be tolerable when cost reductions by private suppliers come at the expense of undesirable quality deterioration or reductions in access by the poor. In particular, unregulated private providers may undersupply the socially optimal quality of water in the presence of externalities because they fail to take into account the marginal social benefits in their decisions. Similarly, private owners may exclude low-income households from the network by raising prices, strictly enforcing payment, and concentrating their investments in high-income areas.

However, the fear of quality deterioration or access exclusion can only be genuine when supply conditions are non-contractible (Shleifer, 1998). In the water industry, information asymmetries in service quality are relatively unimportant, and regulatory agencies can monitor

water quality, pressure, repair delays, and shortages. Network expansions and universal coverage can also be enforced through regulation.

The arguments in favor of private provision are even stronger when we consider non-benevolent governments. Politicians may use the control of state firms to channel benefits for themselves and their supporters (Shleifer and Vishny, 1994). Excess employment, corruption, subsidies, and pork barreling are typical of state owned enterprises (SOEs) around the world. As Shleifer (1998) explains it, state companies not only are unproductive because of the lack of managerial incentives, but also because inefficiency results from the political use of SOE resources.

Finally, the process of resource allocation within the aggregated public sector does not guarantee the assignment of funds to the most profitable projects. The chronic under-investment in physical capital that plagues many SOEs is aggravated for debt-ridden governments with large fiscal deficits. Privatization can significantly improve the access of firms to capital markets and therefore boost their ability to invest.

2. THE ARGENTINE PRIVATIZATION PROGRAM

The privatization of public water systems in Argentina represented a small part of a massive program that transferred almost all SOEs to private hands during the 1990s. The privatization process was, in turn, a part of a larger program of structural reform intended to revert decades of economic decline.

In the late 1980s Argentina was experiencing growing inflation driven in large part by printing money to finance huge fiscal deficits. The deficit averaged approximately 9% of GDP during the decade (Heymann and Navajas, 1989). While federal and provincial overspending generated the lion's share of these deficits, a non-trivial portion was due to significant SOE losses. By the end of the decade the ruling Radical government was unable to balance the budget. Further deficit spending could not be financed through printing money or new debt issues. In

1989 the country entered a period of hyperinflation that lead the Radical government to resign six months before the official end of their administration.

The newly appointed Peronist government immediately launched an ambitious structural reform program designed to reduce the budget deficit, control inflation and put the country back on a positive growth path. The program consisted of financial and trade liberalization, a monetary currency board, the decentralization of health and educational services, the reform and privatization of the national pension system, the emancipation of the Central Bank, a general deregulation of economic activities, and the privatization of SOEs.

The privatizations were intended to reduce the budget deficit (Galiani and Petrecolla, 1996; Gerchunoff, 1992; Heymann and Kosacoff, 2000). The acquiring firms paid the government substantial sums for the privatized companies in the form of cash and Argentine external debt bonds. In addition to the revenues from privatization, the government no longer needed to cover SOE losses from the budget.

The privatization was also intended to reverse a long period of physical infrastructure neglect (Chisari et al, 1999). During the 1970s and 1980s there was little capital investment in most public utilities and indeed much of the physical infrastructure had seriously depreciated. After this long period of negative net investments, huge capital inflows were needed to improve both the quality and access to SOE services. While the public sector had no capacity to finance those capital investments, private firms generating positive cash-flows were able to obtain private financing. Indeed, the transfer of the SOEs to the private sector, mostly to large foreign companies, greatly improved the firms' investment and access to credit markets (Heymann and Kosacoff, 2000; Galiani et al, 2002). Most of the privatized firms sold equity and bonds in international capital markets.

Argentina implemented one of most ambitious privatization programs in the world. Table 1 summarizes the main federal privatizations, the income received from the sale of the companies, and the timing of privatization. The privatized SOEs were mainly large natural

monopolies in sectors such as electricity, oil and natural gas, telecommunications, transportation, mail service and water systems. According to the official statistics (CEP, 1998; and Central Bank, 1998), 154 privatization contracts were signed during the 1990s. The privatization revenues collected by the federal government reached more than 19 Billion US dollars. This figure understates the true amount of revenues obtained from privatization, as it does not include revenues from royalties received from SOEs that were privatized as concessions, and revenues from the privatization of provincial and local SOEs. As a percentage of public resources, privatization revenues were particularly important during the initial years of 1991 and 1992, when they represented more than 1% of GDP and approximately 10% of public revenues (Heymann and Kosacoff, 2000).

The privatization of the water sector was but a very small portion of the overall privatization program. In fact, the water companies represented only a small fraction of the total SOE production (3.5 percent) and a tiny share of GDP (0.3 percent).

3. THE PRIVATIZATION OF WATER SERVICES

From 1870 through 1980, water services in Argentina were provided by the federal company Obras Sanitarias de la Nación (OSN) and a number of not-for-profit cooperatives. In 1980, OSN's jurisdiction was restricted to the federal district and 17 municipalities of the suburban Greater Buenos Aires area. While OSN remained under control of the federal government, the responsibility for public water services in the rest of the country was transferred to local governments (Artana et al, 2000). Most of the companies provided both water and sanitation; however, a few supplied only water. In these cases, there was no sewage service in the community.

In 1990, before privatization, public companies provided water services in two-thirds of the municipalities while private not-for-profit cooperative companies provided services in the remaining one-third. Between 1991 and 1999, about half of the public water companies servicing

28 percent of the country's municipalities and covering almost 60 percent of the country's population were transferred to private for-profit control (see Table 2). The remaining municipalities continued receiving water services from either public or private nonprofit cooperative companies.[2]

In section 2, we argued that the privatization of water services was a small part of a political response to the macro-economic crisis around the turn of the decade. Unlike most sectors that were privatized, the water sector is controlled at the local level, and therefore, the decision to privatize is a local one. In the early 1990s, the newly installed federal government focused its efforts on privatizing the larger centrally controlled SOEs and did not put pressure on local governments to privatize their SOEs until later. Indeed, the privatization of water services accelerated after the elections in 1995, in which the ruling Peronist government was re-elected. This is reflected in Figure 1, which depicts the percentage of municipalities served by private water companies over time. Notice that the rate of privatization of municipalities was slow in the first half of the decade, but accelerated in the second half.

Another hypothesis, which is not inconsistent with the political story, is that poorer municipalities with a lower tax base choose to privatize. These are the municipalities that may have had the most to gain from privatization. This hypothesis states that when the whole country started privatizing all SOEs, the municipalities that jumped on the bandwagon were the poorer ones.

However, the hypothesis that poor areas jumped on the privatization bandwagon is different from the hypothesis that the decision to privatize was in response to an economic shock. Whether privatization is driven by time varying shocks is important to the subsequent impact analysis. We propose to exploit the variability in firm ownership across time and space to identify the causal effect of privatization on child mortality using a difference in difference approach in

[2] The only exception is a small mining town in Jujuy, where the private mining company throughout the period of analysis provided water service.

regression form. While this approach controls for time invariant heterogeneity, one of the main threats to the validity of this approach is the existence of time-varying unobserved covariates that are correlated with both privatization and mortality. For example, local economic shocks may affect both the privatization decision and child mortality. While we cannot test this directly, if we find that the decision to privatize is uncorrelated with observed time-varying covariates, then it less likely to be correlated with unobserved ones.

In order to better understand why some local governments choose to privatize, we estimate a discrete time hazard model of the probability of transiting from public to private water service provision using methods described in Prentice and Gloeckler (1978) and Jenkins (1995). We model the probability that a public water system in a given municipality and period of time is privatized as a function of a set of municipality time-invariant and time-varying covariates, and allow for duration dependence.

We now describe the covariates and why we believe they should affect privatization. The exact definitions of the covariates and their sources are described in the data appendix, and descriptive statistics are reported in the first column of Table 3.

First, we include a set of political variables that indicate whether the privatization decision was taken by the central government or by a local government of a particular political affiliation. One would expect that the public water systems controlled by the federal government and local governments controlled by the party in power (Peronist) or provincial parties allied with the Peronists, would be more likely to privatize than municipalities controlled by the opposition radical party.

One also might expect that regions that are on average poorer areas with a lower tax base are also more likely to privatize. We measure the socio-economic status of the areas using time-invariant socioeconomic covariates including area GDP per capita, income inequality, and unemployment measured in 1990, and a set of characteristics from the 1991 Census such as the

proportion of households who have unmet basic needs, housing characteristics, and demographic characteristics of the heads of households.

Another hypothesis is that it is not the level of socio-economic status that matters, but rather socio-economic shocks that cause institutional change. We test this hypothesis by including changes in GDP per capita, income inequality, and unemployment lagged one year. We use lagged shocks for two reasons. First, the privatization itself may have affected these time-varying variables (GDP per capita, income inequality, and unemployment), and, second, the long length of time required by privatization processes suggests that the privatization decisions could not have been a response to contemporaneous shocks.

The results are reported in the second column of Table 3. First, as expected, we find that the likelihood of privatization is higher when the federal government or a local government run by the Peronist party administers the public company than when the Radical party controls local government. This is consistent with the fact that the federal government launched the privatization wave of all SOEs, when the Peronists were the party in power and the Radicals were loyal opposition. Second, the fixed baseline municipality socio-economic characteristics are individually and jointly significantly different from zero, and explain a good portion of the decision to privatize. Again consistent with expectation, larger and less well off municipalities were more likely to privatize. Third, we used a fifth order polynomial to control for duration dependence, which shows that the likelihood of privatization increased over time. This is consistent with the sequencing of the overall privatization program where the transfer of water systems to private operation occurred later in the decade. Fourth, none the economic shocks are statistically significant.

While the results discussed above suggest that the decision to privatize is uncorrelated with economic shocks, it might be correlated with mortality for other reasons. Therefore, we estimate a second model where we include both the 1990 mortality rate and lagged changes to

mortality (column 3). In this model we find that both baseline mortality and lagged mortality are not correlated with the decision to privatize.

4. PATHWAYS

There are a number of potential pathways by which the privatization of water systems might have affected child mortality. First, privatization may have expanded the water supply and sewage network providing access to service to households that were not previously connected to water and sewage. Second, there may have been improvements in service quality in terms of reduced water and sewage spillage, faster repair rates, fewer shortages, cleaner water, and better water pressure and sewage treatment. All of these quality enhancements improve the epidemiological environment (WHO, 2002b). Finally, prices may have changed and the enforcement of service payment cutoffs may have tightened, potentially reducing the access to service by low-income households. In this section, we present evidence that privatization affected these pathways.

4.1. A Case Study

The largest privatization was the transfer of the federal company OSN to a private consortium, Aguas Argentinas. The analysis of this privatization, described in Abdala and Spiller (1999), Artana et al (2000), Shirley (2000), and Noll et al (2000), illustrates the changes experienced by water systems in Argentina after the transfer to private operation.

Rather than selling the assets to the private firms, water services were transferred to the private sector through concessions.[3] In some cases, such as OSN in Buenos Aires, the royalty was set at zero and firms competed for the concession by offering the lowest tariff. In other cases, the privatized companies paid a canon to the government for the use of the public assets. For example, in the provinces of Cordoba and Corrientes, where a canon is paid on an annual basis,

[3] This is the most common method of privatizing water services worldwide (Noll et al, 2000).

the royalty payments represented about 0.4% and 0.1% of the fiscal revenues in 1999, respectively. Thus, the revenue from the water service privatization royalties constituted at best a very small share of the public budget.

In May 1993 Aguas Argentinas, a consortium lead by the French company Lyonnaise des Eaux, won a 35-year concession to provide water services previously provided by OSN. The terms of concession stipulated that 100% of households had to be connected to water service and 95% to sewage service by the end of the 35-year period. It also established service quality and waste treatment standards.

Water use fees in Buenos Aires were initially lowered by 26.9 percent as a result of the privatization bid. However, thirteen months after privatization, the regulator authorized a 13.5 percent increase in the usage fee, and a significant increase in connection fees. The increase in the connection fee was controversial as it was very close to the monthly household earnings level for the official poverty line. In response to protests, the connection fee was quickly lowered and replaced with a small fixed charge that was added to the water use bills for all clients. This explicit network expansion cross-subsidy allowed the firm to reduce the connection fees to about one tenth of the previous levels.

The enforcement of service payment was toughened after privatization. While delinquency was high for OSN, the private operator was allowed to cut service to customers with three unpaid bills (although it could be reconnected under the regulator's request). According to Artana et al (2000) and Water World Vision (2000), over 90 percent of customers regularly pay the service fees, although only about 60 percent do it on time.

Privatization drastically increased efficiency and profitability. Before privatization, OSN was overstaffed as indicated by the fact that employees' average age was above 50 years and absenteeism was high. During the first year under private management, the number of employees was reduced from 7365 to 3800. The employment reduction, together with the increase in coverage and production, resulted in large productivity increases. In fact, soon after the

privatization, the financial performance of Aguas Argentinas became outstanding. After a first year of negative returns, it turned into a highly profitable company (Artana et al, 2000).

A major question was whether these efficiency gains were translated into service quality improvements. OSN had invested very little in infrastructure during the decade prior to privatization (Galiani et al, 2002). Low revenues and inefficiencies led to such low investment levels that they were not even sufficient to replace depreciating assets and maintain current supply. In 1985 OSN investment was 67.8 percent of what was needed to maintain current supply, and only 19.5 percent in 1990.[4] In the late 1980s, water coverage as a share of population was contracting, spilled water rates were very high, pressure and service quality were low, and summer shortages were frequent (Artana et al, 2000).

Things improved dramatically after the privatization. The private company was able to invest a substantial amount in physical infrastructure and service quality. For the ten years before the privatization, OSN invested an average of 25 Million US dollars annually. From 1993 through 2000, Aguas Argentinas's investment jumped to around 200 Million per year. Table 4 shows large increases in water and sewage production, reductions in spillage, and significant service enhancements. In addition, summer water shortages disappeared, repair delays shortened, and water pressure improved.

The investments also paid off in terms of increased access to the network. The number of connections to the water and sewage networks in Buenos Aires expanded by 30 percent and 20 percent, respectively, after privatization. Figure 2 pictures the log of the number of households connected to the OSN-Aguas Argentinas water and sewage network by year from 1986 through 1999. While the number of households connected was relatively flat from 1986 to 1993, the network grew rapidly each year after privatization.

[4] For the whole country, investment in the water sector as a percentage of total domestic investment fell from 1.5% in 1970 to 0.5% in 1981-1993 (Rey, 2000).

Moreover, the network expansion was concentrated in the poorer suburban areas of Greater Buenos Aires. Since 98% percent of households in the city of Buenos Aires were already connected to water services before privatization, most of the expansion in access necessarily had to be among lower income households in the suburban areas. Indeed, Table 5 shows that 84.6 percent of the new connections were to lower-middle and low-income households.

4.2. Access to Water Services

While the data for Buenos Aires show that the privatization improved service quality and expanded access to water services, we are unable to similarly assess the impact of privatization for the rest of the country. We are, however, able to say something about the effect of privatization on access to water services. Even though increased access may not be the only mechanism through which privatization can affect child mortality, it is likely to be among the more important causal channels. Indeed, acquiring water services for the first time is likely to imply a more important change in access to safe water relative to service improvements to households with existing water and sewage connections.

We evaluate the impact of privatization on access to water services using data from the 1991 Census and from the 1997 Encuesta de Desarrollo Social Survey (EDS). The EDS was a stratified random sample of about 30,000 households from urban municipalities with more than 5,000 inhabitants, and asked questions about household connections to water services identical to those asked in the Census.

To identify the effect of privatization on access to water, we exploit the fact that by 1997 a number of municipalities had already privatized their water services (Figure 1). Using the data from municipalities in the EDS survey, we calculate the difference-in-differences estimate of the impact of privatization on the proportion of households who had access to the water network. The difference in difference estimator compares the change in the proportion of households connected to water services in municipalities that privatized to the change in the proportion connected in

municipalities that did not privatize water services. A municipality is in the privatized group if the privatization of water services occurred between 1990 and 1996.

The results, reported in Table 6, show a significantly larger increase in the proportion of households connected to water services in the municipalities that privatized than in municipalities that did not.[5] The estimated impact is even higher when we exclude the capital city, where 98 percent of households were already connected to water service before privatization. Specifically, the results suggest that the number of households connected to the water network increased by 4.2 percent.

This estimate, however, most likely underestimates the impact of privatization on access for two reasons. First, it only includes the impact of privatization through 1997. In Cordoba, for example, water services were privatized in that year and coverage increased by more than 10 percentage points in the first three years of concession. Second, the EDS grossly under-sampled poor areas, and access expanded most in poor areas where fewer households were connected at baseline.[6] Indeed, Table 5 showed that connections increased the most among the poor in Greater Buenos Aires. And Artana et al (2000) reports that after privatization in Corrientes, one of the poorest provinces in the country, the number of connections to the water network in the province rose by 22 percent and the number of sewerage connections increased by 50 percent.

Finally, results from a recent World Bank household survey (2002b) confirm that network expansions during the privatization period were concentrated in the poorer income groups. The survey inquires about connections to water and sewage services in 1992 (prior to privatization) and again in 2002 (well after privatization). Table 7 reports the share of households

[5] We obtained very similar results when we consider the proportion of population rather than the proportion of households.

[6] Specifically, the government measures the poverty of a municipality by the percentage of households with Unmet Basic Needs (UBN) in the 1991 Census. When we split the sample into 3 groups: non-poor municipalities where less than 25 percent of households have UBN, poor municipalities where between 25 and 50 percent have UBN, and extremely poor municipalities where more than 50 percent have UBN, we found that the EDS does not include any extremely poor municipalities and only includes a few poor municipalities.

connected to the water and sewage networks in both years. Overall household connection to the water network increased by 14 percentage points and to the sewage network by 10 percentage points. However, most of the increase came from households in the lower income groups. Indeed, connections to the water network increased by 21 percentage points and to the sewage network by 16 percentage points among households living in the poorest quintile of the income distribution. Table 7 demonstrates that while the poor still suffer the lowest connection rates, they had the largest gains in access after 1993.

5. THE EFFECT OF PRIVATIZATION ON CHILD MORTALITY

In this section, we evaluate the impact of the privatization of water services on the mortality of children under five. We focus on young children because they are particularly vulnerable to water-related diseases due to weak body defenses, higher susceptibility, and greater exposure from inadequate knowledge of how to avoid risks; and because water related diseases can easily be prevented through access to clean drinking water, better hygiene and better sanitation (WHO, 2000).

5.1. Methods

Our objective is to identify the average effect of privatization on child mortality rates in the municipalities where the water supply system has been privatized (i.e. the average impact of treatment on the treated). Specifically, we are interested in comparing mortality when water services are privately provided compared to the counterfactual—i.e. mortality when services are publicly provided in the treatment areas at the same point in time. Since the counterfactual is never observed, we must estimate it. In principle, we would like to randomly assign private and public ownership across municipalities and compare the average outcomes of the two groups. In the absence of a controlled randomized-trial we are forced to turn to non-experimental methods that mimic it under reasonable conditions.

A major concern is that the municipalities that chose to privatize could be different from the municipalities that chose not to privatize, and that these differences may be correlated with mortality. For example, poorer less urban areas where mortality rates were higher may have been the ones to privatize. In this case, the correlation between privatization and mortality would be confounded with the wealth effect. In principle, many of the types of (unobservable) characteristics that may confound identification are those that vary across municipalities, but are fixed over time. A common method of controlling for time invariant unobserved heterogeneity is to use panel data and estimate difference in differences models.

Therefore, without the benefit of a controlled randomized trail, we turn to a difference in differences approach, which compares the change in outcomes in the treatment group before and after the intervention to the change in outcomes in the control group.[7] By comparing changes, we control for observed and unobserved time-invariant municipality characteristics that might be correlated with the privatization decision and as well as with mortality. The change in the control group is an estimate of the true counterfactual—i.e. what would have happened to the treatment group if there was no intervention. Another way to state this is that the change in outcomes in treatment areas controls for fixed characteristics and the change in outcomes in the control areas controls for time varying factors that are common to both control and treatment areas.

This difference-in-differences model can be specified as a two-way fixed effect linear regression model:

$$y_{it} = \alpha\, dI_{it} + \beta\, x_{it} + \gamma_t + \mu_i + \varepsilon_{it} \qquad (1)$$

where y_{it} is the mortality rate in municipality i in year t, dI_{it} is an indicator variable that takes on the value one if municipality i's water services are privately provided in year t and 0 otherwise, x_{it} is a vector of control variables that vary both across municipalities and time, m_i is a fixed-effect unique to municipality i, l_t is a time effect common to all municipalities in period t, and e_{it} is a

municipality time-varying error distributed independently across municipalities and time and independently of all m_i and l_t (see Chamberlain, 1984; and Heckman and Robb, 1985). In this model, a is the difference in difference estimate of the (average) effect of privatization of water services on mortality.

There are three critical assumptions for a to be an unbiased estimate of the program impact. The first is the assumption that the change in mortality in control areas is an unbiased estimate of the counterfactual—i.e. what would have happened to mortality in the treatment areas if water services had not been privatized. While we cannot directly test this assumption, we can test whether the secular time trends in the control and treatment municipalities were the same in the pre-intervention periods (Heckman and Hotz, 1989). If the secular trends are the same in the pre-intervention periods, then it is likely that they would have been the same in the post intervention period if the treated municipalities had not privatized.

The second concern is that there may be unobserved characteristics that vary across time and space, and that are correlated with both mortality and privatization. For example, it could be that the areas that privatized were also hit with large unemployment at the time they privatized or there were improvements in the health care system or increases in public welfare programs.

We address this concern in three ways. First, the analysis in section 3 provided evidence consistent with the notion that privatization is driven by fixed characteristics and not by the observed time-varying socio-economic variables. This suggests that privatization is also less likely to be correlated with time-varying location-specific unobserved shocks. Second, we directly control for a number of observed time-varying economic and political characteristics such as GDP per capita, unemployment, income inequality and local public spending. Finally, we investigate the impact of privatization on mortality by cause of death. The privatization of water

[7] The difference in difference estimator is one of the most widely used in the evaluation literature (see, among others, Angrist, 1995; and Heckman et al., 2000).

should affect only mortality caused by infectious and parasitic diseases and not affect mortality from other causes.

The third concern is that the impact of treatment on the treated may not be homogenous across municipalities, but rather varies as a function of the characteristics of the municipalities. For example, the impact of the privatization may matter more in areas where families are better educated. In this case, simple difference in difference estimates may suffer from two additional sources of bias (Heckman et al, 1997, and Heckman et al, 1998a). The first bias arises when there are some municipalities where privatization has taken place, but there are no comparable municipalities for which privatization did not occur and vice versa. The second bias may arise from different distributions of the vector of observable variables that affect mortality (**x)** within the two groups of municipalities.[8,9]

Matching methods eliminate these two potential sources of bias by pairing privatized municipalities (treatments) with non-privatized municipalities (controls) that have similar observed attributes. Using observations in the treatment and control groups over the region of common support in the distribution of **x** eliminates the first source of concern, while the bias due to different distributions of **x** between treated and untreated municipalities within this common support is eliminated by reweighting the control group observations.

In general, conventional matching methods assume that, conditional on the observed variables **x**, the counterfactual outcome distribution of the treated units is the same as the observed outcome distribution of the units in the control group. This assumes that there is no selection into treatment on the basis of unobservables. To avoid the necessity of this assumption, Heckman et al (1998b) propose a generalized difference in differences matching estimator that extends conventional matching methods to longitudinal data. By conditioning on fixed-effects,

[8] The vector **x** includes variables that vary across municipalities and also across time and municipalities.

[9] Heckman et al (1997) suggests that, in practice, the first of these two sources of bias is likely to be the most severe.

the generalized difference-in-differences estimator identifies the parameter of interest without ruling out selection into treatment on the basis of time-invariant unobservables.

The objective, then, is to construct a control group by finding controls that have similar observed **x**'s as the treatments. Rosenbaum and Rubin (1983) show that to match treated and untreated units on the basis of **x** is equivalent to match them using a balancing score B(**x**). The coarsest balancing score is the propensity score which gives the conditional probability of receiving treatment given the pre-treatment values of the vector **x,** i.e. $P(\mathbf{x}) = Pr(D = 1 \mid \mathbf{x})$. Then, the method of matching assumes that conditional on $P(\mathbf{x})$, the counterfactual outcome distribution of the treated units is the same as the observed outcome distribution of the controls. This result is very important in practice since it reduces the potential problem of matching on a high dimensional vector **x** to matching on a scalar.

We estimate propensity scores from a logit model of the probability that a municipal water system that was public in 1990 was privatized sometime before the year 2000 as a function of the pre-intervention characteristics used in Column 3 of Table 3. These models are then used to predict the propensity (probability) that a municipality will privatize.

We identify control and treatment observations on a common support as follows. We exclude all control observations whose propensity scores are less than the propensity score of the treatment municipality at the first percentile of the treatment propensity score distribution, and exclude all treatment observations whose propensity score is greater than the propensity score of the control observation at the 99^{th} percentile of the control distribution. Then, our second set of estimates is obtained as difference-in-differences on the observations that lie on this common support. Finally, we use a kernel density weighting procedure to obtain the generalized difference-in-differences matching estimator (see Heckman et al, 1997).

5.2. Measuring Mortality

The dependent variable in our analysis is the child mortality rate constructed from information contained in vital statistics registries complied by The Argentine Ministry of Health. The database includes the 165,542 child deaths that occurred from 1990 through 1999,[10] and is aggregated to the municipality level on an annual basis for 20 pathology groups

Mortality rates are traditionally defined as the probability a child dies before she reaches age 5, and is usually approximated by the number of deaths of children less than 5 years old divided by the number kids born that year. Applying this definition of child mortality to vital statistics, the mortality rate in Argentina has fallen from 72 per 1,000 live births in 1960 to 22 in 1999.

Rather than using the probability that a child dies before she reaches age 5, we prefer to use the probability that a child less than five years old died in a given year. Therefore, we measure our dependent variable as the ratio of number of deaths of children less than five years old to the total number of children less than 5 alive at the beginning of the year. We estimate the total number of children using census data and the vital statistics records. Our results do not change when we use the more traditional definition. In that case, the estimated coefficients are equal to five times ours.

5.3 Control Groups

Our main result is evident in Figure 4, which depicts the evolution of the mortality rates per 1000 for privatized and non-privatized water companies. Until 1995, the mortality rates of the municipalities that privatized their water systems decreased at the same rate as the mortality rates of the municipalities that did not privatize. However, after 1995 the mortality rates of the municipalities that privatized decreased faster than the mortality rates of those that did not

[10] We exclude from the analysis 5,042 child deaths for which the municipality is unspecified. The mortality data is not available at the municipality level before 1990.

privatize. This timing is commensurate with the timing of privatization (Figure 1). Before 1995 only a few municipalities had privatized; whereas the bulk of privatizations occurred after 1995.

The fact that the levels and trends in mortality rates in both groups of municipalities were the same before privatization is important. One of the threats to the validity of the difference-in-difference approach is that the post intervention trend in the control group is not a good estimate of the counterfactual—i.e. what would have happened to the treatment group if there had not been an intervention. Since the control and treatment group time trends are the same in the pre-intervention period, it is harder to believe that they would be different in the post-intervention period had there been no intervention. Moreover, not only do both groups have the same trends in the pre-intervention period, they also appear to have the same levels.

We formally test that the pre-intervention time trends for the control and treatment groups are not different by estimating a slightly modified version of equation (1). We use only the observations of the control municipalities and the treatment municipalities in the pretreatment period—i.e. we use 1990-98 for all of the control municipalities and only the pre-intervention years for the treatments municipalities. However this covers nine of the ten years since a number of treatment municipalities were not privatized until 1999, the last year of our sample. We modify equation (1) by excluding the privatization dummy variable and including separate year dummies for (eventual) treatments and controls. In this model, we cannot statistically reject the hypothesis that the pre-intervention year dummies are the same for both the control and (eventual) treatment municipalities at the 1 percent significance level. This implies that the mortality rates in treatment and control groups had identical time trends in the "pre-treatment" period and validates our difference-in-differences identification strategy (Heckman and Hotz, 1989).

A related issue is that we are using both the municipalities that always had public provision of water services and the municipalities that had nonprofit cooperatives as controls. While the cooperatives were never at risk of privatization, they are just as good as the always-public municipalities as controls for estimating the counterfactual. In fact, we cannot reject that

the year dummies are the same for the always-public and cooperative municipalities in a mortality model that also controls for municipality fixed effects over the whole sample period. This implies that the time trends of the always public and cooperative municipalities were the same over the sample period, and therefore they are equally as good in predicting the counterfactual. However, while the cooperatives serve as valid controls for secular trends, our results can only be interpreted as the impact of privatization of public companies on mortality and says nothing about the possible privatization of cooperatives, as we observe no cooperatives converting to for-profit private companies in the sample.

5.3 Main Results

We present the estimation results for child mortality from all causes of death in Table 8. Each column reports the results from a different specification using the same dependent variable. The first three columns report the results for the whole sample, while the last four columns report the results using municipalities only with observable characteristics in the common support of the distribution of propensity scores.

The first column reports the results for a model using the whole sample and includes no covariates except for municipality fixed effects and year dummies. We find that the privatization of water is associated with a 0.33 reduction in the mortality rate, which amounts to a 5.3 percent reduction of baseline mortality. Both the year and municipality fixed effects are jointly significantly different from zero. However, a Hausman test cannot reject the hypothesis that the fixed effect and random effect estimates are the same. This suggests that the treatment variable is uncorrelated with the fixed municipality unobservables.

One concern with these results is that there may have been positive economic shocks to municipalities that privatized, which caused the reduction in mortality. In order to test this hypothesis, we included GDP per capita, unemployment, income inequality, and public spending per capita in a model reported in column 2. The public spending variable controls for the

possibility that the impact of privatization is coming from correlated improvements in the local public programs. However, only inequality appears to be significantly correlated with child mortality at the ten percent level. More importantly, the estimated impact of privatization is unchanged.

A related concern is that the same political parties that choose to privatize might, in general, run better administrations or have stronger preferences for child mortality reduction. While the public spending variable picks up overall government activity, it does not control for mix of spending or administrative efficiency. In model 3, we add dummy variables for the political party that controlled the local government. While it appears that mortality rates were marginally higher when the Radical party took over, the estimated impact of privatization was unaffected. Overall, we find that privatization is associated with a significant reduction in child mortality of about 5 percent using the full sample regardless of controls.

However, the estimated impact of privatization on mortality increases dramatically when we restrict the sample to observations only on the common support. In columns 4 through 6 we report the results of estimating models 1 through 3 using observations restricting the sample to observations on the common support. In the basic model in column 4, privatization is associated with an 8.6 percent fall in child mortality. This estimate does not change when we control for socio-economic characteristics in column 5 and for political variables in column 6. However, while there is no longer a statistical difference in mortality by political party, increases in public spending do appear to be significantly associated with lower mortality.

Finally, the generalized difference in difference estimate, which uses kernel density weighted matches on the common, is reported in the last column. The model estimates that privatization is associated with a 10 percent reduction in child mortality.

In summary, the results, regardless of method, show a statistically significant negative association between privatization and child mortality. The estimated impact varies from 4.5 percent to 10.0 percent of baseline mortality. While the addition of time-varying controls does

not change the estimated impact, conditioning on control and treatment observations that have common support increases the estimated impact by over 60 percent. However, adding kernel density weighted matching increases the estimated impact by only and additional 16 percent. This is consistent with the results in Heckman et al (1998a) where they evaluated matching estimates using data from a controlled randomized experiment and found that most of the bias comes from not being on the common support.

5.4. Results by Cause of Death

In spite of the robustness of our results to the inclusion of the economic and political controls, it is still possible that at the time of privatization there may have been some other unobserved changes in the municipalities that privatized that are correlated with mortality in general. For example, there may have been enhancements in the health care system or increases in public welfare programs not captured by the public spending or political variables. It is also possible that that there were different migratory trends among treated and untreated municipalities correlated with water privatizations.

In order to rule out possible unobserved changes correlated with privatization, we examine the impact of privatization on mortality by cause of death. The mortality data is disaggregated for 20 specific pathology groups. The privatization of water provision on child mortality should mainly operate by affecting deaths from infectious and parasitic diseases. These deaths are classified into two of the pathology groups. If the death occurred after the first 28 days of life, then it is classified in the Infectious and Parasitic Diseases group. However, all deaths that occurred during the first 28 days of life are placed into the Perinatal Deaths category, regardless of the cause of death. Thus, even if the death occurred from an infectious or parasitic disease it is assigned to the Perinatal Deaths during the first 28 days of life, and not to the Infectious and Parasitic Diseases category. Therefore, if the observed reduction in child mortality is operating through improved access and quality of water, then we should see significant

negative effects on deaths in the Perinatal Deaths and Infectious and Parasitic Diseases categories, and negligible effects on deaths from other causes such as accidents, cardiovascular diseases, or cancer.

We estimate the difference in difference models using municipalities with common support and all socio-economic and political controls for mortality rates for each cause of death.[11] The results are reported in Table 9. As predicted, we find a statistically significant effect on mortality from infectious and parasitic diseases (and perinatal diseases), but no statistically significant effect on mortality from any other cause. In fact, the estimated impact is higher for infectious and parasitic diseases (18.2 percent) than for perinatal deaths (11.5 percent). This consistent with the fact that safe water potentially affects more of the deaths in infectious and parasitic diseases category than it does for the perinatal category.

The importance of this result cannot be overemphasized. Privatization could only be spuriously capturing the effect of unobservables if those uncontrolled variables are correlated with deaths from infectious and parasitic diseases, but not with deaths from any other cause. This result rules out the presence of almost any other plausible explanation of our main results and leads us to believe in their causal interpretation.

5.5. Impact by Socioeconomic Status

If the privatization of water systems increased access and improved quality, privatization should show a higher impact on child mortality in poor municipalities than in wealthier ones. Middle and high-income groups already had a high rate of connection to the water network prior to privatization. Even when they were not connected or when service quality was unsatisfactory, these income groups enjoyed better access to substitutes such as pumped wells, septic tanks, or

[11] As we are analyzing child mortality, we exclude from this exercise the analysis of deaths from suicides; homicides; other violent deaths; and pregnancy, labor, delivery and puerperal diseases. We also exclude the residual category of undefined causes.

bottled water than poor sectors. The main beneficiaries of network expansions and service enhancements, therefore, were low-income households who also are the groups most vulnerable to child mortality.

In Table 10 we report the estimated impact of water privatization on child mortality at three different ranges of poverty at the municipality level. To estimate these heterogeneous impacts of privatization on child mortality, we interact the treatment dummy variable with a poverty indicator function from the 1991 Census. We construct three ranges of poverty: municipalities with a percent of households suffering from Unmet Basic Needs (UBN) lower to 25%, municipalities with UBN between 25 and 50%, and municipalities with UBN higher than 50%.

We find that the privatization of water systems does not affect mortality in those municipalities with low levels of poverty (UBN lower than 25%). The effect on the remaining treated municipalities is increasing in the level of poverty and highly significant. In fact, the privatization of water systems is associated with a 26.5 percent reduction in child mortality in municipalities with high levels of poverty (UBN greater than 50%). This result is consistent with the predictions of our causal model. The effect of privatization on child mortality should be stronger for the groups that are more vulnerable to water related diseases.

6. CONCLUSIONS

During the 1990s Argentina launched a massive privatization program as part of a large plan of structural reforms. The program included the privatization of local water companies providing service to approximately 30 percent of the municipalities and 60 percent of the population. Available information from a number of case studies demonstrates that the newly privatized water firms were more efficient, invested more in physical infrastructure, and provided better service quality than their previous public incarnations. Indeed, our evidence on access to service shows that the network connections increased significantly in the areas that privatized.

We hypothesized that increased access to the water and sanitation network, and potential changes in service quality, improved health outcomes of young children. Using a combination of methods, we find that child mortality fell by approximately 8.6 percent in the areas where water systems were privatized. This drop in child mortality emerges from a reduction in the number of deaths caused by infectious and parasitic disease, and not from deaths due to causes unrelated to water conditions. Moreover, the greater reductions in mortality were in the poorest municipalities.

Our results also shed light on a number of important policy debates. First, while the previous literature demonstrates that privatization raises firms' productivity and profitability, it does not address the question of whether privatization actually increases social welfare. We show that privatization reduces child mortality, a direct and tangible welfare indicator.

One concern that has postponed privatization of water systems around the world is the fear that private operators would fail to take into account the significant health externalities that are present in this industry, and therefore under-invest and supply suboptimal service quality. Our evidence suggests that the deterioration in performance of water systems in Argentina under public management was so large it that allowed for a privatization that generated private profits, improved access, expanded service, and reduced child mortality. While the private sector may not be providing first best services, they are doing a much better job than the public sector.

Finally, there is a growing public perception that privatization hurts the poor. This perception is driven by the belief that privatized companies raise prices, enforce service payment, and invest only in lucrative high-income areas. In contrast, we find that the poorest population experienced the largest gains from privatization in terms of reduction in child mortality. Privatization appears to have had a progressive effect on reducing health inequality.

DATA APPENDIX: DEFINITIONS AND SOURCES

Variable	Definition	Source
Child Deaths	Number of deaths of children less than 5 years old by municipality by year by cause of death.	Ministerio de Salud de la República Argentina, 1990-99
Child Population	Number of children less than 5 years old by municipality by year. Obtained by linearly extrapolation from the 1991 Census using the 1990-2000 INDEC estimates of total municipality population.	INDEC, Censo Nacional de Población y Vivienda 1991. INDEC, Proyecciones de Población por Localidad 1990-2000.
Child Mortality Rate	*Child Deaths / Child Population*	
Private Ownership of Water Services	Equals 1 if the largest fraction of the population in the municipality is supplied by a private company, and 0 otherwise.	Sistema Permanente de Información de Saneamiento, Ente Nacional de Obras Hídricas de Saneamiento, www.enohsa.gov.ar
Unemployment Rate	Unemployment rate (May and October average) in the surveyed cities of the province in which the municipality is located.	Permanent Household Survey (EPH), INDEC 1990-1999.
Income Per Capita	Per capita household income (May and October average in 1995 pesos) in households in the surveyed cities of the province in which the municipality is located.	See *Unemployment Rate*
Inequality	Ratio of top 10% to bottom 10% per capita household income (May and October average) for households in the surveyed cities of the province in which the municipality is located	See *Unemployment Rate*
Population	Total population in the municipality in 1991	INDEC, Censo Nacional de Población y Vivienda 1991.
Overcrowded Housing	Fraction of municipality's households with an average of more than three people per room in 1991.	See *Population*.
No Toilet	Fraction of municipality's households with no faecal evacuation system in 1991.	See *Population*.
Poor Housing	Fraction of municipality's households living in poor housing in 1991	See *Population*.
Below Subsistence	Fraction of municipality's households with 4 or more members per working member and low household-head education in 1991 Census.	See *Population*.
Unmet Basic Needs	Fraction of municipality's households with Unmet Basic Needs (i.e. Overcrowded Housing, No Toilet, Poor Housing, and Below Subsistence simultaneously) in 1991 Census.	See *Population*.
Household Head Age	Mean age of the household head in the municipality in 1991	See *Population*.
No Sewage	Dummy variable = 1 if sewage was not provided in municipality in 1991 Census, and 0 otherwise.	See *Population.*
Unemployment 1991	Municipality Unemployment rate in 1991.	See *Population*.
Head has High School	Fraction of households where head has completed high school in 1991.	See *Population*.
Federal Gov. Operates Services	Dummy variable = 1 if the company providing water services depends on the federal government, and 0 otherwise.	ENOHSA
Governed by Radical Party	Dummy variable =1 if the Peronist party governs province in which the municipality is located, and 0 otherwise.	Jones et al (2000)
Governed by Peronist Party	Dummy variable = 1 if the Union Civica Radical party governs province in which the municipality is located, and 0 otherwise.	See *Peronist*.
Per Capita Public Spending	Public spending per capita in April 1991 pesos of province in which the municipality is located	DataFiel

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Table 1: Privatization of Federal Argentine SOEs

Sector Privatized	Total Sale Income (Millions of US$)	Dates Privatized
Oil and Gas Production	7,594	1990 to 1999
Electricity	3,908	1992 to 1998
Communications	2,982	1990 to 1992
Gas Transport and Distribution	2,950	1992 to 1998
Transportation	756	1990 to 1994
Petrochemical and Oil Derivatives	554	1991 to 1995
Banks and Finance	394	1994 to 1999
Steel	158	1992 to 1992
Other	126	1991 to 1999
Railways	Concession	1991 to 1995
Highways	Concession	1990 to 1993
Ports	Concession	1990 to 1994
Airports	Concession	1998
Radio and TV	Concession	1990 to 1991
Water and Sewage	Concession	1993
Mail Service	Concession	1997
Total Privatization Revenue [(a)]	19,422	

Notes: (a) The total revenue from privatization does not include royalty payments from companies privatized through concessions or revenues from the privatization of provincial and municipal SOEs. Source: Ministerio de Economía (2000).

Table 2: Change in Ownership of Water Systems 1990-1999

Ownership [(a)]	Number of Municipalities	Percentage
Always Public	196	39.7%
Always Private Nonprofit Cooperative	143	28.9%
Converted From Public to Private For-Profit	138	27.9%
Always Private For-Profit	1	0.2%
No Service or Missing Information	16	3.2%
Total	494	100.0%

Notes: (a) In municipalities where more than one company provides water services, we defined the ownership status of the municipality as the ownership of the company supplying the largest fraction of the population. Source: SPIDES, ENOHSA.

Table 3: Discrete Time Hazard Estimate of the Probability of Being Privatized

	Means	Model 1 [(c)]	Model 2 [(c)]
Time-varying covariates:			
Federal Government Operates Water Services (=1)	0.018 (0.134)	17.681 *** (2.825)	17.738 *** (2.833)
Local Government by Radical Party (=1)	0.139 (0.346)	-3.097 *** (1.080)	-3.081 *** (1.082)
Local Government by Peronist Party (=1)	0.719 (0.449)	0.493 (0.445)	0.428 (0.451)
Δ Log GDP per Capita$_{t-1}$	0.047 (0.135)	5.557 (3.521)	5.505 (3.482)
Δ Unemployment Rates$_{t-1}$	0.006 (0.029)	-4.277 (5.619)	-4.199 (5.643)
Δ Income Inequality$_{t-1}$	0.005 (0.014)	-6.437 (7.904)	-6.882 (7.951)
Δ Child Mortality Rates$_{t-1}$	-0.266 (2.994)		0.033 (0.040)
Fixed Pre-Treatment Characteristics as of 1991 [(a)]			
GDP per Capita in 1991 (00s of Pesos)	43.529 (22.005)	-0.044 *** (0.012)	-0.044 *** (0.013)
Unemployment Rate in 1991	0.070 (0.020)	23.204 *** (7.077)	21.539 *** (7.208)
Income Inequality in 1991	0.452 (0.027)	0.276 (5.004)	-0.458 (5.053)
Child Mortality Rate in 1991	6.338 (4.238)		0.032 (0.029)
1991 Population is less than 25,000 (=1)	0.419 (0.493)	0.200 (0.479)	0.277 (0.499)
1991 Population is 25,000 to 50,000 (=1)	0.202 (0.402)	0.099 (0.552)	0.161 (0.572)
1991 Population is 50,000 to 100,000 (=1)	0.114 (0.318)	-0.176 (0.624)	-0.141 (0.640)
1991 Population is 100,000 to 250,000 (=1)	0.079 (0.269)	0.743 (0.645)	0.781 (0.661)
1991 Population is more than 250,000 (=1)	0.066 (0.249)	1.406 ** (0.661)	1.492 ** (0.681)
Proportion of Families with Unmet Basic Needs	0.246 (0.151)	-13.327 ** (6.191)	-15.023 ** (6.349)
Proportion of Families Living in Overcrowded Housing	0.097 (0.059)	12.426 * (7.139)	12.735 * (7.138)
Proportion of Families Living in Poor Housing	0.059 (0.048)	3.491 (3.685)	4.826 (3.750)
Proportion of Families Living Below Subsistence	0.035 (0.022)	4.386 (7.225)	5.028 (7.026)
Proportion of Houses with no Toilet	0.095 (0.116)	11.250 ** (4.505)	12.551 *** (4.679)
Proportion of Houses with No Sewage Connection	0.279 (0.448)	-0.209 (0.324)	-0.240 (0.327)
Proportion Household Heads w/ > High School Education	0.024 (0.012)	-31.197 *** (11.153)	-32.589 *** (11.320)
Proportion of Household Head's Age btw 45 & 52	0.653 (0.476)	-0.073 (0.352)	0.043 (0.368)
Proportion of Household Head's Above 52	0.144 (0.351)	0.078 (0.464)	0.204 (0.480)
Duration Dependence [(b)]		Yes	Yes
Number of Observations		2,239	2,239

Notes: (a) Pre-Treatment Characteristics are from the 1991 Census aggregated to the municipality level. (b) We include a fifth order polynomial in time to control for duration dependence, and each coefficient in the polynomial is statistically different from zero at the 0.01 level. (c) Standard errors are in parentheses. *** Statistically different from zero at the 0.01 level. ** Statistically different from zero at the 0.05 level. * Statistically different from zero at the 0.1 level.

Table 4: Comparison of OSN (Public) vs. Aguas Argentinas (Private) Performance, 1980-1999

	OSN[a] (Before Privatization)	Aguas Argentinas [b] (After Privatization)	Δ After Privatization
Water Production (1) (Millions of cubic meters per day)	3.56	3.89	9.3%
Spilled Water (2) (Millions of cubic meters per day)	1.49[c]	1.27	-14.8%
Water Supply (1- 2) (Millions of cubic meters per day)	2.07[c]	2.62	26.6%
Sewage Drainage Volume (Millions of cubic meters per day)	2.18	2.45	12.4%
Water Network Extension (Km of network)	10,148	13,287	30.9%
Sewage Network Extension (Km of network)	6,875	8,312	20.9%
Average Delay in Attending Repair Requests (Days)	180[d]	32[e]	-82.2%
Water Leakages Repaired per year	42,000[c]	96,383	129.5%
Sewage Blockages Repaired per year	100,000[c]	148,500	48.5%
Usage Fee Index [f]	100	84	-16%
Employees	9300	4000	-57%
Percentage of Clients with Appropriate Water Pressure	17 [c]	54 [g]	217.6%

Notes: (a) Average for the period 1980-1992. (b) Average for the period 1994-1999. (c) 1993 only. (d) 1992 only. (e) Average excludes 1994. (f) Corresponds to the "K" tariff factor. (g) 1996 only. Source: UADE-CEER.

Table 5: Network Expansion by Income Group in Greater Buenos Aires (1993-2000)

Income level	New Connections	Percent of Total
High & Upper Middle Income	90,200	15.4%
Lower Middle Income	282,250	48.3%
Low Income	211,800	36.3%
Total	584,250	100.0%

Source: Subsecretaría de Recursos Hídricos, from Abdala and Spiller (1999).

Table 6: Difference-in-Differences Estimates of the Impact of Privatization on the Proportion of Households Connected to the Water Network, 1991-1997

	All municipalities	Excluding Buenos Aires
Municipalities that were not privatized:		
Proportion of households connected in 1991 $\left(p_{91}^{public}\right)$	0.866	0.866
Proportion of households connected in 1997 $\left(p_{97}^{public}\right)$	0.898	0.898
Difference 1997 – 1991 $\left(p_{97}^{public} - p_{91}^{public}\right)$	0.032	0.032
Municipalities that were privatized:		
Proportion of households connected in 1991 $\left(p_{91}^{private}\right)$	0.730	0.640
Proportion of households connected in 1997 $\left(p_{97}^{private}\right)$	0.780	0.714
Difference 1997 – 1991 $\left(p_{97}^{private} - p_{91}^{private}\right)$	0.050	0.074
Difference-in-Differences $\left(p_{97}^{private} - p_{91}^{private}\right) - \left(p_{97}^{public} - p_{91}^{public}\right)$	0.018	0.042
Z-test for Difference-in-Differences Estimate [(a), (b)]	2.83 ***	5.78 ***

Notes:

(a) The statistic of contrast is $z = \frac{(p_{97}^{private} - p_{91}^{private}) - (p_{97}^{public} - p_{91}^{public})}{\sqrt{\frac{p_{97}^{private}(1-p_{97}^{private})}{n_{97}^{public}} + \frac{p_{97}^{public}(1-p_{97}^{public})}{n_{97}^{public}}}}$, where p_t is the proportion of households with access to water connection in year t in a municipality where water has been privatized (private) or has not been privatized (public), and n is the number of observations. Note that there is no sample variability when we estimate p for 1991 since these statistics are estimated from Census data.

(b) *** Statistically different from zero at the 0.01 level of significance.

Table 7: Share of Households Connected to Water and Sewage in 1992 and in 2002 by Income Quintile

	All	Income Quintile				
		Poorest	II	III	IV	Wealthiest
Share of Households Connected to Water						
1992	0.74	0.61	0.71	0.75	0.77	0.83
2002	0.88	0.82	0.85	0.88	0.92	0.91
Change 1992-220	+ 0.14	+ 0.21	+ 0.14	+ 0.13	+ 0.15	+ 0.09
Sewage						
1992	0.54	0.35	0.47	0.51	0.56	0.74
2002	0.64	0.51	0.57	0.60	0.68	0.79
Change 1992-2002	+ 0.10	+ 0.16	+ 0.10	+ 0.09	+ 0.12	+ 0.05

Source: World Bank (2002b)

Table 8: Difference in Difference Estimates of the Impact of Water Services Privatization on Child Mortality [a]

	Full Sample			Using Observations on Common Support			Kernal Density Matched on Common Support[b]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Private Water Sevices (=1)	- 0.334 ** (0.169)	- 0.320 * (0.170)	- 0.283 * (0.170)	- 0.540 *** (0.177)	- 0.541 *** (0.178)	- 0.525 *** (0.178)	- 0.604 *** (0.168)
% Δ in Mortality Rate(c)	- 5.3 %	- 5.1 %	- 4.5 %	- 8.6 %	- 8.6 %	- 8.4 %	- 10.0 %
Other Covariates:							
Real GDP per capita (00s of Pesos)		0.007 (0.005)	0.009 (0.006)		0.005 (0.006)	0.006 (0.006)	
Unemployment Rate		- 0.555 (1.757)	-0.636 (1.758)		-0.778 (1.797)	-0.836 (1.802)	
Inequality Gini Coefficient		5.171 * (2.868)	5.085 * (2.880)		3.052 (2.926)	3.052 (2.926)	
Public Spending per Capita (00s of Pesos)		- 0.028 (0.038)	- 0.035 (0.038)		-0.068 * (0.039)	- 0.07 * (0.039)	
Radical Party Municipal Government (=1)			0.482 * (0.267)			0.166 (0.284)	
Peronist Party Municipal Government (=1)			- 0.202 (0.191)			- 0.168 (0.193)	
F-Stat for joint significance of Municipality Fixed Effects	13.84	11.92	11.51	10.39	8.65	8.32	
F-Stat for joint significance of year fixed effects	55.03	19.88	18.25	52.25	15.59	12.98	
Hausman Test Statistic for Municipality Random Effect	3.64	58.46	81.87	9.15	47.45	65.04	
R-Squared	0.1227	0.1254	0.1272	0.1390	0.1408	0.1420	
Number of Observations	4732	4597	4597	3970	3870	3870	3970

Notes:

a. Each column reports the estimated coefficients and standard errors a separate regression model where the dependent variable is the child mortality rate and whose mean was 6.25 in 1990. All of the regressions include year and municipality fixed effects. *** Statistically different from zero at the 0.01 level of significance. ** Statistically different from zero at the 0.05 level of significance. * Statistically different from zero at the 0.1 level of significance.

b. The standard errors for the Kernel Weighted Matching Estimate are bootstrapped standard errors using 100 replications.

Table 9: Difference-in-Differences Estimates of the Impact of Privatization by Cause of Death [a]

	1990 Mean Mortality Rate	Estimated Impact Coefficient & Standard Error [b]	Estimated %Δ in Mortality Rate
Infectious and Parasitic Diseases	0.565	- 0.103 ** (0.048)	- 18.2 %
Perinatal Deaths	2.316	- 0.266 ** (0.105)	- 11.5 %
Accidents	0.399	- 0.004 (0.057)	…..
Congenital Anomalies	0.711	- 0.022 (0.056)	…..
Skin and Soft Tissues Diseases	0.000	0.000 (0.001)	…..
Blood and Hematologic Diseases	0.024	- 0.002 (0.008)	…..
Nervous System Disorders	0.163	0.025 (0.026)	…..
Cardiovascular Diseases	0.236	0.006 (0.030)	…..
Gastrointestinal Tract Disorders	0.051	- 0.001 (0.010)	…..
Genital and Urinary Diseases	0.020	- 0.006 (0.007)	…..
Osteoarticular and Connective Tissue Diseases	0.003	- 0.001 (0.001)	…..
Respiratory Diseases	0.511	- 0.038 (0.051)	…..
Immuno-deficiencies, Endocrine and Nutrition System Diseases	0.376	- 0.035 (0.033)	…..
Mental Disorders	0.002	0.001 (0.001)	…..
Tumors	0.068	- 0.006 (0.015)	…..
Number of observations	3870	3870	

Notes:

a. Each cell in column (2) reports the estimated coefficient (and standard error) on the privatization dummy variable from a different regression. All of the regressions also include year and municipality fixed effects, and the socioeconomic and political covariates included in the regression reported in Column 6 in Table 8. All of the regression uses only those observations on the common support.

b. *** Statistically different from zero at the 0.01 level of significance. ** Statistically different from zero at the 0.05 level of significance. * Statistically different from zero at the 0.1 level of significance.

Table 10: Difference in Difference Estimated Impact of Privatization by Poverty Level

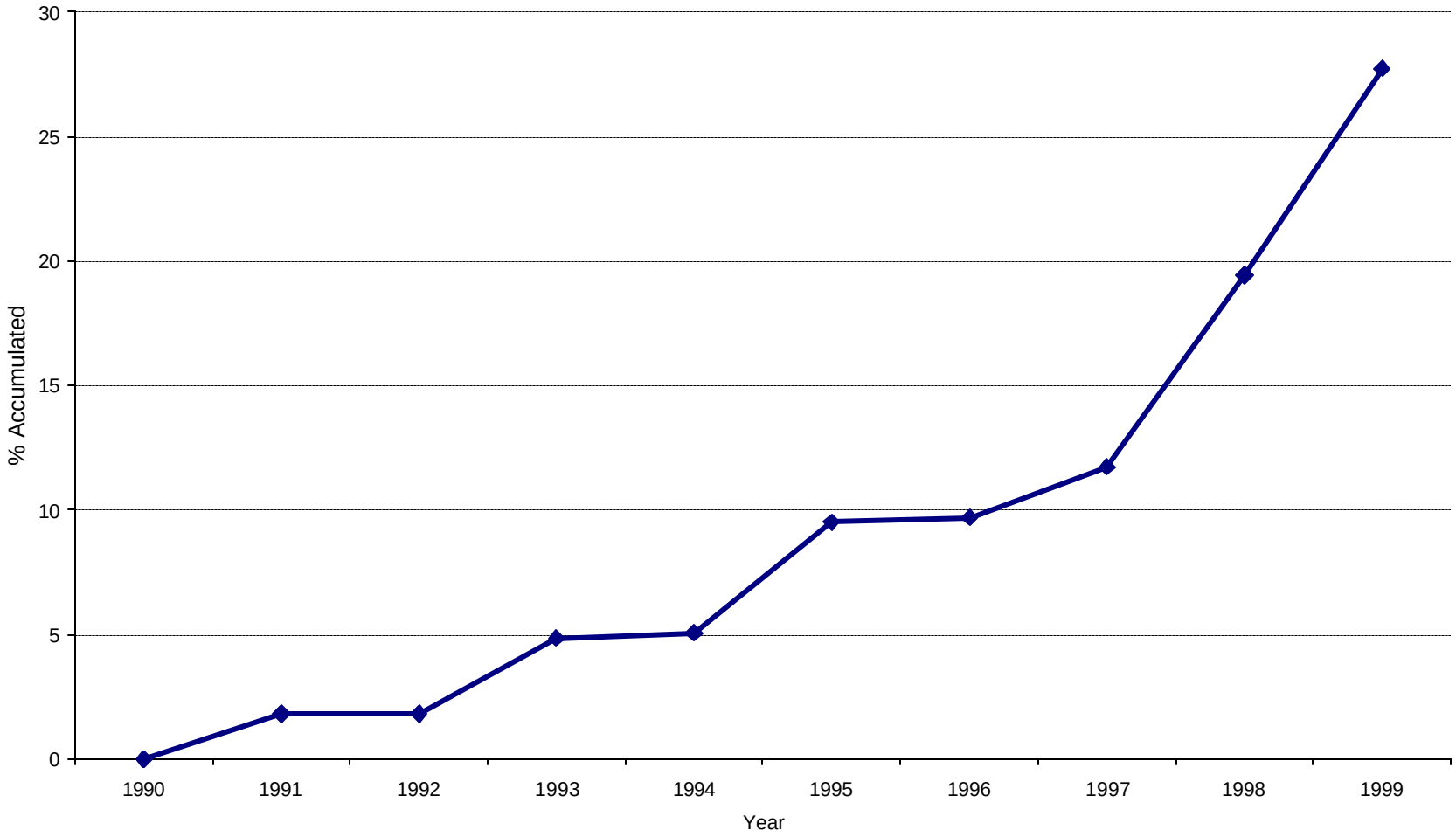
	1990 Mean Mortality Rate	Estimated Impact Coefficient & Standard Error [b]	%Δ in Mortality Rate
Non-poor Municipalities [a]	5.07	0.114 (0.233)	.....
Poor Municipalities	6.97	- 1.004 *** (0.279)	- 14.4%
Extremely Poor Municipalities	9.11	- 2.415 *** (0.544)	- 26.5%

Notes:

a. Municipalities are divided into poverty groups using the government's index of Unmet Basic Needs (UBN) using data from the 1990 Census. The index identifies a family as poor if they live in an overcrowded and poor quality house without access to water and sewage, and have an income below the subsistence level. Non-poor municipalities are defined as those in which less than 25% of households have Unmet Basic Needs. Poor municipalities are defined as those in which 25% to 50 % of households have Unmet Basic Needs. Extremely poor municipalities are defined as those in which more than 50% of households have Unmet Basic Needs.

b. The coefficients reported are the interaction of the Private dummy and UBN (recoded in a set of dummy variables in the following categories: below 25%, between 25% and 50%, and above 50%) in a difference in difference regression using only the control and treatment observations that have common support. All of the regressions also include year and municipality fixed effects, and the socioeconomic and political covariates included in the regression reported in Column 6 in Table 8. Standard errors are reported in parentheses. *** Statistically different from zero at the 0.01 level of significance. ** Statistically different from zero at the 0.05 level of significance. * Statistically different from zero at the 0.1 level of significance.

Figure1: Percentage of Municipalities with Privatized Water Systems



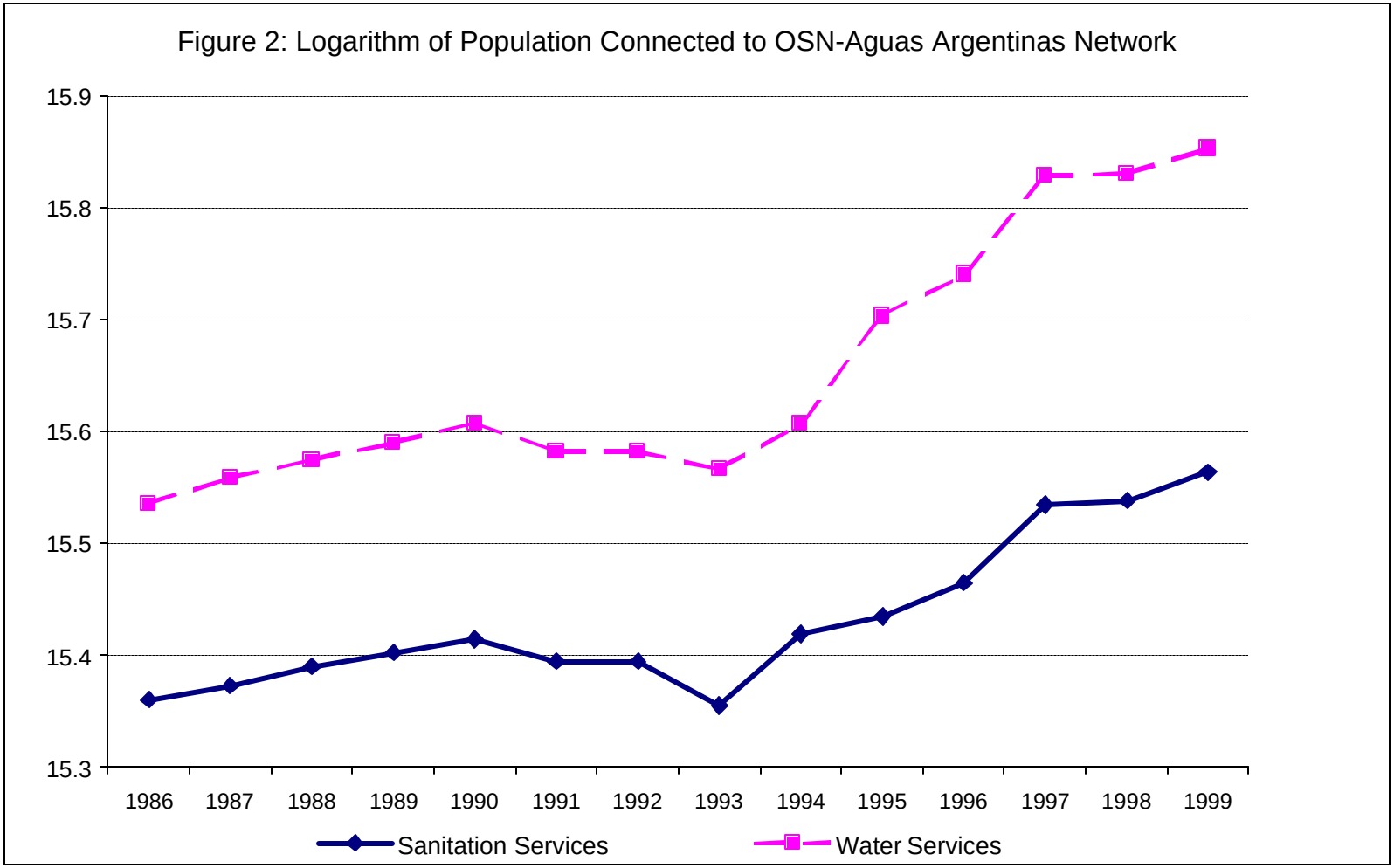


Figure 2: Logarithm of Population Connected to OSN-Aguas Argentinas Network
15.9
15.8
15.7
15.6
15.5
15.4
15.3
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Sanitation Services
Water Services

Figure 3: Change in Share of Households Connected to Water and Sewage 1992-2002

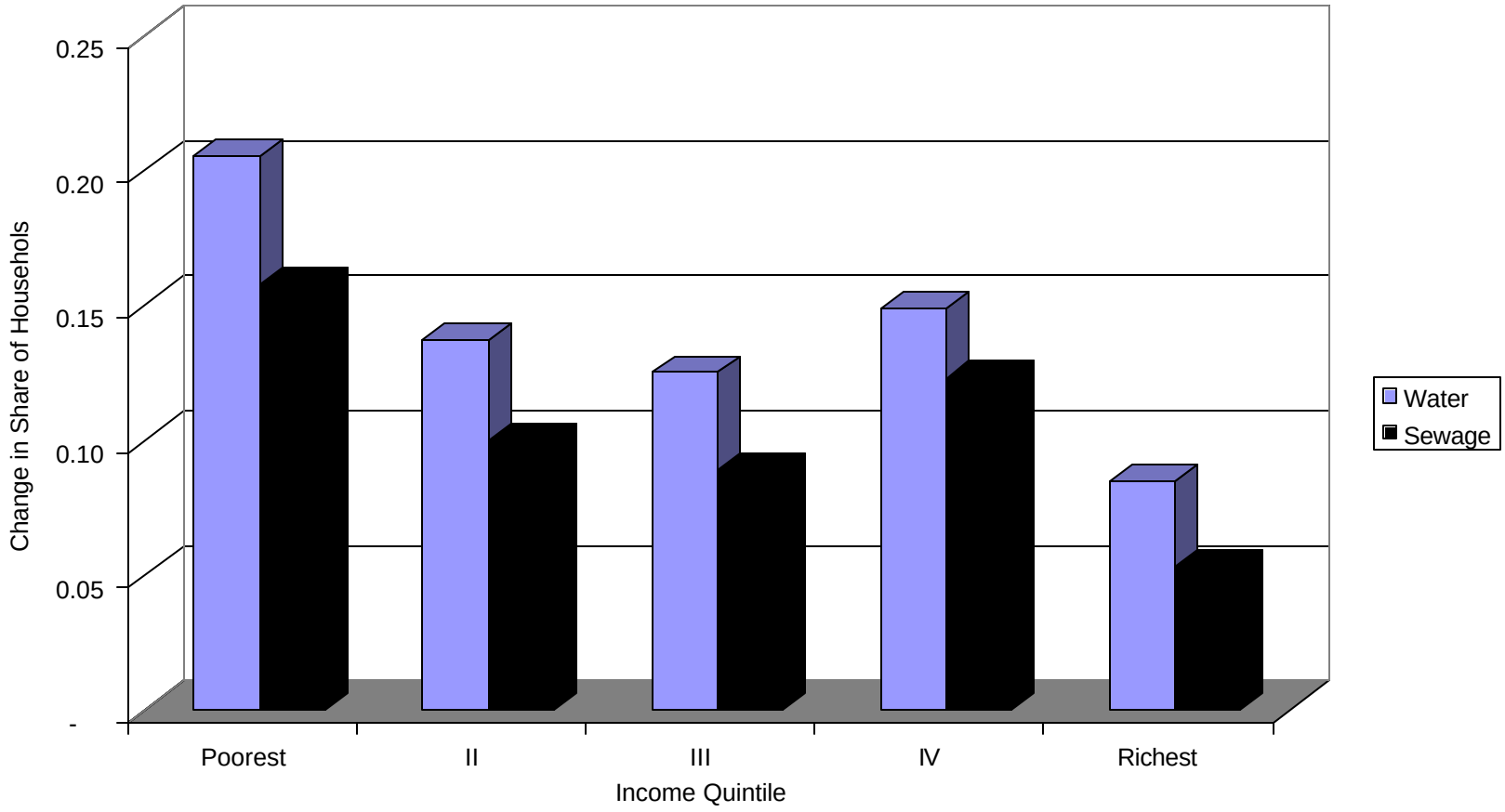


Figure 4: Evolution of Mortality Rates for Municipalities with Privatized vs. Non-Privatized Water Services