Private Provision of Water Service in Brazil: Impacts on Access and Affordability

Andre R de Oliveira

Universidade de Brasilia

30. May 2008

Private Provision of Water Service in Brazil: Impacts on Access and Affordability

André Rossi de Oliveira[a]

Abstract

Brazil has been experimenting with Private Sector Participation (PSP) in the water and sanitation sector in various forms since the mid-nineties, one of the most common being concession contracts. Currently, 25% of the population is served by companies with private sector participation and this figure could grow to 36% within 10 years. This paper studies past and ongoing experiences with private provision of water services in Brazil and assesses their impact on access and affordability indicators. It also discusses the social policies in place to improve those indicators, especially those targeting the poor. It uses different estimation methods and datasets to determine whether or not there is any difference in access to water supply and ability to pay water bills between municipalities that opted to entrust the provision of water services with private operators and those that kept them public. Moreover, whenever possible, the analysis is broken down by income (GDP) deciles in an attempt to evaluate the impact of private provision on lower income families. The results obtained entail the conclusion that PSP in Brazil has delivered higher access to water services, benefiting mostly the poor. They are inconclusive regarding affordability of water services though.

Key words: Water services, access, affordability, panel data, private sector participation.

JEL codes: L33, L51, L95

[a] University of Brasília, Department of Economics, Email: arossi@unb.br.

Impacts of private sector participation on the provision of water services in Brazil

1. Introduction

Up until the 1960's, the provision of water and sanitation services in Brazil was very deficient, lack of appropriate water and sewage treatment, inefficient operation and faulty regulation being the norm. Moreover, there were different management models in place. Some municipalities provided water and sanitation services independently, while others formed consortia with neighboring municipalities. The most successful model was apparently one where state departments were in charge of the entire production process, including planning, construction and operation (Turolla 2002).

Recognizing the close connection between economic and social development and access to basic public utility services, the military government instated in 1964 elected as one of its priorities the promotion of universal water and sanitation services. One of the actions taken by the government in that direction was the creation of the National Housing Bank (BNH) in 1964. Its initial mission was to implement an urban development policy, but it was later expanded to include assessing the situation of the water and sanitation sector in Brazil and financing of its expansion.

In order to have access to the financial resources made available by BNH through the Sanitation Financial System (SFS), municipalities were required to organize service provision in the form of autonomous departments or mixed ownership companies (Turolla 2002). This model resulted in a water and sanitation sector where supply of water and sewage services by municipalities was predominant, with only a few municipalities relinquishing operation of those services to the state.

The establishment of the National Sanitation Plan (Planasa) in 1971, however, changed the picture. The plan laid out investment schedules for the sector, as well as tariff, credit and other sector policies. It also promoted the creation of state water and sanitation companies (CESBs), encouraging municipalities to grant long term concessions to those companies in exchange for financial resources coming mostly from BNH. This centralization was defended at the time based on two arguments. The first one was that there existed economies of scale in large metropolitan areas to be captured and a need to reduce planning costs. The second was the alleged need to introduce cross subsidies, whereby more profitable regions would finance less profitable ones.

The incentives faced by the CESBs under Planasa were such that construction and expansion plans were privileged, with a detrimental effect on operations (Rezende 1996). Loans from BNH, for instance, were not available for activities pertaining to companies' operations, a consequence of the government's directive to finance the expansion of infrastructure. This eventually resulted in the deterioration of water and sewage systems, leading to high system losses. At any rate, coverage of water provision in urban areas in Brazil augmented from 60% in 1970 to 86% in 1990 under Planasa, while coverage of sewage collection increased from 22% to 48% in the same period of time (Seroa da Motta 2004).

By the end of the 1980's, though, the performance of the highly centralized Planasa system had deteriorated significantly. The Brazilian economy was facing a hyperinflationary process which led the government to keep companies' tariffs under tight control in order not to fuel inflation. Dwindling investments due to lack of appropriate financing (BNH ceased to exist in 1996 and there was a sharp decrease in foreign capital inflow), political meddling and mounting debt service from previous loans anticipated a gloomy future for the water and sanitation sector.

With the monetary stabilization achieved by the Brazilian economy after the "Real Plan" was adopted in 1994, the water and sanitation companies tried to recuperate their investing capacity and align revenues and costs, to no avail. Inappropriate management practices and lack of incentives for efficiency played a significant role in that failure. There was a slight increase in investments in the period 1994/1998, when weak fiscal controls were in place, but when those controls were tightened up and a sound primary surplus received high priority investments dropped sharply.

Water supply and sewerage services in Brazil today still reflect the main guidelines established by Planasa. The sector is dominated by the regional companies, the CESBs, which still hold concessions from municipalities. Municipal provision of water and sanitation services is concentrated mainly in larger southern and southeastern states, either through agencies under direct municipal control, autonomous agencies or municipal companies. There is a small but significant number of cases corresponding to private companies currently holding partial or full municipal concessions.

Brazil has been experimenting with Private Sector Participation (PSP) in the water and sanitation sector in various forms since the mid-nineties, one of the most common being concession contracts. In the urban areas, it is estimated that there are some 1,350 water and sewerage entities, of which 32 have been privatized (Owen 2006). Currently, 25% of the population is served by companies with private sector participation (including cases where private investors are minority shareholders) and this figure could grow to 36% within 10 years.

The main objective of this paper is to study past and ongoing experiences with private provision of water services in Brazil and to assess their impact on access and affordability indicators. We will also analyze the social policies in place to improve those indicators, especially those targeting the poor.

We try to determine if there is any difference in access to water supply and ability to pay water bills between municipalities that opted to entrust the provision of water services to private operators and those that kept them public. Moreover, whenever possible, we break down the analysis by income (GDP) deciles in an attempt to evaluate the impact of private provision on lower income families.

In order to do that, we use a series of different estimation methods and two datasets. The investigation of the impact of private provision on access is twofold. First we use a panel containing mostly financial and operational indicators, at the municipality level, to estimate panel data models where access rates are explained by a dummy for private provision of water service and other variables. Ideally, we should be able to include household characteristics in the model, but the household surveys published by IBGE, the Brazilian Institute of Geography and Statistics, omit information on the municipality where the household is located. It is, however, possible to carry out an analysis of the type "control and treatment" using a difference-in-differences estimator. The control group is composed of the municipalities that did not privatize their water service, whereas the treatment group is comprised of those who did. That is our second approach to the problem, for a panel data set of two years, 1991 and 2000, with the data coming from the Brazilian censuses. The investigation of how private participation affects affordability, however, is limited to the first data set, for there are no affordability indicators available in the censuses.

The paper is divided in seven sections, including this Introduction. In the second section we provide, as background, an account of the recent evolution of the sanitation sector in Brazil, with particular interest in the participation of private capital. Section 3 looks at social policies and regulation and describes in some detail the specific programs implemented in the country. Section 4 discusses some indicators of access to and affordability of water supply in Brazil that bear out the main problems in the sector. In Sections 5 and 6 we bring the results from a plethora of estimations of different econometric models that try to measure the effects of private provision on access and affordability. Section 7 offers a discussion of the econometric results and the last section concludes.

2. Private provision of water services in Brazil

2.1. Latest developments in the water sector

The Planasa system mentioned in the introduction was dismantled by the Brazilian Constitution of 1988, conspicuously pro-decentralization, and was subsequently abandoned. After its collapse, no consistent set of policies for the water and sanitation sector was put in place to fill the void, a situation that has persisted until recently. A law regulating the management of water resources in Brazil was passed by Congress (Law 9.433, January 8, 1997), but attempts to pass legislation specific to the water and sanitation sector have faced many hurdles, mainly because of disputes between municipalities and states over the right to grant concessions.

The Constitution established that public services such as water and sanitation should be provided by the State either directly or through concessions, and also authorized municipalities to grant concessions. The Constitution and the “Concessions Law” of 1995 (Law 8.987), however, are ambiguous when it comes to establishing which level of government is responsible for the provision of water and sanitation services and who has the power to grant concessions. The Constitution gave the municipalities the right to grant concessions of public services of local interest, but recognized that the federal and state governments should guarantee efficient and adequate regulation of water and sanitation services. These two provisions caused confusion as to how water and sanitation services in municipal and metropolitan areas, in most cases part of the concession areas of regional companies, should be regulated.

The “Concessions Law” also determined that the municipalities should have the power to grant concessions or provide the services themselves. However, it kept the door open for the regional companies (CESB’s) to play a role by specifying that the municipalities could only renew concession contracts through public tenders, in which the regional companies could participate.

In an attempt to restructure the sector, in 2001 the government submitted a project of law to Congress, known as PL 4.147, which gave sanitation companies administrative and financial autonomy, established pricing principles and concession criteria. Moreover, it established the state as the authority with the power to grant concessions in metropolitan areas, instead of the municipalities. The idea was to assure the financial viability of the state sanitation companies by allowing them to keep, at least in part, their ability to reap scale economies. These gains should be available to finance cross subsidies to poor municipalities within the area covered by the firm.

The pricing principles introduced by the bill were based on incentive regulation, more specifically on price cap and yardstick competition methods. The main objective was to promote efficiency and participation of private capital. The weak flank of the bill was its inability to set a governance structure for the sanitation sector, shying away from a proposal to create a regulatory agency.

The bill ran into the opposition of many stakeholders. The municipalities were against it mainly due to its provision that states were to have the power to grant concessions in metropolitan areas. There was also resistance to the project coming from segments reluctant to accept its directives regarding privatization, universal service and other issues. In particular, some questioned the participation of the private sector in sanitation, arguing that its profit-seeking motive was inconsistent with the provision of such essential services like water and sewage.

One of the major concerns of the government of President Lula da Silva, which came to power in January of 2003, was to restructure and restore investments in the sanitation sector. The federal administration set up a task force within the Ministry of Cities to elaborate a draft bill to be submitted to Congress with the new regulatory framework for the sector. In a nutshell, the proposal suggested that the concession power should be assigned to municipalities when the service was of local interest and that pricing as well as concession procedures should be regulated by autonomous authorities. It should come as no surprise that this proposal ran into the same kind of difficulties as the one submitted by the previous administration, opposing those who support municipalities’ powers against those who want to preserve the cross subsidy system operated by state sanitation companies (Seroa da Motta and Moreira 2004).

After a long period of discussions and some modifications, the bill was approved by Congress and sanctioned by President Luiz Inácio Lula da Silva on January 5, 2007. It establishes criteria for municipalities and states to access federal financing and determines the constitution of councils with the participation of the civil society. These councils have leverage to influence municipalities’ decisions regarding tariff setting and termination of service due to lack of payment. The bill does not clearly define powers of concession, a matter that apparently will have to be decided by the country’s highest court. It does, however, establish that investments made by concessionaires will have to be reimbursed in case their contracts are unilaterally terminated by the municipalities.

It stands to reason that the new bill will change the face of the Brazilian water and sanitation sector, which still reflects the guidelines set by Planasa in 1971.

2.2. Private sector participation in the water sector in Brazil

In the North region of Brazil, Manaus, the capital of the state of Amazonas, and Novo Progresso, in the state of Pará, are the only cities where water is supplied by private companies. In the Midwest, there are private enterprises in the states of Mato Grosso, Mato Grosso do Sul and Tocantins. The Southeast concentrates most of the private experiences, mainly in the states of São Paulo and Rio de Janeiro, but also in Espírito Santo and Minas Gerais. In the South, the states of Paraná and Santa Catarina have tried private provision of sanitation services.

There is considerable diversity in private enterprises undertaken so far in terms of financing and tariff structures. In some cases, companies subscribed the totality of their initial capital, while in others relatively sophisticated financing schemes including equity and debt were set up. However, many loans pledged to the new concessionaires by private and public institutions did not materialize (Parlatore 2000). Tariff structures are in line with those adopted in the past by the sector, based on minimum consumption rates, increasing block-rate tariffs, and differentiated according to user groups. In some cases, price cap regulation was implemented.

Concessions are the contractual instrument of choice in most cases. The municipalities in the state of Rio de Janeiro that privatized their sanitation services have opted mostly for full concessions (including water and sewage), whereas those in the state of São Paulo have preferred partial concessions and, in some cases, permissions.

The private groups that acquired the concessions were typically comprised of construction companies in the public works business lured into the sanitation market by the possibility of restoring their core business (shaken by the decline in public investments) through their concessions. There were a few cases of concessions granted to consortia of domestic and international companies where the domestic partner was usually a contractor and the international partner was a company with experience in the sanitation business (Parlatore 2000).

3. Social policy and regulation

Public policy in the water sector, be it regulatory or social, was until the late 1980's centralized by the federal government in the National Housing Bank (BNH), which managed the FGTS,[1] a sort of retirement trust fund whose resources could be used to finance projects in the sanitation sector, among other uses. As mentioned before, under the Planasa system those resources were used to entice municipalities into turning the provision of water and sewage services over to the CESBs, the regional (provincial) sanitation companies, which would then receive loans at interest rates lower than market rates. For an extended period of time, social policy for the sector amounted to heavy investments in the expansion of water supply systems (sewage was not a priority), thereby increasing coverage, and a system of cross subsidies put in place by the CESBs. According to that system, the same tariff was applied to all the different localities served by the company, irrespective of the cost of service. As a consequence, users in municipalities where the cost of service was smaller than the tariff subsidized those where the tariff was not high enough to cover the cost.

The Planasa system of cross-subsidies, low interest loans, (almost) unlimited resources and heavy investments, resulted in an impressive expansion of coverage of water services. The expansion was uneven, though. Municipalities that didn't sign up for Planasa, commissioning their water and sewage services to municipal companies or autonomous entities, in general did not fare as well as those that did. Moreover, low-income families were by and large excluded from the system, since projects financed by Planasa were in general required to yield a reasonable rate of return.

With the end of BNH and Planasa, the scheme put in place over the years to monitor projects financed by the plan was dismantled. Some cross-subsidies remained, but now lacking transparency and control. As a consequence, companies became less efficient and different parties started to claim rights over the surplus generated by subsidies in places where revenue was higher than cost. No coherent policy for the sanitation sector replaced the Planasa system. Different ministries and federal government departments were put in charge of designing one, to no avail. There are many initiatives aimed at

[1] In Portuguese, Fundo de Garantia por Tempo de Serviço.

increasing investments in low income population areas and improving services in sanitation. Nevertheless, there is no integrated planning for the sanitation sector, with different ministries, like the Ministries of Cities, Health, Environment and National Integration, besides Tourism, Defense and Agriculture, being in charge of programs that finance projects in the sanitation sector. One can claim that this decentralization ends up lowering the quality of the projects implemented and the efficiency of public expenditure. Some of the most important programs put in place are the following: Pro-Sanitation, Pro-Sanitize, Pro-Community, FCP/SAN, Rural Sanitation Program, Sanitation is Life, and Sanitation for Everyone.[2]

In 2005, the federal government pledged R$700 millions to finance public sanitation projects, and R$640 millions to private company projects. From the federal budget, another R$800 millions in grants to state and municipal governments were laid out through individual and party parliamentary bills.

Social policy has been mainly based on loans (investments) to expand and improve quality of water and sanitation services, some of them designed exclusively for low income families. Thus, the main concern is to improve access, affordability being given a much lower priority. Policies that target affordability issues are essentially those based on cross subsidies, which allow companies to charge "social tariffs" to low-income families. These are usually expressed in terms of a certain percentage of the full tariff.

Virtually all sanitation companies, public and private, adopt social tariffs. There are exceptions like Prolagos, a private company that provides sanitation services to some municipalities in the state of Rio de Janeiro. Even though it does not have a social tariff, it uses an increasing block tariff scheme intended not only to favor low income families but also to rationalize the use of water. In the case of state regional companies, their tariff structures generally have to abide by rules specified in state and/or municipal laws, but there are many cases in which they have a lot of leeway to set tariffs.

There is widespread use of increasing block tariffs. For example, most residential tariffs follow an increasing block scheme, with higher prices per cubic meter for higher consumption rates. Some companies charge a flat rate up to a certain consumption level, usually around 10 cubic meters. There are exceptions, though, like SANEPAR, the state company in charge of sanitation services in the state of Paraná. It currently adopts a two-part tariff, with a fixed rate (independent of consumption level) and a per cubic meter charge.

Some private companies, like Citágua, in Cachoeiro de Itapemirim, state of Espírito Santo, actively engage in tariff policies designed for low income families, usually in cooperation with the municipalities. Citágua has a joint program with the city of Cachoeiro de Itapemirim that gives waivers to low income families with up to 10 cubic meters of consumption. Families have to register with the municipal department of social works in order to be eligible.

4. Access to and affordability of water services in Brazil

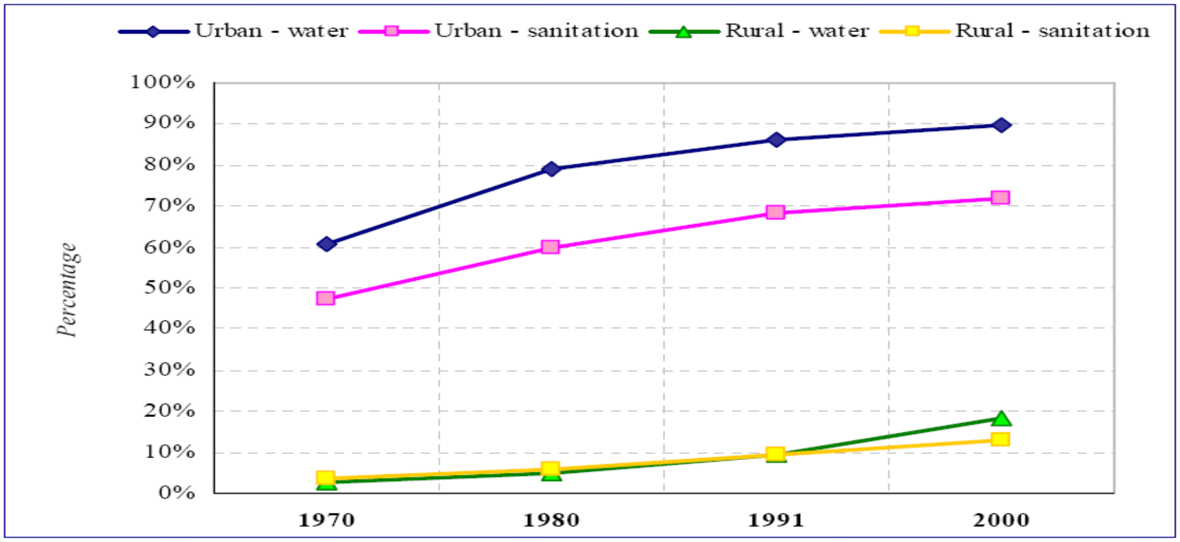
In this section, we provide a depiction of the evolution and current situation of the water sector in Brazil. Access to water as well as sewage services increased significantly in Brazil from 1970 to 2000, as can be seen in Figure 1. This has been possible as the result of heavy investment by the government. In spite of the strong expansion, water coverage rates in rural areas are still very low. The percentage of households with connection to water supply was 76% in 2000, with 90% coverage in urban areas and only 18% in rural areas[3]. Indicators of access to sewage services (including system connections and septic tanks) are even worse: 59.9% access overall, with 72% for urban and 13% for the rural population.[4]

2 Information on these programs can be found at the Brazilian Ministry of Cities site, www.cidades.gov.br.

[3] These are all national figures.

[4] Since our main concern in this paper is with water services, sewage numbers are only mentioned here in this broad picture of the evolution of access to sanitation services in Brazil.

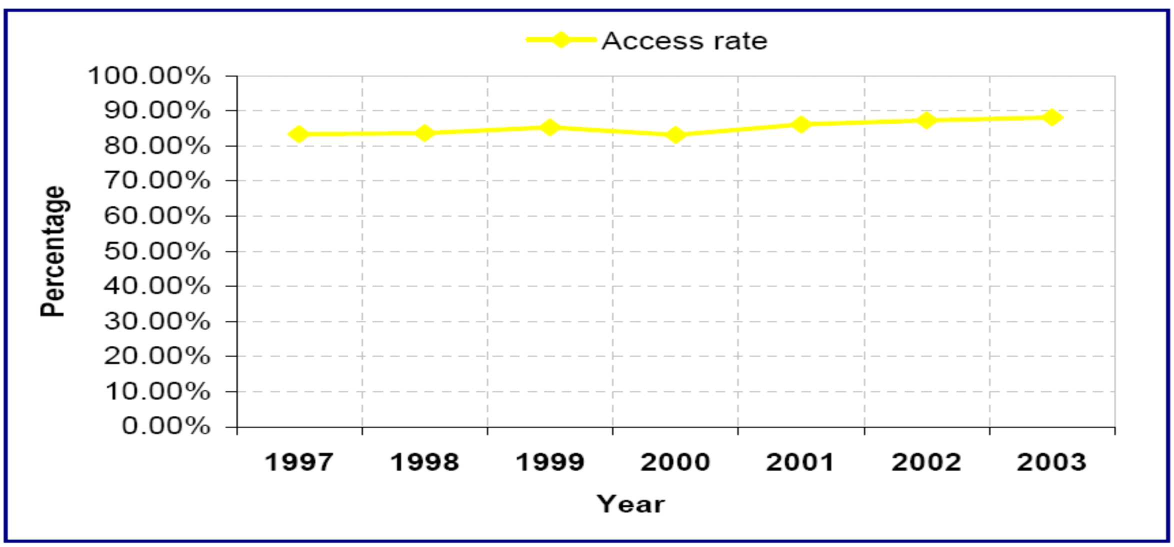
Figure 1 Access to water and sewage services (national averages) – Percentage of Households, 1970, 1980, 1991, 2000



Source: IBGE – 1970, 1980, 1991 and 2000 demographic censuses.

Figure 2 presents annual data on access to water services only from 1997 to 2003. We notice a steady increase in access rates, which seem to be leveling off.

Figure 2 Access to water services (national averages) – Percentage of Households, 1996-2003



Source: IBGE – PNADs 1997-1999 and 2001-2003, Demographic Census 2000.

Access to public services in Brazil is very unevenly distributed. Water supply is no exception. The following table shows the evolution of access to water services by income deciles for the period 1995-2003.

Table 1 Access to water supply by deciles 1995-2003

	1995	1996	1997	1998	1999	2000	2001	2002	2003
1st decile	51.73%	52.37%	53.83%	56.34%	60.05%	60.94%	61.85%	68.16%	68.29%
2nd decile	54.12%	54.66%	56.90%	59.73%	62.41%	69.19%	71.65%	73.22%	75.41%
3rd decile	67.26%	68.15%	69.45%	72.81%	80.13%	77.94%	81.33%	81.98%	81.15%
4th decile	76.47%	78.22%	79.42%	81.95%	82.68%	84.70%	84.07%	82.26%	85.63%
5th decile	84.52%	86.89%	88.57%	86.66%	87.76%	89.19%	87.68%	90.26%	91.02%
6th decile	89.89%	90.02%	91.26%	91.65%	91.71%	93.05%	92.46%	93.26%	94.18%
7th decile	95.12%	94.29%	94.19%	94.61%	95.73%	95.51%	94.91%	94.25%	97.26%
8th decile	95.37%	96.44%	98.21%	97.72%	98.08%	96.97%	97.45%	97.84%	98.26%
9th decile	98.52%	98.79%	99.11%	98.97%	98.74%	98.08%	98.63%	98.74%	98.90%
10th decile	98.79%	99.12%	99.79%	99.53%	99.90%	98.90%	99.02%	99.64%	99.64%

Note: Access to water supply is defined as percentage of households with piped water in at least one room of the house.
Source: IBGE – PNADs 1995-1999 and 2001-2003, Demographic Census 2000

Despite the significant increase in coverage for the lowest deciles, the gap between them and the highest deciles is still very large. In 2003, for instance, the access rate for households in the top 10% income bracket was 31.35% points above that for households in the bottom 10%. Not only is the distribution of access to water by income groups uneven, but also the distributions by region and location (urban or rural). The table below gives us a better idea of how skewed those distributions are:

Table 2 Access to water supply by region and location 2001-2004

Region		2001	2002	2003	2004
North	Total	--	--	--	69.54%
	Urban	73.47%	77.43%	76.48%	79.66%
	Rural	--	--	--	39.19%
Northeast	Total	67.02%	69.52%	71.02%	72.83%
	Urban	83.99%	85.91%	86.80%	87.73%
	Rural	22.85%	25.82%	28.59%	31.49%
Midwest	Total	90.36%	92.26%	93.35%	94.02%
	Urban	93.96%	95.31%	96.21%	96.47%
	Rural	67.17%	72.03%	75.56%	78.69%
Southeast	Total	96.83%	97.32%	97.60%	98.11%
	Urban	98.13%	98.42%	98.54%	99.01%
	Rural	81.76%	83.82%	85.95%	86.76%
South	Total	96.55%	97.41%	97.65%	97.87%
	Urban	98.28%	98.78%	98.64%	98.74%
	Rural	88.43%	90.92%	92.80%	93.52%

Source: IBGE – *PNADs 2001-2004*

Coverage rates in rural areas are significantly lower than in urban areas in all geographic regions, but remarkably so in the North and Northeast, where overall coverage rates are well below those in the Midwest, Southeast and South regions. The North and Northeast regions of Brazil are much less developed than the other regions, and low water supply access rates only reinforce that.

It is also worth drawing a profile of households and individuals with and without access to piped water. It helps determine who should be targeted by social policies. Based on a descriptive analysis of our data, we obtained the following profile[5]:

- In terms of regional location, approximately a third of households with access to piped water supply are in the rich Southeast region. In addition, around one half of the population without access to water is in poor Northeast region. (This is likely linked to the

[5] The results presented here can be found in a monograph by Marcelo Quintão entitled "Setor de Saneamento Básico no Brasil: Características do Setor, Perfil de Acesso do Usuário e Participação da Iniciativa Privada." The monograph was written under the supervision of this paper's author.

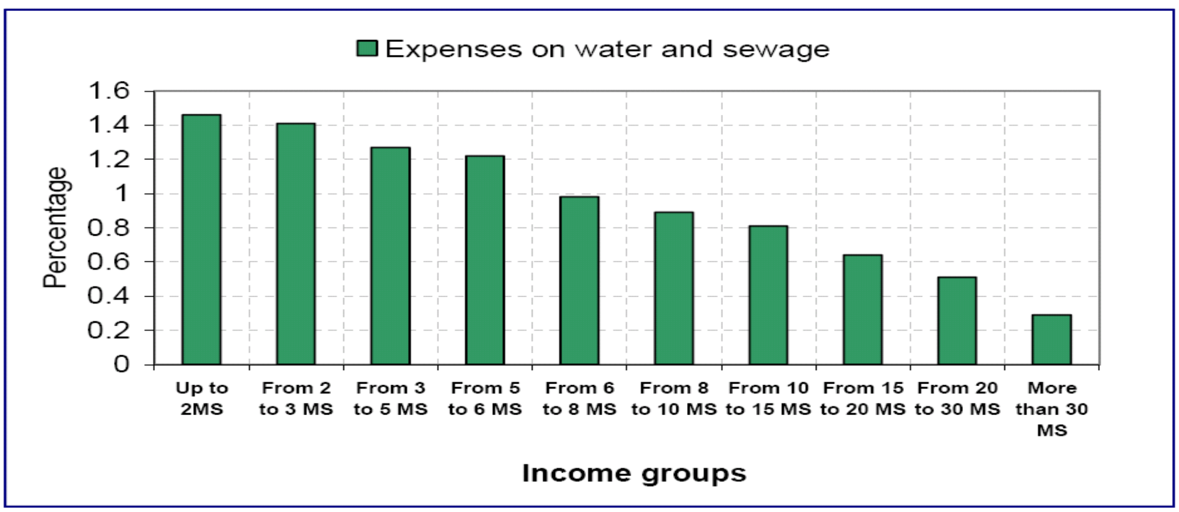
fact that Planasa's emphasis was on projects that could generate reasonable rates of return, mostly implemented in industrialized and developed regions.)

- Families with access that do not own their homes live mostly in rented dwellings. On the other hand, families without access who are not owners usually live in properties made available by their employers or others. (This fact reinforces a characteristic of households excluded from the water system: a great deal of them live in rural areas, where it is customary for employers to provide lodging to their employees.)
- Approximately 51% of households without access are in rural, isolated urban or non-urbanized areas.
- Most of the individuals without access to water service are between 0 and 10 years of age. This is a particularly troublesome statistic, for diseases caused by the consumption of non-treated water affect mostly children less than five years old.
- Illiteracy rate among individuals without access is very high when compared to those with access, approximately 10 percentage points higher.
- Individuals without access have significantly less years of study than those with access. A striking 31% of those without access have less than one year of study, and more than 23% have only between 1 and 3 years of study.

The characteristics associated with households and individuals without access are consistent with those usually found in low income families. This suggests that an increase in coverage of water services should benefit primarily poorer families.

Affordability of water services in Brazil is also a critical issue. We can observe that by looking at the percentage of household income spent on water and sewage payments. The figure below shows the average percentage of household income spent on water and sewage bills by income groups, where these groups are defined in terms of multiples of the minimum salary on January 15, 2003.[6]

Figure 3 Affordability by income groups



Source: IBGE – 2002-2003 Survey of Household Budgets (POF)

The graph above is striking evidence of how water and sewage bills are much more burdensome for low-income families than high-income families. For instance, whereas families with incomes no greater than two minimum salaries (MS) spend 1.46% of their monthly budget on water and sewage payments, families in the top tier, those who earn more than 30 MS, only spend 0.29 percent of their monthly budget on those services.

[6] The minimum salary was R$200 (two hundred Reais) then, approximately US$58 at the average exchange rate at the time, and approximately US$88 at the exchange rate in November of 2005.

5. Impact of private provision on access to water service

The depiction in the previous section of access to water supply in Brazil entails an investigation of whether or not private provision of water services has had any impact on access rates in Brazil. In order to evaluate quantitatively the impact of private provision on access, we use two separate datasets to try and estimate the effect of private provision on access to water supply. The first is the National Sanitation Information System (SNIS), published by the Program for the Modernization of the Sanitation Sector (PMSS) of the Brazilian Ministry of Cities. The second is the Brazil Human Development Atlas (HAD), a publication of the United Nations Development Programme in Brazil. The two sets of regressions will be presented separately.

5.1. Estimations using the SNIS dataset

The SNIS database includes information on close to 170 indicators related to water and sewage services over the period 1995-2003 for a large number of municipalities. In 2003, for instance, 2058 municipalities were included in the database. Since the sample may vary from one year to another, due mainly to changes in the set of service providers at the local level and to the fact that participation in the survey is not mandatory, it is not a true panel. However, by using a smaller sample, where the municipalities are the same for the entire period of time considered, we were able to obtain an (unbalanced) panel of 1548 municipalities in Brazil from 2001 to 2003. The panel contains information on 41 variables, including economic, operational and quality indicators.

We are interested in estimating the relationship between access to water services and the type of company that provides such services, whether private or public. Our model will be of the form

$$ACCESS_{it} = \alpha_0 + \alpha_1 DPRIV_{it} + \sum_{k=1}^{K} \alpha_{k+1} x_{itk} + a_i + u_{it}, \;\; i = 1, \ldots, N, \; t = 1, \ldots, T$$

where the x_{itk}'s are the observations of the *K* other explanatory variables besides *DPRIV*, a_i is the unobserved effect (also called fixed effect) and u_{it} is the idiosyncratic error. The dependent variable is *ACCESS*, defined as population with access to water service over population of the municipality. *DPRIV* is a dummy variable that takes value one if water service is provided by a company under private management and zero otherwise. We postulate that the company's decision regarding how much service coverage to provide depends on whether it is privately or publicly managed. A private company seeks maximum profits whereas a public company might be pursuing social goals, and that might result in different decisions.

The unobserved effect a_i does not vary with time but varies with municipality (our cross-section unit), and as such captures all time-invariant (at least during the sample span) unobserved factors that affect the dependent variable $ACCESS_{it}$. For instance, factors such as the political party running the administration, geographical and demographical characteristics, which are specific to each municipality, are included in a_i. It can also be thought of as capturing historical aspects particular to each municipality, like the pre-sample average access rate, the preferences of the population regarding public versus private provision of public services etc.

When this model (the other explanatory variables will be made explicit below) is estimated by first-differences, fixed effects and random effects, the results vary substantially with the estimation method. That the two first methods produce very different results is surprising, since we know that both the first-difference and the fixed effects estimators are unbiased and consistent, under appropriate assumptions. The main reason behind the different estimates is the fact that the dependent variable is binary and doesn't change much over time, i.e., there are not many instances when municipalities switch from private to public provision or vice-versa. Since the first-difference estimator is the result of a pooled regression of the variables in (time) difference, the explanatory variable can assume only three possible values, 0, 1 and -1. This lack of variation can be held responsible for the non-significance of the variable

DPRIV obtained with first-difference estimation. When the fixed effect estimator is used, however, *DPRIV* becomes significant. That can be attributed to the fact that there is more variation in the explanatory variable.[7]

When the random effects estimator is used, the results differ considerably from those obtained with the other two methods. That can also be explained by the presence of the binary explanatory variable *DPRIV*, better handled by the random effects method.[8] On the other hand, the random effects method is valid only under the assumption that the unobserved effects are not correlated with the explanatory variable. In many applications, including ours, the point of using panel data is exactly to allow for the existence of such correlation.

Let's now specify the other explanatory variables in the model. Since T is small compared to N in our sample, it is a good idea to add time dummies to take into account secular changes that have not been modelled. We use time dummies for the years 2002 and 2003, named D02 and D03, respectively.

The cost of providing water services is certainly an important factor to be included in the model. We use as proxy to cost variables the variables *DENSITY*, *EXCONNECT*, *NUMCONNECT*, *PRODUCTIVITY* and *INVEST*. *DENSITY* is defined as number of water economies[9] by connection, and tries to measure possible economies of density. *EXCONNECT* is the extension of the water system by water connection. It tries to capture geographic effects, for its value depends on the topography of the terrain where the municipality is located. *NUMCONNECT* is the number of water connections and accounts for possible (economies of) scale effects. A large number of water connections is allegedly associated with big economies of scale, and that, in turn, should produce higher access rates.

The variable *PRODUCTIVITY* is defined as the number of employees over thousand water connections and therefore is something under management control. *INVEST* is the company's investment in the water supply system, measured in Reais (the Brazilian currency). The last explanatory variable is *GDPPERCAP*, the municipality's per capita GDP. It is a proxy for the average income of the municipality's population, and as such is included to take account of revenue prospects for the water service provider.

The equation to be estimated is thus:

$$\begin{aligned} ACCESS_{it} &= \alpha_0 + \alpha_1 DPRIV_{it} + \alpha_2 D02_t + \alpha_3 D03_t + \alpha_4 DENSITY_{it} \\ &\quad + \alpha_5 EXCONNECT_{it} + \alpha_6 NUMCONNECT + \alpha_7 INVEST \\ &\quad + \alpha_8 PRODUCTIVITY + \alpha_9 GDPPERCAP_{it} + a_i + u_{it} \\ & i = 1, \ldots, N,\ t = 1, \ldots, T \end{aligned} \tag{1}$$

This equation can be looked at as one describing the factors that affect the water company's decision regarding how much access to provide. It is possible, however, that *ACCESS* and *DPRIV* are simultaneously determined, which would render *DPRIV* endogenous. If that is the case, it is necessary to formulate a simultaneous equations model. The second equation could be the following:

$$\begin{aligned} DPRIV_{it} &= \beta_0 + \beta_1 ACCESS_{it} + \beta_2 D02_t + \beta_3 D03_t + \beta_4 FLUOR \\ &\quad + \beta_5 LOSSES + b_i + v_{it} \\ & i = 1, \ldots, N,\ t = 1, \ldots, T \end{aligned} \tag{2}$$

---

7 Recall that the fixed effects estimator is the result of a pooled regression of the (time) reduced model, where the levels of the variables are replaced by their differences to the time average, i.e., x_{it} is replaced by $x_{it} - \overline{x}_i$. The time averages depend on the sequence of ones and zeros assumed by the variable *DPRIV* for each unit (municipality), which means that there is more variation in $DPRIV_{it} - \overline{DPRIV}_i$ than in $\Delta DPRIV$.

8 In fact, since the random effects estimator is the pooled OLS estimator of an equation of type $y_{it} - \lambda \overline{y}_i = \beta_0 (1-\lambda) + \sum_{j=1}^{k} \beta_j \left(x_{itj} - \lambda \overline{x}_{ij} \right) + \left(v_{it} - \lambda \overline{v}_i \right)$, where $\lambda = 1 - \left[\sigma_u^2 \big/ \left(\sigma_u^2 + T \sigma_a^2 \right) \right]^{1/2}$, it can handle explanatory variables with limited variation (and no variation at all) much better than the other two methods.

9 An economy is defined as a dwelling, apartment, office, shop, industry or similar unit within a building with access to water supply.

The municipality is the decision maker in this second equation. We posit that the municipality's decision whether or not to privatise depends on *FLUOR* and *LOSSES* besides *ACCESS*. The idea is that the lower the quality of service and the higher the losses in distribution, the higher the propensity of the municipality to try privatisation as a solution.

We only estimated this simultaneous equation model for cross-sections, though. It was not possible to do it with our longitudinal data set because of the lack of temporal variation of *DPRIV*. The instrumental variables approach used to estimate simultaneous equations requires *DPRIV* to be instrumented by the exogenous variables in the model, i.e., that an intermediary regression of *DPRIV* on those variables be run. But this intermediary regression cannot be run by any of the panel data methods because of the aforementioned lack of variation of *DPRIV*.

The first equation is the one we want to estimate. It is easy to see that it is identified. The order condition says that the second equation must contain at least one exogenous variable excluded from the first equation. That is true in our model, since *FLUOR* and *LOSSES* are not included in the first equation. The order condition is only necessary, though. The sufficient condition is that either *FLUOR* or *LOSSES* has a significant coefficient in the estimated reduced form of *DPRIV*, which is also satisfied.

The results of the estimation of the simultaneous equation model (1)-(2) for three cross-sections, corresponding to the years 2001, 2002 and 2003, are in Table 3 below. We actually used the logarithm of access to the water system as the dependent variable (*LACCESS*), for it provides a handy interpretation of the coefficients, an approach we maintained in the other regressions.

Table 3 Cross-section estimation of impact of private provision on access to water

Explanatory variables	Cross-section year 2001	Cross-section year 2002	Cross-section year 2003
DPRIV	-0.6072625 (0.327)	-17.07954 (0.384)	2.810708 (0.000)
D02	Dropped due to collinearity	Dropped due to collinearity	Dropped due to collinearity
D03	Dropped due to collinearity	Dropped due to collinearity	Dropped due to collinearity
DENSITY	0.3670115 (0.169)	3.736651 (0.363)	-0.0023606 (0.992)
EXCONNECT	-0.0011727 (0.800)	-0.0009388 (0.856)	-0.0123589 (0.001)
NUMCONNECT	-2.72e-08 (0.986)	-3.72e-06 (0.602)	2.94e-06 (0.000)
INVEST	1.26e-08 (0.727)	8.15e-08 (0.448)	-4.38e-08 (0.026)
PRODUCTIVITY	-0.019149 (0.262)	-0.06492 (0.060)	-.0077489 (0.342)
GDPPERCAP	4.27e-06 (0.444)	0.0000309 (0.233)	7.96e-06 (0.019)
CONSTANT	4.157417 (0.000)	0.4200661 (0.920)	4.018481 (0.000)
Prob > *F*	0.1114	0.2527	0.0000
Number of observations	103	964	1062

Note: Each column reports the estimated coefficients of the regression of the dependent variable LACCESS on the explanatory variables. P-values are in parentheses. The estimation method was two-stage least squares and the instruments used were D02, DO3, DENSITY, EXCONNECT, NUMCONNECT, INVEST, PRODUCTIVITY, GDPPERCAP, FLUOR and LOSSES.

The regressions using the 2001 and 2002 cross-sections are not good fits. All the explanatory variables are non-significant, with the exception of *PRODUCTIVITY* in the 2002 regression. The coefficients are jointly non-significant in both regressions. The 2003 cross-section produced better results. Most of the explanatory variables (all but *DENSITY* and *PRODUCTIVITY*) are significant at the

5% level and have the right coefficients. The exception is *INVEST*, whose coefficient is negative. One would expect higher investment to lead to higher access. The coefficient of *DPRIV*, however, although positive and significant, is unrealistic. If correct, it would mean that private provision of water service, all the rest the same, increases access by 281%. That clearly doesn't make sense.

We conclude then that the cross-section estimations have to be abandoned in favour of panel data regressions. The existence of time-invariant unobserved effects is likely making the OLS estimators inconsistent and biased.

When fixed effects or first difference methods are used, time-constant explanatory variables are not identified, as mentioned before. Also, in cases where the key explanatory variables do not vary much over time, FE and FD methods can lead to imprecise estimates, and that seems to be the case with our estimations. Thus, when we are primarily interested in the effect of a time-constant or almost time-constant variable in a panel data study, the robustness of the FE estimator to correlation between the unobserved effect and the explanatory variables is practically useless. Without using an instrumental variables approach, we may then be forced to use random effects estimation in order to learn anything about the population parameters.

But in cases where the explanatory variable of primary interest is time-invariant and the unobserved effect is correlated with some explanatory variables, random effects will produce inconsistent estimators of all parameters.[10] A possible (partial) solution is to add dummy variables for various groups to control for the part of the unobserved effect correlated with the explanatory variables, assuming there are many observations within each group. Another solution is to follow and IV approach known as the Hausman-Taylor (Hausman and Taylor 1981)[11] method. This method fits random effects models in which some of the explanatory variables are correlated with the unobserved individual-level random effects by using instrumental variables and applying a generalized least squares transformation.

We run the two types of regression. To apply the random effects with additional dummy variables approach, we add 4 location dummy variables to equation (1): *DUMNORTH*, *DUMMW*, *DUMNE*, *DUMSE* and *DUMSOUTH*. They take value 1 when the municipality is located in the north, midwest, northeast, southeast and south regions of Brazil, respectively. One of them is dropped to avoid collinearity.

In order to apply the Hausman-Taylor approach, we need extra time-invariant exogenous variables to use as instruments. We chose to create dummy variables for population size and add them to the model. They are *DUMPOP1*, *DUMPOP2*, *DUMPOP3* and *DUMPOP4*, and they take value 1 when the population is less than or equal to 50,000, between 50,000 and 100,000, between 100,000 and 500,000, and more than 500,000 inhabitants, respectively. One of them is dropped to avoid collinearity.

For each approach, we estimate two types of model. The parsimonious model is just equation (1) with the additional dummy variables. The full model includes dummy variables to take account of the effects of private provision by GDP per capita deciles. There are dummy variables for each GDP per capita deciles, called DGP_1 to $DGDP_{10}$, and interaction dummy variables defined as:

$$DPRIVGDP_k = DPRIV * DGDP_k,\ k = 1, \ldots, 10 .$$

We first discuss the results of the parsimonious model, presented below:

---

[10] We did a Hausman test which detected correlation between the explanatory variables and the unobserved effect.

[11] Hausman, J.A. and W.E. Taylor (1981), "Panel Data and Unobservable Individual Effects," *Econometrica* 49, 1377-1398.

Table 4 Estimation of parsimonious model of impact of private provision on access to water by random effects and Hausman-Taylor

Explanatory variables	Random effects	Hausman-Taylor
DPRIV	0.2665208 (0.000)	0.4136876 (0.001)
DUMNORTH	-0.562246 (0.000)	--
DUMNW	-0.4436507 (0.000)	--
DUMSW	-0.0496323 (0.265)	--
DUMSOUTH	-0.1789914 (0.000)	--
DUMPOP1	--	0.5605235 (0.000)
DUMPOP2	--	0.722 (0.000)
DUMPOP3	--	0.7912657 (0.000)
D02	-0.0241538 (0.162)	-0.0155124 (0.343)
D03	-0.0167523 (0.336)	-0.0045262 (0.784)
DENSITY	0.2249518 (0.001)	0.7292422 (0.000)
EXCONNECT	-0.0029879 (0.000)	-0.0019325 (0.034)
NUMCONNECT	7.83e-07 (0.000)	1.12e-06 (0.000)
INVEST	-2.48e-09 (0.417)	-2.18e-09 (0.461)
PRODUCTIVITY	-0.0122015 (0.000)	-0.011467 (0.000)
GDPPERCAP	1.65e-06 (0.112)	3.50e-06 (0.001)
CONSTANT	4.135724 (0.000)	2.658026 (0.000)
Prob > χ^2	0.000	0.000
R^2 (overall)	0.2550	
Number of observations	3232	3232

Note: Each column reports the estimated coefficients of the regression of the dependent variable LACCESS on the explanatory variables. P-values are in parentheses.

The two methods produce very similar qualitative results. All the continuous explanatory variables with the exception of *INVEST* (and *GDPPERCAP* in the random effects estimation) are significant and their coefficients have the same sign across the two estimations. The time dummies are not significant in any of the estimations, but the location dummies in the random effects model are (with the exception of *DUMSW*), as well as the population size dummies in the Hausman-Taylor model. That is evidence that our choice of dummy variables was appropriate.

Although our main interest falls on the dummy variable *DPRIV*, let's comment briefly on the signs of the other explanatory variables. *DENSITY* has a positive coefficient, as expected, indicating that economies of density tend to increase access to water service. *EXCONNECT* and *NUMCONNECT* have negative and positive coefficients, respectively. That is also in accordance with expectations. Higher values of the extension of the water system by water connection usually reflect higher costs to provide access, whereas larger numbers of water connections are associated with economies of scale. The negative sign of the variable *PRODUCTIVITY* indicates that more efficient companies are associated with larger access rates. Finally, *GDPPERCAP* has a positive impact on access rates, meaning that richer municipalities are likely to have higher water service coverage. These two last effects are also in line with expectations.

The most important effect measured by the estimations above is that of private provision on access to water service, as measured by the coefficient of the dummy variable *DPRIV*. According to the estimation of the first model, private provision increases the access rate by approximately 26.7% when the other explanatory variables are held constant. That impact increases to approximately 41.4% when the Hausman-Taylor approach is used. That is a very strong effect. Even if the absolute values of the coefficients seem to be excessive, the important result is that there is strong evidence that private provision increases access to water service in Brazil.

The next question is whether this impact differs by income decile. Since we don't have information on income by municipality, we use GDP per capita deciles instead. The results of the full model, presented below, help us answer that question.

Table 5 Estimation of full model of impact of private provision on access to water by random effects and Hausman-Taylor

Explanatory variables	Random effects	Hausman-Taylor
DPRIV	0.6445816 (0.000)	0.1342431 (0.404)
DUMNORTH	-0.5281106 (0.000)	--
DUMNW	-0.2547579 (0.000)	--
DUMSW	-0.0451631 (0.295)	--
DUMSOUTH	-0.1930323 (0.000)	--
DUMPOP1	--	0.3147722 (0.030)
DUMPOP2	--	0.4474297 (0.002)
DUMPOP3	--	0.5305866 (0.000)
D02	-0.0346598 (0.047)	-0.024471 (0.129)
D03	-0.0404152 (0.023)	-0.033174 (0.044)
$DGDP_2$	0.0597187 (0.042)	0.0455404 (0.118)
$DGDP_3$	0.1785324 (0.000)	0.1611969 (0.000)
$DGDP_4$	0.24563 (0.000)	0.2454423 (0.000)
$DGDP_5$	0.3234062 (0.000)	0.3474403 (0.000)
$DGDP_6$	0.3442111 (0.000)	0.3856703 (0.000)
$DGDP_7$	0.3796232 (0.000)	0.428812 (0.000)
$DGDP_8$	0.4087276 (0.000)	0.4593574 (0.000)
$DGDP_9$	0.44661 (0.000)	0.5037341 (0.000)
$DGDP_{10}$	0.4963495 (0.000)	0.5526444 (0.000)
$DPRIVGDP_2$	-0.0473192 (0.654)	0.1787632 (0.224)
$DPRIVGDP_3$	-0.1067318 (0.340)	0.1810843 (0.270)

$DPRIVGDP_4$	-0.251691 (0.027)	0.0844862 (0.615)
$DPRIVGDP_5$	-0.3612749 (0.002)	0.0234328 (0.891)
$DPRIVGDP_6$	-0.4779364 (0.000)	-0.0849826 (0.619)
$DPRIVGDP_7$	-0.49469 (0.000)	-0.0820913 (0.629)
$DPRIVGDP_8$	-0.4760866 (0.000)	-0.0638001 (0.709)
$DPRIVGDP_9$	-0.4900681 (0.000)	-0.0815515 (0.637)
$DPRIVGDP_{10}$	-0.5416796 (0.000)	-0.1103929 (0.541)
DENSITY	0.1890071 (0.004)	0.4186046 (0.000)
EXCONNECT	-0.0030651 (0.000)	-0.0020704 (0.020)
NUMCONNECT	6.49e-07 (0.000)	8.02e-07 (0.000)
INVEST	-1.89e-09 (0.537)	-1.47e-09 (0.611)
PRODUCTIVITY	-0.0124824 (0.000)	-0.011942 (0.000)
GDPPERCAP	-3.13e-06 (0.015)	-3.23e-06 (0.009)
CONSTANT	3.867543 (0.000)	3.034657 (0.000)
Prob > χ^2	0.000	0.000
R^2 (overall)	0.3120	
Number of observations	3232	3232

Note: Each column reports the estimated coefficients of the regression of the dependent variable LACCESS on the explanatory variables. P-values are in parentheses.

The coefficients of the continuous explanatory variables keep the same signs as in the previous estimations, so we will not comment on them. The only exception is *GDPPERCAP*, whose coefficient has become negative and very close to zero. That is the result of the inclusion of the GDP per capita decile dummies, which capture the same effects.

In the random effects estimation, the coefficient of *DPRIV* is positive and significant. The impact of private provision on access rates is approximately 65%. That is even higher than the estimates we obtained before. In the Hausman-Taylor estimation, however, despite being positive, the coefficient of *DPRIV* is not significant[12].

In both estimations, the GDP decile dummy variables are significant (except $DGDP_2$ in the Hausman-Taylor model). Notice that the higher deciles display the largest coefficients, as expected. This means that municipalities in higher deciles have higher access rates. For instance, municipalities in the highest (tenth) decile have access rates approximately 44% (0.4963495 - 0.0597187) higher than those in the second decile.

As for the interaction dummies, they are all non-significant in the Hausman-Taylor estimation. In the random effects estimation, the interaction dummies for the lower deciles are not significant, but those for the higher deciles (starting from the fourth decile) are. The table below lists the different impacts of private provision of water services according to GDP per capita decile.

[12] The coefficient is significant if *ACCESS* is used as the dependent variable instead of *LACCESS*.

Table 6 Impact of private provision of water service by GDP per capita decile

Decile	Percentage increase in *ACCESS*
4^{th}	39.29
5^{th}	28.33
6^{th}	16.66
7^{th}	14.99
8^{th}	16.85
9^{th}	15.45
10^{th}	10.29

The number in the table above should be read like this: municipalities with private provision of water service belonging to the 4^{th} decile of GDP per capita, for instance, have, on average, access rates 39.29% higher than those in the same decile but with public provision. Notice how the impact of private provision on access to water service is higher in the lower deciles, indicating that the benefits of higher access rates due to privatization accrue mostly to poorer municipalities.

5.2. Estimation using the HAD dataset

In the models estimated in the previous section, we made no attempt to account for a possible "inertia" effect, i.e., to reckon that access rates in one period are highly dependent on access rates in the previous period. Panel data models with lagged dependent variables should be estimated by conditional maximum likelihood, and several identification and computational issues have to be addressed. Moreover, the inclusion of the lagged *ACCESS* as an explanatory variable would likely blur the effects of the other explanatory variables. We chose instead to use a different dataset to compare the situation of municipalities in terms of access rates before and after the beginning of the privatizations of water supply.

The database used in this new wave of regressions comes from the Brazil Human Development Atlas (HAD), a publication of the United Nations Development Programme in Brazil. This database consolidates data available in the 1991 and 2000 Brazilian Demographic Censuses published by IBGE.

The objective of the second set of regressions is again to identify the average effect of private provision on access to water supply. Ideally, this would be done by comparing access rates when water services are privately provided to the counterfactual, namely access rates when services are publicly provided in the treatment (subject to private provision) areas at the same point in time. Of course, this counterfactual is not observed, and we need to resort to estimation methods. The first choice would be to conduct an experiment where private and public management are randomly assigned to municipalities and then compare the average outcomes of the two groups. Once again, that choice is not available to us, for the decision to privatize water services is hardly random. There is the possibility then that municipalities that choose to privatize are different along some dimensions from those that choose not to privatize and that these differences are correlated with access.

This concern will always be present in our non-experimental estimations, but we will try and minimize it by controlling for time-invariant unobserved effects. This will be done by means of using a panel data and a difference-in-differences estimator. In that respect, we follow Galiani et al. (2005) and Fujiwara (2004), who use this method to assess the impact of privatization on infant mortality rates.

The difference-in-differences method amounts to comparing the change in outcomes in the treatment group before and after the treatment (in our case, privatization) is applied to the change in outcomes in the control group (in our case, the set of municipalities which did not privatize their water services). By comparing changes, it is possible to isolate the effects of treatment from other factors affecting the outcome.

As is well know (see, for instance, Wooldridge (2002)), the difference-in-differences estimator can be obtained by running a fixed effects panel data regression. We follow that procedure here. The dependent variable is again *ACCESS*, but this time defined as the percentage of the population living in households with access to piped water. The explanatory variables are *DPRIV*, defined as before, *INCPERCAP*, the per capita income of the municipality, *GINI*, the Gini index, *POVERTY*, a poverty intensity index, and *RURALPOPPERC*, the percentage of the population of the municipality living in rural areas. The estimation results can be found in the table below[13]:

Table 7 Estimation of impact of private provision on access to water using difference-in-differences approach

Explanatory variables	Fixed effects
DPRIV	6.30713 (0.000)
INCPERCAP	0.07417 (0.000)
GINI	72.82137 (0.000)
POVERTY	-0.61558 (0.000)
RURALPOPPERC	-38.10226 (0.000)
CONSTANT	57.21342 (0.000)
Prob > F	0.000
R^2 (overall)	0.6256
Number of observations	11,014

Note: Each column reports the estimated coefficients of the regression of the dependent variable *ACCESS* on the explanatory variables. P-values are in parentheses.

The model provides a good fit to the data, as confirmed by the significance of all the coefficients. The signs of the coefficients of the explanatory variables are consistent with our *ex ante* expectations. Higher access rates are associated with higher income per capita and lower poverty indices. The percentage of the population living in rural areas has a negative effect on access, indicating that municipalities with large rural populations should be targets for universal service policies. As for the effect of the Gini index of inequality on access, positive according to our estimations, one plausible explanation is that municipalities where there is more inequality are relatively large metropolitan areas where coverage is high due to the existence of economies of scale.

But our main concern here is with the variable *DPRIV*, which measures the effect of private provision on access rates. Just as in our previous estimations, we get a positive and significant estimated coefficient, confirming the positive impact of privatization on access by the population to water services. Given the already relatively high coverage rates of the higher income deciles of the Brazilian population, it is fair to say that the benefits of such increased access rates due to private provision accrue mostly to lower income families.

6. The effect of private provision on affordability of water services

The analysis of section 4 prompted us to investigate the effects of private provision on access to water supply. As pointed out there, affordability of water services is also a major issue in Brazil. We turn now to the task of studying whether or not the participation of privately operated companies has had any impact on the affordability of water services.

The basic model to determine how private provision affects the ability of consumers to pay their water bills is the following:

[13] The regression using *ACCESS* as dependent variable instead of *LACCESS* provided a better fit.

$$AFFOR_{it} = \alpha_0 + \alpha_1 DPRIV_{it} + \alpha_2 D02_t + \alpha_3 D03_t + \alpha_4 DENSITY_{it} + \alpha_5 EXCONNECT_{it} + \alpha_6 NUMCONNECT_{it} + \alpha_7 INVEST_{it} + \alpha_8 PRODUCTIVITY_{it} + \alpha_9 FLUOR_{it} + \alpha_{10} GDPPERCAP_{it} + a_i + u_{it}$$

The variable *AFFOR* was constructed as the product of consumption per capita and tariff divided by GDP per capita, i.e.,

$$AFFOR = \frac{CONPERCAP \times TARIFF}{GDPPERCAP},$$

where the variable CONPERCAP is defined as per capita water consumption, whereas *TARIFF* is the average tariff charged.

This approach evidently has many shortcomings. The first is that the decision unit is the municipality instead of the household. Therefore, we are not measuring the impact of private provision by household income group, but rather by municipality income group. Another shortcoming is that the variable we constructed is only a proxy for average municipal income, and as such is an imperfect measure. Unfortunately, we did not have access to data at the household level where it would be possible to identify if the household was served by a private or a public company.

The model is predicated on the idea that the tariff charged by water companies, who are monopolists in their concession areas, depends on demand and cost factors. That explains the inclusion of the cost variables *DENSITY*, *EXCONNECT*, *NUMCONNECT*, *INVEST* and *PRODUCTIVITY*. The variable *FLUOR* captures the quality of the service provided, and as such is included to reflect possible cost increases due to increased quality. As for the variable *GDPPERCAP*, it is an imperfect measure of the demand dimension.

Contrary to what happened in the model for access, we do not expect any simultaneity between the variables *AFFOR* and *DPRIV*. It is not sensible to imagine, for instance, that municipalities decide whether or not to privatize depending on the ability of households to pay their water bills.

The table below brings the results of the two types of model, parsimonious and full, estimated by random effects.[14]

Table 8 Estimation of impact of private provision on affordability of water service: Parsimonious and full model , random effects and Hausman-Taylor

Explanatory variables	Random effects	
	Parsimonious	Full
DPRIV	-0.2172622 (0.000)	-0.1264653 (0.476)
DUMNW	0.3599308 (0.000)	-0.2871546 (0.000)
DUMSW	0.2710399 (0.000)	0.0455377 (0.475)
DUMSOUTH	0.2672321 (0.000)	0.1154084 (0.078)
DUMMW	0.0683185 (0.182)	-0.1496533 (0.029)
D02	0.0210271 (0.687)	-0.0097488 (0.837)
D03	-0.0153817 (0.769)	0.0175842 (0.711)
$DGDP_2$	--	-0.1895335 (0.008)
$DGDP_3$	--	-0.4104072 (0.000)

[14] The Hausman-Taylor estimations were not satisfactory. Most explanatory variables came out non-significant. The coefficient of the dummy variable *DPRIV*, however, was negative and significant.

$DGDP_4$	--	-0.6292522 (0.000)
$DGDP_5$	--	-0.8001867 (0.000)
$DGDP_6$	--	-0.9280072 (0.000)
$DGDP_7$	--	-1.069333 (0.000)
$DGDP_8$	--	-1.262978 (0.000)
$DGDP_9$	--	-1.402245 (0.000)
$DGDP_{10}$	--	-1.56948 (0.000)
$DPRIVGDP_2$	--	Dropped due to collinearity
$DPRIVGDP_3$	--	Dropped due to collinearity
$DPRIVGDP_4$	--	Dropped due to collinearity
$DPRIVGDP_5$	--	0.09059 (0.701)
$DPRIVGDP_6$	--	-0.0476917 (0.810)
$DPRIVGDP_7$	--	-0.1164308 (0.548)
$DPRIVGDP_8$	--	-0.2367171 (0.221)
$DPRIVGDP_9$	--	-0.196412 (0.310)
$DPRIVGDP_{10}$	--	-0.1943224 (0.334)
DENSITY	0.3569335 (0.000)	0.6033506 (0.000)
EXCONNECT	-0.0019625 (0.016)	-0.0019737 (0.003)
NUMCONNECT	-1.38e-06 (0.000)	-6.11e-07 (0.026)
INVEST	8.39e-10 (0.861)	1.67e-09 (0.689)
PRODUCTIVITY	0.0076757 (0.004)	0.0094054 (0.000)
FLUOR	0.0010848 (0.2777)	-0.0000956 (0.910)
GDPPERCAP	-0.0000481 (0.000)	-0.0000314 (0.000)
CONSTANT	-3.933787 (0.000)	-3.160212 (0.000)
Prob > χ^2	0.000	0.000
R^2 (overall)	0.5639	0.7298
Number of observations	1393	1393

The continuous explanatory variables are all significant in both regressions, with the exception of *INVEST* and the quality variable *FLUOR*

The density of economies per water connection has a positive effect on the average payment for water service as a share of GDP per capita, whereas the extension of the water system by water connection and the number of connections have positive effects. Productivity gains translate into lower water payments, as attested by the positive coefficient of the variable *PRODUCTIVITY*. And *GDPPERCAP* is negatively related to the share of water charges, as expected.

All the interaction dummies in the full model are non-significant, and so we cannot make any inference about the effects of private provision by GDP per capita decile based on the signs or the values of the coefficients. The coefficients of the GDP per capita decile dummies, on the other hand, are all significant and negative. Moreover, they increase in absolute value as the decile increases. This means that water is more affordable to inhabitants of municipalities in the higher deciles.

Last, but not least, the coefficient of *DPRIV* is negative in both estimations, although not significant in the full model. The parsimonious model tells us that the ratio of water payments to per capita GDP in municipalities with private provision of water services is, ceteris paribus, 21.7% lower. This is evidence that private participation in water supply has beneficial effects for the population not only with respect to access, but also to affordability.

7. Discussion of econometric results

There is no evidence in the results we obtained to support the argument that private sector provision in the Brazilian water sector, still a very limited experience, has had an adverse impact on affordability or access. In fact, we obtained some evidence that there was an improvement in access which was more pronounced in municipalities at the bottom of the income (GDP) per capita spectrum. These results allow us to conjecture that low income households have benefited the most in that respect, since Brazil has a relatively high coverage rate in water provision (in comparison to other developing countries) and higher income families are usually the first to get access. We conjecture that part of this result can be attributed to investment obligations assumed by private operators at the time they were granted their concessions. Total scheduled investments by private operators until the end of their concession contracts (between 2025 and 2030) amounts to R$3.38 billions (approximately U$1.54 billion), of which R$1.10 billion (approximately U$500 million) or 32,7% had been disbursed until the end of 2004. Disbursements until the end of 2009 are estimated at half the total value of investments.

The table and figures below show that, despite displaying lower investments than publicly-owned or managed companies on average,[15] privately-owned or managed companies beat their public counterparts in all size categories in that respect.

Table 9 Investments by type and size of operator

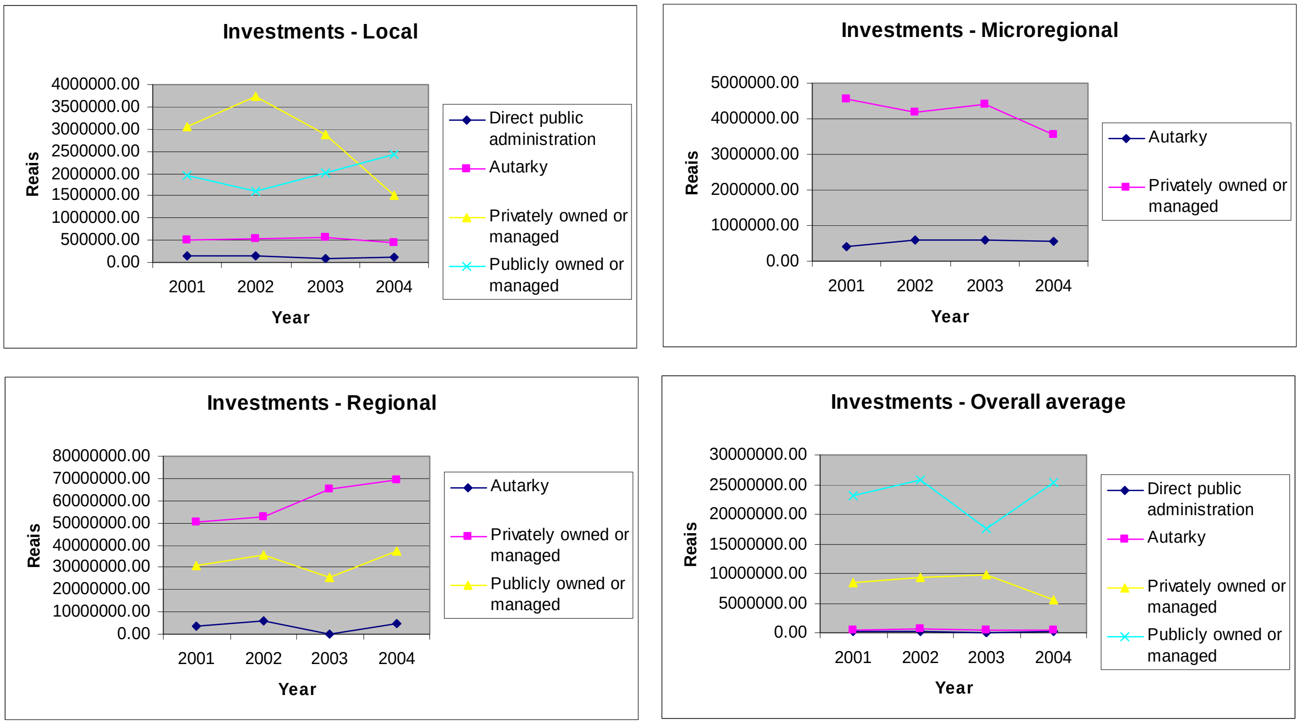
	2001	2002	2003	2004
Direct public administration	136453.49	143025.42	103051.10	111429.17
Local	136453.49	143025.42	103051.10	111429.17
Microregional	--	--	--	--
Regional	--	--	--	--
Autarky	532386.30	557997.06	547126.94	457645.92
Local	513055.39	521468.55	548444.20	434981.40
Microregional	405257.85	602674.69	608623.33	541248.61
Regional	3454309.86	5785506.69	5174.13	4792124.56
Privately-owned company or public company with private management	8480585.47	9251176.07	9686443.71	5560120.69
Local	3041880.35	3725373.26	2876372.75	1516335.76
Microregional	4537491.10	4189316.61	4408820.93	3548444.67
Regional	50494615.71	52993655.18	65273374.62	69234408.74
Publicly-owned company or public company with public management	23075693.54	25684752.22	17500182.89	25234027.12
Local	1950978.61	1587030.93	2007809.76	2431744.95
Microregional	--	--	--	--
Regional	30757408.07	35542910.92	25246369.46	37178079.69

Source: PMSS – National Sanitation Information System (SNIS).

[15] This result is due to the fact that there are no microregional publicly-owned or managed companies, which props up their average

Note: Local operators are those that provide water services only to the municipality where they are located. Microregional operators are those which provide services to more that one municipality, normally in small number and adjacent to each other, including intermunicipal consortia. Regional providers are those that serve several municipalities, including the CESB's (state companies).

Figure 4 Investments by type and size of operator



When it comes to assessing the impact of private provision on affordability, our results are not so clear. We obtained some evidence that in municipalities with a private operator water services are relatively less expensive, as measured by the share of GDP per capita taken up by water payments. Our estimations resulted not significant, though, when we tried to assess the effect of private provision on affordability by income (GDP) per capita deciles.

In summary, there is evidence that greater presence of private undertakings in the Brazilian water sector (and the sanitation sector in general) can be beneficial, not only because the sector has a great demand for investments which cannot come entirely from the public sector, but also because private provision can improve access to the poor without creating an excessive financial burden on them.

This potential greater participation of the private sector in water supply (and possibly other sanitation services) would have a wider social impact if it came together with some measures. For instance, it could be made to serve poor customers by placing emphasis on tariff design, so that low income families were targeted more accurately. Political, social and cultural institutions or norms to monitor the private sector should be furthered. Right now they are almost non-existent. Municipalities and state agencies are the only entities in charge of enforcing concession contracts. Public opinion as well as people from inside the sanitation sector is generally opposed to privatization, but that alone can hardly be considered an effective way to monitor private sector participation. And finally, universal service obligations, currently absent from most concession contracts, could be negotiated with or even imposed on private providers.

8. Conclusion

The provision of sanitation services in Brazil is by and large very deficient. As we discuss in this paper, the main problems can be found in rural areas and the poorest regions of the country, which usually display lower access rates and bear a greater burden from water and sewage bills. The poorer households also have difficulties accessing and paying for water.

Nevertheless, there have been some improvements lately. That can be at least partially attributed to the investment and social policies implemented in the sector. Those policies have been mainly structured in the form of programs managed by different ministries. The main objective of most of those projects is to increase production capacity and coverage of water supply. Some of those programs have targeted projects aimed at increasing water supply and sanitation services for low-income families, while others were tailored to increase coverage and improve quality of service in rural areas. There has been relative success in that area, with coverage rates for the lowest three deciles having increased. This is indication that the poor have benefited from social policies put in place in the sanitation sector. In spite of the relative success of social policies in reducing inequality, the distribution of access across income deciles continues to be very uneven in Brazil.

We argued that these social policies, mainly encouraging investments through loans have focused essentially at increasing coverage and neglecting the affordability issue. Policies that target affordability issues are essentially based on cross subsidies and increasing block tariffs, which allow companies to charge "social tariffs" to low income families, usually expressed in terms of a certain percentage of the full tariff.

Despite the limited experience of PSP in the country, we showed that the private sector has managed to increase coverage. We also obtained some evidence that this improvement was more pronounced in municipalities at the bottom of the income (GDP) per capita spectrum. These results allow us to conjecture that low income households have benefited the most in that respect, since Brazil has a relatively high coverage rate in water provision (in comparison to other developing countries) and higher income families are usually the first to get access. A possibility worth investigating is if part of this result can be attributed to investment obligations assumed by private operators at the time they were granted their concessions.

The impact of private provision on affordability, however, is not so clear, according to our results. There is some evidence that in municipalities with private operators water services are relatively less expensive, as measured by the share of GDP per capita taken up by water payments, but most of our econometric results in that respect were non-significant.

In summary, the evidence and econometric results we brought forth support the case for greater presence of private undertakings in the water sector (and the sanitation sector in general), not only because the sector has a great demand for investments which cannot come entirely from the public sector, but also because private provision tends to improve access to the poor without creating an excessive financial burden on them.

9. References

Estache, Antonio, Andrés Gómez-Lobo, and Danny Leipziger. 2001. "Utilities Privatization and the Poor: Lessons and Evidence from Latin América." *World Development*, Vol. 29, No. 7, pp. 1179-1198

Fujiwara, Thomas. 2004. *A Privatização Beneficia os Pobres? Os Efeitos da Desestatização do Saneamento Básico na Mortalidade Infantil*. Paper presented at the 33rd Annual Meeting of The Brazilian Association of Post-Graduate Centers in Economics, Natal, 6-9 December. ANPEC, Rio de Janeiro.

Galiani, Sebastian, Paul Gertler and Ernesto Schargrodsky. 2005. "Water for Life: The Impact of the Privatization of Water Services on Child Mortality." *The Journal of Political Economy*, Vol. 113, No. 1, pp. 83-120.

Mello, Marina F. 2001. *Privatização do Setor de Saneamento no Brasil: Quatro Experiências e muitas Lições*. Discussion Paper No. 447, Economics Department PUC-Rio, Rio de Janeiro.

Noll, Roger G., Mary Shirley and Simon Cowan. 2000. "Reforming Urban Water Systems in Developing Countries." In Anne O. Krueger (ed.), *Economic Policy Reform: The Second Stage*. University of Chicago Press, Chicago.

Owen, D. L. (2006). Pinsent Masons Water Yearbook, 2006-2007, London: Masons Solicitors.

Parlatore, Antônio C. 2000. "A Privatização do Setor de Saneamento no Brasil." In Armando C. Pinheiro and Kiichiro Fukasaku (eds.), *A Privatização no Brasil: O Caso dos Serviços de Utilidade Pública*. BNDES, Rio de Janeiro.

Quintão, Marcelo. 2006. *Setor de Saneamento Básico no Brasil: Características do Setor, Perfil de Acesso do Usuário e Participação da Iniciativa Privada*. Monograph, UnB, Brasília.

Rezende, F. C. 1996. "Políticas Públicas e Saneamento Básico: A Compesa entre o Estado e o Mercado." *Revista de Administração Pública*, Vol. 30, No. 4, pp. 87-107.

Seroa da Motta, R. 2004. *Questões Regulatórias do Setor de Saneamento no Brasil*. Technical Note No. 5, IPEA, Rio de Janeiro.

Seroa da Motta, R. and Ajax R.B. Moreira. 2004. *Efficiency and Regulation in the Sanitation Sector in Brazil*. Discussion Paper No. 1059, IPEA, Rio de Janeiro.

Shleifer, Andrei. 1998. "State versus Private Ownership." *Journal of Economic Perspectives*, Vol. 12, No. 4, pp. 133-150.

Turolla, Frederico A. 2002. *Política de Saneamento Básico: Avanços Recentes e Opções Futuras de Políticas Públicas*. Discussion Paper No. 922, IPEA, Rio de Janeiro.

Wooldridge, Jeffrey M. 2002. *Econometric Analysis of Cross Section and Panel Data*. The MIT Press, Cambridge, MA.