Qeios

The effect of the regulation on the degree of implementation of the social tariff in the water and sanitation sector

Daniel Penido de Lima Amorim
Federal University of Minas Gerais
daniel_amorim23@hotmail.com

Marcelo Resende
Federal University of Rio de Janeiro

Rômulo José Soares Miranda
Arsae-MG

Jay Freistadt
University of Washington

28 May 2024

Abstract

The social tariff is a policy that provides water supply and sanitation services at affordable prices for financially vulnerable households. A state regulatory agency of the Brazilian water and sanitation sector conducted inspections and drafted a new regulation to promote the implementation of this policy. This article analyzes the effect of the regulation on the degree of implementation of the social tariff. It introduces an index that measures this implementation. Statistical tests indicate an increase in the implementation of the social tariff in all state regions after regulatory efforts. Econometric models suggest that the regulation increases the implementation of this policy. This article contributes to the literature by highlighting the importance of regulation in the implementation of pro-poor policies.

Keywords: regulation; regulatory agency; water; affordability; social tariff.

https://doi.org/10.32388/9FFT46

1. Introduction

Ensuring universal access to water supply and sanitation (WSS) is a challenge for developing countries. The discussion of access to water as a human right has gained prominence since the 2010 United Nations General Assembly. The United Nations declared that safe and clean drinking water and sanitation are human rights that are essential for the full enjoyment of life and all human rights (United Nations, 2010). Furthermore, in 2015, the Sustainable Development Goals (SDGs) set the goal of ensuring universal access to safe and equitable water and sanitation services by 2030 (United Nations, 2021).

Water tariff design plays a relevant role in promoting universal access to WSS because it has the potential to make services affordable for poor households. In the tariff setting, social concerns relate to equity and its trade-off with efficiency. Since income may not always be observable, regulators often adopt increasing block tariffs (IBTs). Price discrimination can also occur through cross-subsidies for financially vulnerable consumers (see Rogers et al. (2002), Martins et al. (2013), and Massarutto (2020) for related discussions). Hoque and Wichelns (2013), Pinto and Marques (2015), and Fuente (2019) review the literature on water tariff design and mention various studies that have compared the demand and welfare associated with different tariff structures through simulations. Tastan (2017) corroborates the role of IBTs in reducing water consumption. However, Whittington et al. (2015) state that IBTs alone are inappropriate for subsidizing poor households in low- and middle-income countries. Therefore, additional policies are necessary to improve this subsidy.

In Brazil, regulatory models adopted in the WSS sector vary between states and municipalities. However, a national law defines the general guidelines for this regulation (Mesquita & Ruiz, 2013). The Brazilian Sanitation Regulatory Framework recognizes the need to expand access to safe drinking water and sanitation for everyone. The mentioned law determines, as a guideline, the

expansion of access to these services for low-income households and localities (Federal Law No. 11,445, 2007a). Furthermore, this law establishes that the tariffs must consider *affordability*[1] for the customers (Federal Law No. 11,445, 2007b). The new Sanitation Regulatory Framework modernized the previous law but maintained the referred guideline (Federal Law No. 14,026, 2020a, 2020b). Sampaio and Sampaio (2020) discuss these institutional changes.

The Brazilian Sanitation Regulatory Framework allowed sub-national regulatory agencies to introduce the *social tariff*. This policy exists in several states in Brazil, but with some differences in the eligibility rules, which often include not exceeding a household income limit (Almeida & Oliveira, 2021). The social tariff makes WSS services affordable for financially vulnerable households. Customers registered in the social category pay lower tariffs than those in the standard residential category. While improving affordability and, thus, enabling poor households to access services, the social tariff contributes to universal access to WSS services (one of the goals of the United Nations' SDGs).

Studies on social tariffs before the Brazilian Sanitation Regulatory Framework are rare. Among them, Andrade and Lobão (1997) simulated the effects of a social tariff (based on the social class of the households) on water demand and customers' welfare in the 1990s. More recently, Ruijs et al. (2008) simulated different tariff structures with data from the Metropolitan Area of São Paulo (Brazil) and found that reducing the first block price (in an IBT structure) improves income distribution. They also suggest that introducing a system of price discrimination by household income (as in the social tariff) improves equity.

Though the literature on social tariffs has grown in recent years, in the Brazilian context it remains scarce. Narzetti and Marques (2021) discuss the relevance of this policy to fostering universal access to WSS. Almeida and Oliveira (2021) state that the social tariff works as a strategy to secure

[1] The law uses the term "customers' ability to pay".

water as a human right. These authors also compare the eligibility rules for the social tariff that some Brazilian regulatory agencies have established.

This article addresses the case of a regulatory agency in Minas Gerais, the state with the highest number of municipalities and the third-highest gross domestic product in Brazil. This state has substantial heterogeneity, comprising rural and urban localities, and has similarities with almost all of Brazil's macro-regions. The Regulatory Agency for Water Supply and Sewage Services of Minas Gerais State (Arsae-MG) regulates WSS services in most of the municipalities in the state. Among the more than 50 regulatory agencies in the Brazilian WSS sector, Arsae-MG is the one that regulates the largest number of municipalities. This agency establishes the regulations that standardize the services and inspects their compliance by the companies that provide them.

The law that created Arsae-MG also established, as a guideline, the expansion of access to services for low-income citizens and localities (State Law No. 18,309, 2009). Arsae-MG introduced a social tariff for the services provided by the regulated companies, considering this guideline and those of the Brazilian Sanitation Regulatory Framework. This regulator created a new category in the tariff schedule for low-income customers, considering significantly lower prices for them.

The major provider of services that Arsae-MG regulates is a mixed company[2] called Companhia de Saneamento de Minas Gerais (Copasa-MG). It provides services in 583 of the state's 853 municipalities. Copasa-MG has a subsidiary company called Copasa Serviços de Saneamento Integrado do Norte e Nordeste de Minas Gerais (Copanor). This state-owned company operates services mainly in the more arid and poorer areas of the state. Copanor also provides WSS services to a minority of customers in 30 municipalities where the Copasa-MG majority operates.

In 2020, Arsae-MG conducted the first economic inspection of the degree of implementation of the social tariff throughout municipalities where Copasa-MG operates. In this article, we formally

[2] The state owns half of Copasa's shares, and shareholders can trade the other half on the stock exchange.

introduce the evaluation method adopted by Arsae-MG into the scientific literature. This method relies on the so-called Degree of Implementation of the Social Tariff (DIST) Index. After finding unsatisfactory results in the first inspection, the regulatory agency sought to encourage the implementation of the social tariff through the improvement of economic regulation. This regulator established a new norm and periodic inspections concerning the social tariff. A year later, the regulator conducted a second inspection, gathering data on the implementation of the social tariff. We compare this data with the previous ones to assess whether the regulatory efforts affected the implementation of the social tariff.

This article analyzes the effect of the regulation on the degree of implementation of the social tariff. Such regulation corresponds to a new norm and periodic inspections concerning the social tariff. In the analysis, we used a unique data sample from 572 municipalities, totaling more than 600,000 households registered for the benefit. First, we aim to analyze whether statistically significant differences occurred in the DIST index after the regulatory efforts, using nonparametric tests. We perform this analysis for the whole of Minas Gerais and each region of this state. Subsequently, we aim to estimate the effect of the refereed regulation on the degree of implementation of the social tariff through econometric models.

This article contributes to the literature by highlighting the importance of regulation in the implementation of pro-poor policies. Its results suggest a positive effect of regulatory efforts on the implementation of the social tariff. Furthermore, by introducing the DIST index in the literature, this article contributes so that other Brazilian regulatory agencies can use it to inspect the implementation of the social tariff. In other countries, regulatory authorities that hold registries of utility customers benefiting from pro-poor policies and access to social registries (registries of poor households) can adapt the assessment method introduced in this article. Leite et al. (2017) mention the existence of

social registries in more than 20 countries. Therefore, this article may inspire improvements in WSS policies around the world.

We strive to fill a gap in the literature since we did not find any studies with the same purpose. While there is extensive literature dealing with regulation in the WSS sector, no previous article has analyzed the effect of this regulation on the degree of implementation of the social tariff. Above all, no study econometrically analyzed whether regulatory efforts could trigger further expansion of access to the benefit. Few articles address specific pro-poor policies, such as the social tariff of Arsae-MG, in the WSS sectors of other countries.[3] As for them, Damkjaer (2020) only comments that social tariffs exist in countries with rigorous regulations, such as Spain, Belgium, Portugal, and France. Gonçalves et al. (2014) and Martins et al. (2020) discuss the social tariff in Portugal. Mayol (2017) investigates the introduction of a social tariff in a city in France (Dunkerque) and evaluates only graphically (not econometrically) the impact of this policy on water consumption. In South America, Mercadier and Brenner (2020) comment on a social tariff in Argentina when dealing with financial sustainability. Meanwhile, Barde and Lehmann (2014) show the distributional effects of means-tested tariffs (including a social tariff) in Lima, Peru. Finally, Narzetti and Marques (2020) advance the literature by drawing lessons for Brazil from the pro-poor subsidies (including social tariffs) granted in Argentina, Bolivia, Chile, Colombia, Paraguay, Peru, and Uruguay.

We have divided the remainder of the article into six sections. Section 2 explains the regulation of the social tariff and describes the efforts that Arsae-MG made to foster the implementation of the policy. Section 3 introduces an index that measures this implementation. Section 4 describes the data, the methods employed in the analysis, and the results. Section 5 discusses these results. Finally, Section 6 provides some final remarks.

[3] Some authors refer to a subsidized consumption bracket in an IBT structure as a social tariff. We had difficulty distinguishing between this subsidized bracket and the subsidized category we discussed in this article when the authors mentioned the existence of a social tariff without detailing it.

2. Background

2.1 Social tariff

As mentioned, Arsae-MG established a social tariff for WSS services of the regulated companies by creating a specific category of the tariff schedule that targets low-income customers, the *social category*.[4] We refer to customers who benefit from the social tariff as *social customers*. They pay substantially lower tariffs than those applied to standard residential customers (in the case of Copasa-MG, the values have been about 50 percent lower in recent years). This policy contributes to affordability by reducing the share of income spent on paying WSS bills by poor households.

Figures 1 and 2 exhibit the tariffs billed by Copasa-MG according to the volume of consumed water for residential customers classified as *standard* and *social*. The first graph shows the tariffs for 2020, and the second demonstrates them for 2021. The difference between the graphs is that there is a limit to the consumption billed with the benefit. The regulatory agency sets increasing block tariffs (IBT) for both the social and standard categories. Copasa-MG carries out the billing, considering integer numbers for cubic meters of water. The fixed fee is a value associated with zero consumption (see the gray and black dots in the graphs). The maintenance of the water infrastructure justifies the fixed fee. The company adds the fixed fee to the one tied to consumption, so the amount billed is equivalent to the *two-part tariff*. Meanwhile, sewage tariffs are percentages of water tariffs.[5]

[4] The social tariff on Copasa-MG bills predates the creation of Arsae-MG. Before 2012, Copasa-MG granted this policy based on house size and water consumption. However, in 2012, Arsae-MG established that it would grant the benefit based on CadÚnico data and income criteria, as it does today.

[5] The tariff schedules also include the tariffs for sewage services. However, for simplicity, we show only the water tariffs. Copasa-MG's tariff schedules are available entirely at https://www.arsae.mg.gov.br/copasa/#doc.

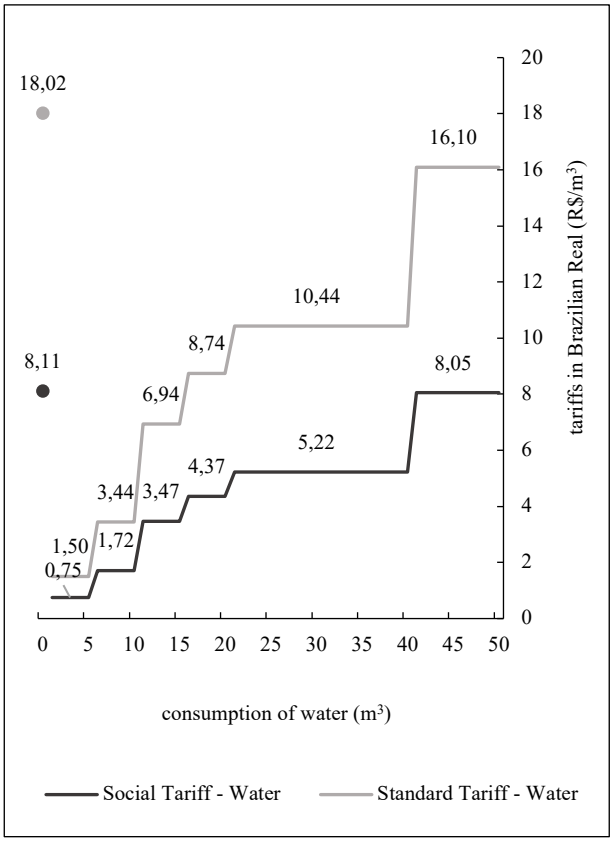

Figure 1
Social and standard tariffs in 2020
Source: Elaborated by the authors using data from Arsae-MG.

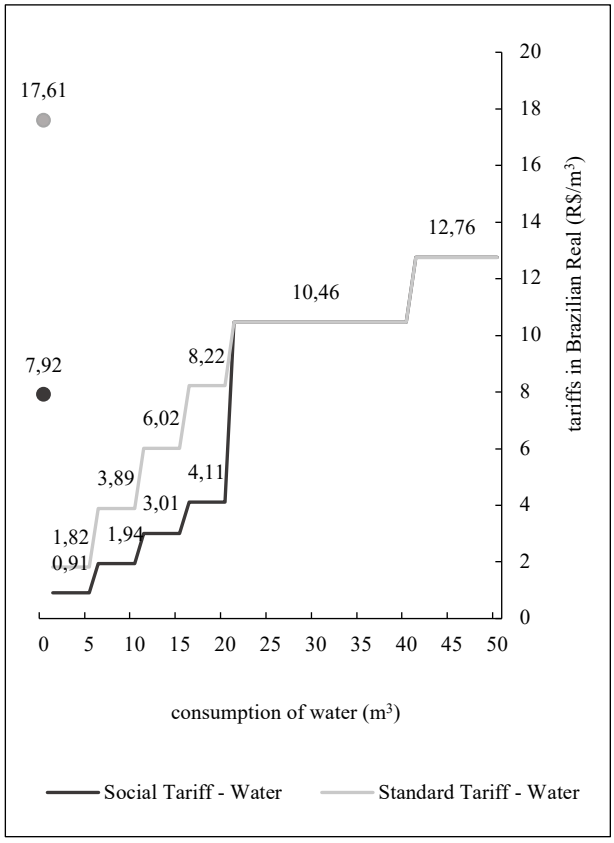

Figure 2
Social and standard tariffs in 2021
Source: Elaborated by the authors using data from Arsae-MG

One argument for establishing a social tariff is that, despite its contribution to sustainability in terms of water conservation, IBT alone is not very efficient in benefiting poor households. The IBT can incorrectly allocate the subsidy when consumption has a higher correlation with household size than income. Through simulations using data from low- and middle-income countries, Whittington et al. (2015) demonstrate that subsidies provided through the IBT alone suboptimally target poor households. Mayol (2017) also points to the importance of income and household size in price discrimination. It is important to emphasize that low-income households tend to be larger than wealthier households in Brazil. Therefore, given that low income is the main criterion for customers to benefit from the social tariff, this policy should improve the granting of subsidies by targeting them precisely at poor households.

A practical tool for accessing low-income customers eligible for the social tariff is the Single Registry for Social Programs (CadÚnico), a unified database of poor Brazilian households that can benefit from various social policies. Eligibility for the social tariff is contingent on updated data from CadÚnico. Municipal governments (through their social service departments) must enroll households in this registry and keep the data updated (Arsae-MG, 2020). Arsae-MG is responsible for selecting the eligible households in the CadÚnico and sending a list of them to the regulated company. In turn, the company is responsible for classifying the customers in its billing database and determining who receives the social tariff. Therefore, the company is indeed responsible for the implementation of the social tariff.

Considering the adoption of the CadÚnico to identify poor households, Arsae-MG established the eligibility rules for granting the social tariff:

i) The customer must be residential;

ii) The customer must correspond to a household with data duly updated in the CadÚnico;

iii) The household must have an average monthly income per person less than or equal to half the Brazilian minimum wage (compatible with the Extreme Poverty, Poverty, or Low Income classifications in the CadÚnico).

Additionally, only one customer per CadÚnico household code can benefit from the social tariff. It is important to emphasize that the regulatory agency establishes that the regulated company must update the register of social customers at least once a year.

The annual tariff adjustments could compensate for the subsidy corresponding to the social tariff since revenues must be at economic cost-recovery levels. Nevertheless, the mismatch between current revenues and the lagged number of social customers considered in these compensations does not exclude the possibility that the regulated company has a certain degree of arbitrage in its cash flows.

2.2 Regulation and inspections

Since the creation of Arsae-MG, State Law No. 18,309 (2009) has established that its Economic Inspection Department could conduct inspections to verify whether the regulated companies had applied the tariffs correctly. However, before 2020, monitoring the implementation of the social tariff was not frequent and did not occur across all municipalities. In March 2020, the agency's new statute, State Decree No. 47,884 (2020), emphasized this inspection role, which is fundamental to regulatory enforcement. Considering the mentioned decree, the Economic Inspection Department planned to introduce a routine of inspections of the social tariff.

In July 2020, State Law No. 23,670 (2020) established that the provider of services must grant the social tariff to the customer (corresponding household) who meets the requirements as soon as it receives the necessary information (household list). Therefore, the granting of the social tariff does not depend on the request of the customer. Although what the law establishes is already a practice of the regulator, this norm could motivate more agility and precision in the registration of the social tariff. The law also stipulates that the regulated company must carry out advertising campaigns to inform customers about the social tariff. Such campaigns should motivate potential social customers who may have experienced a registration error to correct it and thus foster the implementation of the benefit.

In August 2020, Arsae-MG conducted its first economic inspection of the implementation of the social tariff, considering all the municipalities with services provided by Copasa-MG (Arsae-MG, 2020). Since this regulatory agency carried out this specific inspection, it should surprise this regulated company. Arsae-MG conducted this assessment with data from May 2020 (before the regulatory changes featured in this study). It analyzed data from 581 municipalities and highlighted those with an implementation index below 50 percent, which suggests that Copasa-MG would be

gravely out of compliance. The regulator found that this company had registered with the social tariff less than 50 percent of the households on the list of those eligible in 151 municipalities.[6]

Because of this disappointing result, Arsae-MG required Copasa-MG to explain the low implementation of the social tariff. In addition, this regulator requested information on advertising campaigns and practical actions that could foster the policy. It also informed the municipal governments about the economic inspection report and pointed out that they have a role in registering households in the CadÚnico. In response, the company justified the low implementation of the social tariff. However, the regulator did not consider them satisfactory. Afterward, the company highlighted some initiatives planned to improve implementation: training for customer service employees, publicity campaigns, and partnerships with municipal governments to inform customers about the social tariff during registration for the CadÚnico. The regulatory agency agreed that these actions would contribute to the implementation of the social tariff.

In April 2021, Arsae-MG drafted a specific regulation on the social tariff for the first time. In Regulation Arsae-MG No. 150 (2021), the agency gathered and consolidated standards for the policy, which were previously in other norms about tariffs. This new norm emphasizes that the granting of the social tariff and the billing of social customers are subject to inspection by the regulator. Therefore, it encouraged the adoption of periodic (annual) inspections of the social tariff. The eligibility rules for granting this benefit have essentially not changed. What has changed is that the regulatory policy now differentiates residential tariffs only for consumption below 20 cubic meters of water (see figures 1 and 2). In addition to this change, social customers can now request the social tariff through the Internet and a mobile application (app). Lastly, Regulation Arsae-MG No. 150

[6] In five municipalities, additional providers operate services. As the adopted indicator does not consider this issue, we cannot conclude on the implementation of the social tariff in these municipalities.

(2021) introduced standards for the publicity of the social tariff. It is relevant to note that this norm emphasizes the issue of informing potential customers.

In November 2021, Arsae-MG conducted a second inspection of the implementation of the social tariff in all municipalities with services provided by Copasa-MG (Arsae-MG, 2021). Using data from July 2021, this regulator calculated an implementation index for 583 municipalities (two more than the previous year). Adopting the same method, the regulator found better results. Only 17 municipalities had an index of implementation of the social tariff below 50 percent in 2021, compared to 151 in 2020. Thus, the municipalities with a more critical degree of implementation were just over 11 percent of those the agency found previously.

Figure 3 summarizes the events involving regulation and inspections of the social tariff.

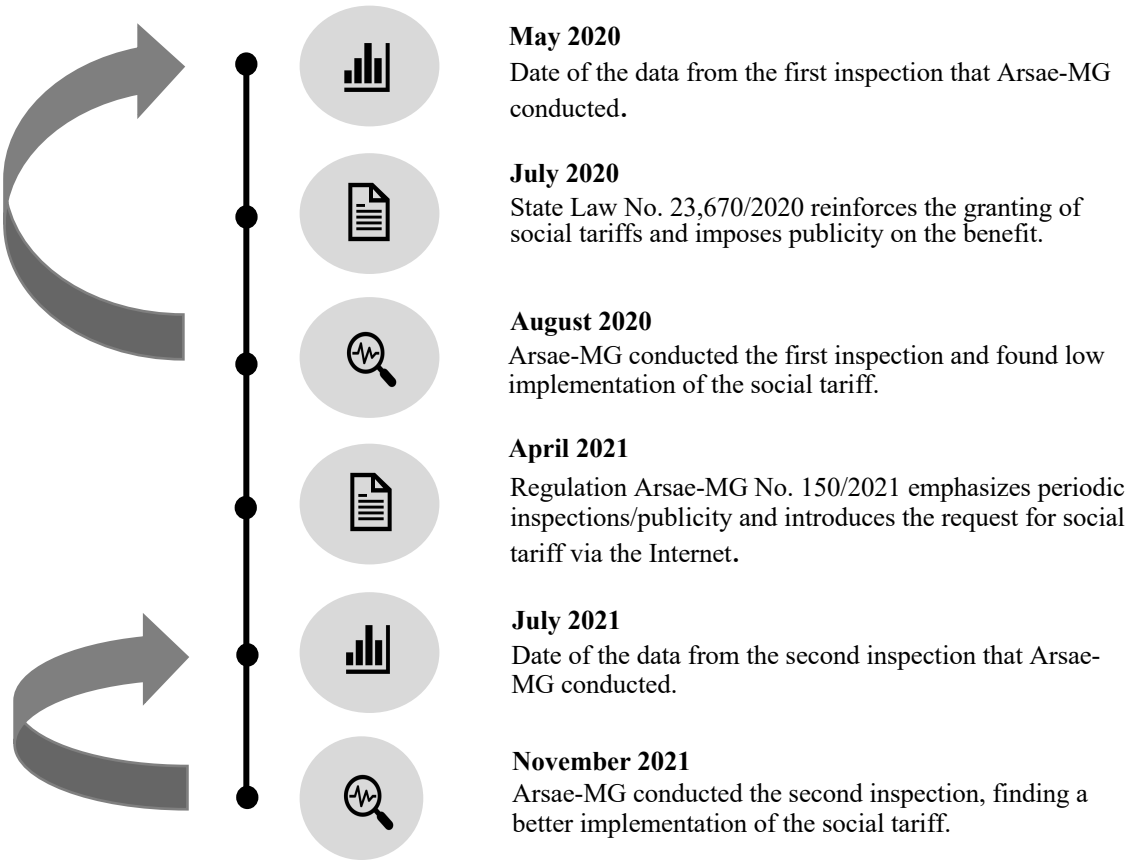

Figure 3
Events of regulation and inspections of the social tariff
Source: Elaborated by the authors.

3. A method for evaluating the degree of implementation of the social tariff

The Arsae-MG conducted the mentioned inspections based on the so-called Degree of Implementation of the Social Tariff (DIST) Index. This regulator has calculated this index using data from the billing databases of Copasa-MG and Copanor, jointly with data from the CadÚnico. This calculation also considers data from Copanor because this subsidiary provides services for a minority of customers in a few of the analyzed municipalities (30 of these localities). The data from companies' billing databases consists of the number of social customers in each municipality. As for the CadÚnico data, the regulatory agency selects the households that will potentially benefit from the social tariff according to three criteria:

i) having access to the public water supply network;

ii) having an updated CadÚnico registry (information updated within the last two years);

iii) having a monthly average per capita income lower than or equal to half of the current minimum wage.

Regarding the first criterion, households must live in residences with access to water supply networks to be water service customers. The second criterion is to keep updated data, ensuring that only duly qualified customers access the benefit. The third criterion is the main requirement for customers to benefit from the social tariff because the regulator aims to impact poor households (Arsae-MG, 2020, 2021). These criteria correspond to the social tariff eligibility rules mentioned in Section 2.

To evaluate the degree of implementation of the social tariff in the municipalities, the regulatory agency calculates the DIST Index according to Equation 1:

$$DIST = \frac{SC_{billing\ databases}}{H_{Cad\acute{U}nico}}, \quad (1)$$

where $SC_{billing\ databases}$ is the number of social customers in the billing databases of the companies, and $H_{CadÚnico}$ is the number of households in the CadÚnico that comply with the three criteria used in the data selection.

The $H_{CadÚnico}$ is a proxy for the degree of implementation of the social tariff in each municipality. This proxy is satisfactory since the selected households are a reasonable approximation of the customers that the company should register for the social tariff in the billing database. Thus, the DIST Index consists of the percentage of social customers registered in the billing databases in relation to the potential number of households eligible for the social tariff in the municipality (Arsae-MG, 2020, 2021). This index has a maximum of 100 percent because a degree of implementation above this maximum is not logical (Arsae-MG, 2020, 2021).

4. Empirical analysis

4.1. Data and variables

In our econometric analysis, we use municipality-level data concerning the following continuous variables: DIST Index (DIST), CadÚnico update rate (CUUR), travel time (TIME), total population (POPU), number of people with elementary education (EDUC), and number of broadband Internet connections (INTE). The DIST Index is the dependent variable of the econometric models, while the others mentioned are only control variables. In addition, we use the REGU dummy variable to capture the effect of the regulation. We also use a dummy to capture different degrees of governance of local governments (MSF) and a set of dummies that capture differences in the degree of implementation of the social tariff among the regions of Minas Gerais state.

As mentioned, the DIST Index (DIST variable) measures the level of implementation of the social tariff (in percentage). Arsae-MG published this index data from 2020 in the Economic

Inspection Report No. 020/2020 (Arsae-MG, 2020) and the data from 2021 in the Economic Inspection Report No. 060/2021 (Arsae-MG, 2021). The data in the first report are from before the regulatory efforts, while those in the second are from after these efforts. Initially, we collected such data in the appendix of these annual reports.[7] Arsae-MG elaborates inspection reports with data from the middle months (May to July). We aligned all other data to be consistent with the months of data from these reports.

The CadÚnico update rate (CUUR) is the percentage of households in this cadaster that have updated registration in the last two years.[8] We collected data on CUUR from a database of the Brazilian Ministry of Citizenship.[9] Since it simultaneously influences the denominator and numerator of the STI index, we do not expect it to result in a coefficient of great magnitude.[10] This variable should indicate how the service provider behaves, implementing the policy in municipalities with greater or lesser efforts by local governments to update CadÚnico records.

The TIME variable is the optimal travel time (estimated in fractions of hours) over the 2010 multimodal transport network from a municipality to the state capital city, Belo Horizonte. Carvalho et al. (2016) provided the travel time data. The values of the TIME variable are the same in 2020 and 2021. This control variable should capture the effect of the distance from the municipality to the regulator's and the company's headquarters. Local governments more distant from the bureaucracy may have difficulty requiring a higher implementation of the social tariff.

[7] Arsae-MG publishes all the economic inspection reports on its website to promote transparency. These reports are available at http://www.arsae.mg.gov.br/fiscalizacao-economica.
[8] The calculation of this indicator considers only households with a per capita income less than or equal to half the minimum wage.
[9] These data are available at https://aplicacoes.mds.gov.br/sagi/vis/data3/data-explorer.php.
[10] When a customer with an outdated register is no longer on the list of households eligible for the benefit (the denominator of the DIST Index), we expected that they would also not be included in the companies' billing databases as a beneficiary of the policy (the numerator of the index).

The POPU variable is a population estimate whose data we collect from the Brazilian Institute of Geography and Statistics (IBGE). In one of our econometric models, the POPU variable controls for the municipality's size.

The EDUC variable consists of the number of people in the CadÚnico who have completed elementary school. We collected the data for this variable from the Ministry of Citizenship database. More educated people are more likely to seek out the company's customer service to access the social tariff when unregistered for the benefit. These people are also more likely to request the social tariff via the Internet.

The last control variable we use is the number of broadband internet connections (INTE). We calculated this variable from the data from the Brazilian National Telecommunications Agency (ANATEL).[11] The INTE variable should capture the population's level of information about the policy since the regulator and the company publicize the social tariff on the Internet. It may also relate to the ease of accessing the benefit, given that Regulation Arsae-MG No. 150 (2021) established that consumers could request the social tariff via the Internet.

As mentioned, we also created some dummy variables. The REGU variable captures the effect of the regulation (in terms of a new norm and inspection) on the implementation of the social tariff. In Section 2, we explained that the regulatory agency surprised the service provider in 2020 during the first inspection, so it captured the situation before the regulation of the social tariff. In 2021, the inspection captured the situation after the regulation of the social tariff. Thus, REGU takes on a value of 1 when the year is 2021 and 0 otherwise.

The MSF variable is a dummy that denotes whether the municipality has a Municipal Sanitation Fund (MSF).[12] MSF assumes a value of 1 if the municipality has a sanitation fund and 0

[11] These data are available at https://informacoes.anatel.gov.br/paineis/acessos/banda-larga-fixa#.
[12] Information on whether the municipality has MSF is available at http://www.arsae.mg.gov.br/habitacao-dos-fundos.

otherwise. To get these funds, local governments must create a Municipal Sanitation Council and a Municipal Sanitation Plan. Local governments with these specific governance structures should be more likely to encourage the company to improve the implementation of the social tariff.

Finally, we created dummy variables according to each macro-region of the Minas Gerais state (REGI). They assume a value of 1 when the municipality is from a specific macro-region and 0 otherwise. These variables capture differences in the degree of implementation of the social tariff across regions. The eleven regions of Minas Gerais are Campo das Vertentes, Central, Jequitinhonha, Metropolitan Area of Belo Horizonte, North, Northwest, South/Southeast, Triângulo Mineiro/Alto Paranaíba, Vale do Mucuri, Vale do Rio Doce, West, and Zona da Mata.

It is relevant to note that income variation does not affect the STI index. For this reason, we did not include income variables or variables that capture events that affect income in our econometric models. When household income increases to the point that it loses eligibility for the social tariff, the company must also exclude the corresponding customer from the social category in its billing database. Thus, variation in income simultaneously affects the number of eligible households (the denominator of the STI index) and the number of social customers (the numerator of the index). Due to this, we do not expect that events affecting income (such as the crisis caused by the COVID-19 epidemic) will affect the STI index. Income affects the number of customers registered with the social tariff, but not the implementation index.

Since we used data for municipalities with services provided by Copasa-MG in 2020 and 2021, we have balanced panel data. The initial data sample had 581 localities. However, we excluded nine localities with additional providers of services (besides Copasa-MG and Copanor). Thus, we obtained a final sample with 572 localities. Disregarding these additional providers can distort the

level of the DIST Index, even if it does not affect its variation. We found additional providers through information from the National Sanitation Information System (SNIS)[13].

Table 1 exhibits the summary statistics of the continuous variables we used in the estimated econometric models. The table shows that the average DIST Index is 77.9 percent when considering the 2020 and 2021 data. The minimum value for this index is 12.51 percent, and several localities reach the maximum of 100 percent.

Table 1
Summary statistics

Statistics	DIST	CUUR	TIME	POPU	EDUC	INTE
Mean	77.90	83.70	4.03	24,870.07	664.01	4,399.82
Median	83.14	84.06	3.44	9,272.50	308.00	720.50
Maximum	100.00	99.07	25.85	2,530,701.00	43,454.00	836,417.00
Minimum	12.51	59.75	0.00	771.00	36.00	12.00
Std. Dev.	22.66	5.30	2.85	114,905.60	2,058.22	35,405.63
N. Observ.	1,144	1,144	1,144	1,144	1,144	1,144

Source: Elaborated by the authors.

Table 2 displays the correlation matrix between the referred variables. There is a strong correlation between the POPU, EDUC, and INTE variables. The DIST Index has a low correlation with all the control variables.

Table 2
Correlation matrix

Variables	DIST	CUUR	TIME	POPU	EDUC	INTE
DIST	1.0000	-0.0759	0.0308	0.0199	0.0296	0.0186
CUUR	-0.0759	1.0000	0.0269	-0.0221	0.0006	-0.0289
EMERG	0.0765	-0.0145	-0.0593	0.6976	0.7120	0.7018
TIME	0.0308	0.0269	1.0000	-0.0852	-0.0785	-0.0834
POPU	0.0199	-0.0221	-0.0852	1.0000	0.9803	0.9816
EDUC	0.0296	0.0006	-0.0785	0.9803	1.0000	0.9348
INTE	0.0186	-0.0289	-0.0834	0.9816	0.9348	1.0000

Source: Elaborated by the authors.

[13] The SNIS website is http://app4.mdr.gov.br/serieHistorica.

4.2. Methods

4.2.1 Statistical tests

Firstly, to evaluate significant differences in the DIST Index before and after the regulatory efforts, we adopted Wilcoxon's (1945) signed-rank tests. We applied these paired sample tests, considering data from all the municipalities in our sample and considering the data segmented into macro-regions of the state. We adopted the exact variance method (one-sided) for the regions and the asymptotic method (two-sided) for the whole state. The first-mentioned method is more accurate than the other method. However, we cannot apply this method to the statewide sample because it has too many observations, requiring a computational capacity exceeding what we have. We opted for a non-parametric test (based on the medians of the data) because there are few observations for some regions and the data does not have a normal distribution. Gibbons and Chakraborti (2010) describe and discuss the Wilcoxon test. In the context of the WSS sector, Mombeni et al. (2015) used this test to assess differences in water consumption arising from a subsidy.

4.2.2 Econometric models

To evaluate the effect of the regulation on the implementation of the social tariff, we estimated econometric models. Such regulation applies to all municipalities with services provided by Copasa-MG, and other Brazilian regulatory agencies do not disclose comparable data on social tariffs. Because of this, we do not have a counterfactual group. Hence, a difference-in-differences approach is not applicable.

Despite this, the data from the two inspections of the Arsae-MG are comparable. These data refer to the same municipalities before and after the regulatory efforts. Thus, we can estimate econometric models using a dummy variable that captures the effect of regulation on the social tariff.

It is relevant to emphasize that this regulation concerns a new norm and the introduction of periodic inspections.

We estimated three models, including POPU, EDUC, and INTE separately, due to the strong correlation between these control variables. This correlation could imply strong multicollinearity if we utilized these variables jointly in one model. To capture the non-observable characteristics of the municipalities, we opted for panel data models with random effects. We consider that when the number of observation units, N, is large (in our case, N is 572), the fixed effects model would lead to an enormous loss of degrees of freedom (Baltagi, 2005). Furthermore, fixed-effects dummies would imply perfect multicollinearity with our time-invariant variables, making the estimation impossible. The three models we estimate correspond to equations 2, 3, and 4:

$$DIST_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 TIME_i + \beta_3 logPOPU_{it} + D'REGI_i + u_{it} \quad (2)$$

$$DIST_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 TIME_i + \beta_3 logEDUC_{it} + D'REGI_i + u_{it} \quad (3)$$

$$DIST_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 TIME_i + \beta_3 logINTE_{it} + D'REGI_i + u_{it} \quad (4)$$

where REGU is the regulation, MSF is the existence of a Municipal Sanitation Fund, CUUR is the CadÚnico update rate, TIME is the travel time, POPU is the population, EDUC is the number of people with elementary education in the CadÚnico, and INT is the number of broadband Internet connections, REGI denotes the regional dummies, and $u_{it} = \mu_i + \upsilon_{it}$ is a composite error term.

As usual, we estimate random effects models using generalized least squares (GLS). This estimation method is more efficient than ordinary least squares (OLS) in the presence of heteroskedasticity. It should deal with the asymmetric residuals of our models, which arise from the

fact that the DIST Index has a maximum of 100 percent. Beyond the GLS estimation, we also adopted White period estimators (robust standard errors). This method deals with heteroskedasticity and serial correlation (Wooldridge, 2010).

4.2.3 Robustness check

To check the robustness of the results, we retroactively extended the data to 2018 and re-estimated the three econometric models. We calculated the DIST Index using data from Arsae-MG and collected the data for the independent variables from the same sources indicated. We opted not to include the MSF variable because there is no data on municipal sanitation funds for 2018. Arsae-MG created this policy in 2018, and it only functioned in the following year. In the models estimated for the robustness check, we reduced the sample to 570 municipalities because two localities had no data for the DIST Index.

4.3. Results

As a preliminary analysis, we can observe the summary statistics of the DIST Index by state macro-regions. In Table 3, the mean of the DIST Index increased after the regulatory efforts in all regions and the whole state. Regarding our entire sample, the average DIST Index was 68.28 percent before the regulatory efforts and increased to 87.53 percent after them. Furthermore, the standard deviation of the index decreased in all regions, suggesting some convergence in this indicator.

Table 3

Summary statistics by macro-regions of Minas Gerais

State Region	Period	Mean	Std. Dev.	Minimum	Maximum	N. Observ.
Whole Minas Gerais state	Before inspection	68.28%	24.76%	12.51%	100%	572
	After inspection	87.53%	15.13%	24.22%	100%	572
Northwest	Before inspection	69.44%	27.28%	30.03%	100%	14
	After inspection	89.42%	12.72%	63.47%	100%	14
North	Before inspection	70.14%	24.07%	12.51%	100%	70
	After inspection	94.09%	12.19%	38.50%	100%	70
Jequitinhonha	Before inspection	80.84%	19.55%	45.85%	100%	27
	After inspection	95.80%	7.49%	73.64%	100%	27
Vale do Mucuri	Before inspection	68.26%	23.99%	25.53%	100%	11
	After inspection	82.72%	16.48%	54.00%	100%	11
Triângulo M./Alto Paranaíba	Before inspection	63.76%	26.51%	14.95%	100%	45
	After inspection	84.02%	18.12%	35.40%	100%	45
Central	Before inspection	78.95%	21.86%	37.36%	100%	25
	After inspection	94.52%	8.91%	64.75%	100%	25
Metropolitan Area	Before inspection	68.79%	23.10%	16.67%	100%	71
	After inspection	87.27%	13.43%	38.65%	100%	71
Vale do Rio Doce	Before inspection	64.34%	22.40%	16.95%	100%	68
	After inspection	86.81%	15.23%	25.17%	100%	68
West	Before inspection	68.25%	27.83%	20.00%	100%	25
	After inspection	82.13%	18.81%	37.86%	100%	25
South/Southeast	Before inspection	72.83%	24.44%	13.82%	100%	97
	After inspection	88.71%	14.01%	37.04%	100%	97
Campo das Vertentes	Before inspection	73.34%	24.92%	16.92%	100%	25
	After inspection	93.07%	9.96%	64.68%	100%	25
Zona da Mata	Before inspection	58.87%	25.44%	12.55%	100%	94
	After inspection	79.82%	16.62%	24.22%	100%	94

Note. Before the inspection corresponds to data from 2020, while after the inspection corresponds to data from 2021. Source: Elaborated by the authors.

4.3.1. Results of the statistical tests

We analyzed whether there were statistically significant differences in the implementation of the social tariff after the regulatory efforts through the Wilcoxon signed-rank test. Table 4 shows the results of the tests applied to the data for the whole state and its regions.

From the whole state data displayed in Table 4, we can see that there was a positive variation in the DIST Index in 419 municipalities (73.3 percent of the total), a negative variation in this index in 48 of them (8.4 percent of the total), and the indicator was stable in 105 of them (18.4 percent of the total). Such stabilization typically occurs when the municipalities have reached full implementation of the social tariff.

Table 4

Wilcoxon tests

Região	Negative Ranks	Positive Ranks	Draws	Z-Statistic	Significance
Whole Minas Gerais state	48	419	105	-17.557	0.000
Northwest	1	11	2	-2.746	0.002
North	2	53	15	-6.418	0.000
Jequitinhonha	1	18	8	-3.743	0.000
Vale do Mucuri	1	8	2	-2.547	0.004
Triângulo M./Alto Paranaíba	6	32	7	-5.011	0.000
Central	2	14	9	-3.361	0.000
Metropolitan Area	5	55	13	-6.198	0.000
Vale do Rio Doce	4	56	8	-6.434	0.000
West	2	19	4	-3.771	0.000
South/Southeast	10	64	23	-6.521	0.000
Campo das Vertentes	0	18	7	-3.724	0.000
Zona da Mata	14	73	7	-7.229	0.000

Note. The tested hypothesis is $DIST_{2021} > DIST_{2020}$. We applied the test using the asymptotic method (two-sided) for the whole state and the exact method (one-sided) for the regions. Source: Elaborated by the authors.

The results of the Wilcoxon tests evidence significant increases in the DIST Index in all regions and the entire sample. Therefore, we can conclude that after the regulatory efforts, there was an improvement in the implementation of the social tariff.

4.3.2. Results of the econometric models

We also econometrically analyzed the effect of the regulation on the implementation of the social tariff. Table 5 exhibits the three econometric models estimated to measure this effect. Respectively, Models 1, 2, and 3 correspond to equations 2, 3, and 4.

The estimated models have satisfactory results regarding the diagnostic test statistics. The F-tests suggest that the set of variables contributes to explaining the implementation of the social tariff, and the coefficients of determination (R2) indicate a reasonable fit. Further, the Durbin-Watson autocorrelation tests for panel data models (Bhargava et al., 1988; Baltagi & Wu, 1999) have values close to 2, suggesting no autocorrelation in the models. In addition, White period estimators should also mitigate heteroskedasticity and serial correlation. Variance inflation factors (VIF tests) smaller than 5 indicate no multicollinearity problem. Finally, the Rho statistics support the adoption of

random effects because they capture the more extensive portion of the composite error variances in the models.

Table 5
Estimated Models

Variables	Model 1		Model 2		Model 3	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Constant	80.9821***	12.9395	89.136***	11.6422	89.4329***	11.6593
REGU	19.2078***	0.8174	19.155***	0.8143	18.819***	0.8101
MSF	0.2410	1.4160	0.3314	1.4131	0.2286	1.3996
CUUR	-0.3627***	0.1300	-0.3809***	0.1303	-0.3571***	0.1298
TIME	-0.4745**	0.2142	-0.4781**	0.2180	-0.4632**	0.2074
Log(POPU)	1.8832***	0.7101				
Log(EDUC)			1.8794**	0.7602		
Log(INTE)					1.2769***	0.4838
State Regions						
Zona da Mata	-6.4938**	2.8571	-6.741**	2.8402	-6.4767**	2.8473
Central	11.7044***	3.5037	11.574***	3.5088	11.4208***	3.4447
Jequitinhonha	13.0943***	3.1393	12.6239***	3.1393	14.3177***	3.1660
North	7.8971***	2.8935	7.3877**	2.8877	9.8613***	2.9696
Campo das Vertentes	6.9284*	3.8953	6.9732*	3.9094	5.9218	3.8520
Northwest	3.9575	5.6705	3.9522	5.6296	4.5327	5.7028
Vale do Mucuri	0.3294	5.6114	-0.0639	5.6533	1.5287	5.6357
Triângulo M./Alto Paranaíba	-1.0903	3.6767	-0.7568	3.7062	-1.7520	3.6603
Vale do Rio Doce	-0.3067	2.9207	-0.8668	2.8956	0.4360	2.9687
West	-1.4953	4.5904	-1.2343	4.6218	-1.8162	4.5790
South/Southeast	4.72*	2.7441	4.9173*	2.7535	4.2332	2.7174
Diagnostic Test Statistics						
R-squared		0.3718		0.3723		0.3716
Adjusted R-squared		0.3629		0.3634		0.3626
F-statistic		41.6840		41.7840		41.6445
p-value (F-statistic)		0.0000		0.0000		0.0000
Durbin-Watson statistic		2.0214		2.0334		2.0224
VIF Test (mean VIF)		0.5507		0.5542		0.5482
Rho statistic (cross-section random)		1.4783		1.4794		1.4885

Note. ***, ** and * denote significant coefficients at the 1%, 5%, and 10% levels, respectively. The number of municipalities that compose the balanced panel is 572, and they have data for 2020 and 2021, totaling 1,144 observations. The models include White period robust standard errors/covariance. Source: Elaborated by the authors.

The models exhibit several significant coefficients. As for the variable of greatest interest in this study, we found that REGU has a statistically significant positive effect on the degree of implementation of the social tariff. The average effect of the regulation (new norm and inspection) on policy implementation is about a 19 percent increase.

We found no significant coefficients for the MSF variable. Therefore, governance structures related to sanitation funds should not affect the implementation of the social tariff. In turn, the negative and significant coefficient of the CUUR variable indicates an inverse relationship between

the efforts of municipal governments to update the CadÚnico and the company's efforts to implement the social tariff. In other words, the company tends to be more negligent in implementing the policy in municipalities where the CadÚnico update rate is high and less negligent where the CadÚnico update rate is low. One possible explanation for this relationship is that the company is trying to compensate for the local government's lack of effort in updating the CadÚnico.

The TIME variable has a negative coefficient, indicating that the greater the distance from the reference municipality to the state capital city, Belo Horizonte, the lower the implementation of the social tariff. This relationship can be due to the isolation of the governments of these municipalities from the bureaucracies (Copasa-MG and Arsae-MG) located in the state capital. In addition, historically, Copasa seems less concerned with municipalities far from the state capital.

The POPU, EDUC, and INTE variables displayed positive and significant coefficients. They indicate that localities with larger populations, more educated people, and more broadband Internet connections tend to have higher degrees of implementation of the social tariff. In fact, the issue of information should be relevant for this implementation. It is important to remember that Regulation Arsae-MG No. 150 (2021) established that consumers could request the social tariff via the Internet. We also observed that some region dummies have significant coefficients. Since we did not insert the dummy of the Metropolitan Area of Belo Horizonte (Minas Gerais' economic epicenter and the headquarters of both the regulatory agency and the company) in the models, the comparisons are in relation to this portion of the state. We can see that the Central, Jequitinhonha, and North regions tend to have higher percentages of the DIST Index, and the Zona da Mata tends to have lower percentages of this indicator. The coefficients of these dummies indicate that the regional differences are expressive in percentage terms.

4.3.3. Results of the robustness check

To check the robustness of the results, we re-estimated the three econometric models with data extended retroactively to 2018. Table 6 exhibits the results of these models. As already explained, this time, our sample has two fewer municipalities, and we did not include the MSF variable due to the unavailability of data. The fits of these models are worse than those that Table 5 exhibits. Even so, considering the diagnostic test statistics and the use of robust estimators, the models are valid.

Table 6
Robustness Check Models

Variables	Model 1		Model 2		Model 3	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Constant	0.8709***	0.0925	0.944***	0.0797	0.9913***	0.0740
REGU	0.1345***	0.0059	0.1348***	0.0059	0.1313***	0.0060
CUUR	-0.0037***	0.0008	-0.0037***	0.0008	-0.0037***	0.0008
TIME	-0.005*	0.0027	-0.0051*	0.0028	-0.005*	0.0027
Log(POPU)	0.0181***	0.0063				
Log(EDUC)			0.0171**	0.0068		
Log(INTE)					0.0083**	0.0040
Regions						
Zona da Mata	-0.069**	0.0275	-0.0722***	0.0274	-0.0734***	0.0273
Central	0.1551***	0.0282	0.1532***	0.0284	0.1484***	0.0275
Jequitinhonha	0.1258***	0.0321	0.121***	0.0320	0.1328***	0.0321
North	0.0738**	0.0294	0.0683**	0.0294	0.084***	0.0301
Campo das Vertentes	0.1009***	0.0381	0.1006***	0.0384	0.0901**	0.0379
Northwest	0.0502	0.0472	0.0495	0.0470	0.0523	0.0470
Vale do Mucuri	0.0217	0.0521	0.0174	0.0526	0.0285	0.0530
Triângulo M./Alto Paranaíba	0.0126	0.0341	0.0147	0.0344	0.0052	0.0339
Vale do Rio Doce	0.0004	0.0285	-0.0056	0.0283	0.0005	0.0287
West	0.0191	0.0415	0.0209	0.0419	0.0138	0.0415
South/Southeast	0.0638**	0.0274	0.0651**	0.0274	0.0585**	0.0271
Diagnostic Test Statistics						
R-squared		0.1990		0.1986		0.1982
Adjusted R-squared		0.1937		0.1933		0.1928
F-statistic		37.5026		37.3991		37.2986
p-value (F-statistic)		0.0000		0.0000		0.0000
Durbin-Watson statistic		1.9192		1.9179		1.9184
VIF Test (mean VIF)		1.5534		1.5624		1.5585
Rho statistic		0.5923		0.5916		0.5900

Note. ***, ** and * denote significant coefficients at the 1%, 5%, and 10% levels, respectively. The number of municipalities that compose the balanced panel is 570, and they have data for 2018 to 2021, totaling 2,280 observations. The models include White period robust standard errors/covariance. Source: Elaborated by the authors.

The results that Table 6 displays corroborate that the regulation affects the degree of implementation of the social tariff. However, when we extend the data period, the magnitude of the

effect becomes smaller. In the robustness check models, the effect of the regulation on the implementation of the social tariff is about a 13 percent increase.[14]

Regarding the control variables, their effects are relatively lower in the models that Table 6 exhibits. We observed that the coefficient of CUUR is substantially smaller than that previously found, being close to zero, although statistically significant. This result suggests that the updating of the CadÚnico by municipal governments tends not to have much influence on the DIST Index. Even so, updating the cadaster should influence access in terms of the number of social consumers.

As for the region dummies, the significant results are for the same regions indicated in Table 5, except for the Campo das Vertentes and South/Southeast coefficients. These two regions, which had only marginally significant coefficients (10% significance) in the two models, now have significant coefficients at the 5% significance level in all models.

Although there are some differences in the magnitude of the coefficients, we can conclude that the results of the robustness check corroborate the positive effect of the regulation on the implementation of the social tariff. Additionally, these results confirm the prevalence of substantial regional disparities in the implementation of the policy.

4.3.4 Discussion

The results found in this article are in line with the conclusions of Economic Inspection Report GFE No. 060/2021 (Arsae-MG, 2021). This article and the referred report indicate an enhancement in the implementation of the social tariff across the Minas Gerais state after the regulatory efforts. However, that report only makes a descriptive analysis of the data without analyzing them by macro-regions of the state. In this article, we advance the investigation compared to the referred report by

[14] The average DIST Index in 2018 and 2019 was 76.1 percent and 78.3 percent, respectively, higher than 68.3 percent in 2020. This information explains the drop in the estimated effect of the regulation.

statistically testing whether the increases in the DIST Index are significant for each macro-region and the entire sample of municipalities. Furthermore, we econometrically estimated the effect of the regulation on the degree of implementation of the social tariff.

The results of the statistical tests indicate significant increases in the implementation of the social tariff in all regions after the regulatory improvements. Furthermore, the results of the econometric models suggest a positive effect of regulatory efforts on the degree of implementation of the policy. The models also exhibit significant regional disparities. Regarding these disparities, the situation in the Zona da Mata region is more critical since it has the lowest implementation index. In fact, in Table 2, the lower averages of the DIST Index before and after the inspection had already indicated this situation. Actions to promote the implementation of the policy should focus more on this region.

This study evaluates the performance of a regulation that seeks to promote the implementation of a pro-poor policy. Such empirical analysis is scarce in the literature, but some authors have theoretically discussed the role of this regulation in favoring pro-poor policies. Narzetti and Marques (2021) emphasize the role of regulation in promoting universal access to WSS services due to its potential to promote affordability for the most vulnerable households. Almeida and Oliveira (2021) suggest that regulatory agencies should exert a decisive role in ensuring the human right to water by providing affordability. The results of our study indicate that Arsae-MG has advanced on these issues by not only creating the social tariff but also fostering its implementation through a new regulation and periodic inspections. Other regulatory agencies can also improve the implementation of social tariffs by making the same regulatory efforts.

Finally, it is relevant to mention that the effects of the regulatory inspections may not be persistent, requiring strategies to ensure that the provider of services maintains a high degree of implementation of the social tariff. Regarding this, it is opportune to refer to the literature on the

superior efficiency-inducing properties of price cap regimes compared to traditional rate-of-return regulation (e.g., Liston, 1993; Resende, 1997). Price cap rules in terms of different productivity offsets (X factor) could affect the implementation of the social tariff. In a tariff review, including the DIST Index as an incentive factor can foster policy implementation and keep it high, even in periods with less regulatory effort.

5. Final remarks

The results of this article suggest that regulation positively affects the implementation of the social tariff. They show that regulation can foster pro-poor policy implementation in the WSS sector. We encourage other Brazilian regulatory agencies to use the DIST Index to measure the implementation of the social tariff in this sector. We also hope that inspections of social tariffs can promote more access to this policy in the Brazilian states, benefiting poor households and fostering universal access to WSS services. Such inspections should contribute to meeting the goals of the New Brazilian Sanitation Regulatory Framework and the United Nations' SDGs. Finally, we hope that regulatory agencies in other countries can take inspiration from the case described in this article.

This study has some methodological limitations. Our statistical approach only allows for before-and-after comparisons. As mentioned, we do not have a counterfactual since other Brazilian regulatory agencies do not disclose data on the implementation of the social tariff. Therefore, we could not adopt difference-in-differences models. However, when these data are available, future research may be able to adopt this econometric method.

It is relevant to point out a limitation in the evaluation using the DIST Index introduced in this study. This policy evaluation approach does not ensure that the customers that the regulated company registered for the social tariff are those who are indeed eligible for the benefit. In fact, high indexes may prevail even with registration errors. In view of this, we suggest that regulatory agencies that

rely on this approach also conduct additional inspections by cross-checking the identification data of customers from the company's billing database with those from the social registry that lists poor households.

Regarding potential future studies, we encourage some research that could use data from the companies' billing databases. One avenue for future research would be to analyze changes in consumption when customers shifted from the social category to the standard residential category. Another research possibility is to evaluate whether the inclusion of sewage treatment tariffs (due to the opening of a new sewage treatment plant) influences the consumption of both classifications of residential customers.

References

Almeida, R. P., & Oliveira, M. V. C. (2021). Direito humano à água e acessibilidade econômica: Uso da Tarifa Social pelos reguladores do saneamento no Brasil. *Planejamento e Políticas Públicas, 54*, 209-228. https://doi.org/10.38116/ppp54art09

Andrade, T. A., & Lobão, W. J. A. (1997). Tarifação social no consumo residencial de água. *Economia Aplicada, 1*(1), 59-80. https://doi.org/10.11606/1413-8050/ea145455

Arsae-MG (2020). Economic Inspection Report GFE No. 020/2020. http://arsae.mg.gov.br/images/documentos/gfe_rf_2020_020_fisc_tarifa_social_copasa_copanor_v2.pdf

Arsae-MG (2021). Economic Inspection Report GFE No. 060/2021. http://www.arsae.mg.gov.br/wp-content/uploads/2021/10/gfe_rf_2021_060_fisc_tarifa_social_copasa_v2.pdf

Baltagi, B. H. (2005). *Econometric analysis of panel data* (3rd ed.). John Wiley & Sons Inc.

Baltagi, B. H., & Wu, P. X. (1999). Unequally spaced panel data regressions with AR(1) disturbances. *Econometric Theory, 15*(6), 814–823. https://doi.org/10.1017/s0266466699156020

Barde, J. A., & Lehmann, P. (2014). Distributional effects of water tariff reforms – an empirical study for Lima, Peru. *Water Resources and Economics, 6*, 30–57. https://doi.org/10.1016/j.wre.2014.05.003

Bhargava, A., Franzini, L., & Narendranathan, W. (1982). Serial correlation and the fixed effects model. *The Review of Economic Studies, 49*(4), 533. https://doi.org/10.2307/2297285

Carvalho, L. R., Betarelli Junior, A. A., Amaral, P. V. M., & Domingues, E. P. (2016). *Matrizes de distâncias entre os distritos municipais no Brasil: um procedimento metodológico* (Working Paper No. 532). Centro de Desenvolvimento e Planejamento Regional da UFMG. http://www.cedeplar.ufmg.br/pesquisas/td/TD%20532.pdf

Damkjaer, S. (2020). Drivers of change in urban water and wastewater tariffs. *H2Open Journal, 3*(1), 355–372. https://doi.org/10.2166/h2oj.2020.031

Federal Law No. 11,445 (2007a), article 49, item II (Brazil). http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445.htm

Federal Law No. 11,445 (2007b), article 30, item VI (Brazil). http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445.htm

Federal Law No. 14,026 (2020a), article 49, item II (Brazil). http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2020/Lei/L14026.htm#art6

Federal Law No. 14,026 (2020b), article 29, item III, § 2º (Brazil). http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2020/Lei/L14026.htm#art6

Fuente, D. (2019). The design and evaluation of water tariffs: a systematic review. *Utilities Policy, 61*, 100975. https://doi.org/10.1016/j.jup.2019.100975

Gibbons, J. D., & Chakraborti, S. (2010). *Nonparametric Statistical Inference*. 5. Ed. Boca Raton: Chapman & Hall/CRC. https://doi.org/10.1201/9781439896129

Gonçalves, I., Alves, D., & Robalo, G. (2014). Social tariffs for water and waste services in mainland Portugal: an impact analysis. *Water Supply, 14*(4), 513–521. https://doi.org/10.2166/ws.2014.002

Hoque, S. F., & Wichelns, D. (2013). State-of-the-art review: Designing urban water tariffs to recover costs and promote wise use. *International Journal of Water Resources Development, 29*(3), 472–491. https://doi.org/10.1080/07900627.2013.828255

Leite, P., George, T., Sun, C., Jones, T., & Lindert, K. (2017). Social Registries for social assistance and beyond: a guidance note and assessment tool. (Social Protection & Labor Discussion Paper No. 1704). World Bank. http://hdl.handle.net/10986/28284

Liston, C. (1993). Price-cap versus rate-of-return regulation. *Journal of Regulatory Economics, 5*(1), 25–48. https://doi.org/10.1007/bf01066312

Martins, R., Antunes, M., & Fortunato, A. (2020). Regulatory changes to Portugal's social tariffs: carrying water in a sieve? *Utilities Policy, 64*, 101038. https://doi.org/10.1016/j.jup.2020.101038

Martins, R., Cruz, L., Barata, E., & Quintal, C. (2013). Assessing social concerns in water tariffs. *Water Policy, 15*(2), 193–211. https://doi.org/10.2166/wp.2012.024

Massarutto, A. (2020). Servant of too many masters: residential water pricing and the challenge of sustainability. *Utilities Policy, 63*, 101018. https://doi.org/10.1016/j.jup.2020.101018

Mayol, A. (2017). Social and nonlinear tariffs on drinking water: cui bono? Empirical evidence from a natural experiment in France. *Revue d'Économie Politique, 127*, 1161-1185. https://doi.org/10.3917/redp.276.1161

Mercadier, A. C., & Brenner, F. S. (2020). Tariff (un)sustainability in contexts of price (in)stability: The case of the Buenos Aires water and sanitation concession. *Utilities Policy, 63*, 101005. https://doi.org/10.1016/j.jup.2019.101005

Mesquita, A. M., & Ruiz, R. M. (2013). A financial economic model for urban water pricing in Brazil. *Urban Water Journal, 10*(2), 85–96. https://doi.org/10.1080/1573062x.2012.699073

Mombeni, H. A., Rezaei, S., Nadarajah, S., & Emami, M. (2015). Reducing water consumption after targeted subsidy plan in Iran. *Water Resources, 42*(3), 389–396. https://doi.org/10.1134/s0097807815030100

Narzetti, D. A, & Marques, R. C. (2020). Models of subsidies for water and sanitation services for vulnerable people in South American countries: Lessons for Brazil. *Water, 12*(7), 1976. https://doi.org/10.3390/w12071976

Narzetti, D. A., & Marques, R. C. (2021). Access to water and sanitation services in Brazilian vulnerable areas: the role of regulation and recent institutional reform. *Water, 13*(6), 787. https://doi.org/10.3390/w13060787

Pinto, F. S., & Marques, R. C. (2015). Tariff structures for water and sanitation urban households: a primer. *Water Policy, 17*(6), 1108–1126. https://doi.org/10.2166/wp.2015.188

Regulation Arsae-MG No. 150 (2021). http://arsae.mg.gov.br/images/documentos/legislacao/2021/150_2021_estabelece_criterios_aplicacao_tarifa_social_prestadores.pdf

Resende, M. (1997). Regimes regulatórios: possiblidades e limites. *Pesquisa e Planejamento Econômico, 27*(3), 641-664. https://repositorio.ipea.gov.br/handle/11058/5406

Rogers, P., Silva, R. Bhatia, R. (2002). Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. *Water Policy, 4*(1), 1–17. https://doi.org/10.1016/s1366-7017(02)00004-1

Ruijs, A., Zimmermann, A., & van den Berg, M. (2008). Demand and distributional effects of water pricing policies. *Ecological Economics, 66*(2-3), 506–516. https://doi.org/10.1016/j.ecolecon.2007.10.015

Sampaio, P. R. P., & Sampaio, R. S. R. (2020). The challenges of regulating water and sanitation tariffs under a three-level shared-authority federalism model: the case of Brazil. *Utilities Policy, 64*, 101049. https://doi.org/10.1016/j.jup.2020.101049

State Decree No. 47,884 (2020), article 21, item I (Minas Gerais). https://www.almg.gov.br/legislacao-mineira/DEC/47884/2020

State Law No. 18,309 (2009), article 2, item II (Minas Gerais). https://www.almg.gov.br/consulte/legislacao/completa/completa.html?ano=2009&num=18309&tipo=LEI

State Law No. 23,670 (2020), article 7, items XV and XVI (Minas Gerais). https://www.almg.gov.br/consulte/legislacao/completa/completa.html?num=23670&ano=2020&tipo=LEI

Taştan, H. (2017). Estimation of dynamic water demand function: The case of Istanbul. *Urban Water Journal, 15*(1), 75-82. https://doi.org/10.1080/1573062x.2017.1395899

United Nations (2010). *The human right to water and sanitation* (Resolution adopted by the General Assembly on 28 July 2010). https://documents-dds-ny.un.org/doc/UNDOC/GEN/N09/479/35/PDF/N0947935.pdf?OpenElement

United Nations (2021). *The Sustainable Development Goals Report 2021*. United Nations. https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf

Whittington, D., Nauges, C., Fuente, D., & Wu, X. (2015). A diagnostic tool for estimating the incidence of subsidies delivered by water utilities in low- and medium-income countries, with illustrative simulations. *Utilities Policy, 34*, 70–81. https://doi.org/10.1016/j.jup.2014.12.007

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics Bulletin, 1*(6), 80-83. https://doi.org/10.2307/3001968

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data* (2nd ed.). MIT Press.