The effect of economic regulation on the implementation of the social tariff in the water sector

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Abstract

A state regulatory agency of the Brazilian water supply and sewage sector conducted inspections of the implementation of the social tariff in more than 500 municipalities with services from its major regulated operator. The regulator established inspections and drafted a new regulatory rule to foster the implementation of this policy. This article analyzes the effect of economic regulation on the implementation of the social tariff. It introduces an index that denotes the level of implementation of the social tariff. The results of the statistical test indicate an increase in the implementation of the social tariff in all state regions after regulatory efforts. The results of the econometric models suggest that the regulation increased the implementation of this policy. This article contributes to the literature by highlighting the role of economic regulation in the implementation of a pro-poor policy. Furthermore, it contributes by introducing the referred index in the literature so that other regulators can use it to inspect the implementation of the social tariff.

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

1. Introduction

A challenge for developing countries is to ensure universal access to water services. The discussion about access to water as a human right has gained more notoriety since the 2010 United Nations General Assembly. The United Nations stated that safe and clean drinking water and sanitation are human rights essential for the full enjoyment of life and all human rights (United Nations, 2010). Moreover, in 2015, the Sustainable Development Goals (SDGs) established an ambitious goal of securing universal access to safe and equitable water and sanitation services by 2030 (United Nations, 2021).

The water tariff design plays a relevant role in fostering universal access to sanitation because of the possibility of making services affordable to poor households. Social concern in the tariff design is more related to the issue of equity and its trade-off in terms of efficiency. However, the tariffs should also consider multidimensional aspects such as financial and environmental sustainability (see Rogers et al. (2002), Martins et al. (2013), and Massarutto (2020) for related discussions). Typically, regulatory agencies design increasing block tariffs (IBT) structured in terms of consumption brackets since income may not always be observable. Price discrimination can also occur through cross-subsidies for financially vulnerable consumers. Hoque and Wichelns (2013), Pinto and Marques (2015), and Fuente (2019) review the literature on water tariff design, mentioning various studies that compare the demand and welfare of different tariff structures through simulations. Whittington et al. (2015) state that increasing block tariff structures alone misdirect subsidies to poor households in low- and middle-income countries.

In Brazil, a country with one of the worst income distributions in the world, the issue of access to water services is critical. The Brazilian legislation, to some extent, considers the need to extend access to safe drinking water and sanitation to all citizens. The Brazilian Sanitation Regulatory Framework has as a guideline to expand access to these services for low-income households and localities (Federal Law No. 11,445, 2007a). The law that governs

the regulation of sanitation in the country also establishes that the tariffs must consider the "user's capacity to pay" (Federal Law No. 11,445, 2007b), something understood as *affordability*. 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 enabled the sub-national regulatory agencies to introduce the so-called *social tariff*.[1] This benefit exists in several states in Brazil, but with some distinctions in the eligibility rules. The policy provides water and sewage services at affordable bills to financially vulnerable households. Users registered in the social category pay lower tariffs than those in the standard residential category. They must meet the eligibility rules, which often include having no more than a household income limit (Almeida & Oliveira, 2021). The social tariff is a policy that enhances affordability, and it can contribute to universal access to services to the extent that it expands access to households that would have difficulty paying the standard residential tariff.

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 social class) on the water demand and users' welfare in the 1990s. More recently, Ruijs et al. (2008) simulated different tariff structures with data from the Metropolitan Area of São Paulo (Brazil), finding that reducing the first block price (in an IBT structure) improves income distribution. Furthermore, they suggest that establishing a system with price discrimination by household income (as the social tariff) improves equity.

The literature on social tariffs in the Brazilian context has grown more contemporary, although it remains scarce. Narzetti and Marques (2021) discuss the relevance of this benefit in fostering universal access to water and sanitation services. Almeida and Oliveira (2021)

[1] Although some authors mention the subsidized range of an IBT as a social tariff, this is not the policy addressed in this study. This mention complicates the distinction between the policies when authors point out the existence of a social tariff without describing it in more detail.

mention that this policy works as a strategy to enforce the human right to water. These authors also compare the eligibility rules of the social tariff established by some Brazilian regulatory agencies for granting this benefit.

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 among those in Brazil. This state has substantial heterogeneity. It comprises diverse rural and urban localities and even a poorer region that borders the northeastern, having similarities with almost all macro-regions of Brazil. In this state, the Regulatory Agency for Water Supply and Sewage Services of Minas Gerais State (Arsae-MG) regulates sanitation services in most municipalities. Among the more than 50 regulatory agencies in the Brazilian water sector, Arsae-MG is the one that regulates services in more localities. This agency stipulates the regulatory rules that guide the provision of the services and inspects their compliance by the operators.

The law that created Arsae-MG established the extension of access to services for low-income citizens and localities as a guideline (State Law No. 18,309, 2009). Considering this guideline and those of the Brazilian Sanitation Regulatory Framework, Arsae-MG introduced a social tariff for services provided by the regulated operators. This regulator created a category in the tariff schedule[2] for low-income users, considering significantly lower prices to be paid by them.

The major operator regulated by Arsae-MG is the mixed company[3] 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

[2] The tariff schedule displays the tariffs charged according to the user's classification (social residential, standard residential, commercial, industrial, and government/public) and the services provided (water supply, sewage collection only, and sewage collection plus treatment) in an increasing block tariff structure.

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

services mainly in more arid and poor regions of the state. Copanor also provides water and sanitation services to a minority of users in 30 municipalities where the Copasa-MG majority operates.

In 2020, the Arsae-MG conducted the first economic inspection of the level of implementation of the social tariff in all the municipalities in which the Copasa-MG operates services. In this article, we formally introduce in the literature the assessment method adopted by the Arsae-MG, based on the so-called Social Tariff's Implementation (STI) index. After finding unsatisfactory results in the first inspection, this regulatory agency endeavored to stimulate the implementation of the social tariff by improving the related economic regulation. A year later, it conducted a second inspection, gathering data on the implementation of the social tariff. We can compare this data with the previous ones.

This article analyzes the effect of the social tariff regulation on the implementation of this policy. Such economic regulation concerns a new regulatory rule and the introduction of periodic inspections. In the analysis, we used a unique data sample from 572 municipalities that totaled more than 600 thousand households registered for the benefit. First, we aim to analyze whether statistically significant differences occurred in the STI index after the regulatory efforts, applying nonparametric tests. We do this analysis for the totality of Minas Gerais and each macro-region of this state. After that, we aimed to evaluate the effect of the regulation on the level of implementation of the social tariff through econometric models.

This article contributes to the literature by highlighting the role of economic regulation in the implementation of a pro-poor policy. Its results suggest positive effects of regulatory efforts on the implementation of the social tariff. Furthermore, by introducing the STI 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 have registries of utility users 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.

We strive to cover a gap in the literature since we did not find any studies with the same purpose. There is extensive literature dealing with economic regulation in the water sector, but no previous study has analyzed the effect of this regulation on the implementation of the social tariff. Above all, none of them had analyzed econometrically whether regulatory efforts could stimulate access to the benefit. Few studies address specific pro-poor policies similar to the social tariff of the Arsae-MG in the water sector of other countries. 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 implemented in Portugal. Mayol (2017) investigates the introduction of a social tariff in a city in France (Dunkerque) and evaluates only graphically (not econometrically) the effect of this policy on water consumption. In South America, Mercadier and Brenner (2020), when dealing with financial sustainability, comment on a social tariff in Argentina. 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 discussion of pro-poor subsidies (including social tariffs) granted in Argentina, Bolivia, Chile, Colombia, Paraguay, Peru, and Uruguay.

We organized the remainder of the article into six sections. Section 2 explains the social tariff rules and describes the efforts that the regulatory agency made in order to foster the implementation of this policy. Section 3 introduces a method to evaluate the implementation of the social tariff. Section 4 describes the data and the methods employed in the analysis and displays the found results, and Section 5 discusses these results. Finally, Section 6 provides some final remarks.

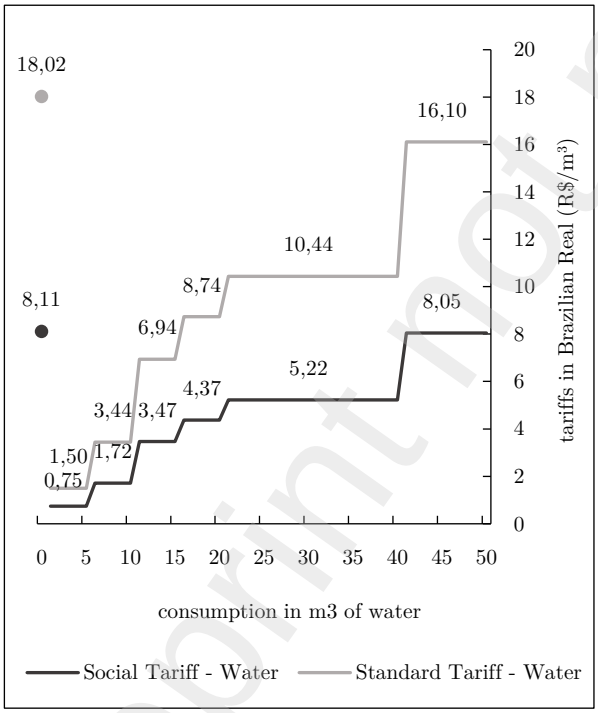
2. Background

2.1 Social tariff

As mentioned, Arsae-MG established a social tariff for the sanitation services of the regulated operators by creating a specific category of the tariff schedule that contemplates low-income users. The users who benefit from the social tariff are called *social users*. They pay tariffs substantially lower than those applied to standard residential users (in the case of the Copasa-MG, the values have been about 50% lower in the last years). The policy contributes to affordability since it reduces the proportion of poor households' income spent on water services. Figures 1 and 2 exhibit the tariffs billed by Copasa-MG according to the volume of consumed water for residential users classified as *standard* and *social*.

Figure 1

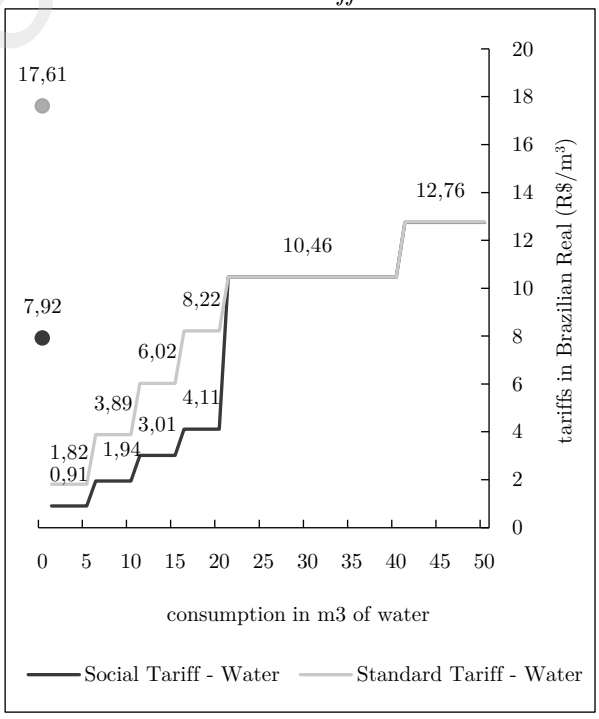
Social and standard tariffs in 2020



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

The first graph shows tariffs for 2020 and the second for 2021. The difference between them is having a limit for consumption billed considering the benefit. The regulatory agency stipulates increasing block tariffs (ITB) for both the social and standard categories, while Copasa-MG does the billing considering integer numbers for cubic meters of consumed water. The value indicated when consumption is zero (points in the graphs) consists of the fixed tariff, justified by the maintenance of the general water network. The fixed tariff is added to the one that varies according to consumption, so the amount billed is equivalent to the so-called two-part tariff. Meanwhile, sewage tariffs are percentages of water tariffs.[4]

One argument for establishing a social tariff is that the IBT alone is not very efficient in benefiting poor households, despite its contribution to sustainability in terms of water conservation. IBT can misallocate the subsidy when consumption is more correlated with the number of people in households than with income. Through illustrative simulations calibrated using data from low- and medium-income countries, Whittington et al. (2015) show that subsidies provided through IBT alone target badly poor households. Mayol (2017) also points to the relevance of income and household size in discriminating among users. Regarding this, it is relevant to emphasize that low-income households tend to be larger than wealthier ones in Brazil. Therefore, given that low income is the main criterion for the user to benefit from the social tariff, this policy should improve the granting of subsidies by targeting them precisely to poor households.

A practical tool to access low-income users eligible for the social tariff is the Single Registry for Social Programs (CadÚnico), a unified database for poor Brazilian households that can benefit from various social policies. The user classification conducted by the operator must consider only duly updated information from CadÚnico. The municipal governments (through their social assistance departments) must register the households in this cadaster and

[4] 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: http://www.arsae.mg.gov.br/copasa/#doc.

keep the data updated (Arsae-MG, 2020). Arsae-MG's information department is responsible for sending the households list from CadÚnico eligible for the social tariff. However, it is the operator's role to classify the users in its billing database, determining which ones benefit from the social tariff.

Considering the adoption of the CadÚnico to identify poor households, Arsae-MG stipulated the eligibility rules for granting the social tariff: i) the user[5] must be classified as residential; ii) this user must correspond to a household registered in the CadÚnico with the cadaster duly updated; iii) the household must have a 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, the benefit is limited to a single user per household code in the CadÚnico. It is relevant to highlight that the regulatory agency establishes that the operator must at least annually update the registry of social users.

The classification of users in the social tariff does not impact the operator's revenue due to being compensated in the annual price review. Even so, the operator does not classify all users that are eligible to benefit. Because of this, Arsae-MG has undertaken efforts to stimulate the operator to expand the implementation of the social tariff.

2.2 Regulatory rules and inspections

Since the creation of Arsae-MG, State Law No. 18,309 (2009) has established that its economic inspection department could conduct regulatory inspections to verify whether the operators had applied the tariffs correctly. 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 this, the economic inspection department planned to introduce a routine of inspections of the social tariff.

[5] Here, the user corresponds to the unit of a property (or part of it), having a connection to the water supply network such that it is possible to use the services.

In July 2020, State Law No. 23,670 (2020) stipulated that the operator now has to apply the social tariff to the user (corresponding household) registered in the CadÚnico that fulfills the requirements as soon as it receives the necessary information (households list). Therefore, this concession is not dependent on the user's request. Although what the legislation established was already a practice of the regulator, it could motivate more agility and precision in the registration of the social tariff. The law also stipulates that the operator must conduct advertising campaigns to inform users about the social tariff. Such campaigns should motivate social users with a registration error to correct it and thus foster the implementation of the benefit.

In August 2020, Arsae-MG conducted the first economic inspection of the implementation of the social tariff in all the municipalities with services operated by Copasa-MG (Arsae-MG, 2020). Since this regulatory agency had never done this specific inspection, it should surprise the operator. Arsae-MG realized this assessment with data from May 2020 (those from before all the regulatory changes featured in this study). It analyzed data from 581 municipalities, highlighting which of them had an implementation index lower than 50%, a more critical situation. The regulator found that social users represented less than 50% of the potential poor households in 151 municipalities.[6]

Because of this disappointing result, the Arsae-MG required the operator to explain the low levels of 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, Copasa-MG provided justifications for the low levels of implementation of the social tariff. However, the regulator did not consider them satisfactory. As favorable aspects, the operator mentioned

[6] In five municipalities, additional providers operate services. Therefore, for these municipalities, one could not draw any conclusions about the status of the implementation of the social tariff based on the indicator that did not consider this issue.

some programed initiatives: training for customer service employees, publicity campaigns, and partnerships with municipal governments to better inform users about the social tariff during the registration in the CadÚnico. The regulator agreed that these actions would contribute to the implementation of the social tariff.

In April 2021, Arsae-MG formulated, for the first time, a specific regulatory rule about the social tariff. In Regulatory Rule Arsae-MG No. 150 (2021), the regulator gathered the norms about the policy, which were previously in other regulatory rules on tariffs. This new regulatory rule reinforces that the concession of the social tariff and the social users' billing are subject to inspection by the regulatory agency. Thereby, the norm encouraged the adoption of periodic (annual) inspections of the social tariff. The eligibility rules for the concession of the benefit have essentially not changed. However, a novelty was that the regulatory policy now differentiates residential tariffs only for consumption below 20 cubic meters of water (see figures 1 and 2). Besides this change, users can now request the social tariff through the Internet and a mobile application (app). Not least, the Regulatory Rule Arsae-MG No. 150 (2021) introduced a series of requirements regarding the publicity of the social tariff.

In November 2021, Arsae-MG conducted a second inspection of the level of implementation of the social tariff in all municipalities with services operated by Copasa-MG (Arsae-MG, 2021). Using data from July 2021, this regulator calculated an implementation index for 583 localities (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% in 2021, compared to 151 of them in 2020. Hence, the municipalities with a more critical level of implementation reduced to just over 11% of those the agency found previously.

3. A method to evaluate the level of implementation of the social tariff

The Arsae-MG conducted the mentioned inspections based on the so-called Social Tariff's Implementation (STI) index. This regulator has calculated this index using data from Copasa-MG's and Copanor's[7] billing databases and those from the CadÚnico database. This calculation must also consider data from Copanor because this subsidiary operates services for a minority of users in a few of the analyzed municipalities (30 of these localities). The operator data consisted of the number of social users in each municipality. As for the CadÚnico data, the regulatory agency defines the number of 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 in the last two years); iii) having a monthly average per capita income lower than or equal to half the current minimum wage. Regarding the first criterion, households must live in residences with access to public water supply networks to be water service users. The second criterion is to keep the data up-to-date so that users only access the benefit when duly qualified. The third criterion is the main requirement for users to benefit from the social tariff because this is a regulatory policy addressed to the poor (Arsae-MG, 2020, 2021). These criteria correspond to the social tariff eligibility rules we mentioned in Section 2.

To evaluate the level of implementation of the social tariff in the municipalities, the regulatory agency calculates the STI index according to Equation 1:

$$STI = \frac{SU_{operator}}{H_{CadÚnico}}, \quad (1)$$

where $SU_{operator}$ is the number of social users in the operator billing database, and $H_{CadÚnico}$ is the number of households in the CadÚnico that comply with the three criteria used in the data selection.

[7] For simplification, we can treat both companies as one.

The $H_{CadÚnico}$ is a proxy for the potential of implementation of the social tariff in the municipality. This proxy is satisfactory since the selected households are a reasonable approximation of the users that the operator should register for social tariff in the billing database. Thus, the STI index (given in percentage) consists of the share of social users registered in the billing database in relation to the potential for implementation of the social tariff in the municipality (Arsae-MG, 2020, 2021).

This STI index is limited to 100 percent because a level of implementation above the maximum potential does not make sense. Furthermore, considering the STI index above 100% could imply a bias in the analyses since negative variations that keep it above this percentage would reflect better precision in the benefit concession instead of worsening in the implementation (Arsae-MG, 2020, 2021).

4. Empirical analysis

4.1. Data and variables

To analyze the effect of regulation on the implementation of the social tariff, we use municipality-level data concerning the following continuous variables: STI index (STI), CadÚnico update rate (CUUR), Emergency Aid (EMERG), travel time (TIME), total population (POPU), number of people with elementary education in the CadÚnico (EDUC), and number of broadband Internet connections (INTE). The STI index is the dependent variable of our econometric models, while the others mentioned are only control variables that could have effects other than those of regulation. Furthermore, to capture the effect of the regulation on the implementation of the social tariff, we created a dummy variable, the REGU. We also created a dummy to capture different levels of governance of local governments (MSF) and a set of dummies that capture differences in the level of implementation of the social tariff among the regions of the Minas Gerais state.

As mentioned, the STI index (STI variable) measures the level of implementation of the social tariff (in percentage). The data for this variable are publicly available. 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 this. Initially, we collected such data in the appendix of these annual reports.[8] The inspection reports are elaborated with data from the middle months (May to July). We aligned all other data used in this study according to 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. The calculation of this indicator considers only households with per capita income less than or equal to half the minimum wage. We have collected the data of CUUR in an information system that belongs to Brazil's Ministry of Citizenship.[9] In our econometric models, this variable can capture the efforts of municipal governments in inscribing households in this cadaster. Local governments more dedicated to updating the CadÚnico should also require the operator to improve the implementation of the social tariff. Thus, the CUUR variable can be relevant to isolating the effect of the actions of these agents from that of the Arsae-MG's regulation.

Emergency Aid (EMERG) is the money that the Brazilian Federal Government provided to poor citizens during the COVID-19 pandemic. We collected the data for this variable in the same information system held by the Ministry of Citizenship. The referred financial aid can make the household income higher than the limit to be eligible for the social tariff, excluding users of the benefit. The EMERG variable can have some effect on the implementation of the social tariff only in 2021, when the operator makes the first billing

[8] 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.

[9] These data are available at https://aplicacoes.mds.gov.br/sagi/vis/data3/data-explorer.php.

database update after the aid creation. Therefore, we assume the values of this variable for 2020 are zero and calculate the amount of Emergency Aid (in millions of Real, the Brazilian currency) accrued until this update, using these as the values for 2021.[10]

The TIME variable consists of the optimal travel time (in a fraction of hours) over the 2010 multimodal transport network when one wants to go from Belo Horizonte (the state capital). The study by Carvalho, Betarelli Junior, Amaral, and Domingues (2016) originated the travel time data, and these authors made them available upon request. The values of the TIME variable are the same in 2020 and 2021. This control variable should capture how isolated a municipality is from the city of the regulator's and the operator's headquarters. Local governments more distant from the bureaucracy may have difficulty requiring a higher implementation of the social tariff.

The population (POPU) we adopted as a control variable is an estimate used by the Federal Audit Court (TCU) to define the distribution of federal government resources to municipalities. We collected population estimates data from the Brazilian Institute of Geography and Statistics (IBGE), the institution that calculates them.[11] In one of our econometric models, the POPU variable controls by the municipality's size.

The EDUC variable consists of the number of people in the CadÚnico who have completed elementary school. Hence, this is a specific educated population registered in this cadaster. We collected the data for this variable in the already-mentioned system held by the Ministry of Citizenship. More educated people are more likely to seek out the operator's customer service to access the social tariff when unregistered for the benefit.

The last control variable we use is the number of broadband internet connections (INTE). We calculate this variable from the data from the Brazilian National

[10] The Brazilian Federal Government created the Emergency Aid in April 2020, and this additional income must have been considered only in the billing database update for 2021 that the operator did in November and December 2020. The 2021 inspection of Arsae-MG captured data updated mainly on these months.

[11] These data are available at https://www.ibge.gov.br/estatisticas/sociais/populacao/9103.

Telecommunications Agency (ANATEL) website.[12] The INTE variable should capture the population's level of information about the policy since the regulator and the operator publicize the social tariff more on the Internet. It may also relate to the ease of accessing the benefit, given that Regulatory Rule 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 economic regulation (in terms of a regulatory rule and inspection) on the implementation of the social tariff. REGU is the variable of most interest in this study. In Section 2, we explained that, in 2020, the regulatory agency surprised the operator in the first inspection, so it captured a pre-regulation situation of the implementation of the social tariff. In 2021, the inspection captured the situation after the social tariff regulation. Thus, REGU takes on a value of 1 when the year is 2021 and 0 otherwise.

We also created other dummy variables. The variable MSF denotes whether the municipality has a Municipal Sanitation Fund (MSF).[13] To get these funds, local governments need to create a Municipal Sanitation Council and a Municipal Sanitation Plan. A local government with these specific governance structures should be more likely to encourage the operator to improve the implementation of the social tariff. Pinto et al. (2017) have associated governance with operator performance. The MSF variable assumes a value of 1 if the municipality has a sanitation fund and 0 otherwise. We expect this dummy variable to capture the effect of the mentioned governance structures on the implementation of the social tariff.

Finally, we created dummy variables according to each macro-region of the Minas Gerais state (REGI). These variables capture differences in the level of implementation of the social tariff across regions. They assume a value of 1 when the municipality is from a specific macro-region and 0 otherwise. The eleven regions of Minas Gerais are: Campo das Vertentes,

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

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.

Since we use data for all municipalities with Copasa-MG operations in 2020 and 2021, we have a balanced panel. The initial data sample was composed of data from 581 localities. However, we excluded nine localities with additional operators (besides Copasa-MG and Copanor) not considered in the calculation of the STI index. Thus, we obtained a final sample composed of 572 localities. Disregarding these additional operators may distort the level of the index, even if it does not affect its variation.[14] We found such providers by comparing the Arsae-MG data with those from the National Sanitation Information System (SNIS)[15] and by observing information from other providers regulated by the regulatory agency.

Table 1 exhibits the summary statistics of the continuous variables we used in the estimated econometric models. The Jarque-Bera test suggests that none of these variables have a normal distribution. Furthermore, the table shows that the average STI index is 77.9% when considering the 2020 and 2021 data. The minimum value for this index is 12.51%, and several localities reach the maximum of 100%.

[14] It is understandable that some residual operation of sanitation services by the municipal government remains in some of the municipalities in the sample. Our focus is on the variation of the STI index over the years and not on its level. Therefore, this issue should not be problematic.

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

Table 1

Summary statistics

Statistics	STI	CUUR	EMERG	TIME	POPU	EDUC	INTE
Mean	77.90	83.70	13.85	4.03	24,870.07	664.01	4,399.82
Median	83.14	84.06	0.40	3.44	9,272.50	308.00	720.50
Maximum	100.00	99.07	2,486.93	25.85	2,530,701.00	43,454.00	836,417.00
Minimum	12.51	59.75	0.00	0.00	771.00	36.00	12.00
Std. Dev.	22.66	5.30	82.40	2.85	114,905.60	2,058.22	35,405.63
JB statistic	135.98	43.80	24,440,110.00	25,151.93	7,417,487.00	4,051,207.00	11,737,980.00
p-value (JB)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N. Observ.	1,144	1,144	1,144	1,144	1,144	1,144	1,144

Note. JB is the statistic of the Jarque-Bera test. Source: Elaborated by the authors.

Table 2 displays the correlation matrix between the referred variables. This table shows that the POPU, EDUC, and INTE variables are strongly correlated, with correlation coefficients higher than 90%. The correlation coefficients between EMERG and the mentioned variables are also remarkable because such aid and other factors vary with the size of the municipality. However, we observed that they did not increase the multicollinearity when estimating the econometric models.

Table 2

Correlation matrix

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

Source: Elaborated by the authors.

4.2. Methods

4.2.1 Statistical tests

Firstly, to evaluate significant differences in the STI indexes before and after the regulatory efforts, we adopted Wilcoxon (1945) signed-rank tests. We applied these paired sample tests with data from all the municipalities in our sample and with 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. However, we cannot apply this method to the statewide sample because it has too many observations, which would require a computational capacity that we do not have. We opted for a non-parametric test (based on the medians of the data) because the data do not have a normal distribution and there are few observations for some regions. Gibbons and Chakraborti (2010) describe and discuss the Wilcoxon test. In the water sector context, 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 social tariff regulation on the implementation of this policy, we estimated econometric models. Such regulation applies to all municipalities with services operated by Copasa-MG, and other Brazilian regulatory agencies do not disclose comparable data on this policy. Because of this, we do not have a counterfactual group. Hence, a difference-in-differences estimation is not applicable. Despite this, the data from the two inspections of the Arsae-MG are comparable. They 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 social tariff regulation. It is relevant to emphasize that this regulation concerns a new regulatory rule and the introduction of periodic inspections.

We estimate three models to analyze the effect of economic regulation on the implementation of the social tariff. The models include POPU, EDUC, and INTE separately because of 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:

$$STI_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 EMERG_{it} + \beta_3 TIME_i + \beta_4 logPOPU_{it} + D' REGI_i + u_{it} \quad (2)$$

$$STI_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 EMERG_{it} + \beta_3 TIME_i + \beta_4 logEDUC_{it} + D' REGI_i + u_{it} \quad (3)$$

$$STI_{it} = \alpha + D_1 REGU_t + D_2 MSF_{it} + \beta_1 CUUR_{it} + \beta_2 EMERG_{it} + \beta_3 TIME_i + \beta_4 logINTE_{it} + D' REGI_i + u_{it} \quad (4)$$

where REGU is the regulation, MSF is the existence of a Municipal Sanitation Fund, CUUR is the CadÚnico update rate, EMERG is the emergency aid, 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 by 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 STI has a maximum of 100%. Beyond the GLS estimation, we also adopted

White period estimators (robust standard errors), a method designed to accommodate arbitrary heteroskedasticity within cross-section 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 STI index using data from Arsae-MG and collected the data for the independent variables from the same sources already indicated. We opted not to include the MSF variable because there is no data on municipal sanitation funds for 2018 since Arsae-MG created this policy that year, and it only started working the following year. In the estimated models for the robustness check, we reduced the sample to 570 municipalities because two localities had no data for the STI index.

4.3. Results

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

We can also observe these changes in the whole sample through boxplots. In Figure 3, when we compare before (first boxplot) and after economic inspection/regulation (second boxplot), we see that the mean and median increase, and the dispersion of the data decreases (see the interquartile range). Except for a few municipalities that are outliers, there has been a trend toward full implementation of the social tariff. Therefore, we have some indications of improvement in the implementation of the policy. However, we need to apply statistical tests to assess whether the increases in the STI index were statistically significant.

Table 3

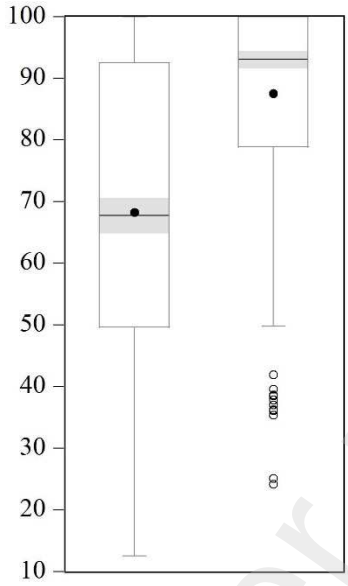
Summary statistics by macro-regions of Minas Gerais

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.

Figure 3

Boxplots with STI index data



Note. The first boxplot is for the 2020 data, while the second is for the 2021 data. Source: Elaborated by the authors.

4.3.1. Results of the statistical tests

The first aim of this study is to analyze whether there were statistically significant differences in the implementation of the social tariff after the new regulatory rule and the economic inspection. We conduct this analysis 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 STI index in 419 municipalities (73.3% of the total), there was a negative variation in this index in 48 of them (8.4% of the total), and the indicator was stable in 105 of them (18.4% of the total). Such stabilization typically occurs when the municipalities have reached the full implementation of the social tariff.

Table 4

Wilcoxon tests

Região	Negative Ranks	Positive Ranks	Draws	Z-Statistic	Signif.
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: $STI_{2021} > STI_{2020}$. The test was applied by the asymptotic method (two-sided) for the whole state and by the exact method (one-sided) for the regions. Source: Elaborated by the authors.

The results of the Wilcoxon tests evidence significant increases in the STI 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

The second aim of this study is to econometrically evaluate the effect of economic 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, exhibiting various significant coefficients. The F-tests suggest that the set of variables contributes to explaining the implementation of the social tariff, and the coefficients of determination (R^2) 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 within cross-section autocorrelation. Variance inflation factors (VIF tests) smaller than 5 indicate no multicollinearity problem. Finally, the Rho statistics support the adoption of random effects since they are related to the larger 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	79.3809***	13.0644	88.4625***	11.6739	89.1135***	11.6744
REGU	19.4084***	0.8335	19.3404***	0.8281	18.9653***	0.8179
MSF	0.2330	1.4160	0.3312	1.4129	0.2467	1.3998
CUUR	-0.3656***	0.1300	-0.3857***	0.1303	-0.3588***	0.1297
EMERG	-0.0072**	0.0031	-0.0069**	0.0030	-0.0064**	0.0028
TIME	-0.4822**	0.2149	-0.4857**	0.2190	-0.4700**	0.2079
Log(POPU)	2.0949***	0.7398				
Log(EDUC)			2.0852***	0.7898		
Log(INTE)					1.3650***	0.4960
State Regions						
Zona da Mata	-6.5746**	2.8580	-6.8417**	2.8420	-6.5868**	2.8470
Central	11.6651***	3.4989	11.5269***	3.5048	11.3133***	3.4418
Jequitinhonha	12.9295***	3.1391	12.4154***	3.1424	14.2580***	3.1632
North	7.8094***	2.8958	7.2492**	2.8920	9.9090***	2.9699
Campo das Vertentes	6.8558*	3.8927	6.9130*	3.9069	5.7416	3.8551
Northwest	3.8073	5.6806	3.8092	5.6354	4.4343	5.7092
Vale do Mucuri	0.2026	5.5981	-0.2280	5.6450	1.5030	5.6306
Triângulo M./Alto Paranaíba	-1.1885	3.6780	-0.8123	3.7079	-1.9028	3.6634
Vale do Rio Doce	-0.3842	2.9211	-0.9989	2.8978	0.3832	2.9675
West	-1.6026	4.5843	-1.3057	4.6184	-1.9592	4.5766
Sul/Sudeste	4.5825*	2.7448	4.8091*	2.7545	4.0655	2.7202
Diagnostic Test Statistics						
R-squared		0.3725		0.3730		0.3721
Adjusted R-squared		0.3630		0.3635		0.3626
F-statistic		39.3220		39.3956		39.2516
p-value (F-statistic)		0.0000		0.0000		0.0000
Durbin-Watson statistic		2.0214		2.0328		2.0223
VIF Test (mean VIF)		1.4958		1.4955		1.4964
Rho statistic (cross-section random)		0.5507		0.5540		0.5480

Note. ***, ** and * denote significant coefficients at the 1%, 5%, and 10% levels, respectively. Random effects models are estimated by GLS. 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.

In Table 5, the variable of most interest in this study is among those with significant coefficients. We found that REGU has a statistically significant positive effect on the implementation of the social tariff. In the estimated models, the average effect of the economic regulation (in terms of a regulatory rule and inspection) on the policy implementation is about a 19% increase.

Regarding the coefficients of control variables, CUUR has a significant effect. A likely explanation for the negative sign of this variable is that the more updated the CadÚnico is, the harder it is to find additional users to register as social. EMERG also appears to have a significant coefficient. However, the effect is so slight in percentage terms that it is negligible. Moreover, in the robustness check, as we will show later, this variable is no longer significant. The TIME variable has a negative coefficient, indicating that the greater the distance from the reference municipality to the capital city, Belo Horizonte, the lower the implementation of the social tariff. This relationship may be due to the isolation of the governments of these municipalities from the bureaucracies (Copasa-MG and Arsae-MG) located in the state capital.

The variables POPU, EDUC, and INTE are related to the size of the municipality. All of them displayed positive and significant coefficients. They indicate that localities with larger populations, more educated people, and more broadband Internet connections tend to have higher levels of implementation of the social tariff. In fact, the issue of information should be relevant for this implementation. The coefficient of the MSF variable was not significant in the models. Therefore, specific governance structures (required for the approval of the sanitation fund) should not affect the implementation of the social tariff.

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 with the headquarters of the regulatory agency and the operator) in the models, the comparisons are in relation to this portion of the state. We can see that the Central,

Jequitinhonha, and Northern regions tend to have higher STI indexes, and the Zona da Mata tends to have lower indicators. There are also clues to differences for the Campos das Vertentes and South/Southeast regions, which have higher STI indexes. 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 reports 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 that we adopt robust estimators, the models should be valid.

The results that Table 6 displays corroborate that regulation affects the 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 average effect of the economic regulation (in terms of a regulatory rule and inspection) on the implementation of the social tariff is about a 13% increase.[16]

Regarding the control variables, their effects are relatively lower in the models that Table 6 exhibits. Furthermore, the coefficient of the EMERG variable is no longer significant.[17] As for the region dummies, the significant results are for the same regions indicated in Table 5. However, there was some change with respect to the magnitude of the regional differences in the implementation of the policy.

[16] The average STI index in 2018 and 2019 was 76.1% and 78.3%, respectively, higher than 68.3% in 2020. This information explains the drop in the estimated impact of the regulation.

[17] The low variability of the EMERG variable, which assumed values of 0 for the whole period before 2021 (when politics did not exist yet), can have influenced the fact that its coefficient is no longer significant.

Table 6

Robustness Check Models

Variables	Model 1		Model 2		Model 3	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Constant	0.8684***	0.0932	0.9425***	0.0801	0.9909***	0.0740
REGU	0.1350***	0.0060	0.1353***	0.0061	0.1315***	0.0061
CUUR	-0.0037***	0.0008	-0.0037***	0.0008	-0.0037***	0.0008
EMERG	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TIME	-0.0051*	0.0027	-0.0051*	0.0028	-0.0050*	0.0027
Log(POPU)	0.0184***	0.0065				
Log(EDUC)			0.0174**	0.0069		
Log(INTE)					0.0084**	0.0041
Regions						
Zona da Mata	-0.0691**	0.0275	-0.0723***	0.0274	-0.0735***	0.0273
Central	0.1550***	0.0282	0.1532***	0.0284	0.1483***	0.0275
Jequitinhonha	0.1255***	0.0321	0.1207***	0.0320	0.1327***	0.0321
North	0.0737**	0.0294	0.0681**	0.0294	0.0840***	0.0301
Campo das Vertentes	0.1008***	0.0381	0.1005***	0.0384	0.0899**	0.0379
Northwest	0.0500	0.0473	0.0493	0.0470	0.0522	0.0471
Vale do Mucuri	0.0215	0.0521	0.0172	0.0526	0.0285	0.0530
Triângulo M./Alto Paranaíba	0.0124	0.0341	0.0146	0.0345	0.0051	0.0339
Vale do Rio Doce	0.0003	0.0285	-0.0058	0.0283	0.0005	0.0287
West	0.0189	0.0415	0.0208	0.0419	0.0137	0.0415
South/Southeast	0.0636**	0.0274	0.0650**	0.0274	0.0584**	0.0272
Diagnostic Test Statistics						
R-squared		0.1990		0.1986		0.1981
Adjusted R-squared		0.1934		0.1929		0.1925
F-statistic		35.1463		35.0491		34.9484
p-value (F-statistic)		0.0000		0.0000		0.0000
Durbin-Watson statistic		1.9179		1.9168		1.9172
VIF Test (mean VIF)		1.5723		1.5756		1.5581
Rho statistic		0.5917		0.5912		0.5894

Note. ***, ** and * denote significant coefficients at the 1%, 5%, and 10% levels, respectively. Random effects models are estimated by GLS. 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.

We can conclude that, although there are some differences in the magnitude of the coefficients, the results of the robustness check corroborate the positive effect of regulation on the implementation of the social tariff. Additionally, they 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 the Economic Inspection Report GFE No. 060/2021 (Arsae, 2021). This article and such report indicate an enhancement in the implementation of the social tariff across the Minas Gerais state after the regulatory efforts. However, the report only makes a descriptive analysis of the data without considering them by macro-regions of the state. In this article, we advance the investigation compared to the mentioned report by statistically testing whether the increases in the STI index are significant for each macro-region and the entire sample of municipalities. Furthermore, we econometrically measure the effect of economic regulation on the 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 implementation of the policy. The models exhibit significant regional disparities. Regarding these disparities, the situation in the Zona da Mata region is more critical since it has a lower implementation index than the Metropolitan Area (the region taken as a reference in the econometric models). In fact, in Table 2, the lower averages of the STI index before and after the inspection had already indicated this situation.

This study evaluates the performance of economic regulation in terms of pro-poor policy implementation. This empirical analysis is scarce in the literature, but some authors have theoretically discussed the role of such regulation in favoring pro-poor policies. Narzetti and Marques (2021) state that the regulation has a relevant role in promoting universal access to sanitation because of its potential to provide affordability to the most vulnerable households. Almeida and Oliveira (2021) also state that regulatory agencies should play 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 the improvement of regulatory rules and the conduct of periodic inspections. Other regulatory agencies should also improve the implementation of the social tariff of their regulated operators by making these 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 operator maintains a high level of implementation of the social tariff. Regarding this, it is opportune to resort to the literature on the superior efficiency-inducing properties of price cap regimes in comparison with traditional rate-of-return regulation (e.g., Liston, 1993; Resende, 1997). Price cap rules in terms of different productivity offsets (the so-called X factor) could affect the implementation of the social tariff. In the tariff setting, the introduction of the STI 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 economic regulation positively affects the implementation of the social tariff. They show that regulation can foster pro-poor policy implementation in the sanitation sector. We encourage some Brazilian regulatory agencies to use the STI index to assess the level of implementation of the social tariff. 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 sanitation services. Thus, such inspections should contribute to meeting the goals of the New Brazilian Sanitation Regulatory Framework and the United Nations' Sustainable Development Goals for Brazil. 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 Social Tariff's Implementation (STI) index introduced in this study. This policy evaluation approach does not ensure that the users that the operator registered for the social tariff are those who are 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 users from the operator's billing database with those from the social registry that lists poor households.

Regarding potential future studies, we encourage some of those that could use data from the operators' billing databases. One possible research question is whether social users consume more water than those registered in the standard residential classification. Another avenue for future research is to analyze changes in consumption when users move from one of these classifications to the other. Finally, an additional research possibility is to evaluate whether the introduction of sewage treatment tariffs (due to the start of operation of a sewage treatment plant) influences the consumption of both social and standard residential users.

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