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The determinants of expenditures with utilities in Brazilian households

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ABSTRACT
This study provides an analysis of the determinants of the per capita expenditure with utilities in Brazilian households. Using microdata from the 2017-2018 Brazilian Household Budget Survey (POF) we used a two-stage estimation procedure: in the first stage, a Probit for the probability of a household acquiring the good or service; and in the second stage, a Seemingly Unrelated Regressions (SUR) for the Engel functions for each good or service. We found that the household head characterization variables had a lower influence on the expenditure of water and sewage. The family size has a negative effect on the per capita expenditure of all utilities for all income groups, but its scale effects are higher in high-income families. Our study highlights the importance of sociodemographic characteristics as drivers of households' expenditures and opens several opportunities for policymakers and the private sector to solve the heterogeneity and inequality that exists in Brazil.

KEYWORDS
Household utilities, Engels curves, Household budget survey

Os determinantes do dispêndio com serviços habitacionais nos domicílios brasileiros

RESUMO
Este estudo fornece uma análise sobre os determinantes do dispêndio com per capita com serviços habitacionais nos domicílios brasileiros. A partir de microdados da Pesquisa de Orçamentos Familiares (POF), utilizou-se uma estimação em dois estágios: no ´primeiro estágio, foi estimado um modelo probit para determinar a probabilidade do domicílio adquirir o serviço habitacional; no segundo estágio, estimou-se as curvas de Engel utilizando um modelo de regressões aparentemente não relacionadas (SUR). Os resultados demonstraram que características indivíduais do responsável pelo domicílio tem baixa influência nos dispêndios com serviços de saneamento. Por outro lado, o tamanho da família tem um efeito negativo no dispêndio per capita em todos os serviços avaliados, em todas as faixas de renda, sendo que o ganho de escala é maior nos domicílios com rendas maiores. O estudo evidencia a importância dos fatores sociodemográficos como determinantes do dispêndio domiciliar, além de fornecer informações importantes e relevantes para os setores público e privado buscarem soluções para as heterogeneidades e desigualdades no acesso aos serviços habitacionais no Brasil.

PALAVRAS-CHAVE
Serviços habitacionais, Curvas de Engel, Pesquisa de Orçamento Familiar

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1. Introduction

Brazil experienced several sociodemographic changes in the last two decades that changed the expenditures with utilities in households, such as the expansion of the country's electricity networks IBGE (2019), the changes in familiar structures to smaller families Sette e Coelho (2020), or the increase in inequality after the 2015-16 recession, which affected mainly the poorest families due to their higher vulnerability Rocha (2019).

Nevertheless, there is a knowledge gap on how the different sociodemographic characteristics shape the households' expenditure on utilities in Brazil. The literature over the determinants of household demand and expenditure with utilities such as electricity, have highlighted income and other sociodemographic characteristics as the main drivers in Vietnam Duy et al. (2023); Son e Yoon (2020). In addition, evidence from Turkey shows that specifically the household size, income and the type of heating are major factors to electricity consumption Guven e Kayalica (2023). Furthermore, previous studies that aimed to model the behavior and patterns of electricity expenditure in the US reflects the relevance of prices, educational level and physical characteristics of the household in the electricity expenditure Adebayo e Alola (2023); Salari e Javid (2017).

In Latin America, evidence for Mexico show how sociodemographic characteristics shape the expenditure and access to different utilities, such as electricity, domestic water and internet Botzen et al. (2021); Martínez-Domínguez e Mora-Rivera (2020); Mora-Rivera e García-Mora (2021); de la Cruz et al. (2017). In addition, evidence by Frimpong et al. (2024) shows that the access and expenditure on water and sewage could be affected by social inequalities. Furthermore, income is one of the main drivers for water use and affordability Khan et al. (2023). Regarding internet and telecommunications, evidence from Australia suggests that rural or remote households with younger heads tend to spend more on this utility Breunig e McCarthy (2020). These suggest that geographical locations change the effect that specific sociodemographic characteristics would have on the expenditure pattern, with rural households been different from urban ones.

However, all previous studies that aimed to analyze utilities choose to do it in individual models, so expenditures with electricity, domestic water, household gas and internet would be individually affected by sociodemographic characteristics. We argue that expenditures related to these utilities will be simultaneously affected by nonsystematic factors related to consumption. Failure to take this into account could make estimates to be less efficient. Thus, to estimate the expenditure patterns for these utilities, it must consider them in a system of equations, that will include the nonsystematic correlations that will influence them, such as the estimations through Seemingly Unrelated Regressions (SUR).

Therefore, this study provides an analysis of the determinants of the per capita

expenditure with utilities in Brazilian households. We used microdata from the most recent Brazilian Household Budget Survey (POF) of 2017-2018, a national survey with household-level information from all different Brazilian regions, as well as rural and urban households. This survey is widely used in the analysis of food demand in Brazil Coelho et al. (2010); Ferreira e Coelho (2017); Queiroz e Coelho (2017); Travassos e Coelho (2015); Zanin et al. (2019), but to the best of our knowledge, POF has never been used to analyze utilities. The POF microdata contains information for several categories of household expenditures, allowing for the analysis of different types of utilities. We built four subgroups of utilities: the first group is for the expenditures with water and sewage; the second group is for electricity; the third group is for household gas (LPG); and finally, the last group is for communication utilities (landline, TV, internet, cellphone, and packages that combines these utilities together). Our main hypothesis in this study is that due to the continental size of Brazil, in addition to cultural and economic disparities among regions, geographical variables are the main drivers of the expenditure on utilities, highlighting a heterogeneous expenditure pattern in Brazilian households.

In this regard, one of the main contributions of this study was to provide an analysis of utility determinants of expenditure using a system of equations and not an individual model for each service. For this reason, we choose to analyze the expenditure patterns of Brazilian households due to the lack of evidence for the country, and because Brazil represents an important developing economy, so the results obtained in this study could help us to understand the utilities expenditure patterns in developing economies.

2. Materials and Methods

Our methodological strategy is composed of different steps and procedures. For the utilities observed in the POF, only the total amount spent on these utilities is available and not the quantity consumed or acquired (except for the service of electricity[1]), so we do not have the individual prices for each service. Therefore, we chose to analyze the expenditure (Engel's Curve), which is also fundamental for microeconomic analysis and for demand studies Banks et al. (1997); Chai e Moneta (2010); Li (2021); Navajas (2009); Queiroz e Coelho (2017). We examine the consumption of these utilities through the relationship of per capita expenditure with household income and several sociodemographic characteristics (Table 1).

We divided our sociodemographic variables in three different groups (Table 1). The first group of variables refers to the geographical location of the household. These variables aim to capture regional heterogeneity, one of the most important determinants of household expenditures Du et al. (2015); Taale e Kyeremeh (2019); Taneja e Mandys (2022); Thomas e Finn (2018). As Brazil is a continental country, this group

[1] For electricity, the POF contains information about the household consumption in kilowatts per hour. For the other utilities, there is no information about the consumed quantity.

Tabela 1. Sociodemographic variables used in vector $\underline{Z}_k$.

Variables	Description
	Geographical Location
Urban	Household located in urban zone = 1; otherwise = 0
North	Household located in the North region = 1; otherwise = 0
Northeast	Household located in the Northeast region = 1; otherwise = 0
South	Household located in the South region = 1; otherwise = 0
Middle-West	Household located in the Middle-West region = 1; otherwise = 0
Capital	Household located in a state capital city = 1; otherwise = 0
	Household Head Characterization
Income	Household monthly income
Income2	Household monthly income square
Age	Household Head age
Age2	Household Head age square
Gender	Female Household Head = 1; otherwise = 0
Schooling	Household Head years of study
Black	Household Head is Black = 1; otherwise = 0
Pardo	Household Head is Pardo = 1; otherwise = 0
Asian	Household Head is Asian = 1; otherwise = 0
Indigenous	Household Head is Indigenous = 1; otherwise = 0
Home Appliances with high consume	Total number of home appliances with high consumption of electricity (ex: Fridge; Freezer; Electric shower; Air-conditioning; Desktop computer).
Home Appliances with low consume	Total number of home appliances with low consume of electricity (ex: Television; Desk fan; DVD/Blu-ray; Washing machine).
	Family composition and Arrangement
Children	The presence of children = 1; otherwise = 0
Adolescents	The presence of adolescents = 1; otherwise = 0
Elderly	The presence of the elderly = 1; otherwise = 0
Total of individuals	Total number of individuals living in the household
Female Single parent	Households with a single mother with at least one child = 1; otherwise = 0
Male Single parent	Households with a single father with at least one child = 1; otherwise = 0
Childless Couple	Household with a couple without child = 1; otherwise = 0
Female solo	Household with a unique female individual = 1; otherwise = 0
Male solo	Household with a unique male individual = 1; otherwise = 0
Other Arrangements	Household with other types of arrangements = 1; otherwise = 0

of variables could also capture part of the climate effect, as Brazilian regions have very heterogeneous climates. We chose the Southeast region as the default, so the effect of the other regions is related to the Southeast.

For the second group, denominated "Household Head Characterization", we set variables that aim to characterize the household head, such as gender, income, schooling, racial identity, and age. The inclusion of these characteristics aims to understand the effect that the household head may have in shaping the preferences in the household Adams (2018); Martínez-Domínguez e Mora-Rivera (2020); Tirumala e Tiwari (2022). We expect that gender could have a negative effect on the expenses with LPG because mothers who are head of the household tend to have a higher opportunity cost to prepare meals at their house, rising the consumption of pre-prepared foods and food away from home Queiroz e Coelho (2017). Schooling should have a positive relationship with the expenses of communication utilities Mendonça e Silva (2019), since with higher schooling, individuals began to be more familiarized with technologies. On the other hand, we expect that older individuals are less familiarized with technologies, so age could have a negative relationship with communication services.

We also considered the number of home appliances in the household, due to

their importance as vectors of change in the level of expenses for electricity, LPG, and communication services. We set two groups of home appliances (high- and low-consumption). Home appliances with high consumption use more energy, such as air conditioning; electric showers; electric ovens; fridges; freezers, and desktop computers. On the other hand, low-consumption home appliances have a lower demand for energy, with more simple gadgets, such as TV; desk fans; Blu-ray and DVDs; washing machines, etc. We expect the relation of home appliances to be positive with the expenditure on electricity, water, and communication services Andrade e Lobão (1997); Silva et al. (2012). However, we expect a negative relation with LPG because many of the home appliances with high consumption are substitutes for heating with LPG, such as the electric oven and the electric shower[2] Bartels et al. (1996).

The last group of variables, entitled "Family Composition and Arrangement", seeks to differentiate households from the "Traditional Family"[3] from other possible arrangements. In this study, we use the arrangements of Single Parents (Female or Male single parent), Solo (Female or Male unique individual), Childless couples, and other arrangements. All arrangements were compared to the traditional family (a couple with a child). We expect that the households with solo individuals will spend more (on a per capita basis) on leisure services, such as communication, however, we also expect that households with a single parent have a lower per capita expenditure on LPG, due to the opportunity cost for these parents Queiroz e Coelho (2017); Schlindwein e Kassouf (2006).

2.1 Estimation

The high level of disaggregation of the POF implies often the household interviewed does not have consumed one good or service, specifically what is known as the Zero Consumption Problem (ZCP) Coelho (2006). For some utilities, such as electricity, the PCZ is less common due to the near universalization of electricity in Brazil, but for other utilities, it is more common. In order to address this problem, we used a two-stage estimation procedure Shonkwiler e Yen (1999): in the first stage we estimated the probability that the household acquires the good or service using a Probit [equation (1)]:

First Stage

$$d_{ik}^{*} = z_{ik}^{\prime}\alpha_i + \vartheta_{ik}$$
$$d_{ik} \begin{cases} 1, if d_{ik}^{*} > 0 \\ 0, if d_{ik}^{*} \leq 0 \end{cases} \tag{1}$$

where d_{ik}^{*} is the latent variable that represents the utility difference between spending or not with utilities in the households; $z_{ik}^{\prime}$ it is a vector with exogenous variables;

[2] In Brazil, LPG is used most for cooking, but also for heating water in some households.
[3] For Traditional Family we consider households composed by a couple with a child.

α_i is the vector of estimated parameters; d_{ik} is an binary variable that represents the consumers choice to spend or not with the utility; ϑ_{ik} is an random error. After the estimation of the first stage, we obtain the cumulative distribution function (CDF) and the probability density function (PDF).

In the second stage, using the CDF and the PDF from the first stage, we estimated the per capita expenditure as in equation (2):

Second Stage

$$\begin{aligned} w_{ik}^{*} &= f(x_{ik}, \beta_i) + \epsilon_{ik} \\ w_{ik} &= d_{ik} w_{ik}^{*}, (i = 1, ..., m; k = 1, ..., K) \end{aligned} \tag{2}$$

where w_{ik}^{*} is the latent variable that represents the expenditure with the i-th utility; w_{ik} is the observed variable of the expenditure with the i-th utility; $f(x_{ik}, \beta_i)$ is the functional form of the expenditure function; x_{ik} is a vector of exogenous variables; and ϵ_{ik} is a random error term.

However, due to unobservable factors or shocks that are influencing the expenditure with households' utilities, the omission of these variables (or others that are highly correlated) can introduce bias into our estimates Khan et al. (2014); Srivastava e Giles (2020). Thus, the error terms could be correlated among all the dependent variables used in our model, reflecting patterns that shape the expenditure with utilities. By employing SUR models, we can account for the correlation between the errors, improving the efficiency and robustness of the estimations. In addition, SUR exploits the information contained in the covariance of the error across the equations, reducing the variance in the estimated parameters and leading to more reliable estimated results Srivastava e Giles (2020). Thus, after the estimation of the parameters α_i at the first stage, we estimate the desired parameters of the second stage using SUR, so that our econometric model could be represented by equation (3):

$$wsh_{ik} = \Phi(z'_{ik}, \hat{\alpha}_i) f(x_{ik}, \beta_i) + \delta_i \phi(z'_{ik}, \hat{\alpha}_i) + \zeta_{ik} \tag{3}$$

where wsh_{ik} represents the per capita expenditure with each subgroup of utility i in the household k; $\phi(z'_{ik}, \hat{\alpha}_i)$ is the PDF; $\Phi(z'_{ik}, \hat{\alpha}_i)$ is the CDF; δ_i is an unknown parameter; and ζ_{ik} it is the random error.

2.2 Data

We used data from the most recent Brazilian Household Budget Survey, which was a survey conducted by the IBGE between July 11 of 2017 till July 11 of 2018. This survey was carried out for a total of 57,920 households, distributed across the Brazilian territory, with information on the composition of the household budgets, living conditions, and quality of life IBGE (2020). For the extraction of the data regarding

the expenditure with utilities, we used POF questionnaire two (POF 2) for collective acquisitions[4] and questionnaire four (POF 4) for individual acquisitions.

Our initial sample had 57,141 households, and then we dropped all the households that did not show any expenditure with at least one service analyzed (441 dropped observations). We also dropped two households that not had information about their income level. Finally, we set our sample with a total amount of 56,698 households.

The utilities that we choose to investigate were composed of four different categories: electricity; water and sewage; LGP; communication services. For the first category, the expenditures are the value of the last bill. For water and sewerage, we also consider the value paid in the last bill. For LPG, we consider the expenditure level as the value of bills with piped gas or through the payment of gas canisters acquired by the household. For the last group, we consider any expense with landlines phones, internet, cell phone expenses, cable TV, streaming services, or any package that combines these utilities in one contract.

We chose to do our analysis among different income groups, so we split our sample into three main income groups: low-income; middle-income; and upper-income. For this split, we divide our sample into four quantiles, so the lower group has 25% of the lowest income households, the middle has 26-75% and the upper group has the top 25%. The first group has a per capita income equal to or less than 625.24 BRL, while the middle has between 625.25 BRL and 1,969.93 BRL. The upper group has an income level higher than 1,969.93 BRL per person. Descriptive statistics of the sociodemographic variables, by income group, are available in the Appendix (Table 1A).

3. Results and Discussion

3.1 Expenditure with Utilities in Brazil

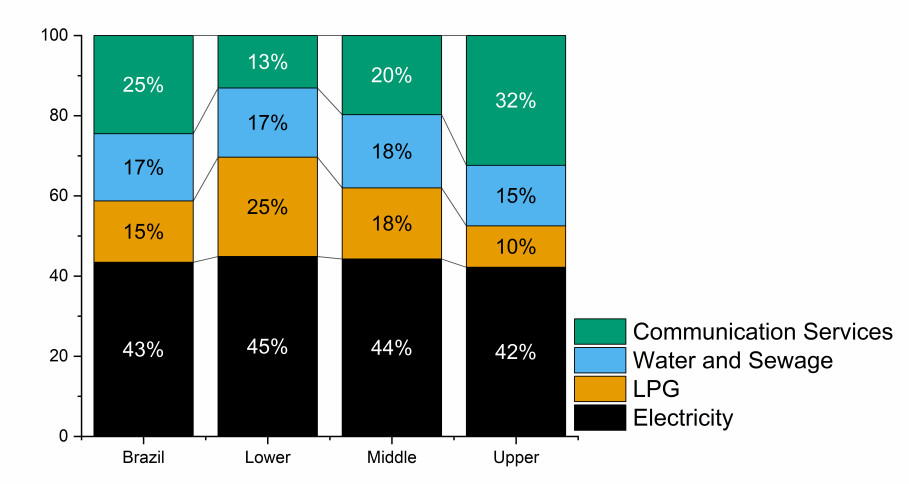
In Figure 1, we show the monthly per capita share of the expenditures with each group of utilities. Expenditures with electricity are the most important for all income groups. We see that the share with less essential utilities, such as communication services, grows up with income and the LPG share decreases. In the upper class the share of communication services are almost three times the share on the lower-income group, 32% versus 13%.

Figure 2 shows the average per capita expenditure with utilities (in Brazilian Real – BRL) for each group[5]. We note how expenditure growths as the income group increases. For the overall population, the average per capita expenditure is about 97.00 BRL, while in the lower group is 44.70 BRL, and in the upper group is 169.00 BRL.

[4]The data for the utilities from the questionnaire two are obtained within a period of 90 days, and the survey accounts for the last bill.

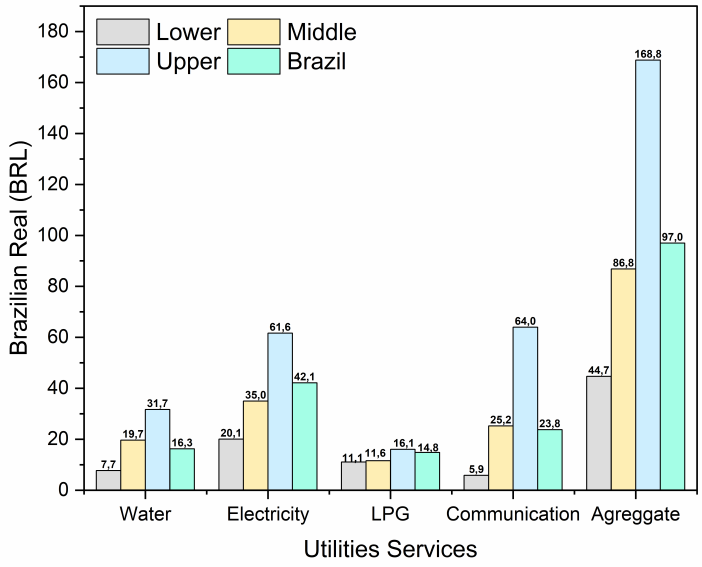
[5]In addition, more information about the mean values, by group, of the expenditure with utilities are available as a table (Table 2A) in the Appendix.

Figura 1. Share of the monthly per capita expenditures with utilities, by type of service, Brazil, and income groups, 2018



For communication services, the expenditure of an upper-class household is almost 13 times higher than that of a lower-income household, while for electricity, the expenditures differ by approximately three times, with an average of 20.10 BRL for the lower-income households and 61.60 BRL for the upper class.

Figura 2. Average per capita expenditure in Brazilian Real (BRL) by type of service, Brazil, and income groups, 2018



3.2 Determinants of utilities expenditure in Brazilian households

We estimate a system with a total of four equations, one equation for each type of service. The dependent variable consists of the per capita expenditure with each utility, and the independent variables are sociodemographic variables shown in Table 1.

3.2.1 Overall

The results of the estimation using SUR for the overall population are in Table 2. For the variable of urban localization, we observe that it has a positive effect on the per capita expenditure with water and Sewage (34.10 BRL), Electricity (2.09 BRL), and Communication Services (7.00 BRL). On the other hand, the effect for LPG is negative (-0.82 BRL). The high impact on the expenditure on water may be related to the lack of supply in rural regions where households must use wells, water trucks, or cisterns. This divergence between rural and urban areas was already evidenced in other countries as well Du et al. (2015); Hung et al. (2017); Thomas e Finn (2018).

Another important factor investigated is the regional heterogeneity in Brazil. We can observe that the households located in the South and Middle West regions had a higher per capita expenditure (compared with the households in the Southeast region) with water and sewage (7.03 BRL and 6.69 BRL, respectively). In contrast, the North and Northeast regions had fewer per capita expenditures (-8.72 BRL and -3.24 BRL, respectively). Considering the continental dimensions of Brazil, those divergences could be related to different factors, such as the charged prices of the sanitation companies or climate differences Clarke et al. (2017); Reynaud e Romano (2018); Risch e Salmon (2017).

Electricity is also linked with regional and climate differences in Brazil. We observe that there are different effects and magnitudes for each region, supporting the idea the climate is an important factor in electricity expenditure Botzen et al. (2021); Pilli-Sihvola et al. (2010). The South region, colder than the other Brazilian regions, has a negative effect on electricity expenditure compared to the Southeast, which is warmer. On the other hand, the Northeast, which also has a different climate than the other regions, highlighted as being one of the hottest regions in Brazil, had lower electricity expenses. We highlight the result of the North region, with a higher per capita expenditure of 13.50 BRL compared to the Southeast. This huge difference may be explained by the hotter climate, but also by the charged prices for electricity. The North region has the higher electricity price (0.7764 BRL/Kwh), while the Northeast has the lowest price (0.6355 BRL/Kwh).

Charged prices can often be related to the energy source used for supply. In Brazil, the North region electricity is mainly generated by fossil fuels, which are costly and environmentally detrimental. On the other hand, in the Northeast there is a growing electricity production from wind energy, a clean and cost-competitive renewable source EPE (2021). In this context we highlight the relevance of renewable energy not only from an environmental perspective, but also as a role to reduce inequalities on the affordability of electricity. Expanding wind energy not only addresses environmental concerns, but also plays a crucial role in promoting social equity, lowering energy costs and improving affordability of electricity Lucena e Ângelo Azevedo Lucena (2019).

The household head characteristics had a lower influence on the expenditure of

Tabela 2. Per capita expenditure estimation for utilities in Brazil, overall population, 2017-2018. Values in Brazilian Real (BRL).

Variables	Household Utilities			
	Water and Sewage	Electricity	LPG	Communication Services
Urban	34.102***	2.089**	-0.824***	7.004***
Capital	2.410***	4.857***	-0.212	11.988***
North	-8.721***	13.500***	1.387***	-7.722***
Northeast	-3.238***	-5.730***	0.983***	-8.823***
South	7.028***	-3.453***	-0.973***	-2.933***
Middle-West	6.690***	1.738***	2.091***	-8.304***
Income	2.126*	-35.424***	-0.336	-92.341***
Income2	0.007	3.004***	0.129***	7.151***
Schooling	0.166***	0.404***	-0.060***	1.259***
Age	0.259***	0.238***	0.104***	-0.033
Age2	-0.001*	-0.002***	<0.000***	0.001
Gender	0.719**	-0.343	0.101	0.995***
Black	-0.124	-0.604	0.125	-0.897
Pardo	-0.469*	-1.231***	0.085	-2.588***
Asian	-0.098	1.122	1.027	1.427
Indigenous	3.415*	-3.936	-1.273*	-9.890***
Home Appliances with high consume	1.043***	4.044***	-0.086***	2.211***
Home Appliances with low consume	0.129*	0.475***	0.029	0.838***
Children	0.868*	3.459***	-0.890***	9.274***
Adolescents	-0.662	1.519*	0.173	2.677***
Elderly	0.951**	1.190**	0.575***	5.276***
Total of individuals	-2.516***	-5.153***	-1.762***	-3.198***
Female Single parent	2.212***	4.208***	1.876***	3.524***
Male Single parent	2.805***	2.106	0.982**	0.911
Childless Couple	3.677***	7.535***	3.446***	1.985***
Female solo	19.399***	30.481***	14.971***	25.086***
Male Solo	17.609***	25.696***	14.051***	10.757***
Other Arrangements	1.924***	2.604***	0.732***	0.525

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

water and sewage. Schooling has a lower influence on essential utilities, such as water (0.17 BRL), electricity (0.40 BRL), and LPG (-0.06 BRL), suggesting that the schooling level does not have a huge effect on these groups of utilities. On the other hand, the influence of schooling on the expenditure on communication services is slightly higher (1.26 BRL). The household head age has a positive effect on the expenditure of essential utilities, but the nonlinear effect is negligible and very close to zero.

Income level had a positive influence only on the service of water and sewage (2.17 BRL). On the other hand, the per capita expenditure of electricity and communication services are initially negatively affected by income (-35.42 BRL and - 92.34 BRL, respectively). Income was already evidenced as one of the utility major determinants of expenditure in developing economies, such as Vietnam Son e Yoon (2020), China Du et al. (2015), and Ghana Taale e Kyeremeh (2019). We highlight that the coefficient for the square income is positive (3.00 BRL, 1.30 BRL and 7.15 for electricity, LPG and communication, respectively), suggesting that in the first moment, the rise of the income would drop the expenditure with these utilities, but for higher income levels the income effect would become positive.

In addition, Brazil has a public policy since 2002 that aims to reduce electricity

bills for lower income households, called “Tarifa Social”. This policy guarantees discounts up to 100%, according to the household’s energy consumption. Furthermore, this policy effect is captured by POF, as the survey measures the amount paid in the electricity bill, which accounts for this discount. Thus, the first negative effect that income have in electricity expenditure could be related to this policy, but after a significant increase in the income level, households will start to lose this social benefit from the government, increasing their per capita expenditure with this utility.

We also show the relationship between the number of household appliances in the household and the expenditure on electricity. Our results suggest that, regardless of the type of home appliance, the per capita expenditure on electricity will rise. However, as expected, high-consumption home appliances increase the expenditure more than those with lower consumption (4.04 BRL and 0.47 BRL, respectively). This result was also evidenced by other analyses in Brazil using home appliance prices in the estimation of electricity demand Andrade e Lobão (1997); Silva et al. (2012). However, the relationship between home appliances and the expenditure with LPG suggests that only home appliances with high consumption have a small negative influence (-0.08 BRL), slightly reinforcing the hypothesis that electricity is a substitute fuel for LPG in heating activities.

For the last group of variables related to family composition, the results suggest that this group has great relevance in the determination of per capita expenditures. The literature already showed that family composition was one of the main determinants of expenditure in developing economies such as Malawi Adams (2018) and India Tirumala e Tiwari (2022). But our results suggest that this importance spreads for all utilities in the household. The presence of children and adolescents in the household increases the per capita expenditure on electricity (3.46 BRL and 1.52 BRL, respectively) and communication services (9.27 BRL and 2.68 BRL, respectively). However, the presence of children in the household reduces the per capita expenditure with LPG (-0.89 BRL).

We highlight one of the most important results that we found related to family size. The family size has a negative effect on the per capita expenditure with all utilities, reinforcing the idea of economies of scale for utilities, suggested by Bosch-Domènech Bosch-Domènech (1991). This relationship was already evidenced in the consumption of LPG Brounen et al. (2012), however, as supposed by Bosch-Domènech Bosch-Domènech (1991), we observed that this behavior occurs for all utilities, with the higher intensity for electricity (-5.13 BRL).

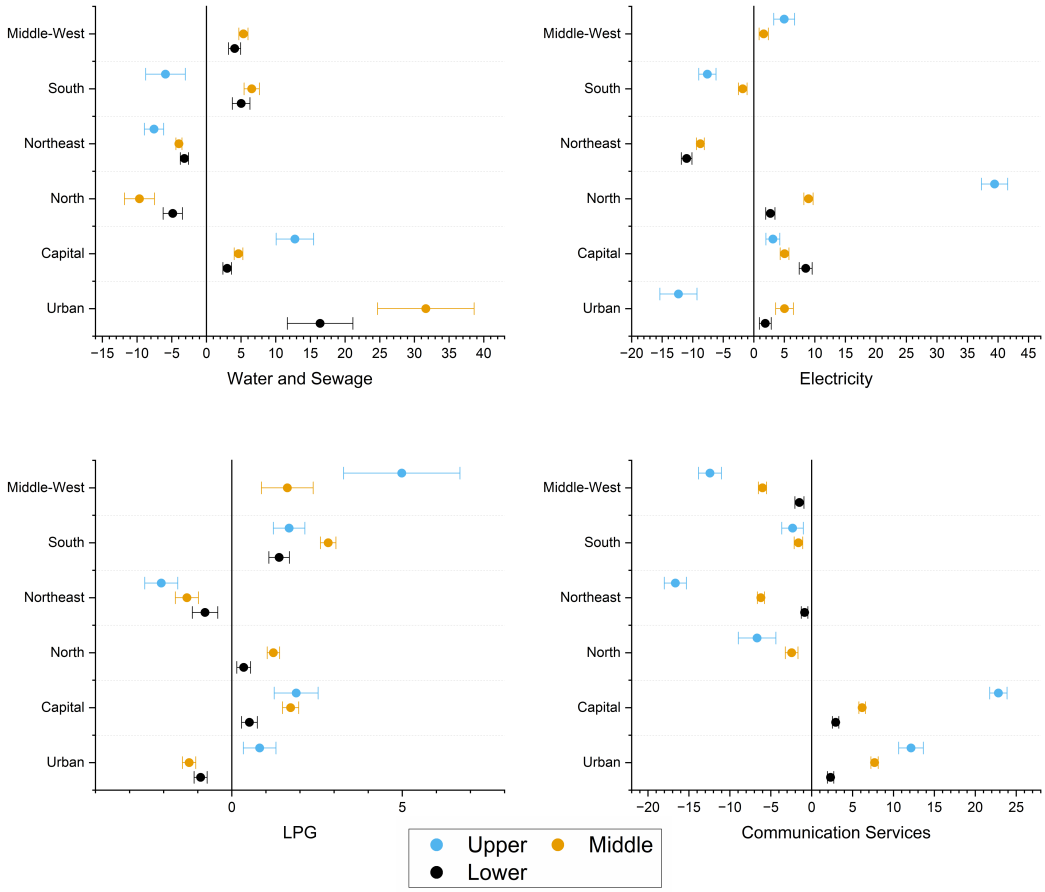
For familiar arrangements, we observe a positive effect on per capita expenditure for all utilities. As we observed for the Family size, it was expected that family arrangements with fewer individuals had higher per capita expenditures, since these arrangements benefit less from the economies of scale Bosch-Domènech (1991). We also observe that among the two types of single-parent arrangements, the female single parents’ households have a higher per capita expenditure on LPG than the male

single parents (1.88 BRL and 0.98 BRL), which suggests that male single parents tend to cook less for their children, consuming more pre-prepared food or tanking food away from home. We also observed in our results that female-single parent households have a higher expenditure on communication services, compared to the traditional family, while the male single parents do not have a difference.

3.2.2 Income groups

The result for the three different incomes groups is presented in the Figures 3, 4, 5 and 6, as we chose to divide the results into the four groups of variables[6]. In Figure 3, we observe that urban households in the upper income group have higher expenditure with communication services and LPG. However, for electricity, being in an urban area decreases the per capita expenditure with this service in upper income groups.

Figura 3. Geographical characteristics that shape the per capita expenditure with each utility, by income group. Values in Brazilian Real (BRL)



Note: Non-significative values were omitted from the plot.

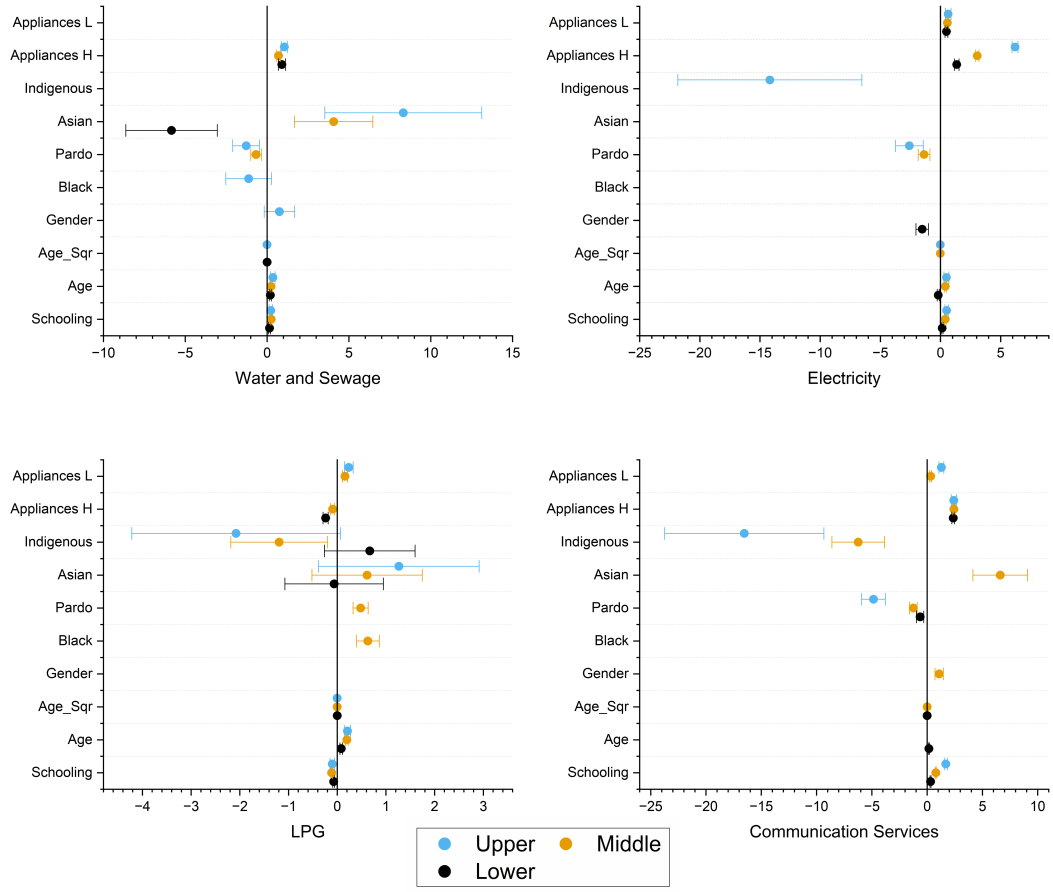
The results for the Brazilian regions showed that the regional heterogeneity increases as income increases. In the North region, we observed that there is a huge gap

[6]The tables with the estimated values are available upon requests.

from the middle-income group to the upper one regarding the expenditure with electricity, increasing the per capita expenses from 8.96 BRL to 39.44 BRL, on average. The increase in the electricity expenditure in the North region might reflect the fact that higher-income households usually can afford to use more appliances that provide more thermal comfort, due to the warmer climate in this region. Electricity expenditure follows a heterogeneous pattern, increasing in some regions and decreasing in other regions.

The results for the second group of variables (household head characteristics and number of home appliances) are presented in Figures 4 and 5. The household head age showed relative importance in the expenditure determination of almost all the income levels, but its effect is a bit low in magnitude; the same happens with the schooling variable. For communication services, schooling slightly increases its magnitude as income rises, suggesting that for the higher income households, more schooling increases, even more, the expenditure with this service.

Figura 4. Household head characteristics that shape the per capita expenditure with each utility, by income group. Values in Brazilian Real (BRL)



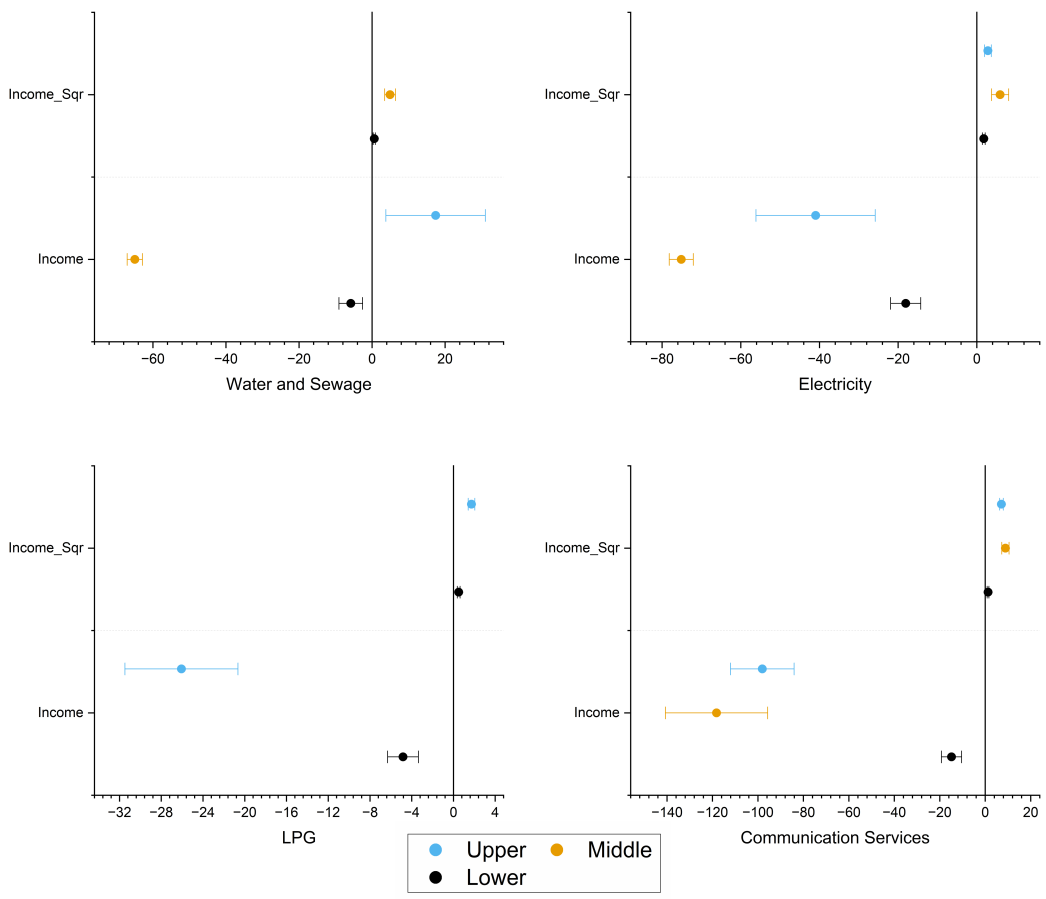
Note: Non-significative values were omitted from the plot.

We expected that both groups of appliances would have a significant effect in the electricity expenditure, however, only the group of high consumption appliances had

a positive effect on the per capita expenditure with electricity. Furthermore, for the upper-income group, we observed that its influence becomes even higher. This could be explained by the fact that households that belong to the upper group tend to acquire more powerful home appliances. In addition, at the beginning of the 2000s, there was a great expansion of credit and loans to individuals in Brazil along with income transfers programs, such as the Programa Bolsa Família Bonomo et al. (2015). This budget expansion increased the acquisition of home appliances, mainly in low-income households Lavinas (2017). However, with a lower financial instruction, individuals tend to buy disposable appliances, or even less efficient ones, which could justify the similar effect observed in all income groups for appliances with low consumption.

We may suppose that low-income households could own home appliances with less energy efficiency, which is one of the greatest influences on electricity consumption Silva et al. (2012); Soares et al. (2017). Thus, we observed that the higher effect over the per capita expenditure that comes from the number of home appliances was for the upper-income groups, so even though the old and less efficient home appliances demand more energy, having other home appliances makes up for it.

Figura 5. Income characteristics that shape the per capita expenditure with each utility, by income group. Values in Brazilian Real (BRL)

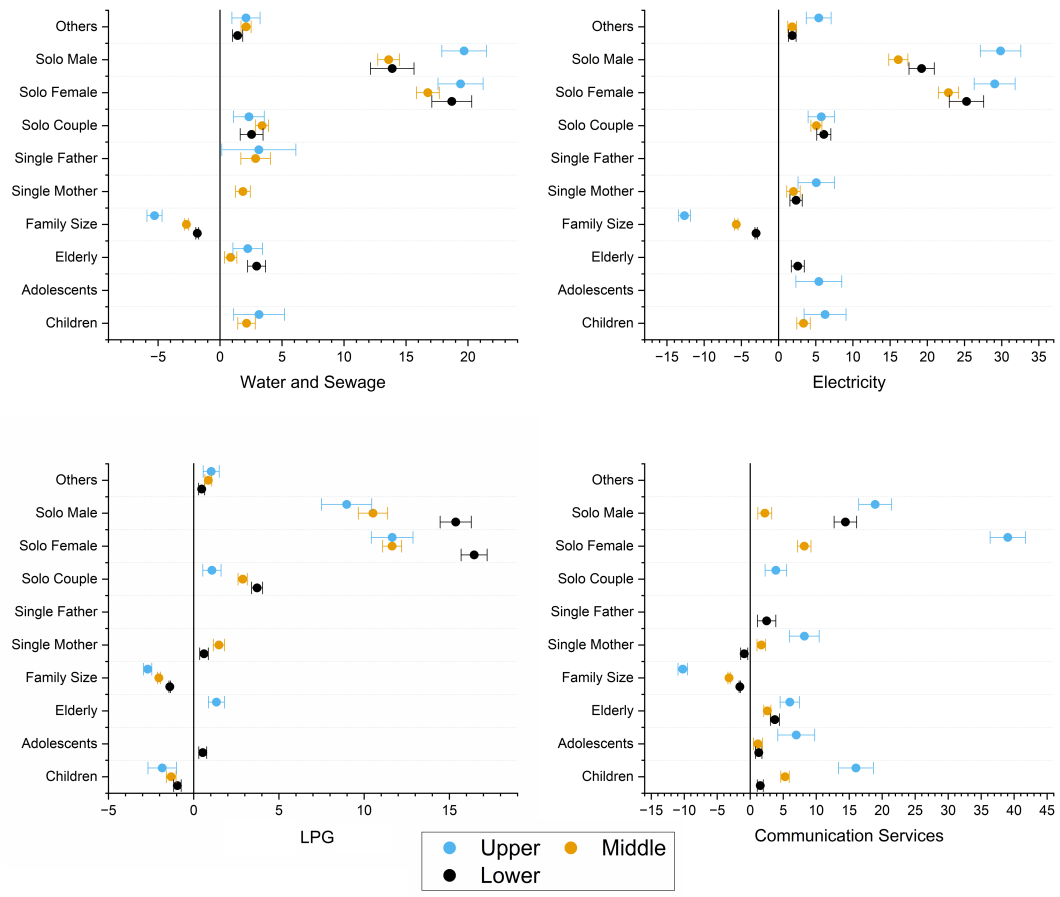


Note: Non-significative values were omitted from the plot.

The results for the income effect are presented in Figure 5. We observed a U-shape for all income groups in the expenditures with electricity and communication services. For electricity, the income seemed to decrease the per capita expenditure, but it does not have a specific pattern among the income groups. The same was observed for communication services, but not for LPG and water and sewage, as these two groups have an indirect relationship between the income effect and the income group.

With an increase in the relevance of the internet to daily activities and the digital economy's expansion, the internet has become more essential to households, shaping their consumption preferences Chunfang et al. (2023); Gurning e Khaliqi (2021). Our results show that the quadratic effect of income over the expenditure with communication services is higher in the upper-income groups, suggesting that richer families tend to spend more with this group of utilities, while lower-income groups struggle to increase their expenditures, probably due to opportunity cost from more essential goods. This result highlights part of an unequal access to better communication services, essential to improve connectivity and opportunities, such as remote jobs and distance learning.

Figura 6. Family characteristics that shape the per capita expenditure with each utility, by income group. Values in Brazilian Real (BRL)



Note: Non-significative values were omitted from the plot.

Finally, for the last group of variables that characterize the family that lives in the households (Figure 6), we observed that, generally, the results are in line with the previous one for the overall population. The family size had a negative effect on the expenditure with all utilities for all income groups, but its scale effects are higher in high-income families. This important result reinforces the idea of scale effects in the expenditure with utilities, which was first discussed by Bosch-Domèmech Bosch-Domènech (1991), however, richer families benefit the most from it.

We observed that for the family's arrangement, there is heterogeneity in almost all income classes, specifically in those households that have only one individual living in it (solo male or solo female). For the upper-income group, households with unique women had an expressive increase in the per capita expenditure with communication services, as this group showed an increase of up to 39.07 BRL in expenses. Meanwhile, households with unique men had an increase in the per capita expenditures with communication services in about 18.93 BRL in the upper-income group.

Having a kid in the household increases the per capita expenditure on communication services, and it grows as income increases as well. On the other hand, the presence of children in the household slightly decreases the per capita expenditure with LPG in the low and middle-income groups. As the income rises, solo couples tend to have a lower per capita expenditure with LPG, probably explained by the increase in the consumption of food away from home.

4. Final Remarks

The expenditure on utilities represents an important share of the families' budgets, and with all the sociodemographic changes that occurred in the last years in Brazil, families' preferences also changed. Our results showed that geographic characteristics are one of the main drivers of the household per capita expenditure with utilities. These main findings show that there is a high heterogeneity between the Brazilian regions and between the rural and urban households.

The North region of Brazil is one of the poorer regions in the country and still has the higher per capita expenditure with electricity, which indicates a higher probability of the households being described in energy poverty. In addition, there is heterogeneity among the income classes, which reinforces the regional heterogeneity. Most of the heterogeneity is related to lack of infrastructure in these regions or less competition in the private sector that supplies these utilities.

One of our highlights was the confirmation of the economies of scale in the expenditure with utilities. As the family size increases, the per capita expenditure drastically drops for all utilities in all income groups. However, we observed that this effect is heterogeneous, as richer families benefit the most from it, mainly for the per capita expenditure on communication services. Our study highlights the importance of sociodemographic characteristics as drivers of household expenditures and opens several

opportunities for policymakers and the private sector to investigate how to solve the heterogeneity and inequality that exists. In this context, we also highlight that policymakers must increase the affordability of some utilities in lower-income families, mitigating the gap between groups and, consequently, the inequalities. Strategies that aim to subsidies the internet in areas with less access and poorer families would be effective in reducing digital exclusion and improve equality.

In Brazil, policymakers need to pay attention to the inequalities that comes from the geographical heterogeneity of Brazilian regions. Some policies were recently implemented, and may reduce the expenditures inequalities, such as the Marco Legal do Saneamento Básico (The Basic Sanitation Legal Framework), which increases investments in utilities of water and sewage, which imply that regions with poor infrastructure would receive new investments and will increase the quality of the provided utility. On the other hand, policies that aim to decrease inequalities in the electricity access, mainly for lower income households, need to focus on the Northern region of Brazil, which has the highest deficit in the structural mesh and, consequently, lower competition, higher prices and poorer provided service. Thus, policymakers need to develop strategies that would attract investment in this region and improve competition.

When the demand for electricity in Brazil increases, companies usually start to use more thermoelectric energy to meet this demand, which is more pollutant and expensive, and consequently increase the consumer price and the environmental damage from CO2 emissions. In this context, strategies that aim to lower the dependence from thermoelectric are important. On the other hand, policies benefiting other renewable energies, such as solar and wind power, may decrease inequalities among income groups, improving the electricity affordability, mainly in the North region. For example, policymakers could subsidize low-income households to acquire solar panels, increasing the independence from other energy sources and making possible for households to sell their surplus energy. In addition, policymakers could support the development of new wind-energy farms over the Brazilian coast, reducing the overall electricity cost. This type of strategy may help the Northern region in Brazil which suffers from a more expensive energy.

Therefore, our study has limitations regarding the data availability for our analysis. The household budget survey used in our study (POF), does not carry information on the prices charged for each service, except for electricity (prices displayed as BRL/Khw). The unavailability of this information restrains our analysis, as we are uncapable to estimate the effect of price changes on the expenditure with utilities, which could change our estimated results. Another limitation of our study is that we do not consider substitution effects that other types of expenditures, such as food, clothing, etc. could have on utilities expenditures. This is a relevant issue since a household's budget will behave differently for goods and services that are essential and those that are more disposable. However, even though we do not consider those issues, our estimations shed some light to the discussion of household utilities expenditure, and

advances further with new evidence on this topic.

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Appendix:

A.1. Descriptive statistics of the sociodemographic variables

Household Location	**Total**	**Lower**	**Middle**	**Upper**
Urban	86,34% (0,34)	73,05% (0,44)	86,93% (0,33)	94,23% (0,23)
North	7,17% (0,25)	13,74% (0,34)	6,73% (0,25)	3,54% (0,18)
Northeast	25,92% (0,43)	45,85% (0,49)	25,55% (0,43)	13,24% (0,34)
South	15,53% (0,36)	8,07% (0,27)	15,07% (0,35)	21,04% (0,40)
Middle West	7,69% (0,26)	5,08% (0,21)	8,07% (0,27)	8,76% (0,28)
Capital	24,01% (0,42)	14,98% (0,35)	21,48% (0,41)	34,06% (0,47)
Household-head characteristics				
Income	2.195,06 (3.982,48)	385,24 (147,65)	1.199,9 (369,45)	4.994,95 (6.325,02)
Age	50,06 (15,73)	43,79 (13,86)	50,87 (15,95)	53,31 (15,33)
Head Gender	42,20% (0,49)	46,11% (0,49)	41,82% (0,49)	39,93% (0,48)
Educational Level	8,31 (5,14)	6,05 (4,48)	7,54 (4,81)	11,07 (4,90)
Black	10,41% (0,30)	12,52% (0,33)	11,32% (0,31)	6,91% (0,25)
Pardo	42,51% (0,49)	58,19% (0,49)	45,19% (0,49)	27,08% (0,44)
Asian	0,73% (0,08)	0,37% (0,06)	0,48% (0,07)	1,33% (0,11)
Indigenous	0,40% (0,06)	0,36% (0,06)	0,41% (0,06)	0,37% (0,06)
High Consumption Home Appliances	4.50 (2,61)	2,80 (1,82)	4,11 (2,07)	6,25 (2,82)
Low Consumption Home appliances	4,48 (2,40)	3,62 (2,01)	4,21 (2,12)	5,50 (2,71)
Family and Arrangements				
Children	11,36% (0,31)	23,18% (0,42)	10,30% (0,30)	4,94% (0,21)
Adolescents	6,65% (0,22)	9,86% (0,29)	5,41% (0,22)	2,83% (0,16)
Elderly	22,13% (0,41)	7,45% (0,26)	23,60% (0,42)	30,18% (0,46)
Family Size	3,04 (1,52)	4,12 (1,74)	2,99 (1,36)	2,38 (1,15)
Childless Couple	16,73% (0,37)	6,12% (0,24)	16,59% (0,37)	24,02% (0,42)
Single Mother	9,69% (0,29)	12,20% (0,32)	10,30% (0,30)	7,04% (0,25)
Single Father	1,43% (0,11)	1,20% (0,10)	1,59% (0,12)	1,33% (0,11)
Single Women	7,49% (0,26)	1,18% (0,10)	6,00% (0,23)	14,08% (0,34)
Single Man	6,48% (0,24)	1,76% (0,13)	5,71% (0,23)	10,84% (0,31)
Other Arrangements	20,71% (0,40)	28.61% (0,45)	22.25% (0,41)	13,00% (0,33)
Observations	56.968	14.034	28.420	14.244

Note: Standard deviations in parentheses.

A.2. Descriptive characteristics of the per capita expenditure with utilities in Brazilian households, 2018. Values in Brazilian Reals (BRL)

Expenditures with utilities	Mean	Std. Dev.	Min.	Max.
Overall Population				
Electricity	116.03	100.00	0	1623.64
Water and Sewage	47.66	57.89	0	1299.89
LPG	38.20	28.80	0	600
Communication Services	79.55	103.86	0	1201.27
Lower Income				
Electricity	78.55	77.28	0	1512.78
Water and Sewage	31.91	48.83	0	1157.37
LPG	39.77	25.01	0	288.99
Communication Services	26.15	50.32	0	702.75
Middle Income				
Electricity	108.11	84.17	0	1623.64
Water and Sewage	48.26	52.72	0	1108.46
LPG	38.59	25.01	0	305.05
Communication Services	60.99	74.82	0	783.00
Upper Income				
Electricity	153.66	122.09	0	1453.63
Water and Sewage	57.19	68.23	0	1299.89
LPG	36.52	35.89	0	600
Communication Services	144.82	133.77	0	1201.27