

Considerations about memory on electricity tariffs: A case study from Brazil

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Abstract— Brazil had experienced a history of very high inflation for many years, having flirted for some time with hyperinflation. By account of this historic, Brazilian society has become accustomed to an indexation that is very present in its the economy. This characteristic makes prices difficult to perceive by society in general. Even considering that nowadays they are under relative control in relation to inflation.

Particularly in the electric power industry, a sector with strong regulation in Brazil, tariff fluctuations have been very volatile. Making this scenario even more complex, the sector is subject to a lot of government influence with intense reductions in the cost of electricity followed by severe readjustments. Although residential electricity tariffs were reduced in real terms between 2001 and 2016, a survey conducted with a group of consumers from two of the country's main concessionaires found that consumers perceived that electricity prices had been increasing.

The authors identify that the complexity of price formation in the electric power industry and the economic crises experienced in more recent years lead to an erroneous perception about the memory of the prices practiced. Opportunities are identified for utilities and the Energy Regulation Agency to improve their communication process with their customers.

Keywords— Brazil, Electricity, Memory, Regulation, Tariffs.

I. INTRODUCTION

During almost the entire 20th century, inflation in Brazil was high. During the last months of the Sarney government (1984-1989) and in the Collor government (1990-1992) the Brazilian economy flirted up with hyperinflation, registering indicators of up to 82% per month (FVG, 2020).

Between July 1964 and July 1994, when the economic measures that controlled the hyperinflationary process in Brazil were implemented, the accumulated inflation was one quadrillion and 302 trillion percent (Leitão, 2011). Social scientist Sergio Abranches identified that because of this experience with high inflation, Brazilian society, to protect itself, introduced a high dose of indexation, in such a way that the Brazilians could even be classified as “homo indexadus” (Leitão, 2011). In the most acute period of the inflationary process, they became accustomed to assessing

the economy's prices and tariffs in light of their extensive variability, with almost all contracts indexed to inflation indicators.

Since July 1994, when a heterodox plan to fight inflation, the Real Plan, was implemented, inflation has been contained and maintained at satisfactory levels. Since 1995, the average annual inflation recorded was 6.84% (IBGE, 2020), with a slight downward trend in more recent years. The table 1 shows these figures with relative stability.

Table.1- Average inflation %

Period	Yearly Inflation average %
2005-2019	5,44
2010-2019	5,84
2015-2019	5,56

Authors own elaboration from IBGE data (2020)

This article seeks to identify the process of memorizing energy prices by the Brazilians in the period between 2002 and 2016.

In chapter 2 the authors discuss the concepts associated with the formation of human memory. Chapter 3 presents the main concepts for the formation of electricity tariffs in Brazil. The reference values used in this study from 3 electricity utilities are also presented. Chapter 3 also explains the reasons for the extreme volatility of tariffs in Brazil. Chapter 4 describes the electrical energy consumers memory experiment in relation to their perception of the bills they played. It details the universe studied and the results obtained. Chapter 5 presents the conceptual framework and the statistical model used. Finally, in Chapter 6 is summarized final conclusion regarding the study.

II. SOME CONSIDERATIONS ABOUT MEMORY

There is an unequivocal growth in the supply of information on all subjects, facilitated by the dissemination of research on the world wide web.

According to Miller (1955) in some cases, this exuberant supply of information may not be fully utilized, as there may be an upper limit on the ability of human beings to process information simultaneously, interacting with different elements, resulting unreliable, or inaccurate analyzes.

The issue of availability of information in people's memories, and how it is used for the decision-making process, has been enchanted researchers in the most diverse areas of knowledge, such as Blumenthal (1977) who endorses Miller's positions (1955) considering that too much information could be useless. Impressions and sensations in profusion disappear from memory very quickly.

Miller (1955) even treats information in excess as a phenomenon similar to the concept of variance in statistics. The excess of information makes these information disposables, due to its excess and the contradictions (scientific as well) that they contain. Forgetfulness is the next step.

However, when information in our memory or knowledge is transmitted or taught, it is preserved. In this case, the paradigm, according to Miller, is the covariance or correlation¹.

¹ In statistics, correlation, dependence or association is any relationship, causal or non-causal, between two or more variables

Tulving conceptualized 3 different types of memory: the Procedural (that is, one that allows us to remember how things are done), the Semantic (which represents the knowledge that someone has of the world in general) and the Episodic (the remembering of some events).

Professor Loftus (1975, 1995), Garry and others (1996) have dedicated to studying aspects related to the perception that the past is remembered differently from reality, depending on the scenarios of their occurrence. These altered perceptions affect judgments about regrets, happiness and deaths for example. Argentines even use an expression to characterize that all the past was better². It should be noted, that these distorted conceptions of reality can affect the role of witnesses in justice. Loftus (1975, 1995) dedicated deeply attention in this matter.

Relevant research on memory was also developed by Schacter and others (2003) featuring 3 types of forgetfulness: The Transient forgetfulness resulting from the inability to keep information for a long time, the forgetfulness resulting from Lapses of Attention (where I left the keys of car?) and the forgetfulness caused by Circumstantial Blocks (the tip of the tongue).

Schacter and others (2003) also identified 4 distortions about memories: (I) Attribution misconceptions, where the person remembers a fact but attributes it to an incorrect source, (II) Suggestibility misconceptions where personal values, criteria of pride or shame lead to a distorted memory of the past, preventing personal image from being affected by bad or worthless events, (III) Misconceptions arising from Bias by which present knowledge and beliefs distort our memories of the past (for example changes in past facts to maintain the coherence with current beliefs; memorable events — "fisherman's stories"; conflicts and discomforts — for example the purchase of a car that a posteriori proved to be a bad choice), and finally (IV) Misconceptions arising from Persistence where some ideas or their forgetfulness, cannot be changed by traumas or beliefs so ingrained that they do not change even with objective evidence.

Tversky and Kahneman (1973, 2011) have studied the heuristics³ of psychological mechanisms for decision-

that can be expressed by math (for example, the relationship between the stature of parents and the of their children).

² Fue mejor todo el tiempo que pasó.

³ Heuristics are cognitive processes used in non-rational decisions, being defined as strategies that ignore part of the information in order to make the choice easier and fast.

making processes where problems that are overly simplified can lead to errors, some of them primary.

In particular Kahneman's book, "Thinking fast and slow" (2011) deals with this effect. Kahneman (2011) has also demonstrated that the speed of a positioning makes the memory processes less efficient and leads to bias in the perception of the actual facts.

The literature on the subject is very vast and represents a topic of great interest for economic and personal relations. Psychology is the recipient that organizes most of the findings in these researches.

III. ELECTRICITY TARIFFS IN BRAZIL

The privatization of Distribution concessionaires, started in the mid 90s changed the tariff model in Brazil from a cost-of-service methodology to a price cap model.

This process happened simultaneously in the mid of a liberal reform very inspired by those that took place in the United Kingdom, initiated in the Thatcher government.

Subsequently, with the advent of a major rationing (June 2001 to February 2002), new reforms were developed in 2004, making the Distributors utilities exclusively companies that must operate in the regulated market.

The tariff model is based on the English incentive price cap model (RPI-X) with tariff revisions every 4 years. Two main aspects influence energy prices to the final consumer, namely the tariff adjustment or review processes and the cost of fossil fuels resulting from the necessary dispatches from thermal plants when there are no hydro resources.

Brazilian electrical system is largely based on hydroelectric power plants and with the new trend of run-of-the-rivers power plants developed in the last 20 years for environmental protection, has increased the need to activate thermal plants in times of hydraulic scarcity.

Consequently, the variable cost of thermal plants is passed through on to the tariffs annually, causing them to be readjust above inflation. On the other hand, when the utilities have their tariff review processes, frequently they show gains in productivity, on these occasions can occur negative readjustments.

Society in general does not understand that similar companies can have such different adjustments. It is worth mentioning that the tariff reviews occur in different years for different concessionaires. One of the reasons is that the National Regulatory Agency- ANEEL (in portuguese acronym) does not have resources to carry out all the

reviews all in the same year, the second is related with the privatization birthday (bureaucratic request).

Recently the regulator developed a new methodology, named Tariff Flags. This procedure indicates "ex ante" that in certain period with a bad forecasted hydro affluency, the dispatch of thermal plants will be more frequent. In the yellow and red flag, the costs of fuel are charged in advance, in the green one there is no additional charges.

The regulator informs the flag color in the expectancy that consumers refrain the usage of electricity in unfavorable periods, however the information is not understood by consumers and even by press. Probably, by misunderstanding as a consequence of an inefficient communication process by ANEEL.

To complex the situation in 2012, the government of President Dilma Rousseff (2011-2016) changed the rules for hydroelectric and transmission concessions, with the objective of reducing tariffs. Although the objective was partially achieved, the measure included a robust contribution from the National Treasury for social works expenses and cross subsidies existing in Brazilian tariffs.

The same measures have substantially reduced electric utilities revenues, resulting in an imbalance in their cash flow.

During 2013 and 2014 a severe hydro crisis happened. The crisis produced the need for special loans to help the cash flow of Distribution concessionaires. The government justified the help as a need to support an essential public service.

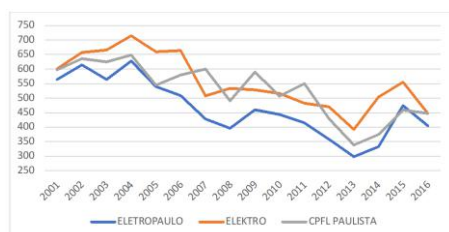
In 2015, the imbalance in the Treasury Accounts produced the inability to make new contributions to this subsidy. Due to the large loans signed with public and private banks, in February of 2015, the Brazilian Government authorized the National Agency of Electricity to exceptionally readjust all tariffs in a single time, in some cases this adjustment has exceeded the 50% barrier. A quick analysis of table 1 and subsequent figure 1 evidence this increase. Even with this exceptional readjustment, figure 1 shows that the tariffs practiced in 2015 were lower than those in force in 2001, considering in the analysis the present values adjusted to 2016 base year.

Table 02 and Figure 01 show the residential class tariffs of three main electricity distributors in the State of São Paulo. These utilities were chosen for this analysis because they allow evaluating both the metropolitan and inland regions of São Paulo State.

Table.2 – Household tariffs (no taxes included).

	Present Value 2016 R\$/MWh		
	Eletropaulo	Elektro	CPFL Paulista
2001	564,10	601,26	597,12
2002	614,67	657,25	635,72
2003	564,37	665,87	624,77
2004	627,72	714,33	648,28
2005	539,54	659,91	545,16
2006	508,73	663,92	579,95
2007	428,53	508,04	600,15
2008	396,11	533,08	491,03
2009	459,84	528,82	590,16
2010	443,12	516,02	507,15
2011	415,25	482,84	549,87
2012	358,64	470,51	429,24
2013	298,30	392,09	338,55
2014	333,26	504,24	374,54
2015	474,68	555,00	459,03
2016	404,42	447,89	447,19

ANEEL – Tariff Normative (2001-2016)

Fig.1: Household tariffs (no taxes included) R\$/ MWh
Present Value 2016

Their tariff values were adjusted to present value until the date of the last adjustment that each concessionaire faced in 2016. (CPFL Paulista in April, Eletropaulo in July and Elektro in August). For this adjustment to present value, the IPCA indicator, the official index of Brazilian inflation, was used.

As is easy to understand, the Brazilians served by these concessionaires paid more for the electric of their homes in 2001 than in 2016.

Figure 1 presents the same data from the previous table graphically, in order to make the reader understands the tariffs volatility. It is worth noting that Brazil has 64 different Distribution concessionaires spread across its continental area. Although only three concessionaires from

the State of São Paulo, the most economically developed region in Brazil, were selected for this study, must be noted that the profile presented is similar for all concessionaires, and the curves in figure 1 can be considered homothetic with all the other utilities.

It should be noted that the primary research methodology used in this work and detailed in the following section used consumers from Eletropaulo concessionaires, which represent metropolitan and urbanized regions and for Elektro representing inland regions. CPFL data, also included in table 1 and figure 1, aim to give consistency to the concept of homothetic similarity presented by the authors.

IV. RESEARCH METHODOLOGY AND RESULTS

For this experiment, a survey research methodology was chosen, where the sample studied does not represent the universe of electricity customers, but it allows to analyze the behavior of a group chosen in relation to the objectives investigated. The primary research was carried out in person, in the self-response mode.

The survey was developed from December 2016 to March 2017, where it is worth noting that there was no material change in the price of energy during the interval of application.

A total of 92 residential consumers were interviewed, of which 52 subjects were Elektro customers and 40 were Eletropaulo customers.

Given the complexity of price formation, the authors of this article investigated the perception of energy prices among non-specialists based on the construction of 4 scenarios, 3 hypothetical and 1 real. Curves were constructed for each concessionaire. Each curve showed different trends, increasing prices (alternative B), declining prices (alternative C), relatively stable prices (alternative D) and of course the actual option (alternative A).

During the survey, the respondents in addition to the comparative analysis of the price curves to choose one, they could also inform their income, profession and gender.

The declared income result that 40 participants have income greater than 10 minimum wages in Brazil and 52 with income below this amount. Of the respondents, 30 were female, 49 were male and 13 preferred not to provide their name, gender and profession at the time of the survey. Regarding the study level, 44 respondents had university degrees.

The participants were invited to choose the curve that represented his best perception of the prices practiced by the distribution concessionaire in his residence over the last few years, being emphasized for each one, that the inflation had been used to correct the prices until the present date of the search.

Figure 2 shows the curves that were shown to respondents in the Elektro concession area, to illustrate part of the instruments used in primary research. For the other concessionaire (Eletropaulo), the graphics presented were similar to this example, following the same criteria for their design. It should be noted that in all alternatives, the trend lines showed a decrease in prices in 2012 and 2013 with a high adjustment in 2015, to give greater reality to the price curves presented in the survey.

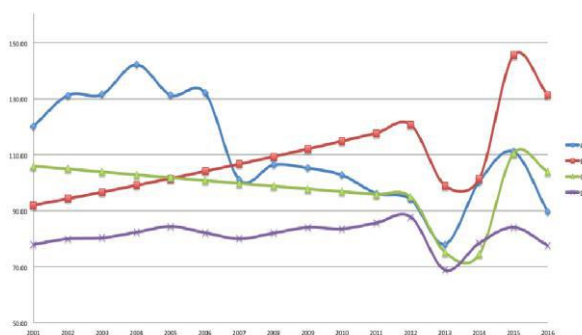


Fig.2: Curves shown to Elektro Customer (R\$/ 200 kWh Month)

Figure 3 presents the results of the research regardless of the concessionaire that served the respondent.

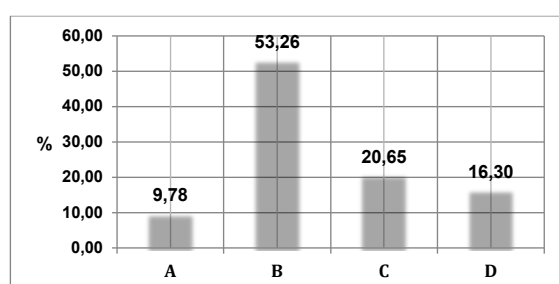


Fig.3: Survey Results (%)

V. CONCEPTUAL ANALYSIS AND STATISTICAL MODEL OF THE STUDY

As presented in section 4, it was found that approximately 90% of the interviewed consumers chose non-valid alternatives (B, C and D, alternatives) considering the four curves with the costs of an electric bill in the concession areas investigated.

In addition, most of these consumers (53.26%) opted for a single alternative (alternative B), where the behavior of the price curve shows an upward trend.

In resume, the consumers have done a biased choice, disregarding the real values actually payed.

These results can also be validated by using appropriate models, taking into account criteria such as the number of available alternatives and the total of consumers interviewed.

Mathematical modeling of problems related to consumer preferences is often performed in the literature as a way to formally study subjective results about a given phenomenon (for example Hensher, 1982; Clark et al., 2014).

In other works, for example, Dublin (2014) performs econometric analyzes that capture consumer preferences when they use electric appliances, considering aspects such as durability and energy efficiency.

Hackbarth, (2013) applied a multinomial model to analyze the choice of vehicles powered by alternative fuels, considering a wide range of alternatives (gasoline, diesel, natural gas, hydrogen, hybrids, electric), among other attributes of these vehicles.

In Danziger et al. (2014) consumer preference is analyzed in relation to price uncertainty in two types of retail stores: EDLPs (everyday low price), which have lower average prices and that tend to vary less over time; and HILOs (high and low prices), which have higher average prices, but which vary more over time, and consequently more bargains, even they exist only in a short window of time.

Formally, consumer preferences were characterized from the use of a binomial distribution, as studied by Chen (2010), which combines the average and variance of the prices of a given type of product.

In this work, the use of a mathematical formalism is performed to demonstrate the differences obtained between the actual consumers' choices and the expected values in an unbiased (random) scenario, considering the four choices already mentioned.

Considering a set with N consumers, where each consumer can choose one of four possible choices (A, B, C or D) it was considered that each choice is not biased by any external factor, such as gender or consumer income. In this context, if the choice is made at random, the probability that each graph will be chosen is 25%.

The distribution function that specifies the number of times that an event (choice of an alternative) with

probability of occurrence p can occur in N independent tests (or number of consumers) is called binomial distribution [Chen, 2010].

A peculiarity of this type of distribution is that, if N becomes large ($N > 50$), it can be treated as a Gaussian distribution, or also known as a normal distribution.

For the data set of the experiment reported here, a probability (p) of 25% (a choice not biased) and a sample (N) of 92 respondents result in an average value (μ) of 23 respondents and an expected standard deviation (S_d) of 4.15.

The same analysis can be done for the expectations related with the consumers that would choose only the “wrong” alternatives (alternatives B, C and D).

The table 03 shows the results with the probability not biased using the Gauss Distribution.

Table 3 Probabilities for non- biased choices

($\mu=23$, $S_d=4.15$)

Alternatives	Consumer choices	Tendency	Probability for non-biased choices. (95% confidence)
A	9.78%	downward	0.13%
B	53.26%	upward	$\approx 0\%$
C	20.65%	downward	20.78%
D	16.30%	neutral	6.23%

From the results obtained, it can be seen that there is a strong bias in choosing Chart B as the one that most reflects the perception of consumers in relation to the cost of an electric bill.

Robust results are also found in the probabilities that the choices of the other alternatives were not made at random, especially the correct alternative (option A) that presents the same probability (order of magnitude) of the choice most selected by the respondents (option B).

To reinforce this conclusion, someone can also consider only those consumers who indicated the wrong alternatives for each of the four alternatives, that is, 90.22% of the total of subjects.

In this situation we would have a probability of 33% (1 out of 3 alternatives) and a sample of 83 respondents (excluding those who answered correctly the correct

alternative). In this case the figures result in an average value of 27.66 and a standard deviation of 4.29.

These results are shown in Table 04. The results obtained show that, considering only consumers who had an erroneous perception regarding the behavior of electricity tariff, it is possible to verify an even greater evidence to support the hypothesis that the choice was biased.

Table 4- Probabilities for non- biased choices -Only wrong selections

($\mu=27.66$, $S_d=4.29$)

Alternatives	Consumer choices - Normalized data	Tendency	Probability for non-biased choices. 95% confidence
B	59.04%	Upward	$\approx 0\%$
C	22.89%	Downward	7.85%
D	18.06%	Neutral	1.10%

All the figures from statistics calculation were produced with the simulators from SISA- Simple Interactive Statistical Analysis (2020).

VI. FINDINGS AND CONCLUSIONS

The results obtained in this qualitative investigation allow us to conclude that Brazilians have a skewed perception that energy tariffs are becoming more expensive, when actually, in the period analyzed they became cheaper in the residential class.

The conceptual framework discussed in sections 2 and 3 support some findings:

The complexity of Brazilian tariffs contradicts any concept with regard to transparency and easy understanding as recommended by the classic work of Bonbright (1961). Price oscillations are chaotic and do not have coherence, neither in regional, or in a relationship with aspects including the service in poor areas. Finally, there is a lack of coherence related to equilibrium in supply and demand and tariffs. This fact stems from the great influence from grid operator strategy choice related about energy safety in future. Energy security decisions makes the water value problem in a trade off with the thermal alternatives an extremely complex one.

The communication process is not adequate, neither by the concessionaires nor by the regulatory agency. Public hearings are elitist and of low transparency to society. The low perception, for example, of the tariff flags strategy is an excellent example of this inability to communicate.

Successive economic and political crises with a significant reduction in economic growth measured by GDP (three years in this century showed negative economic growth - recession in the years 2009, 2015 and 2016) produces the feeling that people became poorer (which in a certain way form is a truth) and, therefore, even with the reduction of tariffs in real terms compared to the past, the perception results that they remain more expensive.

The concepts developed by Loftus (1997) and those proposed by Schacter (2003) explain the loss of prices memory, specially related with a more comfortable income in past and Misconceptions arising from Persistence effect.

The interviewer's own model that simplifies in graphical alternatives a topic of relevant complexity may have influenced misunderstandings according to Kahneman (2011).

It turns out that there is an important opportunity of improvement for the regulator and concessionaires to better understand their communication process with the electricity consumers about the amount actually paid. The results could be used to relief the public opinion each new readjustment

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