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WATER COST OF BEER PRODUCTION: A COMPARATIVE ECONOMIC ANALYSIS IN BRAZIL

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ABSTRACT

The construction and maintenance Brazil has grown a lot in the brewing segment with the large brewers and the artisan breweries that are constantly appearing in the market. However, water consumption in a brewery can be 4 to 10 times higher than the volume of beer produced. In view of the large amount of water needed in the production of beer, this study aimed to verify whether the use of water in beer production is sustainable, taking as a parameter the price charged to users and the costs for using it. Two evaluation methods were adopted, the construction of a production function and the evaluation of the willingness to pay for water in production. It was concluded that there is an investment in technologies by the main breweries for the preservation of natural resources especially water and that the propensity to pay for the resource is treated from the speeches of the representatives as already being done from the investments in technologies for greater impact on the environment and decrease of negative externalities.

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INTRODUCTION

Water has historically accompanied the civilizing process of mankind, and over time has become a limiting asset for the development process in which human beings are inserted. Given the growth in demand for water worldwide since the late twentieth century, there has been a paradigm shift in water management policy. The old policy of water promotion has given way to a policy of control, efficiency, and demand, with the increasing introduction of economic criteria such as prices, tariffs and water markets (Gleick, 2000). In this sense, it can be deduced that the efficiency of water use is linked to the minimization of waste and to the optimal efficiency of the resource, where the production efficiency frontier should be as close as possible to the marginal productivity value equal to the marginal costs in its different uses (Fragoso, 2001; Henrique, *et al*., 2006). Understanding that equity is linked to equal access to water and the redistribution of income, water prices are parameters for measuring sustainability when they are charged to users. Efficient results depend first on an efficient water management policy, considering even the recovery of water costs, but it is frequent that the budgetary balance of the supply is incompatible with efficiency and equity due to the growing incomes and the scale of the natural monopoly in which the supply for water takes place, a factor for which it can be regulated by public tariffs. (Cordeiro,2003).

Tariff policy is an instrument of economic regulation of the demand for water, which through price changes or income transfer aims to influence the decisions of beer producers to voluntarily change their behavior(Tsur, *et al*., 2003).The tariff policy is fundamentally based on the neoclassical microeconomic theory, establishing a correlation between supply and demand, which leads to the understanding that from the point of view of demand the optimal point is given by the value of marginal productivity and competition among the various uses of the good, in this case water(Hal, 1992). On the supply side, tariffs are intended to cover the costs of the supply services, the scarcity costs related to the use of the resource, the full costs of supply and the social costs, such as those related to pollution, yet the central issue with tariffs relates to a tariff level that is adapted to marginal cost or average cost (Cordeiro,2003). The composition of the costs of water use in beer production1, besides the aspects mentioned above, directly related to the economic aspects of the equation, it is necessary to consider the type of water to be used in the activity, the amount of water used for the production of one liter of beer, the environmental services that water does not perform due to the decision to use it in beer production and, most importantly, the environmental impacts considered the externalities of the activity. Brazil has grown substantially in the beer segment with the large brewers and the artisanal breweries that are constantly appearing in the market.

It currently occupies the third position in the ranking of the largest producers, with an average of 13 billion liters of beer per year. In 2020 the country reached the mark of 1,2091 registered breweries in 26 Federation Units, where only the state of Acre still has no registered breweries. The growth in the number of establishments has been constant over the last twenty years, with an average growth rate of 19.6% per year. Recently this growth rate has increased, being 26.6% if the period of the last 10 years is analyzed, and 36.4% in the period of 5 years. Thus, projections were made that if the growth rate of 36% is maintained until 2025 the country would reach the mark of 7,504 breweries, which exceeds the number of breweries in the USA in the latest available balance of 2018 with 7,346 breweries. With an intermediate growth projection this number would reach close to 5,000 breweries and the most modest at 3,500 (Beer Yearbook, 2020).

According to Junior, *et al*., (2009) water is one of the main inputs of beer and is therefore considered for defining the locations where breweries will be installed. The water used for brewing beer must be drinkable and may undergo chemical corrections according to its composition. Filladeau, *et al*.,(2006) describes that breweries have a specific water consumption that varies from 4 to 11L per liter of beer produced. For Mathias, *et al*., (2014), water consumption in a brewery can be from 4 to 10 times the volume of beer produced. In the water treatment plant, there are three types of water: Brewing water (added to the process), and the amount of water used at this stage is not yet agreed; however, Trommer (2011) calculates that in the production process of a Brazilian brewery, in order to produce 1 liter of pilsner beer (pale beer), an average of 8 liters of water are used. Another use is industrial water (with more chlorine to be used in sanitizing the industry) and finally utility water (for boilers and refrigeration, with low chlorine and calcium content). This water, unlike the brewing water, must have a higher pH.

The brewing water corresponds to 93% of the beer and is therefore the main ingredient. This water must be innocuous, free of contaminations, and hard (with a high calcium and magnesium content) to serve as a nutrient for the fermentative yeasts. The calcium present in the water will also act to bring sugar into the beer. The water must also be chlorinated, with no iron present. The author also says that the pH should be adjusted to 5.0. This adjustment is important for two purposes: to enhance the effect of chlorine (which should be between 0.1 to 0.2 ppm of free chlorine, because above this value there is the formation of chloramphenicol in beer) and for the effect of enzyme action, because the α and β amylases and proteases present in the grains only act at low pH (Júnior, *et al*., 2009). As for the use of water in the cooling process, Barros (2020) explain that the system used for cooling is done through heat exchangers (open circuit with the use of water in the process), where the water used in this process is discarded at each production process, thus leading to excessive water consumption. It is worth noting that in this process the water has no contact with the beer (wort), its function is to cool the product through heat exchangers.

Therefore, in view of the information presented here, the brewing industry in Brazil needs a large amount of water, consuming approximately 100 billion liters of water per year. Thus, the objective of this work will be to verify whether the use of water in beer production is sustainable, taking as a parameter the price charged to users and the costs for its use. The present work arises from the context that water is fundamental for the maintenance and sustainability of natural ecosystems and of biogeochemical cycles and biodiversity, which are crucial for the very survival of human beings. However, the increase in demand and the diversification of multiple uses have intensified the water crisis, and the severity and complexity of these crises are likely to persist for long periods of time. These crises demand solutions ranging from long-term strategic planning to advanced governance and structural measures (Cortes & Torrente, 2015). Then, domestic, and industrial demand reduction is an imperative and must be guided by proper communication, new management and mobilization processes, and advanced technology. Technologies for domestic demand reduction should be encouraged (Jimenez, 2015).

MATERIALS AND METHODS

For the economic analysis of water use in beer production, two evaluation methods were adopted, the construction of a production function and the evaluation of the willingness to pay for the use of water in the brewery. In theory, the production function allows the establishment of an economic value for water when it is considered a production good as an input to increase productivity. In this case, its value would be equivalent to net gains in production, which would be determined for different producers in the same group represented by a production system that incorporates the traditional costs of labor, capital, equipment, inputs, among others, linked to water consumption to be evaluated later (Cordeiro Neto, 1995). If each producer indexed by i = 1, ..., I, producing up to M products, using N inputs, the production of the m-th product, $Y_{m,}$ requires the use of the input vector, $X_m=(X_{m1}X_{m2}, \ldots , X_{mn})$, simplifying, each product is produced using the production function $F_m(X_m)$ admitting that the technology is separable and the same for all producers. The inputs are available in limited quantity per product according to the vector X = $(X\text{-}_{11}X\text{-}_{12},\ldots X\text{-}_{1m)}$ where $X\text{-}_{1m}$ denotes the physical quantity available of the n-th input for the i-th product. Producers are price takers and determine the quantity to demand of each input, according to the solution of the problem of minimizing the total cost of production.

$$\begin{array}{l} M \\ C_{1(}X_{i,}P,Y_{i)} = \text{Min } \sum PX_iM \\ \{X_{i1} \ldots X_{im}\}\ M=1 \end{array} \qquad (i)$$

$$\begin{array}{l} Fm(X_1m) \geq Y_1m \text{ for } m=1, \ldots, M \\ m \\ X_1 \geq \sum X_1m \\ M=1 \end{array} \qquad (ii)$$

Where: C1(X-1,P,Y) production cost function of product i;

'$Y_1 = (Y_{i1}Y_{i2} \ldots Yi_{m)}$' is the production vector for product i;

$X = (X_{i1}X_{i2} \ldots X_{1m)}$ is the vector of inputs for producer i and P € RN_+ is the vector of input prices. Being *i* the input water in the functions market.

To evaluate the willingness to pay for water as an economic good, we considered a fictitious market, established through indications that producers would be willing to pay for the water used in the production of beer so that it would be available at the brewery. The information for this evaluation was obtained in scientific articles on the subject, in the national yearbook of beer production from 2014 to 2020 and in news from newspapers and magazines recognized nationally and internationally from interviews conducted by these vehicles to representatives of five brands, all with national and international markets, except for brand X, which operates only in the domestic market. The objective of this search was to see if the producers expressed preferences for which type of water to use and based on this preference, to evaluate the marginal willingness to pay for different quotas of water volume in the fictitious market. The analysis of the speeches was done through comparative tests by assembling a random sample taken from clippings of the interviewees' speeches, randomly selected by groups of interest in the five brands studied. The interviews to compose the sample were chosen for their representativeness of different types of production systems and socioeconomic conditions of the producers, as well as the existence in their speeches of their brands being or not environmentally responsible for the externalities caused in the production process, aiming at a sustainable production and, considering especially in their process the decision for the use of water considering gains and losses of the value of this resource for the environmental services promoted by it. For reasons of time and resources, the time and costs were considered as the main factors to define the sample size, so a sample with a sampling error of 5% and a size equal to 30 (thirty) interviews and articles together was chosen, being able to disregard any interviews and/or articles that did not meet the purpose of the study. The research took place between August and October 2020 and was developed with the support of the CAPES/CAFE journal database, Google Scholar, Web of Science, and in the yearbooks of national beer production between 2014 and 2020.

RESULTS AND DISCUSSION

From five brands consulted, the following results were obtained considering the use of water and the way it is collected: the leading brands in the national ranking in terms of sales are concerned about the use of water and its relationship with society, since beer production demands a high consumption of the resource and, as such, demands studies and research in search of a sustainable and responsible use of the resource; the two smaller brands with a smaller share of the market understand the concern, but do not yet have research directly related to technologies for a better efficiency in the use of water, but they make it understood that they pay for the rights to use technologies developed by partnerships. When evaluating the willingness to pay for the resource in a fictitious water market, the three leading brands demonstrate in the speeches of their representatives that they already behave this way, since they use a water reuse process in different stages of the production process and when they use around 80% of the water from wells, which mitigates the externalities and present themselves as environmentally responsible, As for the two brands with smaller market share, they show an understanding of the need to apply a policy within the standards of the leading brands, but they still do not practice it because their market share does not cover the costs, and they seem inclined to apply the policy of reuse and improvement in technologies for the efficient use of water in beer production (Beer Yearbook, 2020).

Regardless of the market share and the technology developed to minimize the amount of water used in beer production, the best result obtained and observed is 3.5 (three and a half liters) of water for producing 1 (one) liter of beer. The two breweries with the smallest share and that claim not to develop technologies achieve these results by using the technology developed by the largest ones and that pay for the rights (Beer Yearbook, 2014). All five brands studied claim to be concerned with environmental issues, and especially with the use of water resources, since this is the main resource in beer brewing, and that according to Beer Yearbook (2016), based on technologies developed and applied in the production of 4, 5 (four and a half liters) of water used in beer production was reduced to 3.5 (three and a half) for the production of one liter of beer, a result better than the projected 3.61 (three point sixty-one). On the topic of responsibility for water use, Beer Yearbook (2016) states that among its actions to improve the efficiency of these resources is the reuse of water (recirculation), rainwater harvesting, preservation of watersheds through its own projects and participation in the Watershed Committee leding by ANA-National Water Agency; These actions linked to the price paid for the resource and insertion of this resource in the market as an input promoting an improvement in production and a competitive capacity under normal conditions that for Brazil, this policy has resulted in quantitative improvements in production and qualitative improvements in reducing negative externalities, even improving the Brazilian position in the world ranking of beer production.

According to Beer Yearbook (2015), Brazil ranks third in the world in beer production, behind China and the United States and is responsible for 1.6% of the national GDP - Gross Domestic Product, collecting more than R$ 20 (Twenty) billion in taxes throughout the country. According to Table 1, the largest producers are not the largest consumers, of the producers only Germany appears in third place as the largest consumer and fifth in production, which can be understood that if the main resource in production is water and this is a product typically sold in foreign markets, then there is a flow of these resources in the order of 89%, considering 11% in domestic consumption, except for Germany that appears on both sides of the equation as high producer and high consumer. Seen the equation from the point of view of the flow of domestic markets to foreign markets, considering the production and high consumption of water by the producer market, there is an outflow of resources from these markets for an injection in consumer markets, so it is necessary in the production function the value of water resource estimated as an input, increasing production and thus being returned in the form of financial resources to the producing countries, understood this relationship from the description below. In the production function, the value of the water resource is estimated as an input or production factor of another product, so that it only estimates a demand curve. The values of production costs for each factory/country evaluated based on the production cost system contracted by the industry itself and/or the country consortium or in the producing country; the gross incomes calculated from the production and valuing based on the annual average wholesale prices of the product, considering the consuming countries as well as the internal markets; the net incomes calculated by subtracting from the gross incomes, the production costs calculated according to the theoretical income obtained with the commercialization and so the theoretical income is obtained with the hypothesis that the product performs the activity considering the price of water in the common standards used from the public supply services. The value of water is considered *ceterisparibus* with the average increase in productivity resulting from the use of the resources as an input, estimating the value of water as a production good, and being considered an input that serves to increase production, its value can be considered equivalent to the net gain of the production achieved (Cordeiro Neto, 1995), and, considering the decision to use water as an input starts from the premise that the additional costs would be compensated with the extra income thanks to the increase in productivity (Fernandez, 1996).

Table 1. World beer production - the five largest producers and the five largest consumers worldwide

Country	Production in million L	Consumption per capita in L
China	381,2	-
United States	214,6	-
Brazil	114,4	-
Mexico	119,8	-
Germany	93,7	-
Czech Republic	-	143
Austria	-	108
Germany	-	107
Ireland	-	94
Poland	-	89

Source: Catalise, 2018 Beer Yearbook, 2014 to 2020, adapted for the article.

For the above description, it is necessary to calculate the value of the net gains of the product, in this case, beer as: the annual gross income by type of product produced, the value of the product income considering water as an input compared to the product without this consideration, add the value of depreciation of the product the opportunity cost of capital employed in the water harvesting system understanding it as an input. In this process, we calculate the net income, the production and marketing costs, decreasing the net income by calculating the value of the product considering the depreciation and opportunity cost, we can obtain the gain of the product to be attributed to water as an input and the product that does not consider it, thus, dividing the value of the net gain by the average annual consumption of water as an input, we obtain the average unit value that could be attributed to the cubic meter of water used in beer production as an input. See table 2 and 3 below. According to table 2, there are net gains in both cases for A and B, and a slight positive oscillation of 0.02 in net gains for A compared to B, this gain being explained according to the technologies used, considering that A has its own technology for reducing water use in production and B uses the technologies developed by A, according to the description above, with A being the leading company in the market and B being a company on its way to domination that currently lives in consortium with the leaders.

Table 2. Average net product gain using water as an input

	Calculated average annual net income (1 U$/l)		
	Income of the Producer considering water as an input (1)	Income from production considering water not as an input depreciação + oportunidade (2)	Net gains (1)– (2)
A	1,20	0,49	0,71
B	1,24	0,55	0,69
≠A-B	-	-	0,02

Source: Beer Yearbook 2020 adapted for the article.

According to Table 3, there is a slight oscillation upwards of U$ 7,99 (Seven and ninety Nine) of A in relation to B, this is explained by the same reasons of the use of A's own technology in relation to B that is part of producer groups with lower purchasing power, which uses technologies from groups with greater power.

Table 3. Average unit value of cubic meter of water in U$ based on the calculated net gain

Producer	Net Gain	Average annual water consumption (m^3/l/year)	Unit gain value per year (U$/$m^3$)
A	0,71	16,254	2,09
B	0,69	14,141	2,08
≠A-B	-	-	7,99

Source: Beer Yearbook, 2020 adapted for the article.

The value found adds the maximum average value to the increase in income using water as a tool to increase productivity based on income criteria calculated by comparing the values obtained from the net income declared by the production function, Table 2 shows the table of results for the average values referring to 1. 000m3 of water consumption, so that the results found when comparing the values of willingness to pay for water as an input and the value resulting from the net income declared for the use of this resource are approximate and present the evaluation as a consistency for the use of water as an input, see Table 4.

Table 4. Average unit value of m3 of water in U$ in relation to the declared net income

Producer	Direct consumption m3	Annual consumption (1,000m3)	Declared net income	Unit cost (U$/m3)
A	44.530	16.245	0,19	0,012
B	38.744	14.143	0,22	0,016

Source: Beer Yearbook, 2020, adapted for the article.

Observing table 4, those who use technology for the efficient use of water, in this case group A producers, show better results than those who don't and apply the water use efficiency policy through a consortium, in this case group B producers. Even so, using water as an input is an efficient alternative from the point of view of the flow of the resource and considering that the market returns in the form of financial resources the flow now measured, considering the payment of these resources in cubic meters, see table 5.

Table 5. Values in Dolars for 1,000m3 of water

Producer	Water as input	Production function	
		Declared	Calculated
A	6,59	11,54	43,72
B	4,10	16,64	48,80

Source: Beer Yearbook, 2020, adapted for the article

It is evident the absence of technology in the increase of courses, so that those who hold the techniques save a little more when closing the account, this becomes clear when observed the value calculated in the production function, there is a gain of U$ 4.53 (Four Fifty-three) of A in relation to B, considering the technology used, the social responsibility and the balance of the use of the water resource as an input in beer production. Since the values obtained through the calculated income are significantly higher, they reflect the values resulting from the income obtained when the market values are used to commercialize the product. The calculated values, which are still much higher when compared to the declared values, reflect the contribution of water in the production process and show that Group A has an advantage over Group B, given the initial investments in technology.

CONCLUSION

The article showed that there is a perception of the importance of water for the brewing industry and that it has implemented actions both to preserve the watersheds and to reduce the impact of production. For this there is an investment in technologies by the main breweries for the preservation of natural resources, especially water. It was verified that the main producing countries are not the biggest consumers, so there is a water resource flow from the producing countries to the consumers. By analyzing the graphs and the results one can see that if there is an outflow and water is considered as an input in the production function, the added value can be passed on to the consumer, and thus the outflow becomes compensated by the financial resources returned to the producing countries. Finally, it is noted that the propensity to pay for the resource is treated from the speeches of the representatives as already being done from the investments in technologies for greater impact on the environment and reduction of negative externalities.

APPENDIX

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REFERENCES

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2014.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2015.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2016.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2017.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2018.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2019.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2019.

CERVBRASIL, Brazilian Beer Industry Association. Beer Yearbook, 2020.

Cordeiro Netto, O. M. A estimativa de um valor econômico para o uso da água como um dos elementos integrantes de gestão racional dos recursos hídricos. *Seminários sobre a água*, 2016. Brasília anais.

Cordeiro Netto, O. M. 1995. A estimativa do valor econômico da água: uma discussão teórica. In *simpósio brasileiro de Recursos Hídricos*, 11.: simpósio de hidráulica dos países de língua oficial Portuguesa. 2. Recife, Anais, Recife; ABRH, 1995. P.45-449.

Cordeiro, J. A. D. 2003. *Abundância e escassez da água: a cobrança pelo uso-um modelo de formação de preços aplicável à bacia hidrográfica GL-1*, Pernambuco (Master's thesis, Universidade Federal de Pernambuco).

Côrtes, P. L., Torrente, M., Pinto Alves Pinto, A., Ruiz, M. S., Dias, A. J. G., & Rodrigues, R. 2015. Crise de abastecimento de água em São Paulo e falta de planejamento estratégico. Estudos Avançados, 29(84), 7-26.

Fernandez, J. C. 1996. Projeto de implantação da cobrança pelo uso e poluição da água dos mananciais do Alto Paraguaçu e Itapicuru. Salvador: Superintendência de Recursos Hídricos do Governo do Estado da Bahia.

Fillaudeau, L., Blanpain-Avet, P., & Daufin, G. (2006). Water, wastewater and waste management in brewing industries. *Journal of cleaner production*, 14(5), 463-471.

Fragoso, R. M. D. S. 2001. *Avaliação dos impactos sócio-económicos do plano de rega de Alqueva no sector agrícola do Alentejo: o caso do bloco de rega da infra-estrutura 12*.

Gleick, P. H. 2000. A look at twenty-first century water resources development. *Water international*, 25(1), 127-138.

Hal, R. V. 1992. Microeconomic analysis. WW Norton & Company, Inc.

Henriques, P. D. D. S., Branco, M. C., Fragoso, R. M. D. S., & Carvalho, M. L. D. S. 2006. *Direito de acesso à água-princípios económicos para seu usufruto na agricultura*.

Jimenez-Cisneros, B. (2015). Responding to the challenges of water security: the Eighth Phase of the International Hydrological Programme, 2014–2021. *Proceedings of the International Association of Hydrological Sciences*, 366, 10-19.

Junior, A. A. M., & de Barros, Z. X. 2020. Utilização Racional De Água Em Cervejaria Brasileira. *Energia Na Agricultura*, 35(2), 287-294.

Junior, A. A., Vieira, A. G., & Ferreira, T. P. 2009. Processo de produção de cerveja. *Revista Processos Químicos*, 3(6), 61-71.

Mathias, T. R. S., MELLO, P. D., & Servulo, E. F. C. 2014. Caracterização de resíduos cervejeiros. In *Congresso Brasileiro de Engenharia Química* (Vol. 20, pp. 1-8).

Mega, J. F., Neves, E., & ANDRADE, C. J. D. 2011. A produção de cerveja no Brasil. *Revista Citino*, 1(1), 34-42.

Trommer, M. 2011. Brasilien–Bier markt mit Potenzial. Brauwelt. *Hans Carl Fachverlag*. Germany.

Tsur, Y., Roe, T. L., Doukkali, M. R., & Dinar, A. 2004. Pricing irrigation water: Principles and cases from developing countries. Resources for the Future.

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