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Sugar-sweetened beverages tax and obesity: Simulation of economic impacts from input-output analysis for Brazil

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ABSTRACT
Given the growing interest in taxing sugar-sweetened beverages, we estimated the effects of tax increase of sugary drinks for the Brazilian economy, focusing on the impact on household consumption, production, employment, and tax revenues of the government. To identify these effects, we considered productive relations of SSB sector by calculating the forward and backward indices and employment multipliers based on the input-output matrix of Brazil. Additionally, we performed two simulations. In the first simulation, we used the Leontief price model incorporating the disaggregation of household consumption vector by income decile an increase of 10% in the production cost of SSB due to a tax increase. The results show a tax increase applied to the sugary drink industry generates a slight negative impact on the economy, but it reaches the expected effect: reduction of household consumption for this product. The distributional analysis shows the tax is clearly progressive over the decision, when measured by the compensatory variation. In the second simulation we additionally assumed all revenue generated would be invested in public health. In this scenario, the positive effects on employment compensate the tax burden bringing positive aggregated effects on employment despite slightly negative effects on production.

KEYWORDS
Sugar-sweetened beverages, Tax, Input-output

Imposto sobre bebidas açucaradas e obesidade: Simulação de impactos econômicos a partir da análise de insumo-produto para o Brasil

RESUMO
Dado o crescente interesse pela taxação de bebidas açucaradas, o objetivo deste estudo é estimar os efeitos de um aumento na tributação destas bebidas sobre a economia brasileira, com enfoque no impacto sobre o consumo das famílias, produção, emprego e receitas tributárias do governo. Para identificar esses efeitos, considerou-se os encadeamentos do setor de bebidas açucaradas na economia por meio do cálculo das ligações para frente (FL) e para trás (BL) a partir dos dados da matriz insumo-produto do Brasil. Adicionalmente, os efeitos sobre as variáveis macroeconômicas foram estimados a partir de dois cenários de simulação considerando o modelo de preços Leontief incorporando a desagregação do vetor consumo das famílias por decil de renda. No primeiro cenário, estimou-se o efeito de um aumento de 10% no custo de produção do SSB devido a um aumento de impostos. Os resultados mostram que um aumento de imposto aplicado à indústria de bebidas açucaradas atinge o efeito esperado de reduzir o consumo doméstico desse produto e gera um leve impacto negativo na economia. A análise distributiva mostra que o imposto é claramente progressivo ao longo da decisão, quando medido pela variação compensatória. Na segunda simulação, além do aumento tributário, pressupõe-se que toda a receita gerada é investida na saúde pública. Nesse cenário, os efeitos positivos sobre o emprego compensam a carga tributária trazendo efeitos agregados positivos sobre o emprego, apesar dos efeitos ligeiramente negativos sobre a produção.

PALAVRAS-CHAVE
Bebidas adoçadas com açúcar, Imposto, Insumo-produto

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1. Introduction

Obesity affects more than 300 million people worldwide and has become one of the main public health problems (James, 2008). Identified when a person has a body mass index (BMI) greater than or equal to 30, obesity has become increasingly prevalent in Brazil in recent decades. Current estimates show that the prevalence among adults has risen from just 12.2% in 2002/2003 to just over 18% in 2019 (IBGE, 2020b). Considered to be an epidemic, obesity is associated with various aspects of social, economic and behavioural standards. The changes on these aspects affect the dietary pattern and physical activity of individuals. Among these, it stands out: the technological advances in food production, which contributed significantly to increase supply of unhealthy food, and to make them cheaper (Philipson and Posner, 2003). In addition, Mazzocchi et al. (2009) point out the time cost of food preparation reduced with technology resulting in individuals consuming more prepared and ultra-processed food, such as fast food and ultra-processed food. These foods typically are calorie-dense food which contributes to rise the individual caloric intake.

Sugar-sweetened beverages (SSB) consumption may be contributing to the increasing obesity prevalence (Hu, 2013; Bodo et al., 2019). Clinical studies suggest that the consumption of SSB is associated with an increased caloric intake and a significant weight gain in children and adults, in addition to a higher risk of diabetes type 2, coronary artery disease and osteoporosis (Chen and Huffman, 2009; De Ruyter et al., 2012; De Koning et al., 2012; Ebbeling et al., 2006; Feferbaum et al., 2012; Fung et al., 2009; Gibson, 2008; Malik et al., 2006; Mozaffarian et al., 2011; Vartanian et al., 2007). Furthermore, the effect of SSB on weight gain is greater than that observed in any other food or beverage (Woodward-Lopez et al., 2011).

Tracking closely to the growth of obesity, sales of SSB is increasing worldwide, especially in middle-income countries. Popkin and Hawkes (2016) analyzed adult data for 187 countries and found that SSB consumption is steady rising in Latin America countries. In this region are four of the ten countries with higher caloric intake from SSBs per capita (Brazil: 90kcal/day/person; Argentina -135kcal/day/person; Mexico - 158kcal/day/person; Chile -166kcal/day/person). Currently, 1 in 6 Brazilians consume SSB, with an average daily consumption of 61.7 ml/day (IBGE, 2020a).

Policy proposals to reduce the consumption of drinks with high sugar content appear to be an effective way to contain the increase in obesity. More specifically, the idea of taxing sugary drinks has come to prominence in the literature, in light of the effect of prices on consumption (Brownell and Farley, 2009; Escobar et al., 2013; Kristensen et al., 2014; Lustig et al., 2012; Bodo et al., 2019; Pereda and Garcia, 2020). However, the effectiveness of this policy in the countries where it has been implemented is still inconclusive. Moreover, there is a lack of evidence on the macroeconomic impacts of SSB-related fiscal policies (Sharma et al., 2014; Mounsey et al., 2020).

Most of the evidence that was gathered in developed countries suggests that taxation can be an effective measure to reduce caloric intake and thus lead to lower obesity rates (Appendix A). Thow et al. (2010) examine the effect of fiscal policy on diet and obesity and show that the imposition of tax has decreased consumption of SSB. The authors show that the higher the tax, the more significant are the changes in consumption, body weight and disease incidence. A systematic review for middle income countries indicates similar results in terms of consumption and health outcomes (Nakhimovsky et al., 2016).

In terms of the macroeconomics effects, little is known on case of SSB tax impacts and two opposite points of view exist. Industry-sponsored studies have reported economic losses in terms of production and employment. On the other hand, empirical evidences from Mexico show that there was no reduction on employment in the manufacturing industries, the commercial sector or the economy as a whole. Guerrero-López et al. (2017); Powell et al. (2013) using a macroeconomic simulation model to two states in USA find modest effects of SSB tax on employment but a considerable capacity to generate revenues for investment in health policies. These findings suggest that the eventual losses on SSB would be offset by gains related to governmental sector (as result of spending of taxes) and other sectors (in response to reallocation of the consumer's expenditures in others good or services). In this sense, Nordström and Thunström (2011) suggest that such policies can be progressive and generate positive effects on the economy.

A smaller set of studies estimates the economy-wide implications of SSB tax using modelling based on input-output analysis (IOA). Mostly the simulations consider an *ad valorem* tax calculated on wholesale or retail price (Mounsey et al., 2020). Cantu et al. (2015) simulated the effects of SSB tax implemented in Mexico in 2014 and observed a reduction of –0.04% on Gross Domestic Product (GDP) as result of a decrease in the non-alcoholic beverages (NAB) sales, loss of jobs (-10,815) and labor income (-$686 million pesos). The effects would be concentrated in NAB sector, but sectors such as other food industries, wholesale grocery and food, manufacturing of plastic products, sugar, and others would be indirectly affected. Gabe (2008) analyzed the economic impact of the Maine Public Law 629 which imposed an excise tax in wine, beer soft drink and sport drink. The author uses the lost sales revenue to estimate the impact on job and earnings and use the input-output model to estimates the wide-economy effects related with the decrease on beverage sales. The results reveal an impact of $17,5 million lost in beverages net sales revenue, and most of this decline would be related to a further reduction in soft drink sales. This reduction is made up of $4.3 million decline in sales revenue to beverage manufactures and wholesalers, and $13.2 million to food and beverages stores, food services and drinking places. In addition, the estimates show a loss of 295 jobs and $5.9 million in wages and salaries associated with reduced beverages sales.

A similar predictive model was estimated by Oxford Economics and American Beverage Association, (Oxford Economics and American Beverages Association, 2022), to analyze the economic impact of Philadelphia's beverage tax. The authors estimate the impact of 29% decrease in bottler sales on manufacturing and bottling activities, trade and transport margins on beverages sales, and non-beverage retail. Stemming from these three sets of impact, the modeled results indicate a 0.14% decline on employment (-1,192 jobs), a 0.08% reduction in GDP, a $54 million decline in labor income, and a local tax loss $4.5 million. Most part of this impact results from the reduction in retail margins on non-beverage retail. Manufacturing; Trade, transport, utilities, and Business Services sectors were the other sectors most affected.

To contribute to the discussion on the effects and implications of a tax on SSB, this paper focus on the potential macroeconomic and sectoral impact assessment of SSB taxation in Brazil using the Leontief input-output price model. We simulated two scenarios. In the first, we adopted a different modeling strategy and assumed an increase of 10% in the production cost of SSB due to a tax increase, which is passed through onto the prices. The chosen tax level was similar to that implemented in Mexico, which considers a 1 peso by liter excise tax (about 10% increase in price) to be paid by the producer (WHO, 2016). Additionally, a 10% SSB tax would have meaningful effect on health outcomes (Barrientos-Gutierrez et al., 2017; Briggs et al., 2013). We seek to evaluate the effects of this policy in terms of production of sugary drink and other productive sectors, aggregate consumption of households in different income deciles, employment, and government tax revenues. In the second scenario, we also simulate a 10% increase in the production due to a tax increase, and we assume all revenue generated would be invested in public health.

The Leontief price model is implemented to simulate the direct and indirect effects of the SSB tax police. In this model, the effect of a change in relative prices is calculated through the corresponding change in the cost of production inputs. Furthermore, it incorporates all the traditional components of the input-output models, such as sectoral relations of productive activity, final demands and the cost of primary factors. Based on this information, it becomes possible to identify aggregate effects (on production and employment) and sectoral effects. The model also incorporates a household consumption vector disaggregated by income decile that sheds light on the distributional effects of this policy, which are extremely important given the inequalities in Brazil.

The remainder of the article is composed of three sections. Section 2 presents a description of the selected methodology and its application to the problem we study. Section 3 describes the results. Section 4 concludes and notes the main implications of the work.

2. Methodology

2.1 Data

The proposed methodology enables us to assess the economic impacts of a tax on SSB. The starting point is to construct an input-output matrix (IOM) that includes SSB as a productive sector connected by input and output linkages to the remainder of the economy. For this analysis, we used the Brazilian Tables of Resources and Uses for 2015. The original data were provided by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, abbreviated as IBGE) and transformed into an IOM according to the procedures described in (Guilhoto and Sesso Filho, 2005, 2010). This matrix contains information 67 industries and 110 commodities.

To construct the specific information on SSB, we used two different data sources: Annual Industrial Survey (Pesquisa Industrial Anual, abbreviated as PIA) for 2015, and Consumer Expenditure Survey (Pesquisa de Orçamento Familiar, abbreviated as POF) for 2008-2009. From PIA, we used the value of production of sugary beverages to calculate the share of SSB sector on manufacturing beverage (which is 48.15%). Using this information, the SSB sector was disaggregated from manufacture of beverages in terms of production. This procedure assumes that the intersectoral relationship of the SSB sector are identical to the relationships observed to manufacturing beverages. From POF, we considered the overall household expenditure and the consumption shares for all 111 commodities. The shares were used to split the original consumption vector from National Accounts. Our final matrix has 68 industries and 111 commodities. Table 1 shows the main components of the two sectors. It is important to notice, the expenditure concentration in high-income families. The household consumption is the main component of final demand, and the last decile accounts alone for 23.67% of total household consumption.

Table 1. Social Account data for Sugar-sweetened and other beverages (BR$millions)

Variable	Sugar-sweetened beverages	Other beverages
Value Added	11.037	11.886
Final demand (total)	35.767	38.515
Labour (occupations)	92.752	99.880
Total Household Consumption	34.872	37.551
H1	1.022	1.101
H2	1.407	1.515
H3	1.987	2.139
H4	2.060	2.219
H5	2.594	2.793
H6	3.079	3.315
H7	3.865	4.162
H8	4.627	4.982
H9	5.975	6.435
H10	8.256	8.891

Source: Own elaboration

2.2 Empirical Model

The input-output model is a linear system of equations describing the economy. The basic equation of the input-output model is expressed as:

$$(x = Z + f) \tag{1}$$

where x is the vector of total output by industry, Z is the intermediate input matrix that represents the economic flows between industries, and f is the vector of final demand by industry (Miller and Blair, 2009). The technical coefficient matrix is then given by:

$$(A = Z\widehat{x}^{-1})(A = Z\widehat{x}^{-1}) \tag{2}$$

where each element of $A = a_{ij}$ represents the amount of industry *i*'s product used as an intermediate input by industry *j*. Therefore, the model's solution can be represented as:

$$(x = (I - A)^{-1} f) \tag{3}$$

where $(I - A)^{-1}$ is the total impact matrix called the Leontief Inverse matrix.

In this model, all the flows between industries are monetary and prices are fixed at the base year value. However, to estimate a tax effect, we essentially change the production cost, which directly affects prices. The input-output literature has traditionally offered two solutions: the Ghosh, (Ghosh, 1958), model and Leontief price model (Leontief, 1941, 1946)[1]. In this paper, we adopted the latest model, under which variations in production costs are converted into price increases. Thus, initially, industrial output x is equal to the inputs cost plus the component of value added v, as captured by the following equation:

$$(x^{'} = i^{'}A\widehat{x} + v')(x' = i'A\widehat{x} \ + v') \tag{4}$$

Multiplying equation (4) by $\widehat{x}^{-1}$we obtain:

$$(i^{'} = i^{'}A + v^{'}\widehat{x}^{-1} \ ) \tag{5}$$

Given that $L = (I - A)^{-1}$ and assuming that the price is equal to the production

[1]It is important to highlight, however, that according to Miller and Blair (2009) both models produce the same results. For different interpretations of Ghosh's model, see Dietzenbacher (1997); Oosterhaven (1996) and De Mesnard (2009).

cost so that $i^{'} = p_0 i^{'} = \check{p}$, the price index for the base year is given by:

$$(p = L^{'} v^{'} \widehat{x}^{-1}\ ) \tag{6}$$

We represent a tax on SSB by a vector T, which is calculated according to the value added to this sector:

$$(T = \varphi s \widehat{v}) \tag{7}$$

where φ is the tax rate and s is a vector representing the SSB industry. Using the fact that $\tau = T\widehat{x}^{-1}$, it follows that the adjusted prices vector (p^*) is:

$$(p^* = L^{'} \left(v\widehat{x}^{-1} + \tau \right) p) \tag{8}$$

Following Gemechu *et al.* (2014), if the monetary values of the sectoral output are held constant before and after the tax is introduced, the sectoral output becomes:

$$(x^* = \frac{p}{p^*} x) \tag{9}$$

Therefore, the impact on the price index (π) is given by:

$$(\pi = \sum_j p_j^* \alpha_j) \tag{10}$$

where α_j represents the share of industry j's production in the total output. The estimation of government revenues with the new tax is:

$$(R = \varphi x^*)(R = \ \varphi m') \tag{11}$$

Assuming that households maximize their utilities using a Leontief function and that their income and savings are unchanged, none of the representative households can afford the same portfolio of goods. Therefore, using the price changes derived from the model, we can calculate the additional income necessary to compensate households for the welfare loss. Formally, the change in household welfare in decile k (Δw_k) is:

$$(\Delta w_k = \left(\sum_i c_{\text{ik}} p \right) - \left(\sum_i c_{\text{ik}} p^* \right)) \tag{12}$$

where c_{ik} is the quantity of industry i's products consumed by decile k.

Using this model, we performed two simulations: in the first scenario we set the tax as $\varphi = 0,1$, increasing production cost. In the second, the revenue (R) was used as a final demand change in public health consumption (through regular Leontief model), partly compensating the tax burden.

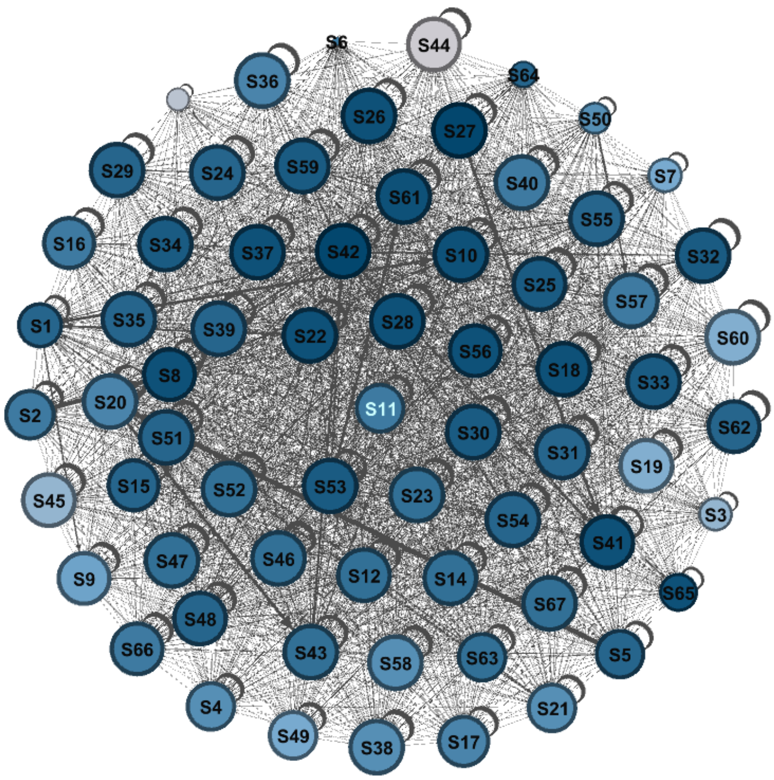
Additionally, to visualize the input-output matrix values we consider the social network analysis, proposed by Seeley (1949)[2]. In this case, the productive linkages existing between the sectors are presented by a graph: the node represent the sectors (see the Appendix B) and the lines represent the productive linkages. The node was identified by numbers and its size correspond to the sum of the matrix lines (out-degree in terms of social network). The higher the node, the greater the number of forward connections, which defines the sector as a supplier of inputs. The node's color is associated to the backward linkages, and the more intense, the greater the number of backward linkages. The monetary flow between two sectors is represented by an arrow, whose thickness is directly related to the magnitude of the monetary value. Thus, the higher the node and the more intense its color, the better the structural position and the greater the economic relevance of the sector.

[2]The social network analysis is widely used in Computer Science and it has been applied in other areas of research (Cardoso and Silva Junior, 2013).

3. Results and Discussion

The network representation of the input-output matrix (Figure 1) presents the sectoral interaction of the Brazilian economy. The results show the important activities as reflected by the number of interactions or direct connections between sectors. Regarding the SSB, the corresponding node (S11) has a relatively medium size, its colour is relatively light and the connections are relatively significant, judging by the thickness of the connecting lines as shown in Figure 2. The main inter-sectoral flow of SSB sector occurs with the food sector (S48). This indicates that the SSB sector has little influence on the remainder of the economy, since it has little productive connections with other sectors[3].

Figure 1. Representation of the Brazilian Input-Output Matrix

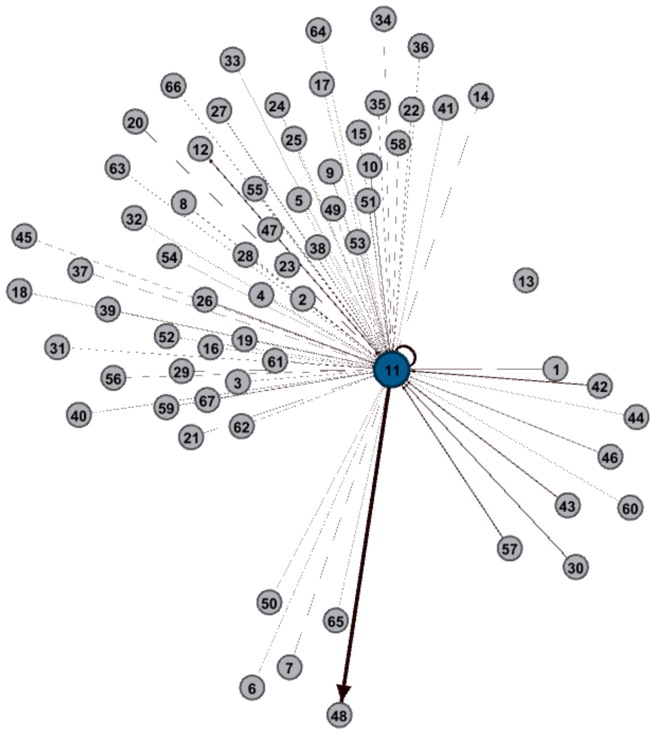


Source: Own elaboration based on POF 2008-2009 and National Accounts data.

Considering these connections, the first simulation shows that a tax increase of 10% on the value added of sugary drinks contracts this sector by 2.84% due to an increase of 2.95% in the final price of these beverages. The other sectors are less affected by the tax increase because their prices are impacted indirectly via inter-sectoral relations as shown in Figure 3. As expected, sectors with strong input-output relations with the target sector were also affected, but in smaller proportions. This is the case of other beverages sector, with an estimated drop in production of 0.250%, food services (-0.205%) and accommodation services (-0.045%).

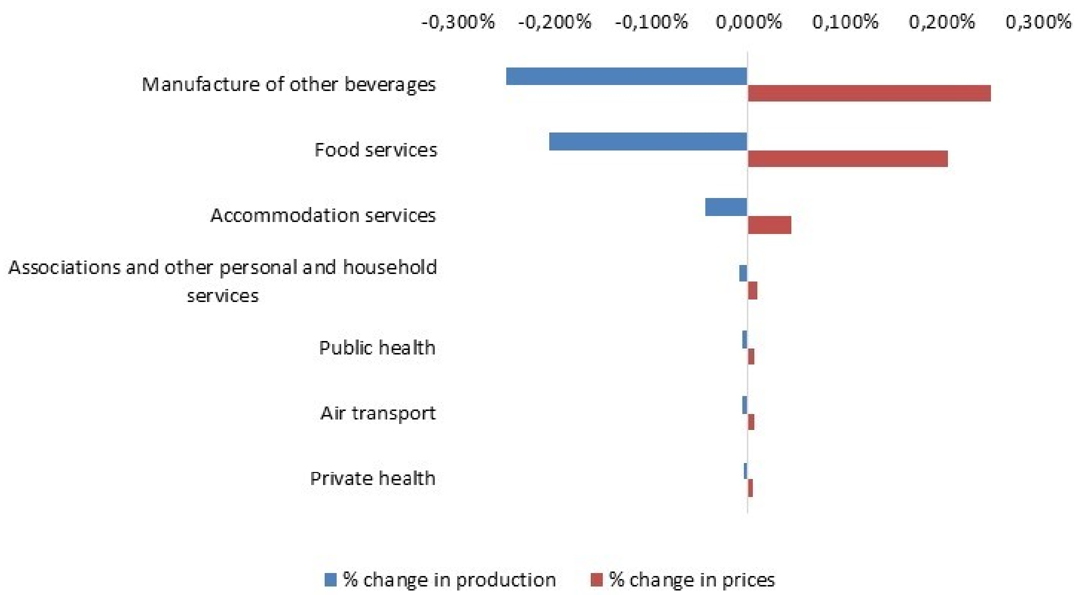
[3]The identification of other sectors is shown in Appendix B.

Figure 2. SSB sector input-output matrix



Source: Own elaboration based on POF 2008-2009 and National Accounts data

Figure 3. Simulation 1: change in production and prices of a 10% increase in SSB tax in selected sectors

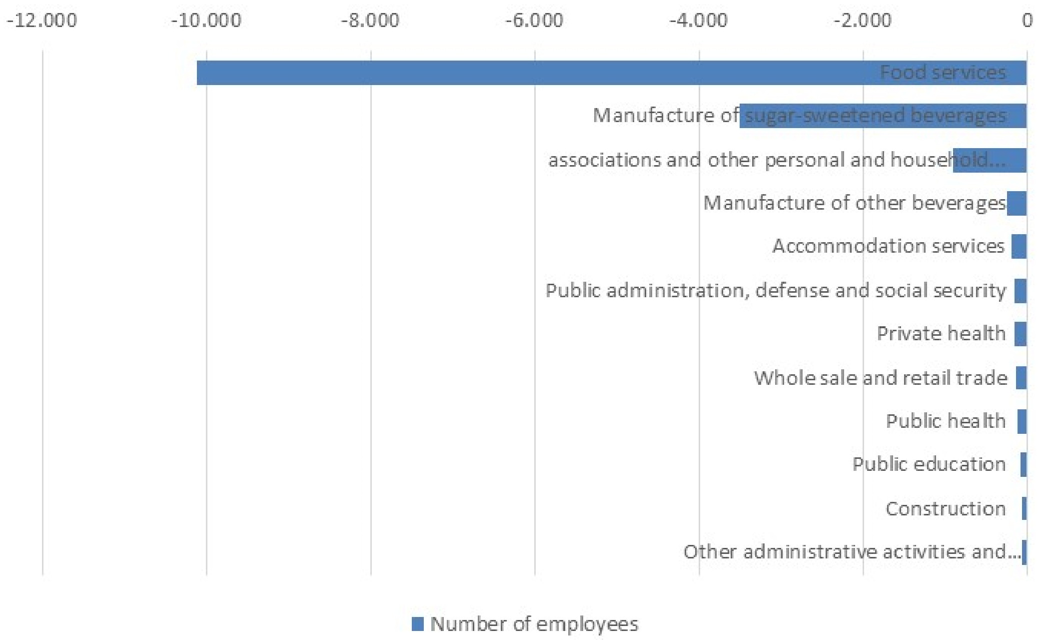


Source: Own elaboration based on POF 2008-2009 and National Accounts data.

The sum of all variations results in a decrease of 0.0207% in the total output of the economy. The results also show the impact on prices increase (0.0213%) by an amount lesser than the tax amount, considering a pass-through rate of 100%.

Concerning to employment, the economy loses 16,176 jobs, among which 21.66% occur in the sector itself, and the remaining in sectors directly related to the SSB or sectors related to food and drinks in general. Due to the high intensity of labor usage, and the deep connection with SSB sector, food services losses 10,127, or 62.60% of total losses. These losses were calculated by employment coefficients, and they are directly linked to changes in the estimated sector production after the introduction of the tax. Figure 4, resumes sectorial information.

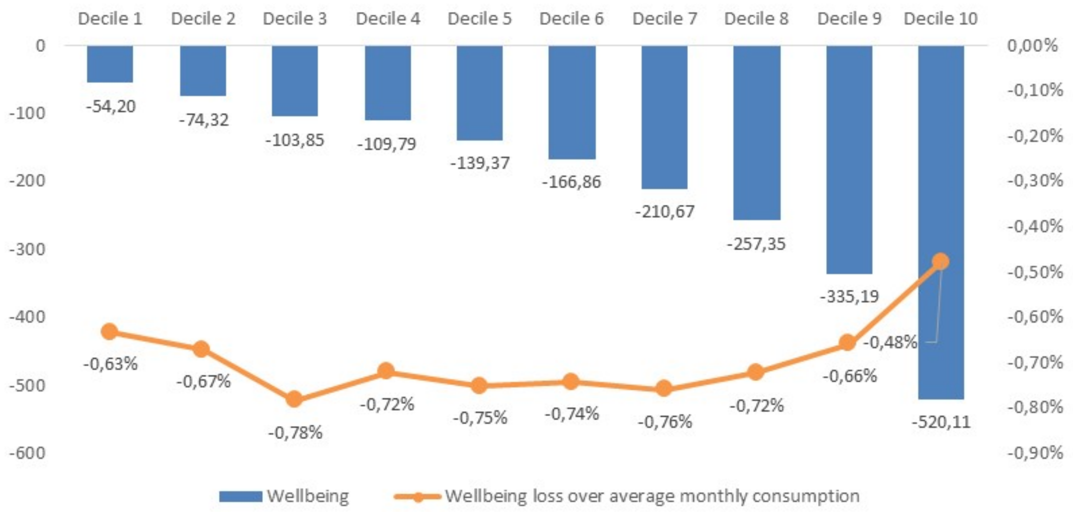
Figure 4. Simulation 1: effect of a 10% increase in SSB tax on employment in selected sectors



Source: Own elaboration based on POF 2008-2009 and National Accounts data.

Another important result is the compensatory change in well-being of families, since the SSB tax affects the consumption and do not reflect who bear more the tax burden. According to the model assumptions, the introduction of a tax increases the production costs and hence the price. Thus, with the same budget constraint and assuming families do not change preferences immediately after the change in relative prices, it necessarily leads to a loss of well-being for all family types as shown in Figure 5. The welfare loss was calculated in monetary terms; therefore, the last decile has a larger loss because total expenditure in SSB is bigger. However, when we look at the relation between wellbeing loss and the average monthly consumption for each household, low- and medium-income families are relatively the most affected.

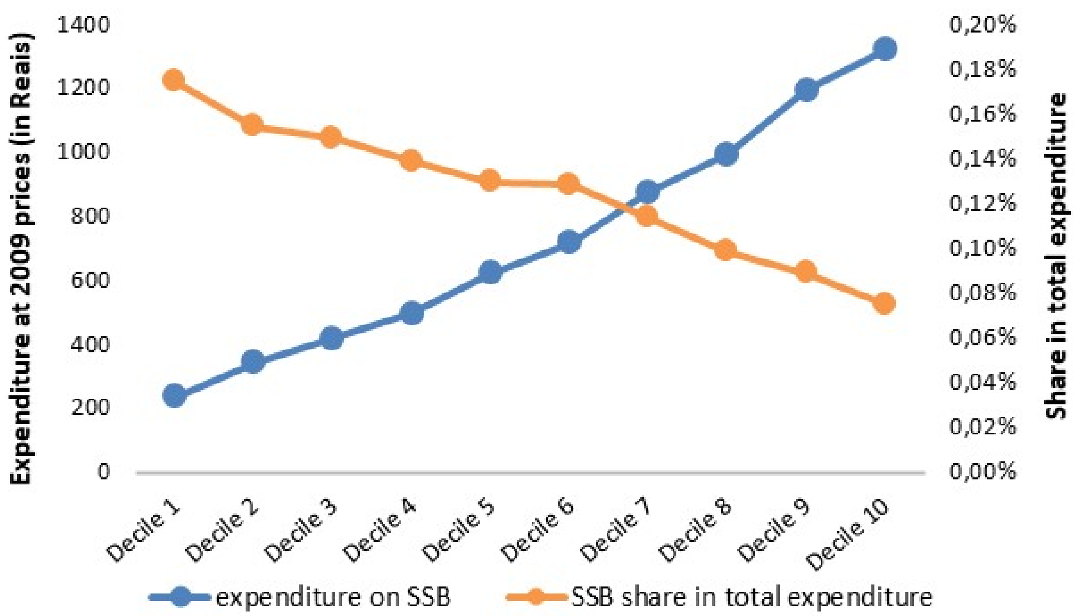
Figure 5. Simulation 1: compensatory variation of welfare by decile of per capita income resulted from a 10% increase in SSB tax (in R$ millions)



Source: Own elaboration based on POF 2008-2009 and National Accounts data.

The values represent the monetary values that the families of each decile would receive to be offset by the welfare loss, so that they could continue to buy the same products after change in prices. The distribution is clearly progressive over the decision. In other words, the highest deciles of income distribution lose more with taxation. This occurs because they are the major consumers of SSB in Brazilian population in terms of gross expenditure, even though the share of sugary drinks in total household expenditure is decreasing along the income distribution, as shown in Figure 6.

Figure 6. Expenditure on SSB per decile of per capita income

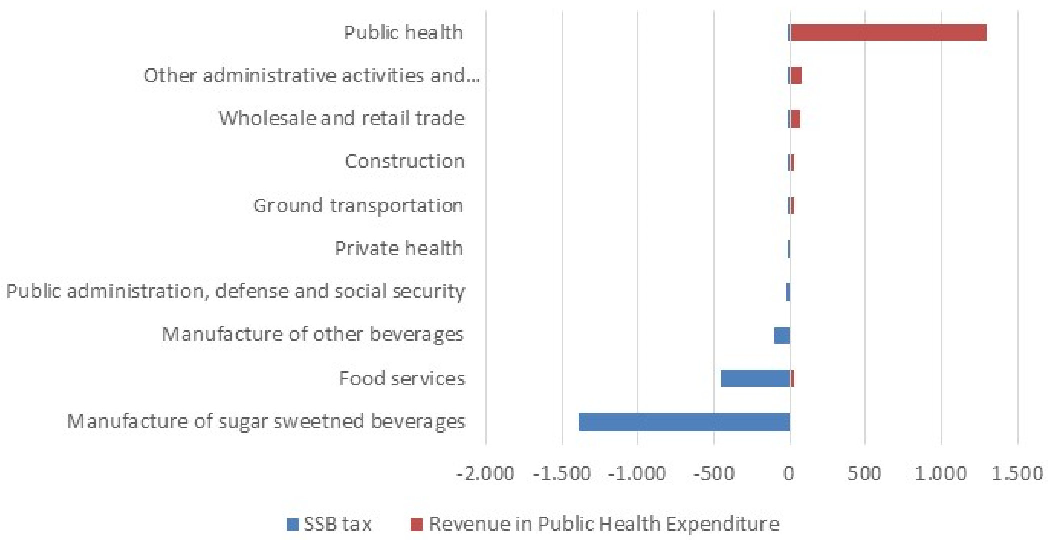


Source: Own elaboration based on POF 2008-2009 and National Accounts data.

In terms of government revenues, the results indicate that a 10% increase of SSB tax can raise the revenue at BR$ 1,301.44 million at 2015 prices[4]. If this value were used directly in obesity prevention actions, it could contribute to increase the effectiveness of this policy and to reduce obesity.

In the second simulation, in addition to tax induced price changes, the revenue from the SSB tax is allocated in public health, partly compensating the negative effects. Figure 7 shows public health production would increase by BR$ 1.3 billion, which corresponds to a net effect of 0.72% increase, and other sectors related to it would also be benefited, such as Other administrative activities and complementary services and Wholesale and retail trade. On the other hand, Manufacture of sugar sweetened beverages would recovery only BR$ 2 million, compared to around BR$ 1.4 billion losses after tax. At the aggregate level, the net loss estimated in the second simulation is BR$ 218 million.

Figure 7. Simulation 2: effect of a 10% increase in SSB tax and revenue invested in public health on sectoral production (million BR$)

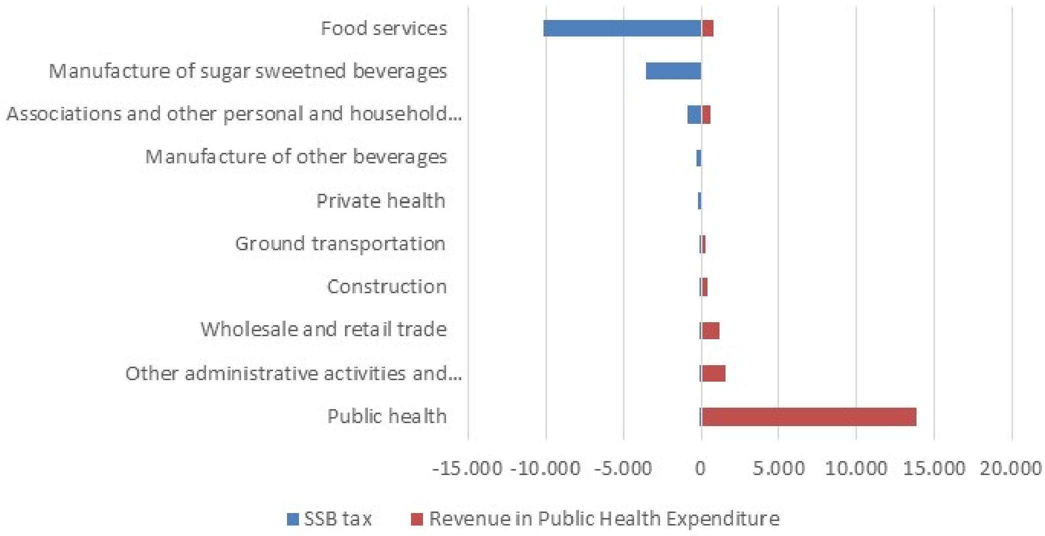


Source: Own elaboration based on POF 2008-2009 and National Accounts data.

In terms of employment, Figure 8 shows an increase in 13,828 occupations in public health after the revenue reinvestment, leaving a net effect of 13,713 jobs created in simulation 2. In aggregated terms, we estimate a net increase in 4,743 occupations in the economy, compensating the reduction imposed by the tax.

[4]It corresponds to around 333 million (American) dollars, according to the exchange rate in the end of 2015, which was 3.90 BR$/$.

Figure 8. Simulation 2: effect of a 10% increase in SSB tax and revenue invested in public health on employment



Source: Own elaboration based on POF 2008-2009 and National Accounts data.

4. Final Remarks

This paper estimated the effects of tax increase of sugary drinks for the Brazilian economy, focusing on the impact on household consumption, production, employment and tax revenues of the government. In order to identify these effects, we considered productive relations of SSB sector by calculating the forward and backward indices and employment multipliers based on the input-output matrix of Brazilian economy. Additionally, we used the Leontief price model incorporating the disaggregation of household consumption vector in order to identify this effect for different income groups.

The main conclusion of this study is that a tax increase applied to the sugary drink industry generates slightly impacts on the economy to reach the expected reduction of household consumption for this product. The additional tax would significantly reduce the consumption of sugary drinks in the short term. Additionally, if the revenue is invested in public health, the aggregated effects on production could be partially offset, and employment effects could be positive.

These results reflect a short-term effect of rising prices on the economy. Over time, it is expected that raising the price would change the consumption profile of families and that they would further reduce the sugary drinks consumption. This effect may be sensitive to the pass-through rate, that was 100% in our model. A recent study of Pereda and Garcia (2020) suggests that this pass-through rate ranges from 15-124% depending on the firm size and the type of product. In case of carbonated sugary drink, specifically, only larger firms pass on taxes to final prices.

Considering the additional tax of 10% and its effects on economy, the results show little reduction in aggregate output given that: 1) the sector has few intersectoral relations, 2) it is intended to meet final demand and 3) it has small share in the total economy. The effect on employment was negative, with most part of this impact occurring in other sectors. This result does not account for either income effect, which allows increase the consumption of other goods and services or government spending of new tax revenue. It is in the same direction to the results evidenced to Powell et al. (2013) in similar condition.

The model results also showed the direct increase of more than 1.3 billion in government revenue that could be used in the prevention of obesity and contribute further to contain the epidemic progress of this disease. In summary, the results show that the tax on sugary drinks have a significant impact on consumption in the desired direction and in the capability of revenue generation, but generating harmful results in terms of aggregate employment and production when we don't consider the income effect and the government spending.

Despite the contributions made by this paper, it has limitations arising from the assumptions made in constructing the model. Firstly, as we do not have better data, the SSB sector was disaggregated considering a fixed percentage, used for all intermediate and final consumption. Secondly, the increase in prices is assumed to come from a full transfer of a tax increase, which is a function of the producer decision to bear that cost or pass it on to consumers. The same effect could be achieved if there were increased costs due to increases in the cost of inputs, for example. Thirdly, the model does not allow the specification, or the distinction of the effects obtained by increasing specific taxes such as IPI and PIS/Cofins. Fourthly, we regarded SSB as its own unique sector of economy, but SSB producers also make other beverages like diet beverage, bottled water, etc. Finally, the model does not consider substitution effects in household consumption. Nevertheless, such limitations do not invalidate but complement the results obtained here. These in turn allow us to identify the effects of this policy in a broader way, leaving future works to investigate these differences. Some of the limitations such as the possibility of substitution could be better addressed in a Computable General Equilibrium framework.

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Larissa B Cardoso: Conceptualization, Methodology, Data curation, Writing - Original Draft. **Giácomo Balbinotto Neto:** Supervision, Writing - Review & Editing. **Flaviane Souza Santiago:** Methodology, Investigation, Visualization, Writing - Review & Editing. **Kênia Barreiro de Souza:** Methodology, Data curation, Software. **Rafael Morais de Souza:** Writing - Original Draft, Visualization.

Appendix:

A. Summary of the effect of tax on soft drinks consumption

A.1. Summary of the effect of tax on soft drinks consumption

Author/year/country	**Population**	**Model**	**Outcome Variable**	**Own-price elasticity**
Brown (2008)	National sample of retailers	Rotterdam model (two specifications)	Juice drink sales Carbonated soft drink sales	**-1.71, -1.52 -1.76, -1.96**
Barquera et al. (2008), Mexico	National sample of households	Cross-sectional	Soda	**-1.09**
Zheng and Kaiser, (2008b), USA	Aggregated US national sample	AIDS	Carbonated soft drink consumption per capita	**-0.61**
Zheng and Kaiser, (2008a), USA	Aggregated US national sample	AIDS, Rotterdam model	Carbonated soft drink consumption per capita	**-0.52, -0.31**
Duffey et al. (2010)	Adults aged 18-30 in baseline year	Cross-sectional	Regular carbonated soft drink consumption	**-0.71**
Finkelstein et al. (2010), USA	National sample of households	Demand system	Carbonated SSB purchases	**-0.87**
Smith, Lin, and Lee (2010), USA	National sample of households	AIDS	SSB purchases	**-1.27**
Zheng, Kinnucan, and Kaiser (2010)	Aggregated US national sample	Linear, Semi-log, Rotterdam model and AIDS	Carbonated soft drink consumption per capita	**-0.60, -0.37, -0.43, -0.77**
Lin et al. (2011), USA	National sample of households	AIDS	SSB purchases	Low income: **-0.95** & High income: **-1.29**
Zhen et al. (2011), USA	National sample of households	AIDS	Regular carbonated soft drink purchase & Fruit drink purchase	**-1.06 to -1.54** & **-1.44 to -2.65**
Claro et al. (2012), Brazil	National sample of households	Cross-sectional	SSB purchases	-0.85
Dharmasena and Capps (2012), USA	National sample of households	AIDS	Regular carbonated soft drink purchase & Fruit drink purchase	**-2.26** & **-0.69**
Finkelstein et al. (2013), USA	Aggregated US national sample	Cross-sectional	SSB purchases per capita	**-1.32**
Zhen et al. (2013), USA	Aggregated US national sample	AIDS	Carbonated soft drink consumption per capita	**-1.035**
Basu et al. (2014), India	National sample of households	QAIDS	SSB purchases	**-0.94**

Source: Powell et al. (2013), Cabrera Escobar et al. (2013)

B. Identification of the vertex on Figure 1 and Figure 2

Sector	Label
S1	Agriculture, including support to agriculture
S2	Livestock, including support to livestock
S3	Forest production, fishing and aquaculture
S4	Coal and non-metallic minerals
S5	Oil and gas extraction
S6	Iron ore
S7	Non-ferrous metallic minerals
S8	Meat, dairy and fish products
S9	Sugar manufacturing
S10	Other food products
S11	Sugar-sweetened beverages
S12	Other beverages
S13	Tobacco products
S14	Textiles
S15	Clothing and accessories
S16	Leather and footwear
S17	Wood products – exclusive furniture
S18	Cellulose and paper products
S19	Newspapers, magazines and records
S20	Oil and coke refining
S21	Biofuels
S22	Chemicals
S23	Pesticides, disinfectants, paints and others chemicals
S24	Perfumery, hygiene and cleaning
S25	Pharmaceuticals products
S26	Rubber and plastic itens
S27	Non-metallic mineral products
S28	Manufacture of steel and derivatives
S29	Metallurgy of non-ferrous metals
S30	Metal products – excluding machinery and equipment
S31	Manufacture of computing, electronic and optical products
S32	Machinery and equipment, including maintenance and repairs
S33	Machinery and mechanical equipment
S34	Trucks and buses
S35	Parts and accessories for motor vehicles
S36	Other transport equipment
S37	Furniture and products from various industries
S38	Maintenance and repair services
S39	Electricity, gas and other utilities
S40	Water and urban clean
S41	Construction
S42	Wholesale and retail trade
S43	Ground transportation
S44	Water transportation
S45	Air transport
S46	Storage and mail
S47	Accommodation
S48	Food services
S49	Editing
S50	Television, radio
S51	Telecommunications
S52	Information services
S53	Financial intermediation and insurance
S54	Real estate and rental services
S55	Legal, accounting and consulting services
S56	Architectural, engineering and technical services
S57	Other services
S58	Non-real estate rentals and intellectual property asset management
S59	Other administrative activities
S60	Surveillance and security
S61	Public administration, defense and social security
S62	Public education
S63	Private education
S64	Public health
S65	Private health
S66	Artistic and entertainment activities
S67	Associative organizations and other personal services