Investigating the Supply-side effects of a tax on Sugar-Sweetened Beverages in South Africa

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Abstract

This paper investigates the impact of the Health Promotion Levy (HPL) on the supply-side response by Sugar Sweetened Beverage (SSB) producers. The supply-side response consists of two key actions undertaken by suppliers: product reformulation and changes in packaging size. The paper seeks to fill important gaps in the existing empirical literature, given the relatively limited research conducted on this topic, particularly in the South African context. The paper finds evidence of significant product reformulation in response to the HPL. Furthermore, there appears to be an industry-wide shift towards smaller packaging sizes for SSBs, as producers aim to reduce their tax liability from the HPL. Combining these results with findings from elsewhere, the high level of product reformulation in response to the HPL is estimated to cause a reduction in sugar consumption of approximately 3.27 kilograms per capita, per year. Given the limited scope of this analysis, the paper assumes that this reduction in sugar consumption is synonymous with improved public health levels. However, it is noted that future research should be conducted on the extent to which producers have used sugar substitutes in beverages, in order to gain deeper insights into the impact of the HPL on public health.

1. Introduction & Background

In April 2018, a tax on the sugar content of sugar-sweetened beverages – called the Health Promotion Levy -- was implemented in South Africa (Essman *et al.,* 2020). The primary aim was to reduce the sugar consumption levels of consumers. SSBs are classified as non-alcoholic beverages that contain added levels of sugar, for example carbonated sodas and "juice drinks" (Hu, 2013). Exempt from the HPL are 100 per cent fruit juices and unsweetened milk and milk products (National Treasury, 2016).

The importance of a policy of this nature is that it is based on empirical research that has determined strong links between sugar intake, obesity, and a variety of other non-communicable diseases, such as type 2 diabetes (Du *et al.*, 2018). Given the large amounts of "readily absorbable" sugars contained in the majority of SSBs (Schulze *et al.,* 2004), the implementation of the HPL was a pressing need for the government, particularly against the backdrop of the rapidly increasing incidence of obesity, both nationally and internationally (National Treasury, 2016).

The initial tax implemented in South Africa in 2018 entailed the determination of a threshold level of sugar content within beverages, 4g/100ml. Beyond this threshold level, SSBs were taxed at a rate of 0.021 ZAR per additional gram of sugar in the beverage (Stacey *et al.*, 2019). The tax was increased in 2019 to 0.0221 ZAR per gram of sugar beyond the 4g/100ml threshold (DiabetesSA, 2020).

The extent to which the policy succeeds in curbing consumer intake of sugar from SSBs depends on two key assumptions, grounded in economic theory. First, it is assumed that by implementing the tax, the price of sugar-sweetened beverages will rise (assuming that sugar content in the beverages does not decrease to levels below the taxable amount). This will potentially induce consumers to reduce their demand for these products, through income and substitution effects. Alternatively, the tax may incentivize producers either to reduce the sugar content of their beverages (product reformulation), or to change the sizes of the bottles/cans in which the beverages are distributed. Both of these supply-side responses are expected to impact the sugar intake of consumers.

Despite the fact that the SSB tax is expected to have non-trivial effects on the supply-side response, the existing literature on the topic primarily deals with the demand-side effects of the HPL (Claudy *et al*., 2020). This paper will focus solely on the supply-side response to the sugar tax in the country, in an effort to address this gap in the literature.

The paper uses a sample of thirty-eight unique SSBs. The small size of the sample is due to the lack of available information on sugar content prior to the implementation of the HPL. A Difference-in-Difference (DID) regression is implemented to determine the extent to which the sugar content of the SSBs in the sample differed between pre- and post-tax levels. Beverages below the taxable threshold of sugar content, pre-HPL, form the control group, while the remainder of SSBs in the sample form the treatment group.

The regression results indicate significant declines, both statistically and practically, in the sugar content of SSBs in the treatment group, from pre- to post-HPL. Furthermore, the paper finds evidence in favour of an industry-wide shift towards the use of smaller packaging sizes in response to the HPL. Both of these results arise from the incentives for suppliers to reduce their tax liability resulting from the HPL. These findings are important, given the expected reductions in sugar consumption as a result of these two supply-side responses.

It is, however, important to note that this paper does not explicitly consider the impact on public health levels from changes in the supply-side response. Owing to its limited scope, the paper does not consider the impact of substitution to other sweeteners by producers or the potential negative health effects that these alternative sweeteners may have. It is therefore imperfectly assumed, for this paper, that a reduction in sugar consumption is synonymous with improved health. Substitution towards non-nutritive sweeteners, such as stevia and aspartame, is therefore a third supply-side response that has likely occurred in response to the tax. The long term health benefits of these sweeteners are still relatively unknown (Zhang *et al*. 2015). Hence, the paper recommends that further research be conducted on the potential health effects of substituting sugar in favour of non-nutritive sweeteners. This will help give a clearer indication of the success of the HPL in improving public health levels.

Section 2 of this paper will briefly discuss the empirical literature relating to the HPL, including an overview of the empirical findings on the effectiveness of similar taxes that have been implemented elsewhere. *Section 3* briefly describes the data and methodology used in the paper. *Section 4* and *Section 5* discuss the results found in the study, including limitations of the paper and recommendations for areas of further research.

2. Literature Review

In light of the “severe and growing” obesity epidemic faced by South Africa (Stacey *et al.*, 2017), there is a need to determine the extent to which the tax on SSBs has impacted sugar intake (which is strongly correlated with the development of type 2 diabetes) by consumers.

Despite this, and possibly because the SSB tax in South Africa is relatively recent, literature relating to its impact within the country is sparse, especially in empirical studies that investigate the supply-side response. The following literature review will discuss the key empirical work that has been conducted on both the demand-side and supply-side responses to the introduction of SSB taxes, both nationally and internationally.

2.1 Brief Overview of Different Tax Regimes

South Africa currently uses an ingredient-based tax on SSBs – meaning that the level of tax liability for brands in the industry depends on the sugar content of the beverages. Tax levels may vary substantially between brands, creating an incentive for firms to reformulate their products in order to reduce their tax liability (Stacey *et al*., 2019). Similar ingredient-based tax structures have been implemented in other countries, such as the United Kingdom and Portugal (WHO, 2016).

This form of ingredient-based taxation is recommended for SSBs, given the additional supply-side incentives created by the tax, above and beyond the demand-side effects of the tax (WHO, 2016). It is expected that taxes of this type will have a greater effect on curbing sugar consumption levels, relative to taxes that solely impact the demand-side response (WHO, 2016; Hernandez & Ng, 2021). Despite this expectation, the ingredient-based tax structure is not uniform across the globe, with many countries, such as Mexico and France (amongst others), opting to implement fixed taxes based on volume (WHO, 2016). The supply-side incentives, or lack thereof, resulting from the different tax structures therefore differ significantly between countries.

Of the ingredient-based taxation structures, the United Kingdom uses a tiered tax structure on SSBs (Scarborough *et al*., 2019). A “lower rate” of tax (0.18 GBP/litre) is applied to beverages containing between 5g and 8g of sugar per 100ml, while a “higher rate” of tax (0.24 GBP/litre) is charged on SSBs containing more than 8g of sugar per 100ml (F.O. Licht, 2019). This is therefore considered to be an ingredient-based tax, implemented with the explicit aim of encouraging producers to either reformulate beverages or reduce portion sizes (gov.uk, 2016).

Fixed/volumetric taxes on SSBs, the alternative to ingredient-based taxes, fail to create the same supply-side incentives observed elsewhere (Stacey *et al*., 2019). Mexico provides an example of a country implementing this type of tax structure, where a 1 peso/litre tax is placed on all SSBs produced within the country, irrespective of sugar content (Colchero *et al*., 2015). Direct comparisons between the outcomes of Mexico's fixed-tax structure and the ingredient-based taxes implemented in South Africa and the United Kingdom were conducted by Hernandez & Ng (2021). Their findings indicate, as hypothesized, that ingredient-based taxes were more effective at reducing sugar consumption than volumetric taxes. Reductions in sugar purchases under the ingredient-based taxes were twice as large as those arising from the volumetric taxation (Hernandez & Ng, 2021). This indicates the key role that product reformulation can have on sugar consumption levels.

2.2 Demand-Side Effects

The theoretical intuition behind the HPL lies in the assumption that potential increases in prices as a result of the tax will serve to reduce consumer demand for these products – a feature of consumer behaviour that depends on the price elasticities of the goods. Research conducted by the WHO (2016) indicates that SSBs typically tend to be price inelastic, citing the need for taxes on these products to be "high enough" to reduce consumption levels significantly.

Prior to the implementation of the HPL in South Africa, empirical work was conducted by Stacey *et al. (*2017) to determine the estimated price and expenditure elasticities of beverages throughout the country. In contrast to the analysis by the WHO (2016), the study concluded that implementation of a SSB tax in South Africa is likely to curb the demand for these products significantly, due to the "sufficiently" high level of price elasticity of demand associated with SSBs (the own price elasticity of demand was found to be -1.18 for SSBs). Similarly to Stacey *et al. (*2017), international studies, such as Colchero *et al. (*2015), also find evidence that SSBs in Mexico are price elastic. Hence, both papers highlight the potential for SSB taxes to significantly reduce demand in these regions.

The results obtained from Colchero *et al. (*2016) give credence to the elasticity predictions discussed above, by showing that the implementation of a tax on SSBs in Mexico induced a decline in household purchases of SSBs by 6%, within its first year of implementation. Although the study was conducted in a wholly different environment to that of South Africa, the findings at least provide some insight into how consumers are likely to respond to changes in the price of sugar-sweetened beverages, providing evidence in favour of the use of SSB taxes as an effective mechanism to reduce sugar consumption. Furthermore, the ingredient-based tax structure, as implemented in South Africa, also provides incentives for producers to reformulate their products. It is expected that this will create further reductions in sugar consumption levels relative to Mexico, where the tax is primarily focused on reducing demand for SSBs.

In terms of the effects of the HPL on price levels, Stacey *et al. (*2019) follow up their previous research and find that post-tax prices of all carbonated beverages were 1.006 ZAR per litre higher after the 2018 tax than they were before the tax was implemented. Ultimately, the results from this paper back up the intuitive expectation that SSBs subject to the tax experienced significant price increases, while null price increases were observed for beverages not subject to the tax, at the aggregate level (Stacey *et al*., 2019). Given that previously Stacey *et al. (*2017) found evidence that SSBs in South Africa are price elastic, it can be deduced that the increase in prices of the beverages at the aggregate level were met with significantly large reductions in purchases, thereby reducing the level of sugar consumption throughout the population.

2.3 Supply Side Effects

Up to this point, the literature discussed has been primarily concerned with the demand-side effects of SSB taxes under different tax structures. This analysis has been included to show that demand-side effects of the tax can be effective in reducing sugar consumption levels. However, the analysis overlooks the additional effect, over and above the demand-side effects, that taxes may have on sugar consumption, through the supply-side response. In the case of SSBs, this can involve both product reformulation and changes in packaging size – two factors that may significantly impact sugar consumption levels.

The ingredient-based SSB tax implemented in South Africa incentivises producers to implement the supply-side responses mentioned, as they can reduce their tax liability through these measures (Blecher, 2015; Stacey *et al*., 2019). This provides producers with an additional option when faced with the tax, as opposed to simply increasing the prices of their products. According to Blecher (2015), this may have the knock-on effect of significantly benefitting public health by reducing the sugar intake of consumers, without simply relying on consumers changing their spending behaviours in response to price increases resulting from the tax (Blecher, 2015).

Stacey *et al. (*2019) conducted the primary local empirical study on the role of the HPL on product reformulation. The findings in this paper confirm the prediction of product reformulation in response to the tax, with results indicating significant differences in sugar content across brands pre and post-tax. A further interesting observation is that brands that reformulated also showed price increases, despite the reductions in tax liability (Stacey *et al.,* 2019). This finding is probably indicative of the fact that product reformulation is costly, perhaps because of shifts towards using more costly sugar substitutes (Stacey *et al.,* 2019). This may create a scenario wherein both the supply- and demand-side effects work in tandem to reduce overall sugar consumption.

These findings support implementing taxes that create supply-side incentives, in order to reduce sugar consumption levels beyond the levels achieved by taxes that only induce demand-side effects. This logic appears to be backed up by Stacey *et al.* (2021), who find a far larger reduction in the volume of SSB sales, post-tax, in South Africa, relative to the reductions in sales, post-tax, in Mexico. The significant differences may indicate that tax regimes centred around creating supply-side incentives (South Africa) are more effective at reducing consumption levels of SSBs, relative to taxes that do not create these types of incentives (Mexico). Results of this nature have been confirmed by multiple separate studies on the topic, such as Essman *et al.* (2020) and Hernandez & Ng (2021).

Stacey *et al*. (2021) provides important, and recent, insights into the impact of the HPL on sugar consumption levels in South Africa. The paper finds significant reductions in mean sugar consumption from pre-HPL announcement to post-implementation (5.62g/capita per day). Furthermore, the paper finds that post-announcement of the HPL, but pre-implementation, there was a decline in the average sugar consumption from taxable beverages by 1.99g/capita per day. The data were collected through use of monthly household purchases of beverages, using Kantar Europanel data. Although it is implicit in these results that shifts in the supply-side response have been caused by the HPL; the paper does not explicitly model or discuss these changes at a brand level of analysis. Hence, this paper seeks to build on the results in Stacey *et al*. (2021), by analysing the mechanisms through which the observed reductions in sugar consumption have occurred. The main argument of this paper, is that this has primarily occurred through product reformulation and changes in the packaging sizes of SSBs.

The international literature on the supply-side effects of SSB taxes appears to be relatively more well-developed. Findings from empirical studies in the United Kingdom indicate that producers of SSBs there are undertaking product reformulation to reduce sugar content significantly in response to the ingredient-based tax (Roache & Gostin, 2017). Confirming these findings, Scarborough *et al.* (2020) find significant reductions in the proportion of SSBs containing over 5 grams of sugar per 100 ml – falling from an expected level of 49% to 15% of the market. Conversely, demand-side effects in response to the tax, resulting from price level increases, were found to be minimal (Scarborough *et al.,* 2020). The lack of demand-side adjustment may, however, be a fairly trivial matter. This is because recent studies conducted on the impact of SSB taxes on public health, such as Briggs *et al.* (2017), have determined SSB reformulation to be the most effective measure of improving public health levels. These findings provide strong evidence in favour of implementing ingredient-based tax regimes in order to improve public health levels most effectively.

Beyond product reformulation, the second type of supply-side incentive created by ingredient-based sugar taxes, such as the HPL, is the incentive for producers to reduce the packaging size of their products (termed “shrinkflation”). While this response has not necessarily been measured in the SSB industry, empirical studies have noted the significant impact of sugar taxes on reductions in the size of chocolate bars (Houghton & Houghton, 2018). This “unintended” consequence of sugar taxes has occurred as manufacturers attempt to maintain profits without corresponding increases in price. Hence, consumers pay the same price for chocolate bars, yet have lower sugar intake than before (Houghton & Houghton, 2018). According to Houghton & Houghton (2018), sugar taxes levied on SSBs may have a similar effect on the supply-side response by SSB manufacturers to what has been observed in the chocolate industry. This hypothesis is backed up by Jensen *et al.* (2021), who find that the ingredient-based tax implemented in the United Kingdom was an “important” cause of the observed decrease in pack sizes across the SSB industry.

3. Data

The data used for this paper consist of both primary and secondary data. The primary data were obtained by physical inspection of the sampled brands' sugar content levels. The information was gathered from various stores in the area[1], using the nutritional information panel (NIP) found on the packaging of beverages. The primary data collection provides the data for the 2021 sugar content levels of the brands studied.

The secondary data were obtained from a wider range of sources. A portion of the pre-tax sugar content information (collected in March 2018) was provided by an unnamed source[2], who collected the data using the NIP found on all food and beverage products between 2017 to 2021. This research has been conducted for an, as yet, unpublished research paper. The sugar content information was directly provided by the authors of this paper, via email communications. Further data on the pre-tax sugar content (collected in 2014) were provided by Nick Stacey, who curated the information for Stacey *et al.* (2019). Further secondary data pertains to the industry-wide changes in packaging sizes from pre- to post-HPL. This information was collected in July 2017 and July 2018. Given the sensitive nature of this information, the source has asked to remain anonymous.

The final source of data was documents provided by a senior employee at RCL foods (of which Selati is a brand), which provided further information on the effectiveness of the HPL in curbing sugar consumption levels pre and post-tax. The data provided in this document are based on five SSB brands in the industry (Coca-Cola, Quality Beverages, Twizza, Kingsley and Little Green Beverages [LGB]), which, combined, account for 98% of the market for SSBs in South Africa. This information was used to determine, in part, the role that the HPL played in inducing product reformulation and, as a result, changes in sugar consumption levels. Changes in sugar consumption are calculated by using the pre-tax volumes of consumption and extrapolating how much sugar "should have" been removed, given the product reformulation that occurred in response to the HPL.

[1] Here, "area" refers to spaza shops and chain stores in the Western Cape, Southern Suburbs. Data were collected over the period between April to July 2021.

[2] Given that this paper explicitly uses brand names in the analysis of results, this source has specifically asked to remain anonymous. This is due to the fact that the anonymous researcher has agreed with the supermarkets from which the information was collected, to "not disclose any information by brand name."

To observe changes in product reformulation, the paper uses panel data. These consist of the sugar content of thirty-eight SSBs at three distinct points in time: 2014 (prior to the announcement of the HPL), 2018 (pre-implementation of the HPL) and 2021 (3 years following the implementation of the HPL). Nine of the thirty-eight beverages in the sample were “No Sugar” versions of drinks. The remaining twenty-nine beverages all had a sugar content above the taxable threshold prior to the implementation of the HPL.

The sample size was restricted because of limitations in the data. In particular, the sugar content information obtained in the primary data collection phase (for the post-tax values) was dependent on the beverages having existing, pre-tax, sugar content information. As such, data collection was guided by the information provided by the abovementioned sources. The relatively limited pre-tax sugar content information that could be found for this paper significantly reduced the size of the sample that could be used.

However, the fact that all non-zero SSBs in the sample had sugar contents above the 4g/100ml threshold pre-HPL is unlikely to bias the results. This is because the majority of available SSBs across the industry are also likely to have contained sugar content levels above the taxable threshold prior to the HPL implementation. Furthermore, as indicated in *Table 3* (in *Section 4* of the paper), the sample consists of brands with a large cumulative share in the SSB industry. The table indicates that, as of 2016, Coca-Cola and Kingsley alone had a combined market share of 79%. Both of these brands are included in the sample for this paper. It is unlikely that these figures have deviated substantially since 2016, hence the small sample can still provide a relatively accurate indication of the sugar content levels of SSBs throughout the industry. The results are, therefore, likely to give a realistic indication of product reformulation in response to the HPL, across the industry.

Table 1: Pre-Post Sugar Content in grams/100ml (Excluding Sugar Free Beverages)

Brand	**Type**	**Pre-Tax (2014-2018)**	**Post-Tax (2021)**	**% Change**
Bos	Original	6,6	4,8	-27.27
Stoney	Stoney	11,6	7,4	-36.21
Coca-Cola	Original	10,6	10,6	0
Sprite	Lemon Lime & Cucumber	10,2	3,1	-69.61
Sprite	Lemon Lime	10,2	3,1	-69.61
Lipton Ice Tea	Peach	8	3,9	-51.25
Lipton Ice Tea	Lemon	4,5	3,8	-15.56
Lipton Ice Tea	Raspberry	4,5	4	-11.11
Fanta	Grape	13,5	6,4	-52.59
Fanta	Pineapple	12,3	7,5	-39.02
Fanta	Orange	12,4	3,6	-70.97
Pepsi	Original	11	7	-36.36
Sparletta	Apple Rush	12,4	3,6	-70.97
Sparletta	Crème Soda	11	3,7	-66.36
Sparletta	Iron Brew	6,6	3,5	-46.97
Sparletta	Sparberry	6,6	3,6	-45.45
Schweppes	Lemonade	11,5	6,3	-45.22
Schweppes	Dry Lemon	12,8	3,1	-75.78
Schweppes	Ginger Ale	8,9	3,7	-58.43
Schweppes	Tonic Water	8,9	8,9	0
Energade	Orange	5,6	4	-28.57
Energade	Grape	5,6	4	-28.57
Powerade	Naartjie	7,7	6,1	-20.78
Powerade	Jagged Ice	7,6	5,9	-22.37
Powerade	Mountain Blast	6,3	6,3	0
Twist	Granadilla	12,5	3,5	-72
Twist	Lemon	9,1	3,6	-60.44
Kingsley	Cola	11	3,5	-68.18
Pick n Pay	Cola	10,8	3,1	-71.30

Table 1 shows the sample of twenty-nine beverages with non-zero sugar content, used for this paper. *Table A1* in the *Appendix* shows the full sample of thirty-eight beverages used for this paper. Information on SSBs with sugar content of 0 grams/100ml were collected purely for the use of the DID regression (discussed below in Section 3.1). A surface-level analysis of the pre- and post-tax columns indicates that the majority of SSBs in the sample were reformulated in response to the HPL. In fact, only three SSB brands in the sample were not reformulated from pre- to post-HPL implementation. Namely, Coca-Cola "Original" (10.6g/100ml), Schweppes Tonic Water (8.9g/100ml), and Powerade "Mountain Blast" (6.3g/100ml). More in-depth analysis of these figures will be conducted in *Section 4* of the paper, in order to determine the extent of the effect of the HPL on product reformulation.

3.1 Methodology

The paper makes use of a single DID regression, in order to determine whether the HPL has caused significant changes in product reformulation. DID regressions are used to determine whether there are significant changes in variables from before, to after a policy intervention has taken place. Hence, the DID regression is useful in this instance, as analysis will be used to determine if there are significant changes in the average sugar content levels of SSBs from pre- to post-HPL. The regression technique requires both a control and a treatment group to compare results. The control group is unaffected by the policy implementation; hence for this paper, the control group consists of beverages below the taxable threshold of sugar content, pre-HPL. Conversely, the treatment group consists of variables that are affected by the policy change. Hence, for this model, the treatment group consists of SSBs above the taxable threshold of sugar content, pre-tax.

The DID model is given by:

$$Sugar = \beta_0 + \delta_0 Time + \beta_1 Treated + \delta_1 Treated * Time$$

where Treated refers to beverages above the taxable level of sugar pre-tax (twenty-nine of the beverages in the sample). Time is the dummy variable that is equal to one if the sugar content of the beverage is its post-tax level, and zero otherwise. Finally, the interaction between Treated and Time is the DID estimator, which is used to indicate whether significant changes in average sugar content occurred from pre- to post-HPL implementation.

4. Results

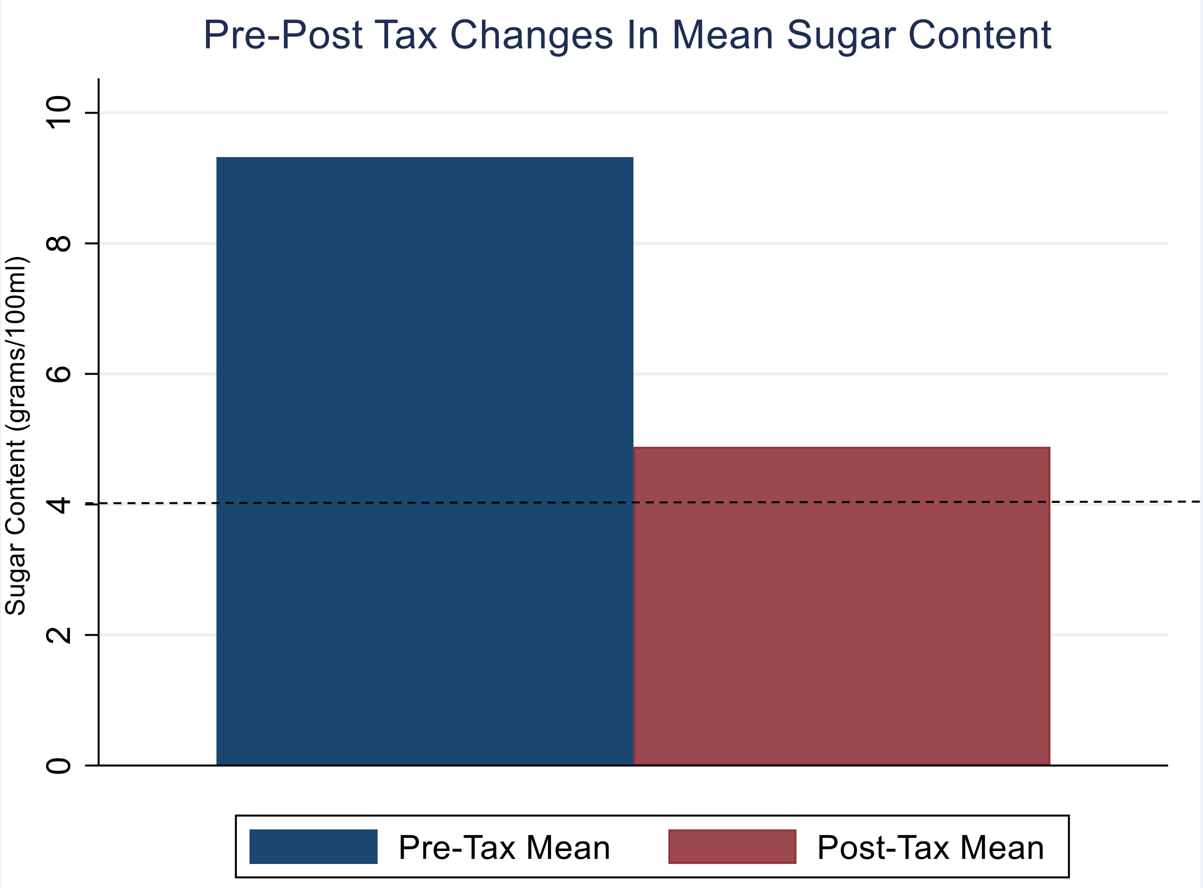
The main aim of the HPL is to reduce sugar consumption levels by consumers – which is necessarily linked to the sugar content found in SSBs. This section looks at the impact of the HPL on the sugar content levels of SSBs from pre-tax to post-tax levels. The expected reductions in sugar consumption resulting from product reformulation, for 2016, will also be analysed. This will help to determine the extent to which the supply-side response has aided the state's goal of reduced sugar consumption levels. Finally, changes in the package size of SSBs, from pre- to post-HPL, will also be considered, given the potential for this type of supply-side response to impact sugar consumption levels by consumers.

Table 2: Descriptive Statistics for Taxable Beverages

Descriptive Statistics of Pre-Post Sugar Content (Excluding Sugar-free Beverages)

	Pre-Tax	Post-Tax
Mean (grams/100ml)	9,320	4,882
Standard Error	0,501	0,364
Median	10,2	3,9
Standard Deviation	2,702	1,960
Sample Variance	7,304	3,844
Minimum	4,5	3,1
Maximum	13,5	10,6
Count	29	29

Figure 1: Changes in Mean Sugar Content



Sources: Unnamed Source, Stacey, N. & Own Data
Note: Dotted Line Represents Taxable Threshold Level of Sugar

Table 2 shows descriptive statistics for the changes in sugar content from pre- to post-HPL implementation. Although these are descriptive statistics, causal effects can still be inferred. This is because there is no logical reason for sugar content levels of SSBs decreasing across the industry post-HPL implementation, other than the tax itself. Row 1 of *Table 2* indicates that the HPL resulted in a reduction in the average sugar content of beverages in the sample, from 9.320g/100ml to 4.882g/100ml, i.e. an average reduction of 4.438 g/100ml. The mean changes in sugar content from pre- to post-HPL are shown in *Figure 1* above.

The above result was then formally tested for statistical significance, found in *Table A2* in the *appendix*. *Table A2* uses the same sample of beverages as *Table 2*. The table indicates, as hypothesized, that there are significant differences in the mean sugar content of beverages between pre- to post-tax levels. The changes in average sugar content, for beverages in the sample above the taxable threshold, from pre- to post-HPL implementation are significant at the 1% level. At least at a surface level of analysis, the HPL appears to have achieved its aim of inducing SSB producers to reformulate their products.

Figure 2:

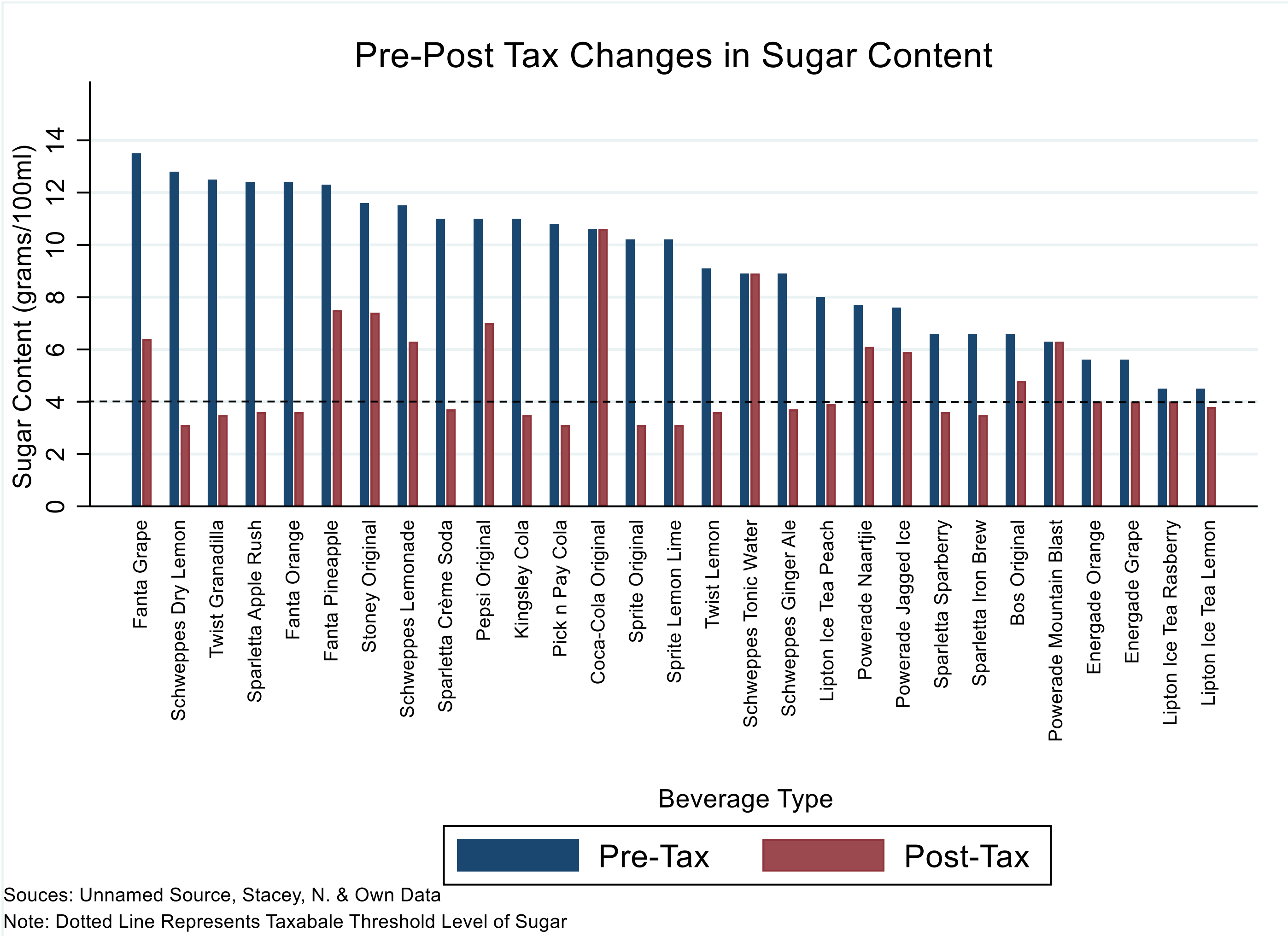


Figure 2 shows pre- and post-HPL information relating to sugar content per litre of several key brands in the industry. Altogether, the pre-post sugar content data of twenty-nine individual South African beverages were collected (excluding sugar-free versions of beverages). The sample is, therefore, relatively small. In order to ensure the sample size was large enough for meaningful inferences to be made, sugar content information from 2014 was combined[3] with sugar content levels from March 2018 to form the "pre-tax" component of *Figure 2*.

[3] This combination of sugar content information for 2014 and 2018 increased the sample size from nineteen to twenty-nine beverages. In other words, sugar content on nineteen of the twenty-nine SSBs in the sample were provided by Stacey *et al.* (2019), while data on the remaining ten beverages were provided by the unnamed source that was mentioned in *Section 3*.

This is a limitation of the dataset, as the paper is unable to determine whether any changes in product reformulation occurred as a direct response to the announcement of the tax in 2016. Previous empirical studies conducted elsewhere, such as Scarborough *et al.* (2020) and Bandy *et al.* (2020), have found evidence to suggest that significant product reformulation occurs during the period between tax announcement and tax implementation. Furthermore, Stacey *et al*. (2021) indicate that prior to the implementation of the HPL in South Africa, but post-announcement of the tax, there was a decline in average sugar consumption levels (from SSBs) of 1.99g/capita per day. Implicit in this finding is that a significant shift in the supply-side behaviour of SSB producers occurred in response to the announcement of the HPL.

Figure 2 suggests that a large majority of SSBs experienced reductions in sugar content levels in response to the HPL (twenty-six of the twenty-nine beverages in the sample reduced their sugar content from pre- to post-tax). Furthermore, eighteen of the twenty-nine beverages that were above the taxable threshold prior to the HPL reformulated their products to sugar content levels below (or equal to) the taxable level cut-off of 4g/100ml, post-HPL implementation. When averaged across the sugar content of all the sampled brands, mean sugar levels decreased by approximately 4.32g/100ml from pre-to post-tax levels (pre-tax mean = 9.27g/100ml, post-tax mean = 4.95g/100ml). This is strong evidence in favour of the hypothesis that the ingredient-based tax implemented in South Africa incentivised SSB producers to reformulate their products. This was expected, given the incentive for producers to reduce, or altogether remove, the tax liability induced by the HPL.

For example, in *Figure* 2, the beverage *Kingsley Cola* contained 11g/100ml of sugar prior to the implementation of the tax. Using the current 2021 tax rate on sugar content (R0.0221 per gram above the threshold level of 4g/100ml), this translates to a tax of R1.54 per litre. Kingsley produced approximately 700 million litres of output during 2016, and assuming that all Kingsley products contained a similar level of sugar content prior to the tax (emails with a high-ranking employee at Kingsley indicate that this was the case) the total tax liability for a single year would have been more than R1 billion. However, due to product reformulation in response to the tax – which resulted in reductions to levels below 4g/100ml for all Kingsley beverages (Anonymous, 2021) – the SSB tax liability was reduced to zero. This indicates the clear incentive that has been created by the HPL for producers to reformulate their SSBs.

Table 3: Sugar Lost (2016 Financial Year)

Sugar Lost									
Brand	**F16 vol (Tonnes)**	**CAGR 3%**	**Share**	**Old Sugar (%)**	**New Sugar (%)**	**Var**	**Sugar Lost (Tonnes)**	**Sugar Lost (Kg's)**	**Sugar Lost (Kg's/Capita)**
Coca-Cola (Red)	195000	206876	36%	10,60%	10,60%	0%	0	0	0,00
Coca-Cola (Other)	165000	175049	30%	11%	6%	-5%	79568	79568000	1,36
Twizza	45000	47741	8%	11%	4%	-7%	30380	30380000	0,52
Kingsley	70000	74263	13%	11%	4%	-7%	47258	47258000	0,81
LGB	30000	31827	5%	11%	6%	-5%	14467	14467000	0,25
Quality Bev	30000	31827	5%	11%	6%	-5%	14467	14467000	0,25
Other	11595	12301	2%	11%	6%	-5%	5591	5591000	0,10
Total CSD	546595	579884	99%				191731	191731000	3,27

Source: RCL Foods & Own Calculations

The incentive for product reformulation has had significant effects on the total sugar consumed by the population. *Table* 3 uses data from the 2016 fiscal year and, hence, provides information on the changes in sugar content that occurred after the announcement of the tax, but before its implementation. The table estimates the amount by which consumers' sugar consumption "should have" reduced, based on the changes in sugar content of the sampled beverages and on the volumes of the beverages consumed.

From the information provided in *Table 3*, the primary reason for the substantial reductions in sugar consumption (or "sugar lost") appears to be the product reformulation that was undertaken by most suppliers in response to the tax (or, at this stage, simply in response to the announcement of the tax). For example, *Table 3* indicates that Coca-Cola, Twizza, Kingsley, Little Green Beverages, and Quality Beverages make up 97% of the South African market for SSBs. Following the announcement of the HPL, significant reductions were observed in the sugar content of these beverages.

Estimates suggest that four of the five aforementioned suppliers reduced the sugar content levels of their beverages in response to the announcement of the HPL. All beverages had sugar contents ranging between 10 and 11 grams per 100ml prior to the announcement of the HPL, with all but one beverage reducing its sugar content to within the range of 4-6 grams per 100ml in response to the announcement in 2016. The only beverage that did not reduce its sugar content was Coca-Cola "Red," which remained at a level of 10.6 grams per 100ml. This is in line with the results seen in *Figure 2*, which indicate no changes in the sugar content for Coca-Cola "original" from its pre-tax to its post-tax levels. The official indication from Coca-Cola is that they opted against reducing the sugar content of their Original beverage, as consumers "love it [Coca-Cola Original] the way it is" (Coca-Cola, 2020). This perhaps implies that the volume of sales associated with the beverage are so large, that this outweighs the need to risk losing sales by reformulating the product in order to avoid the tax. Given that Coca-Cola Red has the highest share of the market (36%, as indicated in *Table 3*), this finding may indicate that the current tax rate should be increased in order to put more pressure on the largest suppliers to reformulate their products.

However, despite the fact that the Coca-Cola product was not reformulated, the impact of the HPL (and HPL announcement) on sugar consumption levels has still been significant. Aggregating the five aforementioned suppliers, approximately 191 million kilograms of sugar were removed from these beverages, over the course of the 2016 financial year, in response to the announcement of the tax. Using estimates of the amount by which sugar consumption should have reduced based on the volumes consumed, this translates to a reduction in sugar consumption of approximately 3.27 kilograms per capita, per year. The reliability of these results is strengthened by the fact that similar results were obtained by Essman *et al*. (2021). They found that a 9 gram per capita per day reduction in sugar consumption occurred in response to the HPL, which translates to a 3.28 kg reduction in annual sugar consumption.

However, it is important to note that Stacey *et al*. (2021) find less significant changes in sugar consumption from pre- to post-HPL. The paper finds a 0.77 kg reduction in average sugar consumption from SSBs per capita, per year, during the pre-HPL announcement to post-announcement period. This is followed by a 2.05 kg decline in mean sugar consumption one year after the implementation of the tax. (Stacey *et al*. 2021). Despite these discrepancies in the results of the studies, all three papers indicate non-trivial reductions in yearly sugar consumption as a result of the HPL. Hence, this is indicative of the HPL achieving its primary goal. However, the extent to which this is the case may require further investigation, given the contrasting results presented above.

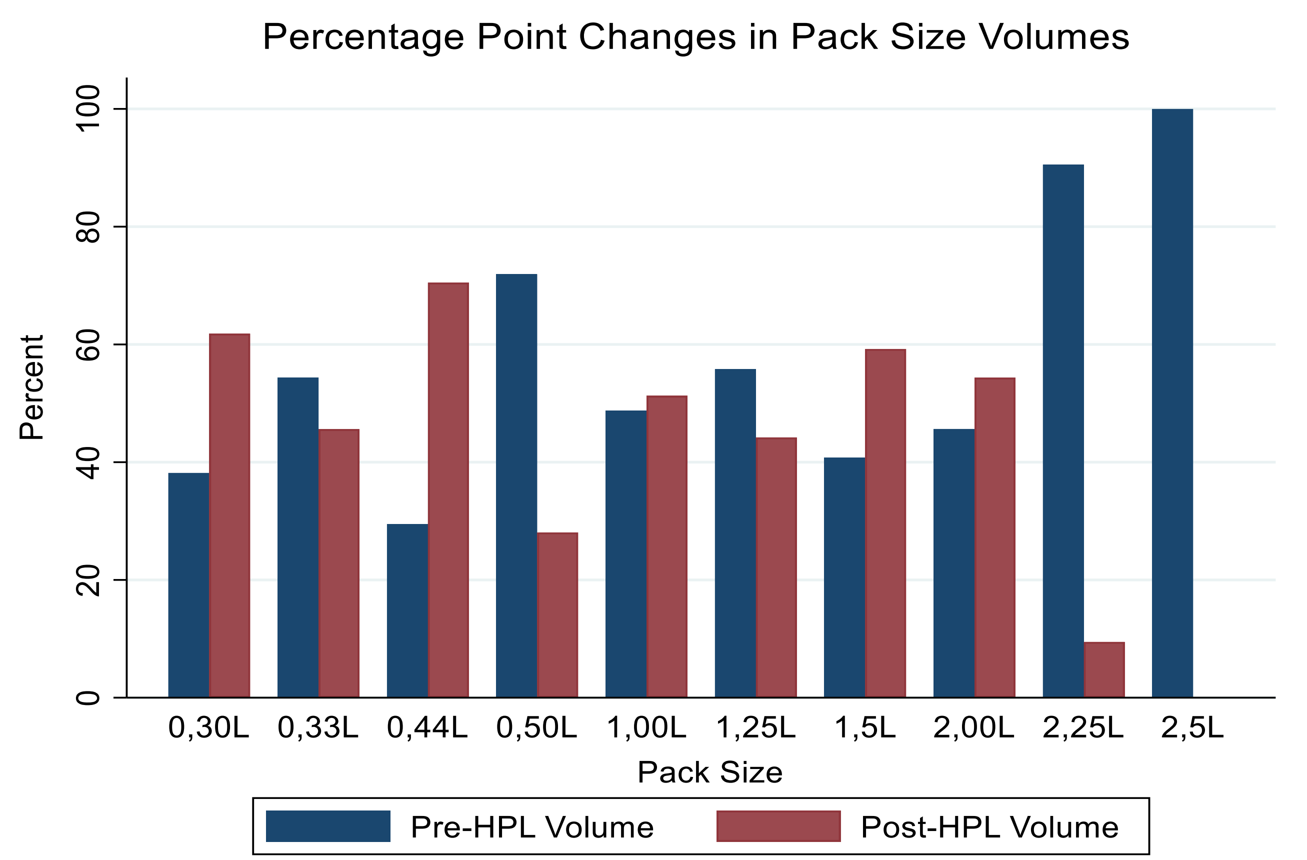
4.3.1 Changes in Packaging Size

Table 4: Changes in Pack Size Pre- to Post-tax (In millions of litres)

Pack Size	Jul-17	Jul-18	Growth
300ml	7 688	12 451	61.96
330ml	73 671	61784	-16.14
440ml	50 686	121 154	139.03
500ml	143 709	56 067	-60.99
1L	106 898	112 465	5.21
1.25L	391 877	310 525	-20.76
1.5L	86 756	126 011	45.25
2L	2 013 446	2 398 253	19.11
2.25L	190 303	19 918	-89.53
2.5L	10 434	1	-99.99

Source: Confidential & Own Calculations

<u>*Figure 3:*</u>



Source: Confidential & Own Calculations

The final impact of the HPL to be investigated is the way in which the implementation of the tax has induced changes in the packaging sizes of SSBs. *Table 4* shows the changes in the package volumes of SSBs from pre- to post-HPL (excluding sugar free beverages). *Figure 3* shows graphically the percentage changes in package volumes from pre- to post-HPL implementation. The figure corresponds to Column 4 in *Table 4*. For example, the 23.65 percentage point increase in 300ML pack volumes (indicated by the first double-bar in *Figure 3)* is equivalent to a 61.96% increase in volume from pre- to post-HPL (as shown in Row 1, Column 4 of *Table 4*).

Within three months of the HPL implementation, there was a noticeable shift away from the 500ml plastic container size towards the now standard 440ml size (Anonymous, 2018). Coupled with this has been the shift from 330ml cans to 300ml cans. Both of these shifts were motivated by the tax incentives that were created by the HPL (Anonymous, 2018).

Table 4 indicates that the 2 litre container has experienced the largest absolute value increases in volume of production compared to other bottle sizes, in response to the HPL. Moving from pre- to post-tax levels, the number of 2 litre bottles produced, (Row 1) increased by over 400 million units year-on-year, which corresponds to a 19.11% increase from pre- to post-HPL. Furthermore, as of July 2018, the 2 litre bottle accounted for 72% of the total volume of bottles in the market, with the majority of suppliers attempting to keep bottle sizes within the 1-2 litre range, post-HPL (Anonymous, 2018). In terms of percentage changes, the 440ml bottle experienced the largest relative increase in volume of production after the implementation of the HPL, by approximately 139%. Conversely, the largest decreases from pre- to post-HPL were experienced by the largest-sized bottles. The largest absolute decrease in volume was seen by the 2.25 litre bottle, with decreases of over 170 million units. Furthermore, the 2.5 litre bottle experienced the largest relative decrease from pre- to post-HPL, approximately 99%.

These results are indicative of a clear response by suppliers in the industry of changing container sizes in order to reduce their tax liabilities. The evidence suggests that suppliers of SSBs relatively quickly, and significantly, reduced the production of the largest available container sizes, in favour of relatively smaller sizes. This appears to be true for all size levels. For example, the 2.5L and 2.25L bottles have been reduced in favour of 2L bottles, whereas the 500ml and 330ml bottles are being replaced with 440ml and 300ml bottles respectively. These findings appear to be in line with the prediction of "shrinkflation" in *Section 2* of the paper.

The role of the HPL in inducing "shrinkflation" and hence promoting lower sugar consumption can be explained as follows. Using the 500ml and 440ml bottles as an example, suppliers are able to reduce their tax liability by shifting production away from the larger container size to the smaller size. For example, were Coca-Cola to remain with the 500ml container, rather than switching to the 440ml ones, then for every 500ml container produced their tax liability would be equal to R0.729. However, in switching to the 440ml container, they reduce their tax liability to R0.641 per unit produced. This represents a reduction in tax liability of approximately 12% per unit produced which, given the large quantities produced by Coca-Cola each year, may have significant effects on their profitability. Changing to smaller packaging sizes, as a result of the HPL, ensures that the manufacturers are able to maintain profit levels without increasing prices – as predicted by Houghton & Houghton (2018). Furthermore, the intake of sugar by consumers (per beverage consumed) is reduced because of the decrease in container size. This indicates the positive impact on public health that this supply-side incentive can create.

4.4 Regression Analysis

Table 5: DID Regression

VARIABLES	(1) Sugar
Time	2.18***
	(0.80)
Control	-1.82
	(1.26)
Treated	7.50***
	(1.48)
Difference-in-Difference (DID)	-4.49***
	(1.08)
Constant	1.82
	(1.43)
Observations	76
R-squared	0.77

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table Notes: Standard errors in parentheses. Treated refers to beverages that had sugar content above the taxable threshold prior to the implementation of the HPL. Conversely, Control refers to beverages below the taxable threshold of sugar content prior to the HPL implementation.
DID refers to the interaction between Time and the treatment group, where Time is a binary variable that takes on a value of one if post-tax and zero otherwise.
*** p<0.01, ** p<0.05, * p<0.1

The above DID regression (*Table 5*) was estimated by using untaxed beverages in the sample to form the control group, while the treatment group consists of beverages that were above the taxable threshold of sugar content prior to the implementation of the HPL. The dependent variable refers to the sugar content (per 100ml) of the beverages in the sample.

The relatively small sample size of thirty-eight beverages was divided into two groups, according to their pre- and post-tax sugar content values. Hence, the entire sample was treated twice, once pre-HPL and once post-HPL. This resulted in an overall sample size of seventy-six observations. The DID estimator was then calculated by creating a dummy variable, labelled "Time," which takes on a value of one for post-HPL sugar content values, and a value of zero for pre-HPL values. The interaction between the variables for "Time" and the treated group was then obtained in order to find the DID estimator.

Despite the limitations of the sample size, the results obtained are still promising. The findings indicate that significant product reformulation occurred among the beverages that were subject to the HPL, from pre- to post-HPL implementation. The coefficient on "Treated" indicates that, prior to the HPL implementation, beverages in the treatment group had an average sugar content of 7.50 grams/100ml higher than beverages in the control group, *ceteris paribus*. The coefficient on the DID estimator shows that the implementation of the HPL caused a reduction in average sugar content for SSBs in the treatment group by approximately 4.49 grams/100ml, *ceteris paribus*. This result is statistically significant at the 1% level, indicating that there is strong evidence to reject the null hypothesis that sugar content levels were unchanged from pre- to post-tax levels. Furthermore, this result has a high level of practical significance. Given that the mean sugar content level across beverages above the taxable threshold level of sugar was 9.320g/100ml, pre-HPL, the reduction in average sugar content of 4.490g/100ml constitutes approximately 48% of the mean sugar content pre-HPL. Finally, as expected, the implementation of the HPL had no impact on the sugar content levels of beverages with a sugar content below the taxable threshold. This is indicated by the small and insignificant coefficient obtained on the variable labelled "Control." These results confirm the main hypothesis that the HPL caused significant product reformulation by suppliers.

5. Discussion

The results obtained in this paper offer strong evidence in favour of the hypothesis that significant product reformulation of SSBs has occurred in response to the HPL. Furthermore, the results indicate that the supply-side response to the HPL has also included an industry-wide shift towards smaller container sizes (a finding that is in line with of the concept of "shrinkflation"). Both of these effects have combined to reduce the level of sugar consumption by consumers significantly throughout the country. This is indicated by estimates provided in *Section 4* of the paper, which indicate that sugar consumption per capita, per year, has been reduced by 3.27 kilograms as a result of the HPL. The findings of this paper therefore appear to back-up the general empirical literature surrounding the impact of ingredient-based taxes on the supply-side response (as discussed in *Section 2* of the paper).

5.1 Limitations

These results appear to be indicative of the HPL's successful achievement of its main goals. However, some important considerations should be taken into account before concluding that the policy has been a resounding success. There are significant limitations to the present study. For example, as has been highlighted throughout the paper, the sample size used is small, primarily owing to a lack of pre-HPL information on sugar content levels. There are significantly more SSBs in the country than are included in the sample for this paper. While it would be unrealistic to gather information on all SSBs pre- and post-HPL, the lack of data on a wider range of beverages may have impacted the robustness of the results across the entire industry. However, as previously noted, the sample was likely still able to capture a significant share of the market for SSBs (approximately 79%, assuming that market shares have stayed relatively constant since 2016). This likely serves to negate any substantial bias in the results, while still providing a relatively accurate representation of the industry as a whole.

A further issue that arose, owing to the the lack of available data, is that the 2014 and 2018 sugar content information were combined to form the pre-HPL component of the sample. This further limited the scope of the paper, as it was unable to measure the effects of the announcement of the tax on the supply-side response – something that, as indicated by Scarborough *et al.* (2020) & Bandy *et al.* (2020) has had significant effects on product reformulation elsewhere. While furthermore, in South Africa, Stacey *et al*. (2021) indicate that the announcement of the HPL played a role in reducing mean sugar consumption levels from taxable SSBs. Implying that product reformulation occurred in response to the announcement of the HPL, prior to the tax being implemented.

5.2 Avenues for Further Research

Primarily owing to the limitations mentioned above, the scope of the paper is relatively narrow. There are numerous recommendations that can be made for future research into the topic. For example, the paper has discussed in depth the measures that suppliers have taken to avoid increased tax liabilities as a result of the HPL. Despite the fact that strong evidence is provided of product reformulation, the paper has not considered the alternative sweeteners that suppliers may be substituting to in order to reduce their sugar content. Non-nutritive sweeteners, such as aspartame and stevia, have increased in use as suppliers aim to substitute away from sugar to reduce their tax liabilities. As yet, there is insufficient evidence to conclude whether substitution away from sugar to non-nutritive sweeteners is good for long term health (Zheng *et al*. 2015). However, the paper does conclude that substitution of SSBs towards various sugar alternatives (including non-nutritive sweeteners) was associated with lower weight gain in the long term (Zheng *et al*. 2015).

Further research on this topic could help to provide important further analysis on the effect of the HPL on public health levels, given that substitution to other methods of sweetening beverages does not necessarily equate to "healthier" beverages. Despite the fact that, in this paper, the reduction in sugar consumption is taken to mean that public health levels are improving, this is not necessarily the case. This will be a key area for further research in determining the extent to which the HPL has achieved its goal in improving public health levels.

Furthermore, this paper does not explicitly recommend an optimal type of tax on SSBs; it only analyses the effectiveness of the HPL in reducing sugar consumption in the South African context. Further research could perhaps take into account the wider range of factors required to determine the potential effectiveness of taxes of this type elsewhere. The fact that the tax curbed sugar consumption in South Africa does not mean that this will be universally true. Important causal factors, such as beverage market structures, tastes and preferences, and demographics vary substantially with location (Hernandez & Ng 2021). Further studies should be conducted in both the local and global contexts in order to gain a greater understanding of the impact of different tax regimes on sugar consumption and public health.

Furthermore, Hernandez & Ng (2021) indicate that Mexico's volumetric tax resulted in the collection of significantly higher tax revenues for the government relative to ingredient-based taxes. Given the limited scope of the paper, this possible benefit of demand-side taxes was not studied. Perhaps policymakers should attempt to balance tax revenue goals and sugar consumption goals when attempting to design an optimal tax structure for SSBs. The tax structure could be adjusted based on the main goal that the country is trying to achieve by implementing an SSB tax. For example, some countries, such as the United Kingdom, may view the loss of tax revenue as a success, given the government's 100% pro-health stance on the topic (gov.uk, 2016). However, other countries may benefit relatively more from the additional tax revenues that could be raised by implementing SSB taxes. In this case it is perhaps more logical for a country to implement the volumetric type of tax seen in Mexico. Further research will be needed (and results will need to be country-specific) in order to gain deeper insight into questions of this nature.

6. Conclusion

This paper set out to determine the extent of the impact of the HPL on the supply-side response by producers of SSBs. The supply-side response was looked at in terms of changes in both the sugar content and packaging sizes of SSBs, from pre- to post-HPL. Although the form of analysis was generally descriptive in nature, the causal effect of the HPL on changes in producer behaviour was still inferred. This is because there is no plausible reason for such distinct changes in the supply-side response that were observed from the pre-tax to the post-tax periods, other than as a response to the HPL itself. More traditional Econometric analysis, in the form of a DID regression, was used to determine the extent, and significance, of the changes in average sugar content from pre- to post-HPL levels.

Despite the limitations of the data – most notably the small sample size – the findings confirm the main hypotheses of the paper. Specifically, the results indicate significant shifts in supply-side behaviour occurring in response to the HPL – both in terms of product reformulation and changes in packaging size. The greater majority of suppliers with beverages above the taxable threshold were found to have reformulated their products so that sugar quantities were below the taxable threshold, post-HPL implementation. Regression analysis confirms that the overall changes in the sugar content of SSBs across the sample are both statistically and practically significant. Furthermore, evidence is provided to suggest an industry-wide shift to relatively smaller packaging sizes in response to the HPL – a finding that is consistent with the prediction of "shrinkflation." Both of these supply-side responses arose from the tax incentives that have been created by the ingredient-based tax structure of the HPL.

These observed shifts in producer behaviour are expected to have significant impacts on sugar consumption levels. Estimates suggest that sugar consumption "should have" been reduced by approximately 3.27kgs per capita, per year, given the extent of product reformulation that occurred in response to the HPL. These expectations were formulated on the basis of the levels of product reformulation that occurred in 2016, prior to the implementation of the HPL, but subsequent to the announcement of the HPL.

Reductions in sugar consumption, however, should be analysed with caution when determining the overall success of the policy in improving public health levels. This is because it is possible that sugar is being substituted with alternative sweeteners in SSBs, which may not necessarily equate to "healthier" beverages being produced. Analysis of this topic is beyond the scope of the present paper, and is therefore recommended as a key area of future research, in order that deeper insights into the public health benefits of the HPL can be gained.

Appendix

Table A1: Pre-Post Sugar Content in grams/100ml (Full Sample)

Pre-Post Tax Sugar Content			
Brand	**Type**	**Pre-Tax (2014-2018)**	**Post-Tax (2021)**
Bos	Original	6,6	4,8
Bos	Sugar Free	0	0
Stoney	Stoney	11,6	7,4
Tab	Tab	0	0
Coca-Cola	Original	10,6	10,6
Coca-Cola	Zero	0	0
Coca-Cola	Low Sugar	0	0
Sprite	Lemon Lime & Cucumber	10,2	3,1
Sprite	No Sugar	0	0
Sprite	Lemon Lime	10,2	3,1
Lipton Ice Tea	Peach	8	3,9
Lipton Ice Tea	Sugar Free	0	0
Lipton Ice Tea	Lemon	4,5	3,8
Lipton Ice Tea	Raspberry	4,5	4
Fanta	Grape	13,5	6,4
Fanta	Pineapple	12,3	7,5
Fanta	Orange	12,4	3,6
Fanta	Low Kilojoule	0	0
Pepsi	Original	11	7
Pepsi	Light	0	0
Pepsi	Max	0	0
Sparletta	Apple Rush	12,4	3,6
Sparletta	Crème Soda	11	3,7
Sparletta	Iron Brew	6,6	3,5
Sparletta	Sparberry	6,6	3,6
Schweppes	Lemonade	11,5	6,3
Schweppes	Dry Lemon	12,8	3,1
Schweppes	Ginger Ale	8,9	3,7
Schweppes	Tonic Water	8,9	8,9
Energade	Orange	5,6	4
Energade	Grape	5,6	4
Powerade	Naartjie	7,7	6,1
Powerade	Jagged Ice	7,6	5,9
Powerade	Mountain Blast	6,3	6,3
Twist	Granadilla	12,5	3,5
Twist	Lemon	9,1	3,6
Kingsley	Cola	11	3,5
Pick n Pay	Cola	10,8	3,1

Table A2: Testing for Significance in Mean Sugar Content Changes

	Pre-tax Mean	Post-tax Mean	P-value (pre-post)
Sugar	7,113	3,726	0,00

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