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Heterogeneous welfare effects of corrective taxes: Evidence from South Africa's soda tax

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Heterogeneous Welfare Effects of Corrective Taxes: Evidence from South Africa's Soda Tax

PRELIMINARY DRAFT

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Abstract

Sin taxes are increasingly being used to discourage the consumption of goods perceived to harm individuals and society. This paper examines the impact of South Africa's Health Promotion Levy (HPL)—the first sugar tax implemented in Africa—on the consumption of sugar-sweetened beverages (SSBs) in the country. Using comprehensive data from excise returns submitted by manufacturers and importers of SSBs, we find that the HPL was extremely effective in reducing the consumption of sugar through these beverages. Within two years of its introduction, the levy caused a substantial 33 percent reduction in the consumption of sugar through taxable beverages. We also find that the consumption partially shifted to non-taxable beverages, resulting in an increase of 15 percent in the consumption of non-taxable SSBs. These findings suggest that while the HPL is effective in reducing SSBs consumption, policy adjustments, including broader product coverage and targeted use of tax revenues, could enhance its impact.

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I Introduction

Overweight and obesity are rapidly becoming one of the most pressing public health concerns in Africa. Latest analysis from the World Health Organization shows that the obesity rate among adults in the 10 high-burden African countries ranges between 13.6 percent and 31 percent. The continent is also home to 24 percent of the world's overweight children aged under 5 (WHO, 2020). Overweight and obesity are the key risk factors for many non-communicable diseases, including cardiovascular diseases, diabetes, and some cancers (Imamura *et al.* 2015, Xi *et al.* 2015). Due to less advanced medical care and other risk factors, such as smoking and air pollution, most African countries have higher death rates from obesity per capita than high-income countries. Rising prevalence of overweight and obesity is thus likely to be the next major public health challenge Africa would face in the coming years.

There is now abundant epidemiological and experimental evidence showing that excessive consumption of sugar-sweetened beverages (SSBs) is one of the strongest causes of overweight and obesity (Malik *et al.* 2013). The most cost-effective policy to counter the excessive consumption of SSBs and to reduce morbidities arising out of it is price intervention in the form of taxes on sugar contained in SSBs. Analysis by the Department of Health of South Africa, for example, shows that sugar taxes have the lowest per capita cost (0.2 ZAR per head) among all the policy measures that are effective against obesity (DoH 2013).[1] Primarily for this reason, so called "sugar taxes" have now become a popular instrument in fight against overweight and obesity. They have now been implemented in 44 countries including 4 countries in Africa (Global Food Research Program 2020). While they have generally proven effective in reducing consumption, their impact varies by context, population, and tax structure (see Allcott *et al.* 2019b and Griffith *et al.* 2019 for recent surveys of this literature). Most of the existing research on sugar taxes has focused on high-income countries, and in comparison evidence from low- and middle-income countries (LMICs), especially those in Africa, is limited. Theoretically, it is not clear if sugar taxes in LMICs will produce the same types of responses as they do in high-income countries. In LMICs, the interplay between affordability, dietary alternatives, and cultural preferences might yield unique responses to such taxes. For instance, the elasticity of demand might be high in low-income populations and accordingly the impact on dietary habits and

[1] These other policies include food advertising and labeling; worksite interventions; mass media campaigns; school-based interventions; and physician counseling. Their costs range between 0.9 ZAR per person and 11.8 ZAR per person (DoH 2013).

substitution to other caloric sources could vary more widely. We fill this gap in the literature, providing evidence on the effects of sugar taxes from South Africa. South Africa is not only a representative middle-income country but also is the country most affected by overweight and obesity in Africa.[2] South Africa is also one of the most unequal countries in the world (World Inequality Database 2024), which makes the redistributive effects of the tax extremely relevant.

To estimate the causal effects of a sugar tax, we exploit the introduction of the Health Promotion Levy in South Africa as a natural policy experiment. The levy was implemented on April 1, 2018, and it targets sugar-sweetened beverages with sugar exceeding 4 grams per 100 milliliters of the drink. The levy applies to a broad range of non-alcoholic beverages containing added sugar or other sweetening matter. This includes sodas, flavored waters, energy drinks, and fruit juices with added sugar. Pure fruit juices without added sugars and milk products are exempt. The tax rate is set at 2.1 cents (ZAR) per gram of sugar content exceeding 4 grams per 100 ml of the drink. The first 4 grams of sugar per 100 ml are exempt. Being a specific tax, the tax's design requires regular increases in its rate to keep up with inflation, otherwise the tax stops being effective. However, despite multiple planned increases of the tax, heavy lobbying from the industry as well as sugar- producers' interest groups has led the government to halt any sugar tax increases at least until 2026.[3] While not legally earmarked, the HPL was introduced with the intention of using revenue generated to support public health initiatives, such as combating non-communicable diseases (NCDs) and funding nutrition programs. However, specifics on allocation vary, and transparency about revenue usage has been an ongoing public interest issue.

Through our partner organization UNU-WIDER, we have entered into a collaborative relationship with the National Treasury of South Africa. This collaboration allows us to access administrative data comprising the universe of excise declarations. Through the excise return, manufacturers and importers report the quantity of sugar cleared by them in SSBs. For at least two reasons these data are the most appropriate data for estimating the causal effects of the sugar tax. First, being administrative data they have little or no measurement error. We directly observe the filings of manufac-

[2] In South Africa, obesity has grown in the last 30 years and the country is now considered the most obese in sub-Saharan Africa. Over half of the country's adults are now overweight and obese with 42 per cent of women and 13 per cent of men being obese (National Treasury 2016).

[3] See for example one news item here, where a leading executive from the beverage industry argues that the sugar tax will cost South Africa 60,000 jobs. See also here for the reasons behind postponing any increase in the tax to 2026.

turers through which they report the quantity of sugar cleared by them each month and sugar tax paid by them on the quantity cleared. Second, we separately observe the quantity of sugar cleared in taxable and non-taxable drinks. Given that the sugar tax applies only to drinks containing more than 4 grams of sugar per 100 ml, it creates an incentive for manufacturers to reformulate their taxable products, reducing the sugar content below the threshold to make the product non-taxable. Because we observe the clearance of sugar in taxable and non-taxable products separately, we can estimate any shifting response through the reformulation channel.

The excise data have some limitations as well. Importantly, a manufacturer is required to file an excise declaration only if it supplies any taxable product. Since SSBs were not taxable before the introduction of the levy, manufacturers were not required to file their excise declarations before April 2018. It means the excise data do not cover the baseline period and we do not observe any pre-existing trends in the consumption of sugar through SSBs. Our analysis, however, shows that this is not a major limitation of our empirical framework as sugar consumption in South Africa through SSBs is essentially flat: once the effects of the sugar tax are completely realized, the sugar consumption in the country remains virtually constant over a long period of more than 36 months.

Using the excise data, we first document four broad trends on sugar consumption in South Africa and its response to the sugar tax. First, there is a strong seasonality in the consumption of SSBs in South Africa, with peaks typically observed in warmer months spanning from November to February. Second, if one controls for these seasonal fluctuations, the consumption of SSBs in the country is essentially flat with no upward or downward trend seen in long periods. Third, the introduction of the sugar tax resulted in a large reduction in the consumption of taxable SSBs. The maximum sugar consumed per month through taxable drinks reduced by nearly 45 percent from around 20,000 metric tons in 2018 to around 11,000 metric tons in 2022. Fourth, there was a strong shifting response, where the consumption shifted toward non-taxable drinks. This becomes evident when one compares the clearance of sugar in all SSBs with the clearance of sugar in taxable SSBs. During the same period (2018–2022), when the latter sugar reduced by 45 percent the former reduced by only 15 percent.

Motivated by the above four facts, our empirical framework uses a before-after estimator to estimate the causal effects of the sugar tax. To account for the seasonal variation in the consumption of SSBs, we use the fraction of sugar cleared in taxable SSBs as our outcome variable. Under the assumption that the seasonal variation in sugar consumption is the same across taxable and non-taxable SSBs, the consumption of taxable sugar as a fraction of total sugar will be independent of the seasonality. Indeed, we find evidence consistent with this assumption. In the last three years of our sample, when the reform's effects have been fully realized, the fraction of taxable sugar consumed through SSBs remained flat throughout the period with no fluctuations within the year. Since the excise data are only available after the implementation of the sugar tax, we are constrained to compare sugar consumption in the first few months after the introduction of the tax to sugar consumption in later months. To the extent that the supply and demand of SSBs are inelastic in the short term, our approach will deliver unbiased estimates of the response. Consistent with this assumption, we observe that the reduction in SSBs consumption occurs gradually, with the full response materializing only after two years of the reform. It is, however, important to emphasize that very inelastic demand and supply in the short run is a strong assumption. Forward-looking firms and consumers will optimize their production and consumption immediately after the change in incentives. While optimization frictions may slow down these adjustments, it is unrealistic to assume that the equilibrium quantity of SSBs consumed just a few months after the reform will remain completely unaffected. For this reason, our estimates have a lower bound interpretation, representing the minimum reduction in the consumption of taxable sugar arising from the tax.

Following the above empirical strategy, we find that the fraction of taxable sugar consumed in SSBs declined sharply after the introduction of the Health Promotion Levy. The fraction reduced by nearly 20 percentage points by the end of our sample period. Because the fraction of taxable sugar consumed in SSBs was around 51 percent in the baseline period, the 20 percentage point reduction translates into a causal effect of nearly 40 percent reduction in the fraction of taxable sugar consumed in SSBs. Assuming that the total quantity of sugar consumed in SSBs would have remained constant in the absence of the reform (a plausible assumption in our setup as explained above), a 20 percentage point reduction in the fraction of taxable sugar means that the quantity of sugar consumed in taxable SSBs reduced by nearly 33 percent. Our regression results also show that the total sugar consumed in SSBs decreased less than the taxable sugar. The difference between the two are the shifting responses, where either consumers shifted towards non-taxable drinks because they were cheaper or producers shifted towards non-taxable products by reformulating the existing products. Our estimates show that these shifting responses mean that the consumption of non-taxable sugar in SSBs increased by 15 percent as a result of the levy.

Our paper contributes to an emerging literature that studies the economic and health consequences of sugar taxes. Theoretically, sugar taxes are a class of corrective taxes imposed to discourage over-consumption of goods that are harmful to the individual and others in society. As we note above, sugar taxes have now been implemented in more than 44 countries by central or local governments. A strand of empirical literature evaluates some of these taxes, examining if they cause a reduction in the consumption of sugar. In general, these taxes have been found effective, although outcomes vary based on tax design and demographic factors (please see Allcott *et al.* 2019b and Griffith *et al.* 2019 for recent surveys of this literature). Most of these studies are based in developed countries, where the environmental and economic factors, including the sensitivity of consumption to price, may be too different from those in developing countries. One notable exception in the literature is Colchero *et al.* (2017), who study the effects of a 1 peso per liter excise tax on SSBs implemented in Mexico from 2014. They find that following the tax the consumption of taxed beverages reduced on average by 7.6 percent, whereas the consumption of untaxed beverages increased by 2.1 percent during the same period. These estimates are in line with the emerging consensus in this line of literature where a 10 percent tax is considered to reduce consumption by approximately 6-12 percent, with lower-income groups showing higher sensitivity to price changes (Allcott *et al.* 2019a). Our estimates are almost an order of magnitude larger than these estimates and show that responses to the sugar taxes are indeed highly context-specific and therefore may vary among other things on the distribution of tastes in the population.

We are not the first to study the effects of South Africa's Health Promotion Levy. Before us, Stacey *et al.* (2019) and Stacey *et al.* (2021) used data from Statistics South Africa's Consumer Price Index (CPI) and household scanner data from Kantar Worldpanel to document that the levy increased prices of taxed SSBs in the country while not affecting prices of untaxed products significantly. These studies further find that purchases of taxed SSBs fell by 30 percent while sugar consumed from these SSBs fell by 50 percent. These results are broadly in line with our result, although we rely on administrative supply-side data, whereas these studies rely on demand-side data from different sources. Relative to these studies, our paper examines responses over a longer time period and studies shifting responses as well.

The rest of this paper is organized as follows. Section II describes environmental features of the South African context, focusing especially on the structure of the Health Promotion Levy. Section III describes the conceptual framework, laying down the forces that shape responses to a corrective tax like the HPL. Section IV describes our data and section V our results. The final section VI concludes.

II Context

South Africa's sugar tax, the Health Promotion Levy (HPL), was proposed in 2016 and implemented on April 1 2018, becoming the first sugar tax in Africa. After discussions with lobbying groups, including beverage manufacturers and the sugar industry, the tax became around half as large as initially proposed, levied at the rate of 10 percent rather than the initially proposed 20 percent. The tax imposes a levy on SSBs at the rate of ZAR 0.0221 per gram of sugar exceeding 4 grams per 100 milliliters. The design of the tax with a kink at 4 grams per 100 milliliters creates an incentive for producers of products with sugar content just right of this threshold to reduce its sugar content just below the threshold as this sugar is tax-free. Such shifting responses have been observed in other contexts. For example, the UK's Soft Drinks Industry Levy is a tiered tax based on sugar content. It levies the tax at the rate of £0.24 per liter for drinks with over 8 g sugar per 100 milliliters (high levy category), £0.18 per liter for drinks with 5 to 8 g sugar per 100 milliliters (low levy category), and no charge for drinks with less than 5 g sugar per 100 milliliters (no levy category). Scarborough *et al.* (2020) finds that as a result of the levy over 50 percent of products decreased their sugar content to avoid higher tax rates.

An important feature of the HPL is that it is denominated in nominal terms, which mean that the real value of the levy has decreased each year due to inflation as South Africa has not inflation-adjusted the HPL. Given that the annual inflation rate in South Africa averaged 5 percent annually in the years 2019-2023, the real value of the HPL has decreased by at least 22 percent since its implementation. An increase of the HPL was scheduled for 1 April 2022, later postponed until 1 April 2023, and eventually scrapped at least until 2026. If inflation in South Africa continues to average 5 percent annually, the levy will lose more than 30 percent of its real value by 2026.

In 2023, South Africa's government publicly acknowledged that "limited published evidence [exists] about the effectiveness of [measures] to reduce obesity" (NDoH 2023). Our study aims to fill this evidence gap by investigating the effects of South

Africa's sugar tax on important economic outcomes.

III Methodology

Allcott *et al.* (2019a) develops a comprehensive optimal taxation framework for corrective taxes, which embodies both corrective and redistributive motives as well as revenue recycling. For the simple case with no market power, i.e., assuming perfect pass-through on consumers, they show that the optimal tax for a sin good commodity, such as SSBs, is given by :

$$t = \underbrace{\bar{\gamma}(1+\sigma) + e}_{\text{corrective motive}} + \frac{1}{\frac{d\bar{s}}{dt}} \underbrace{\text{Cov}\left[g(z), s_{\text{pref}}(z)\right]}_{\text{redistributive motive}}. \tag{1}$$

where $\bar{\gamma}$ is the internality or average marginal consumer bias, σ is the progressivity of bias correction, e is the negative externality, $\frac{d\bar{s}}{dt}$ represents the responsiveness of average sin good consumption $\bar{s}$ to the tax t, $g(z)$ is the social marginal welfare weight on income z, s_{pref} is a sufficient statistic for preference heterogeneity representing the amount of SSB consumption at income z relative to SSB consumption at the lowest income level. This intuitive representation makes clear that the optimal taxation depends on both the corrective and redistributive motives.

The corrective motive rises with the internality $\bar{\gamma}$ and externality e. The internality is scaled by the term $1+\sigma$ because the internality correction depends on i) how large the bias is for the rich relative to the poor, and ii) the elasticity of demand of the rich relative to the poor.

The redistributive motive depends on the covariance of social marginal welfare weights and sin good consumption, which is the only consumption component determined by preference heterogeneity. This covariance term is thus determined by how sin good consumption tags ability; it rises if sin good taxation can redistribute over and above redistribution with just income taxation. The term is scaled by the responsiveness of average sin good consumption $\bar{s}$ to the tax t. If consumers are highly elastic, the redistributive motive loses importance relative to the corrective motive.

To illustrate this optimal sin tax formula further, notice that under no inequality aversion—if the planner has no redistributive motive and thus uses constant social marginal welfare weights—the optimal sin tax is just equal to the internality plus the externality, $t = \bar{\gamma} + e$, corresponding to the standard Pigouvian tax. Now suppose that the planner has inequality aversion but that sin good preference heterogeneity is uncorrelated with ability (or income). In this case, sin good consumption is not a tag of ability, so any redistribution must be carried out by the income tax. Since in this case the covariance term is zero, the whole redistributive motive component is zero and the optimal sin tax will be $t = \bar{\gamma}(1+\sigma) + e$, where $(1+\sigma)$ scales the internality by the uncorrelated sin good preference heterogeneity. Finally, suppose that both the internality and externality are zero, so the corrective motive component is zero. Then only the distributional motive remains and $t = (1/\frac{d\bar{s}}{dt}) \cdot \text{Cov}\left(g(z), s_{\text{pref}}(z)\right)$. It can be shown that $(t/(p+t)) = -\left(\text{Cov}\left(g(z), s_{\text{pref}}(z)\right)\right)/\left(\bar{\bar{s}}\bar{\zeta}^c\right)$, which is a generalization of the Atkinson-Stiglitz theorem to deal with arbitrary preference heterogeneity (Allcott *et al.* 2019a). This shows that with a nonlinear income tax, the optimal sin good tax continues to resemble the familiar inverse elasticity rule for commodity taxes, but here the planner taxes the goods that high earners prefer rather than the goods they consume.

Imperfect competition changes the optimal sin tax formula in the following ways (O'Connell & Smith 2021). First, it adds a market correction motive with positive price-cost margins distorting resource allocations and, all else equal, lowering the optimal tax rate. As in Buchanan (1969), the optimal tax on an externality produced by a monopolist is less than a Pigouvian tax. O'Connell & Smith (2021) shows that the strength of this component is determined by the relative price-cost margins of the sin relative to the untaxed goods. Second, the redistributive motive interacts with market power because the distribution of positive profits in the population impacts the distributional effects of the sin tax. Finally, firms may re-optimize prices in response to a tax change, so the prices of untaxed goods may also change, leading to a potentially imperfect pass through of the sin tax. If the tax reduces profits of rich individuals, then the tax is more progressive and, at optimum, higher. We can incorporate market power into our empirical analysis by directly estimating the pass through on consumers by estimating the demand and supply elasticities and by analyzing the distribution of net-of-tax profits before and after the tax change.

IV Data

Our collaboration with UNU-WIDER allows us to use administrative data from the National Treasury of South Africa. The data comprise the universe of the HPL excise form (DA 179) filed after the introduction of the levy in April 2018. The excise form, DA 179, provides detailed information on the levied excise amounts collected from sugar-sweetened beverages across the country. This form captures information on both the volume and sugar content of taxed and non-taxed beverages, as well as the specific excise amounts calculated based on the HPL rate. The DA 179 data, submitted by producers and importers, includes identifiers for each registered business, allowing for analysis by company or brand within the SSB sector. These details allow for granular insights into the excise's direct impact on consumption and production adjustments, helping to identify trends such as product reformulation to reduce sugar content or volume-based shifts to non-taxed or lower-taxed beverages. Additionally, the DA 179 form enables tracking of seasonal patterns and demand fluctuations, given its regular submission schedule. Seasonal data points, in combination with excise amounts, can highlight consumption patterns related to weather, holidays, and other events that impact SSB purchases.

Using excise data for our empirical analysis offers us two comparative advantages. First, being administrative data they do not have the measurement error one usually encounters with survey data. We directly observe the filings of manufacturers and importers through which they report the quantity of sugar cleared by them each month and sugar tax paid by them on the quantity cleared. Second, we separately observe the quantity of sugar cleared in taxable and non-taxable drinks. Given that the sugar tax applies only to drinks containing more than 4 grams of sugar per 100 ml, it creates an incentive for manufacturers to reformulate their taxable products, reducing the sugar content below the threshold to make the product non-taxable. Because we observe the clearance of sugar in taxable and non-taxable products separately, we can estimate any shifting response through the reformulation channel.

Table I reports summary statistics of the data for the whole period 2018-2023 and separately by fiscal year. We present the mean, standard deviation, and number of observations of the variables used in our empirical analysis. Our dataset comprises around 4,000 observations. The table shows taxable and total sugar in thousands of metric tons as well as fraction of taxable sugar cleared in each fiscal year. We also show the categorization of products observed based on the tariff subheadings from the South Africa Tariff Book's Schedule No 1 Part 2A, which indicates excise duties. The most important categories are syrups (24 percent), fruit-juice-based syrups (29 percent), and flavored drinks in bottles not exceeding 2.5 liters (28 percent).

V Results

South Africa introduced the Health Promotion Levy (hereinafter called the reform) on 1 April 2018. Using the excise data, described in section IV, we estimate the effects of the reform on the consumption of sugar-sweetened beverages in the country. The excise data, as we note above, are available only for the post-reform months. It is because firms supplying SSBs became liable to file excise returns only once the Health Promotion Levy became applicable on them. Before we describe our empirical strategy to estimate the causal effects of the levy, we first present graphical evidence on how firms producing SSBs reacted to the levy. Our empirical strategy is inspired by these high-level responses observed in the raw data.

V.A Graphic Evidence

Figure I plots the quantity of sugar removed in SSBs by firms. Panel A shows the total sugar removed by these firms, whereas Panel B restricts attention to taxable sugar only. Taxable sugar, as we describe in section II, is the sugar removed in SSBs containing more than 4 grams of sugar per 100 milliliters of the beverage. Note that our data show the clearance and not production of SSBs. The quantities shown in both plots thus represent the equilibrium quantity of goods traded in the market. We therefor refer to these quantities as the consumption of SSBs in the country.

The analysis in Figure I produces four key insights. First, unsurprisingly, there is strong seasonality in the consumption of SSBs, with more quantity consumed during summer than in winter. To account for this seasonality, we aggregate our data to the yearly level for our main estimates. Second, the quantity of sugar consumed in SSBs drops substantially in the post-reform months. Total sugar consumed per month, for example, reached a peak of 42,000 metric tons in the first year after the reform. This peak dropped by more than 15 percent to a level of around 35,000 metric tons in later years. Third, the drop in the consumption of sugar was observed in the first two years only, with the consumption of sugar stabilizing from 2020 onward. This stable trend in the consumption of sugar is important for our empirical strategy, and we come back to this point when we discuss our year-level results. Third, the drop in the consumption of taxable sugar is far more pronounced than the drop in the consumption of total sugar. For example, the maximum taxable sugar consumed per month reduced by nearly 45 percent from a peak of around 20,000 metric tons in

2018 to a peak of around 11,000 metric tons in 2022, whereas during the same period the peak of total sugar consumption reduced only by around 15 percent. The fact that the reduction in taxable sugar is three times the reduction in total sugar suggests that the response we document is driven by the Soda Tax rather than by other factors such as a change in consumer preferences away from consuming SSBs. Fourth, the reduction in the consumption of taxable sugar is more than the reduction in total sugar. Again, comparing the maximum sugar consumption in a year, the consumption of total sugar decreases by around 7,000 metric tons, whereas the consumption of taxable sugar reduces by around 11,000 metric tons. This suggests a strong *shifting* response to the reform. The shifting response could be a supply-side response, where firms shift away from taxable to non-taxable SSBs by either reducing the sugar content in their SSBs below the taxable threshold or by aggressively marketing their non-taxable SSBs. Alternatively, it could be a demand-side response, where consumers substitute strongly toward non-taxable SSBs once the levy became operation. Such shifting responses have also been observed in other contexts such as the Philadelphia soft drink tax, which increased purchases of untaxed natural juices by 9 percent and had no effect on purchases of bottled water (Seiler *et al.* 2021).

Figure II probes this last point even further. Panel A decomposes total sugar consumed in SSBs into taxable and non-taxable sugar, while Panel B plots the fraction of taxable sugar removed in SSBs. Strikingly, the fraction of taxable sugar removed in SSBs reduces by nearly 40 percent from a peak of 50 percent just after the reform to around 30 percent in the next two years. Another striking feature of this plot is that the fraction of taxable sugar stabilizes at 30 percent from the middle of the tax year 2019-2020 and remains flat throughout our sample period after that. This, as we mention above, is a feature of all our time-series plots and is even more pronounced in our next set of plots which are at the year rather than month level.

Figure III replicates the analysis in Figure I, aggregating sugar consumption at the tax year level to get rid of the seasonality. Two features of these plots are important for our empirical estimates. First, there is no long-run trend in the consumption of sugar through SSBs. Once the effects of the reform subside, the trend becomes remarkably flat, with sugar consumption—-both taxable and total—remaining virtually constant over the last three years of our sample. Second, because of the stable trend we can clearly see that the reduction in taxable sugar exceeds the drop in total sugar by a ratio of 3 to 1 in terms of percentage change. The larger drop in taxable sugar, as we note above, suggests that the reduction in SSB consumption is driven by the Soda Tax and not by other factors such as macroeconomic growth or a shift in preferences.

Figure IV compares the consumption of taxable and non-taxable sugar at a yearly level. These plots illustrate more clearly the patterns we document above with reference to Figure II. After the implementation of the Soda Tax, the consumption of taxable sugar reduces sharply and the consumption of non-taxable sugar increases. But the increase in non-taxable sugar was less than the decrease in taxable sugar so that overall sugar consumption through SSBs reduces, though the reduction was modest. These plots also generate a key insight for our empirical analysis. Note that the reduction in the fraction of taxable sugar consumption is smaller when analyzed on a yearly basis compared to a monthly basis (40 percent vs. 30 percent). This occurs because taxable sugar consumption falls sharply in the first year after the reform. The month-level analysis can account for this sharp decrease within the year, whereas the year-level analysis smooths it out, resulting in an underestimation of the response. Primarily for this reason, we run our estimations at a month level.

V.B Empirical Strategy

The above analysis shows that in our setting there are two key challenges to estimate the causal impacts of the Soda Tax. There is a strong seasonality in the consumption of SSBs in South Africa, where intake is much greater during the summer than in the winter. To account for this seasonality, we use the fraction of taxable sugar consumed as our outcome variable instead of the quantity of taxable sugar consumed, making the following assumption.

Assumption A1: *Seasonal variation in sugar consumption through SSBs is the same across taxable and non-taxable consumption so that the fraction of taxable sugar consumed through SSBs remains independent of the seasonality.*

The evidence presented in Figures II strongly supports this assumption. In the last three years of our sample, when the reform's effects have been fully realized, the fraction of taxable sugar consumed through SSBs remains flat throughout the year.

The second challenge we face is that the excise data we use begins only after the introduction of the Soda Tax. This means that we do not have a baseline period against which we can compare any reduction in the consumption of sugar resulting from the implementation of the Soda Tax. We are accordingly constrained to use the first month in our data—July 2018—as the baseline period. Under the following assumption, comparing the consumption of sugar in later periods relative to July 2018 isolates the causal impacts of the Soda Tax.

Assumption A2: *Both supply and demand responses to the imposition of the Soda Tax are slow and do not materialize immediately after the reform.*

This assumption can be justified if both the supply and demand for taxable SSBs are inelastic in the short term. On the supply side, this may occur because firms need time to design and market new products, delaying the reallocation of factors at their disposal to alternative uses. On the demand side, it may happen if the tax is not salient in the short term because it is applicable to a narrow group of goods only (Chetty *et al.* 2009). Indeed, consistent with this assumption, we observe that the reduction in taxable sugar occurs gradually, with the full response to the tax only materializing two years after the reform (please see the second panel of Figures II and IV).

It is important to emphasize, however, that Assumption A2 is a strong assumption. Forward-looking firms and consumers will optimize their production and consumption decisions immediately following the tax announcement. While optimization frictions may slow down these adjustments, it is unrealistic to assume that the equilibrium quantity of SSBs consumed just a few months after the reform remains unaffected. For this reason, our estimates of the causal impacts of the Soda Tax have a lower bound interpretation, representing the minimum reduction in consumption of taxable sugar arising from the tax.

To the extent that above two assumptions are satisfied, we can use the following model to estimate the effects of the soda tax

$$y_{it} = \alpha_i + \beta\, D_t + \boldsymbol{X'\Theta} + \varepsilon_{it}. \tag{2}$$

Here, y_{it} is the fraction of taxable sugar cleared by firm i in month t; α_i is the firm fixed effect; D_t is a dummy variable indicating a month other than our baseline period (July 2018); and $\boldsymbol{X}$ is a vector of controls. Our coefficient of interest is β. It is essentially a before-after estimator, measuring the average within-firm change in the fraction of taxable sugar cleared by it in SSBs relative to the baseline period.

Identification in this setup rests on the following assumption.

Assumption B1: *There is no upward or downward trend in the fraction of taxable sugar* *cleared by firms so that the fraction would have remained the same in the absence of the Soda Tax.*

Lack of secular trends is usually a strong assumption but is highly plausible in our setup. In general, all our outcomes remain completely flat in the 36 month period beginning from July 2020. This suggests that there is no long-standing trend in the consumption of sugar via SSBs. Nor is this consumption subject to abrupt technology or preference shocks. In this environment, the before-after estimator we employ is unlikely to be biased by these factors.

Ideally, we would have liked to use the difference-in-differences estimator to estimate the causal impacts of the Soda Tax. In this framework, we would have used the consumption of goods similar to SSBs but not affected by the Soda Tax such as fruit juices, tea, or coffee as the control group to account for any demand and supply shocks confounding the impacts of interest. We, however, cannot employ the difference-in-differences estimator because the excise data contains only the treated firms—firms that supply SSBs. It is,however, important to emphasize that the difference-in-differences estimator will have its own concerns. Importantly, given the shifting response the estimator is subject to concerns from the violation of the SUTVA assumption. After the implementation of the Soda Tax, consumers are likely to substitute toward non-taxable drinks, some of which could be in the control group. Indeed, closer a product is to the SSBs and hence a better candidate for the control group, the more likely it is to be affected by the substitution response. In contrast, the before-after estimator is not subject to these concerns and given stable trends is more suitable estimator for our setup.

V.C Regression Estimates

We now present our results following the empirical strategy described above. Figure V displays coefficients from estimating a version of equation (2). In this version, instead of having a dummy for each post month, we include a dummy for each post year, excluding the first month in our dataset—the baseline month (July 2018). Our outcome variable is the fraction of taxable sugar. The coefficient thus reflect the reduction in the fraction of taxable sugar in post-reform years relative to the baseline month of July 2018. Table II reports the corresponding regression estimates. The first column combines all post-reform months into a *post* dummy and hence reports the average decline in the fraction of taxable sugar in all post-reform months relative to the baseline month. The second column breaks down this average response by each post-reform year.

Consistent with the graphic evidence presented above, the fraction of taxable sugar consumed in SSBs declines sharply after the introduction of the Health Promotion Levy. The fraction reduced by more than 7 percentage points in the first year after the reform. In the following years, it reduced even further, settling at nearly 20 percentage points lower than the baseline period. Since the fraction of taxable sugar consumed in SSBs was around 51 percent in the baseline period, the 20 percentage point reduction translates into a causal effect of nearly 40 percent reduction in the fraction of taxable sugar consumed in SSBs.

Summary statistics in Table I show that a total of 542,000 metric tons of sugar was consumed in SSBs in South Africa in 2018, the first year after the introduction of the levy. Assuming that the total quantity of sugar consumed in SSBs would have remained constant in the absence of the reform (an assumption borne out by data; see the discussion in the previous section), a 20 percentage point reduction in the fraction of taxable sugar means that the quantity of sugar consumed in taxable SSBs reduced by 178,155 metric tons—nearly 33 percent reduction in the quantity of sugar consumed in taxable SSBs. The summary statistics table also shows that the total sugar consumed in SSBs decreased from 542,000 metric tons in 2018 to 406,000 metric tons in 2022, a 136,000 tons reduction. The difference between the reduction in taxable sugar and the reduction in total sugar is the increase in non-taxable sugar. This captures the shifting responses, where either consumers shifted towards non-taxable drinks because they were cheaper or producers shifted towards non-taxable products by reformulating the existing products. The above numbers show that around 42,000 metric tons of sugar was shifted from taxable to non-taxable products, which constitutes around 15 percent increase in the consumption of sugar in non-taxable SSBs.

Tables III and IV showcase the robustness of our results. We now use micro-data that allow us to include firm, beverage type, and client type fixed effects. Our estimates are insensitive to the inclusion of these additional controls (see the second row in Table III and rows 4–12 in Table IV). The size of the treatment effect is also similar to what we get from our aggregate-level regressions. Our estimate size is also very similar to ones reported in the earlier literature (see Stacey *et al.* 2019 and Stacey *et al.* 2021). These earlier studies used either aggregate macro-level data or household-level scanner data. In comparison, we use administrative supply-side data from excise records. Yet our results are very similar to the earlier studies. This further reinforces the robustness of our results.

It is important to emphasize that our estimates represent a conservative lower bound on the real average treatment effect. It is because we are treating July 2018 as the baseline period. The Health Promotion Levy took effect from April 2018. As such, our estimates do not take into account the reduction in sugar consumed through taxable SSBs from the announcement of the reform to July 2018. Despite having a lower-bound interpretation, our estimate size is really large. This shows that the South African Soda Tax was extremely effective in reducing the consumption of taxable sugar in SSBs. Considering that the South African tax rate was quite low and the reduction in taxable sugar caused by it is an order of magnitude larger than the one observed in other contexts (see for example Colchero *et al.* 2017 for Mexico), it is clear that the consumption of sugar in SSBs is extremely elastic in South Africa, which makes price-intervention such as the Soda Tax an effective policy to reduce consumption.

VI Conclusion

The rapid spread of obesity and overweight is emerging as the next major public health challenge in developing countries, particularly in Sub-Saharan Africa, where rising urbanization and dietary shifts toward high-calorie, processed foods are accelerating weight-related health issues. With limited healthcare resources, these countries face an increasing burden of non-communicable diseases like diabetes and cardiovascular conditions, further exacerbating socio-economic inequalities and straining public health systems. Price interventions like sugar taxes are among the most cost-effective strategies to address public health issues stemming from the excessive consumption of sugar-sweetened beverage, as they directly reduce demand through price sensitivity while generating government revenue that can be reinvested in health initiatives. By encouraging both consumers to reduce intake and producers to reformulate products, these taxes efficiently target the root causes of diet-related diseases without requiring costly, large-scale healthcare interventions.

Our regression results show that the fraction of taxable sugar consumed in SSBs declined sharply after the introduction of the Health Promotion Levy. The fraction reduced by nearly 20 percentage points by the end of our sample period. The reduction translates into a causal effect of nearly 40 percent reduction in the fraction of taxable sugar consumed in SSBs and 33 percent reduction in the quantity of sugar consumed in taxable SSBs. Our results also show that the sugar consumption shifted from taxable to non-taxable beverages. These shifting responses mean that the consumption of non-taxable sugar in SSBs increased by 15 percent as a result of the levy.

In this paper, we study the effects of the first sugar tax implemented in Africa. The sugar tax, known as the Health Promotion Levy, is an excise tax applied specifically to sugar-sweetened beverages containing more than 4 grams of sugar per 100 milliliters, with each gram above this threshold taxed at 2.1 cents (ZAR). Using administrative data comprising the universe of excise returns filed by the importers and manufacturers of SSBs, we first document four broad trends on sugar consumption in South Africa and its response to the sugar tax. First, there is a strong seasonality in the consumption of SSBs in South Africa, with peaks typically observed in warmer months. Second, there is no long term trend in the consumption of SSBs as the consumption essentially stays flat in long periods during which other environmental features affecting demand and supply remain fixed. Third, the introduction of the sugar tax results in a large reduction in the consumption of taxable SSBs. The maximum sugar consumed per month through taxable drinks reduces by nearly 45 percent from around 20,000 metric tons in 2018 to around 11,000 metric tons in 2022. Fourth, there is a strong shifting response, where the consumption shifted toward non-taxable drinks. During the period 2018–2022, when the taxable sugar reduced by 45 percent the total sugar reduced by only 15 percent.

Our findings have important policy implications for addressing sugar consumption and associated public health challenges through targeted fiscal measures like sugar taxes. The observed reduction in taxable sugar consumption underscores the effectiveness of South Africa's Health Promotion Levy (HPL) in curbing sugar intake from sugar-sweetened beverages. However, the partial shift to non-taxable drinks highlights the importance of a more comprehensive tax design that could encompass a broader range of sugary products to reduce the overall sugar consumption more effectively. Policymakers might also consider adjusting tax rates to account for inflation and revisiting the tax structure periodically to enhance long-term efficacy. Furthermore, revenue generated from the levy could be strategically allocated to health and education initiatives, amplifying the public health benefits. Future research could explore the health outcomes linked to reduced sugar consumption post-HPL, examine the economic effects on both producers and low-income consumers, and analyze the effects of alternative policy designs, such as tiered sugar content taxes or incentives for product reformulation, to create a more holistic approach in tackling the health and economic burden of excessive sugar consumption.

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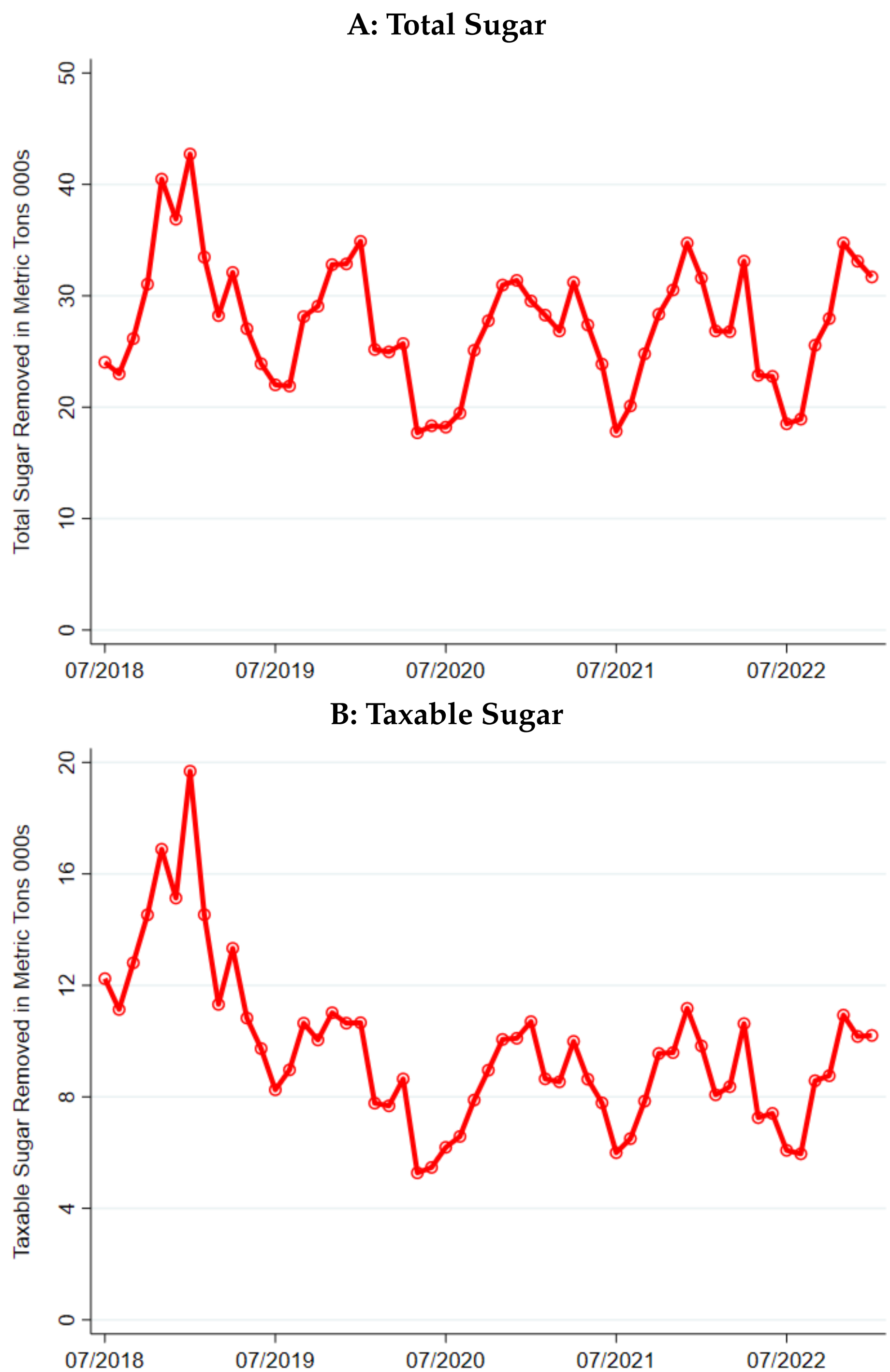
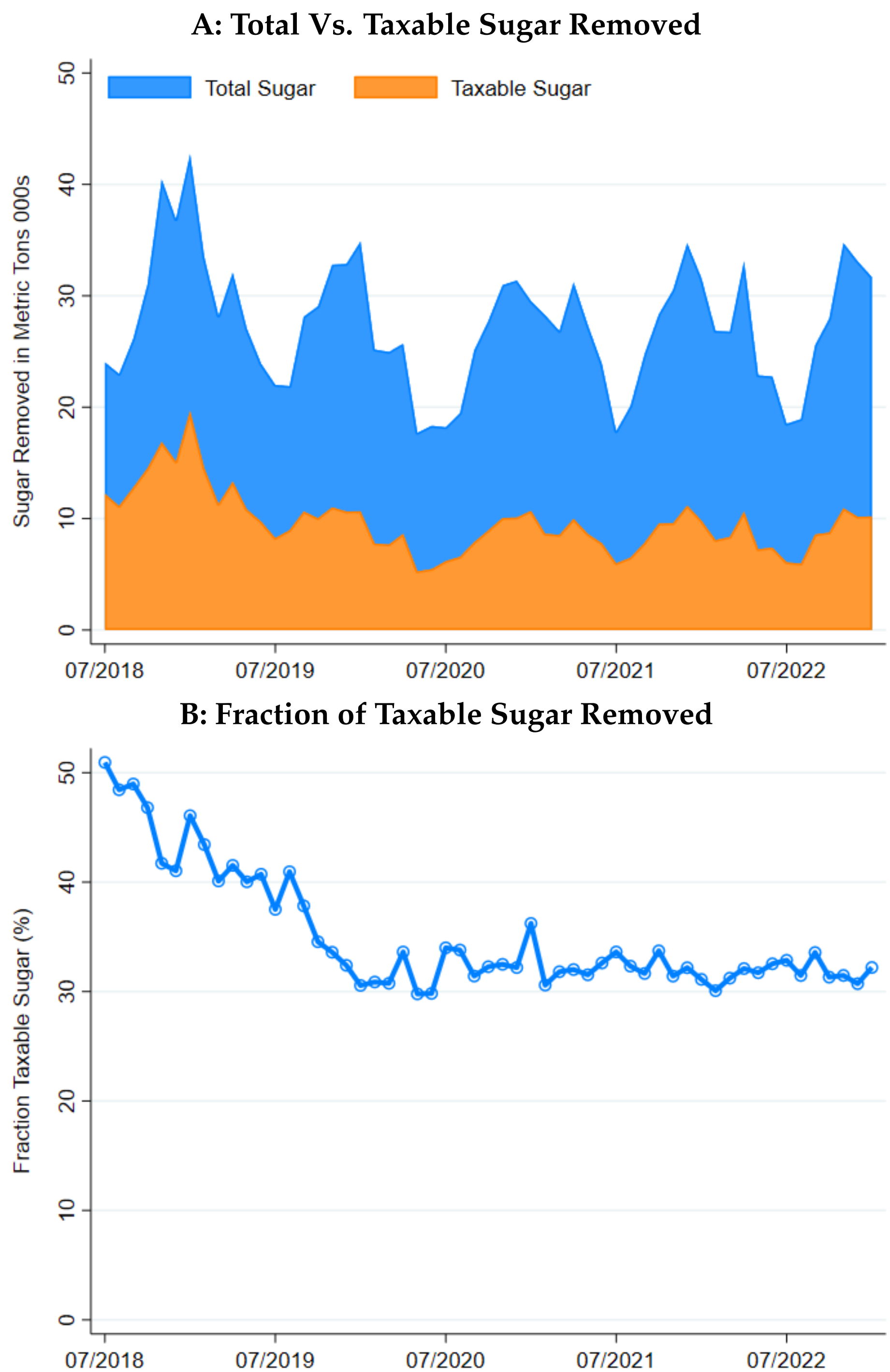
FIGURE I: **SUGAR REMOVED IN SSBS BY MONTH**



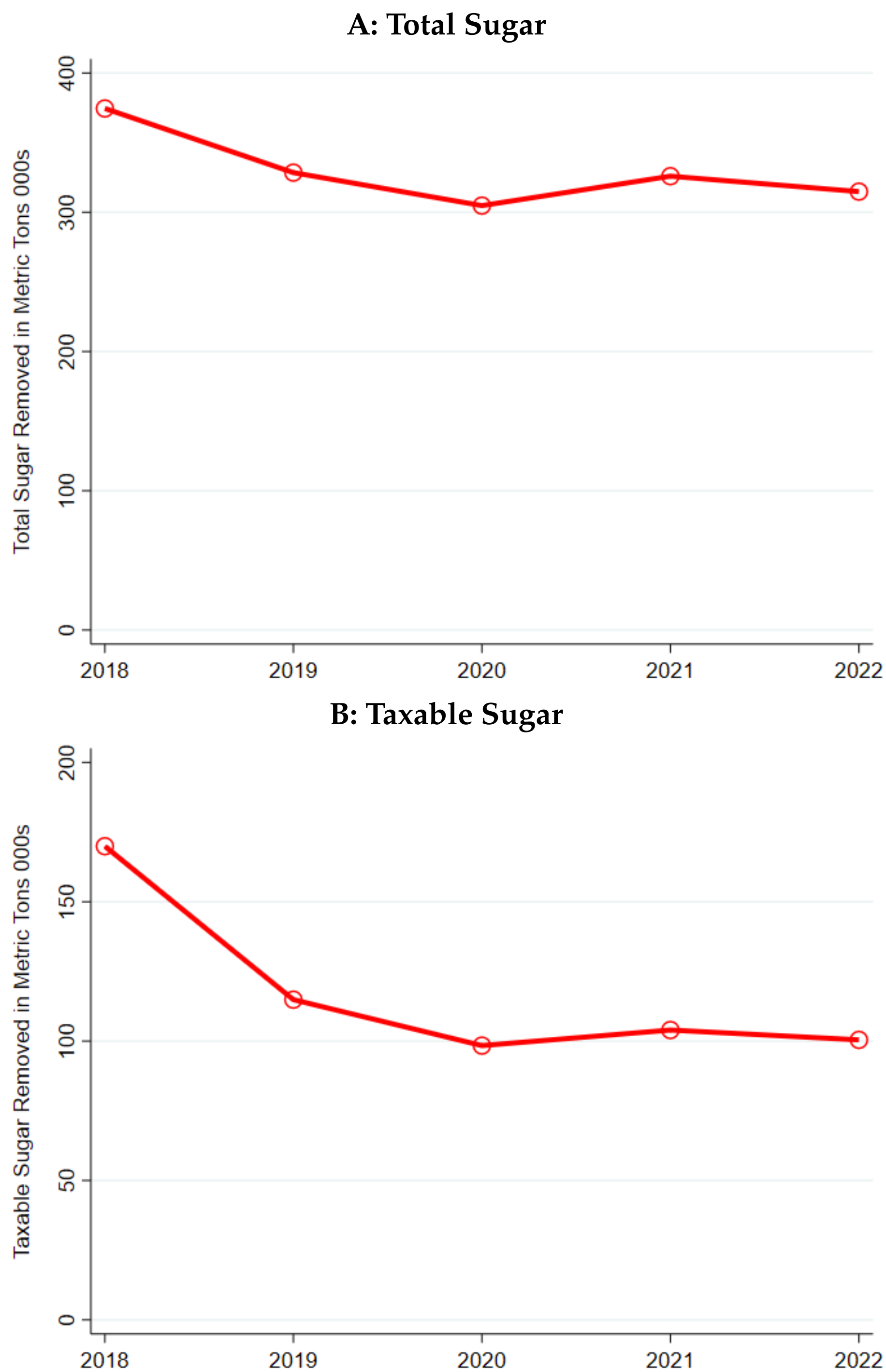
Notes: The figure illustrates the evolution of sugar consumption through SSBs in South Africa. Each marker in the figure denotes the sugar cleared by manufacturers and importers of SSBs from warehouses in the calendar month indicated on the horizontal axis. Panel A examines total sugar cleared, whereas Panel B examines the taxable sugar. Taxable sugar is the sugar cleared in beverages containing more than 4 gram per 100 milliliters of the beverage.

FIGURE II: **TOTAL VS. TAXABLE SUGAR REMOVED BY MONTH**



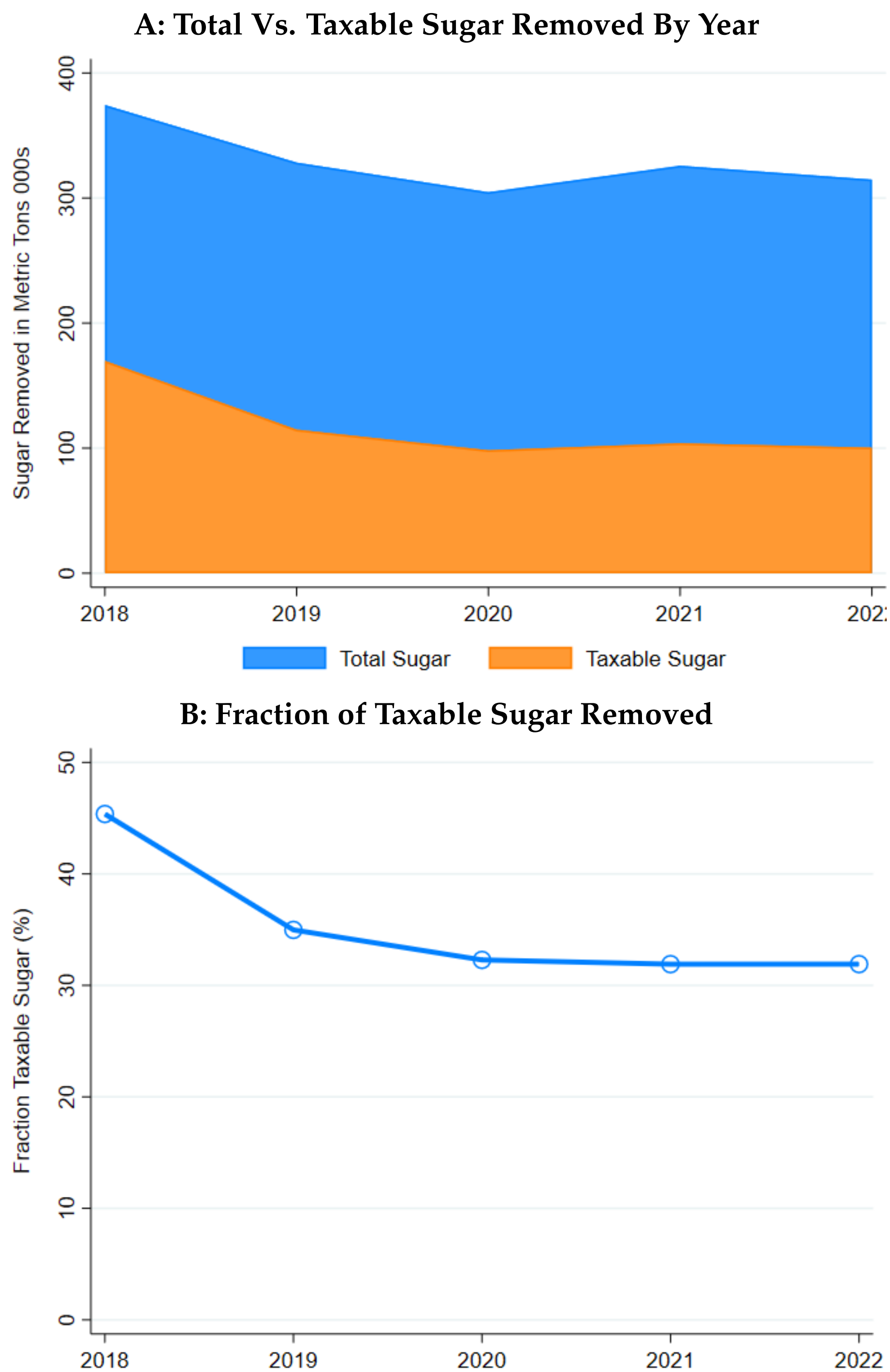
Notes: The figure examines the composition of total sugar cleared by the suppliers of SSBs. Panel A decomposes total sugar consumed in SSBs into taxable and non-taxable sugar, while Panel B plots the fraction of taxable sugar removed in SSBs. Taxable sugar is the sugar cleared in beverages containing more than 4 gram per 100 milliliters of the beverage.

FIGURE III: **SUGAR REMOVED IN SSBS BY YEAR**



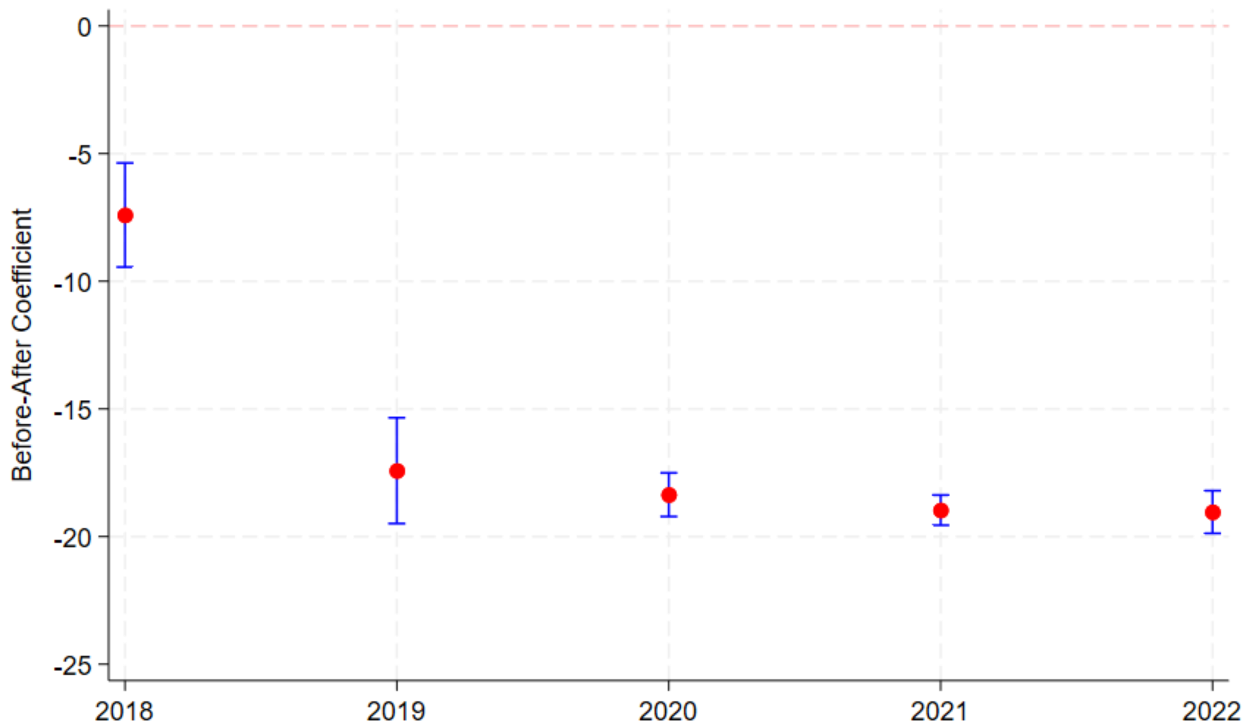
Notes: The figure illustrates the evolution of sugar consumption through SSBs in South Africa. Each marker in the figure denotes the sugar cleared by manufacturers and importers of SSBs from warehouses in the financial year indicated on the horizontal axis. Panel A examines total sugar cleared, whereas Panel B examines the taxable sugar. Taxable sugar is the sugar cleared in beverages containing more than 4 gram per 100 milliliters of the beverage.

Figure IV: **Total Vs. Taxable Sugar Removed**



Notes: The figure examines the composition of total sugar cleared by the suppliers of SSBs. Panel A decomposes total sugar consumed in SSBs into taxable and non-taxable sugar, while Panel B plots the fraction of taxable sugar removed in SSBs. Taxable sugar is the sugar cleared in beverages containing more than 4 gram per 100 milliliters of the beverage.

FIGURE V: **DYNAMIC EVENT STUDY COEFFICIENTS**



Notes: The figure plots the results from our event study specification (2). The outcome variable is the fraction of taxable sugar consumed in SSBs, defined as the total quantity of sugar cleared in taxable SSBs divided by total quantity of sugar cleared in all SSBs, expressed in percentage. We drop the dummy for the month of July 2018 and consequently the displayed coefficients measure the reduction in the fraction in percentage points relative this month. The red markers represent the coefficient and the whiskers the 95 percent confidence interval around them.

TABLE I: SUMMARY STATISTICS

	Total			2018			2019			2020			2021			2022			2023		
	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.	N	Mean	St. Dev.	N
Taxable sugar	153	957	4006	250	1270	522	176	1090	738	125	804	761	133	863	782	127	851	805	126	844	398
Total sugar	432	2110	4006	542	2360	522	462	2330	738	391	1930	761	417	2050	782	400	2030	805	406	2000	398
Fraction taxable sugar	0.299	0.234	3324	0.379	0.228	476	0.328	0.229	621	0.294	0.227	632	0.272	0.231	649	0.260	0.234	640	0.265	0.241	306
Client type WH	0.955	0.208	4006	0.933	0.250	522	0.950	0.218	738	0.951	0.215	761	0.953	0.212	782	0.966	0.180	805	0.977	0.149	398
Tariff subheading																					
Cocoa powder	0.082	0.274	4006	0.079	0.269	522	0.079	0.269	738	0.079	0.270	761	0.083	0.276	782	0.083	0.276	805	0.093	0.291	398
Malt-based food preparations	0.082	0.275	4006	0.082	0.275	522	0.066	0.249	738	0.075	0.263	761	0.100	0.300	782	0.087	0.282	805	0.080	0.272	398
Other food preparations	0.000	0.016	4006	0.000	0.000	522	0.001	0.037	738	0.000	0.000	761	0.000	0.000	782	0.000	0.000	805	0.000	0.000	398
Syrups	0.240	0.427	4006	0.274	0.446	522	0.240	0.427	738	0.240	0.428	761	0.230	0.421	782	0.235	0.424	805	0.226	0.419	398
Fruit-juice-based syrups	0.294	0.456	4006	0.310	0.463	522	0.337	0.473	738	0.306	0.461	761	0.290	0.454	782	0.252	0.435	805	0.264	0.441	398
Flavored drinks (at most 2.5l)	0.276	0.447	4006	0.310	0.463	522	0.289	0.453	738	0.281	0.450	761	0.258	0.438	782	0.260	0.439	805	0.261	0.440	398
Flavored drinks (over 2.5l)	0.084	0.277	4006	0.073	0.260	522	0.085	0.280	738	0.095	0.293	761	0.078	0.268	782	0.086	0.280	805	0.080	0.272	398
Non-alcoholic beer (at most 2.5l)	0.005	0.074	4006	0.000	0.000	522	0.000	0.000	738	0.000	0.000	761	0.005	0.071	782	0.015	0.121	805	0.015	0.122	398
Non-alcoholic beer (over 2.5l)	0.020	0.139	4006	0.004	0.062	522	0.000	0.000	738	0.025	0.156	761	0.027	0.162	782	0.030	0.170	805	0.033	0.178	398
Other drinks (at most 2.5l)	0.135	0.341	4006	0.165	0.371	522	0.150	0.358	738	0.134	0.341	761	0.132	0.338	782	0.117	0.321	805	0.108	0.311	398
Other drinks (over 2.5l)	0.108	0.310	4006	0.151	0.359	522	0.108	0.311	738	0.109	0.312	761	0.102	0.303	782	0.089	0.286	805	0.093	0.291	398

Notes*:* This table shows summary statistics for key variables used in our regressions, for different fiscal years. Taxable sugar and total sugar are in thousands of metric tons. Flavored drinks include waters, mineral waters and aerated waters, that contain added sugar.

TABLE II: **FRACTION OF TAXABLE SUGAR**

	Outcome: Fraction of Taxable Sugar (%)	
	(1)	(2)
Post	-16.088***	
	(0.710)	
2018		-7.407***
		(1.040)
2019		-17.419***
		(1.057)
2020		-18.361***
		(0.436)
2021		-18.966***
		(0.302)
2022		-19.039***
		(0.426)
Constant	50.939	50.939
Observations	54	54

Notes: The table reports the results from our before-after model corresponding to specification (2). The outcome variable is the fraction of taxable sugar consumed in SSBs, defined as the total quantity of sugar cleared in taxable SSBs divided by total quantity of sugar cleared in all SSBs, expressed in percentage. We drop the dummy for the month of July 2018 and consequently the reported coefficients measure the reduction in the fraction in percentage points relative this month. The first column combines all post-reform months into a *post* dummy and hence reports the average decline in the fraction of taxable sugar in all post-reform months relative to the baseline month. The second column breaks down this average response by each post-reform year. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE III: EVENT STUDY RESULTS

	Outcome: Fraction of Taxable Sugar (%)			
	(1)	(2)	(3)	(4)
Constant	0.406***	0.401***	0.343***	0.444***
	(0.032)	(0.021)	(0.035)	(0.052)
Post	-0.109***	-0.103***	-0.106***	-0.104***
	(0.026)	(0.021)	(0.021)	(0.021)
Firm Fixed Effects	-	✓	✓	✓
Tariff Subheading Control	-	-	✓	✓
Client Type Control	-	-	-	✓
N	3,324	3,324	3,324	3,324
R^2	0.00	0.83	0.84	0.84

Notes: The table reports the results from our before-after model corresponding to specification (2). The outcome variable is the fraction of taxable sugar consumed in SSBs, defined as the total quantity of sugar cleared in taxable SSBs divided by total quantity of sugar cleared in all SSBs, expressed in percentage. We drop the dummy for the month of July 2018 and consequently the reported coefficients measure the reduction in the fraction in percentage points relative this month. We combine all post-reform months into a *post* dummy and hence reports the average decline in the fraction of taxable sugar in all post-reform months relative to the baseline month. The first column does not add any fixed effects. The later columns successively introduce the firm, beverage type, and client type fixed effects. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

TABLE IV: DYNAMIC EVENT STUDY RESULTS

	Outcome: Fraction of Taxable Sugar (%)			
	(1)	(2)	(3)	(4)
Constant	0.406	0.373	0.333	0.389
	(0.032)	(0.014)	(0.032)	(0.033)
Post	-0.109			
	(0.026)			
Post X 2019		-0.060	-0.060	-0.059
		(0.015)	(0.015)	(0.015)
Post X 2020		-0.080	-0.078	-0.076
		(0.017)	(0.017)	(0.017)
Post X 2021		-0.095	-0.094	-0.093
		(0.020)	(0.020)	(0.021)
Post X 2022		-0.099	-0.098	-0.096
		(0.021)	(0.021)	(0.022)
Post X 2023		-0.104	-0.104	-0.102
		(0.021)	(0.022)	(0.022)
Firm Fixed Effects	-	✓	✓	✓
Tariff Subheading Control	-	-	✓	✓
Client Type Control	-	-	-	✓
N	3,324	3,324	3,324	3,324
R^2	0.00	0.83	0.84	0.84

Notes: The table reports the results from our before-after model corresponding to specification (2). The outcome variable is the fraction of taxable sugar consumed in SSBs, defined as the total quantity of sugar cleared in taxable SSBs divided by total quantity of sugar cleared in all SSBs, expressed in percentage. We drop the dummy for the month of July 2018 and consequently the reported coefficients measure the reduction in the fraction in percentage points relative this month. In the first column, we combine all post-reform months into a $post$ dummy and hence reports the average decline in the fraction of taxable sugar in all post-reform months relative to the baseline month. In next columns, we break down this average response by each post-reform year. These columns also successively introduce the firm, beverage type, and client type fixed effects. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

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