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The effect of a soft drink tax in Mexico: evidence from time-series industry data*

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We use a time-series approach and industry data to estimate the effect on consumption of a relatively large excise tax on soft drinks imposed recently in Mexico. The tax caused a price increase of 12.8 per cent and reduced per-capita consumption about 3.8 per cent. This effect is small in comparison with the effects that are suggested by most studies that estimate price elasticities using an almost ideal demand system and household survey data. Moreover, we find that the effects of the tax on consumption vary throughout the year. The effect of the tax tends to be higher in the winter but vanishes during the summer. We also find that the effect of the tax does not vary from one year to another.

Key words: Mexico, per-capita consumption, soft drinks, taxes, time series.

1. Introduction

There is an ongoing debate about taxes on sugar-sweetened beverages (SSB) in Australia (Duckett *et al.* 2016; Pincus 2018; Lloyd and MacLaren 2019). One of the crucial elements in the discussion is the expected effect of the tax on consumption. For instance, in their tax proposal for Australia, Duckett *et al.* (2016) assume that the price elasticity of demand is 0.9 and, consequently, estimate that consumption would decline by 15 per cent. These numbers are comparable to those found in the literature and used in Mexico to assess the effects of a similar tax. However, we show that the actual effect of the tax on consumption in Mexico is substantially smaller than expected.

It is worth looking at the effects of the tax on soft drinks in Mexico for several reasons. First, there are proposals to levy excise taxes on SSB in several countries, including Australia. Second, several studies claim that Australia is one of the largest consumers of soft drinks worldwide (Lloyd and MacLaren 2019). The same occurs with Mexico (Basu *et al.* 2013). Third,

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Mexico and Australia have a similar rate of obesity. According to the World Health Organization, in 2016 the prevalence of obesity among adults was 28.9 per cent in Mexico and 29 per cent in Australia (available at https://apps.who.int/gho/data/node.main.A900A?lang=en). Fourth, as it occurred in Mexico, the SSB tax proposal for Australia is based on a relatively large price elasticity, which may lead to overestimating its effect on consumption and, consequently, the reduction in caloric intake.

Consumers in Mexico pay an excise tax of $1 peso per litre on sugary drinks since the beginning of year 2014.[1] Before the introduction of the tax, the average price of a litre of soft drink in Mexico was $7.8 pesos.[2] Therefore, the $1 peso tax represented 12.8 per cent of the price. As expected, the tax was passed on to consumers (Colchero *et al.* 2015b; Grogger 2017). Soft drink price elasticity estimates in the literature – based on household survey data – suggested that consumption would fall between 12.2 per cent and 28.9 per cent. Based on this type of estimates, Grogger (2017) calculates that per-capita consumption of soft drinks in Mexico decreased between 18.2 and 27.4 calories per day because of the tax.

In this article, we use time-series data of industry sales to estimate the effect of a one-peso tax on per-capita consumption of soft drinks in Mexico. According to our estimates, the tax reduced per-capita consumption, on average, about 3.8 per cent. Given that average daily per-capita consumption of soft drinks in Mexico is about 0.44 litres and, as assumed by Grogger (2017), a litre of soda contains 400 calories, the effect of the one-peso tax is to reduce consumption of soft drinks by an amount that provides 6.8 calories per person per day. We also find that the effect of the tax varies within the year. In particular, we find that the tax has practically no effect on consumption during the summer months in Mexico. In terms of calories, the effect of the tax varies between 0.4 (during the summer) and 13.1 (during the winter). Finally, we find that the effect of the tax on consumption does not change throughout the years.

The rest of the document organises as follows: in section 2, we briefly review related literature. Afterwards, we explain the data and the econometric model that we use to estimate the effect of the tax on consumption. In section 4, we discuss estimation results. Finally, we present the main conclusions of the article.

2. Review of the literature

The effectiveness of a tax on soft drinks to reduce obesity depends on a series of events that have been widely discussed – mostly separately – in the

[1] According to the law, the tax adjusts for inflation periodically. In 2018, it suffered its first adjustment. The tax increased to $1.17 pesos per litre.

[2] This figure is calculated with industry sales gathered by INEGI. We take the average implicit price of a litre of soft drink in the last three months of the year 2013 and add the VAT.

economic literature. A tax can be effective to reduce obesity if: (a) it causes a relatively large increase in the price of soft drinks (i.e. a large part of the tax is passed on to consumers); (b) consumption of soft drinks is sensitive to its price (in other words, the price elasticity of demand for soft drinks is large); (c) a lower consumption of soft drinks actually reduces individuals' caloric intake (i.e. soft drink calories are not substituted with other calories); and (d) the lower caloric intake produced by the tax reduces overweight and obesity (this requires soft drink calories to represent a relatively large portion of individuals' caloric intake).

Our article studies specifically the effect of the Mexican soft drink tax on its consumption. Therefore, this review of the literature focuses on the second issue listed in the previous paragraph. Nevertheless, it is worth mentioning that some recent studies such as Lin *et al.* (2011) and Fletcher *et al.* (2015) review with more detail all the relevant literature.

A group of studies such as Lin *et al.* (2011), Zhen *et al.* (2011), and Dharmasena and Capps (2012) evaluate the effects of a hypothetical soft drink tax on the consumption of these goods in the United States. The standard assumption in this literature is that there is a one-to-one transmission of the tax to consumers. The assumption seems reasonable in light of the Mexican experience. With this idea in mind, the authors use panel data on households' food and drink purchases in order to estimate an almost ideal demand system. Afterwards, they use direct and cross price elasticity estimates to simulate the effects of a price increase in soft drinks (presumably caused by the tax) on consumption. The price elasticity estimates that they find are between 0.95 and 2.26. These numbers suggest that a 12.8 per cent price increase would reduce consumption of soft drinks between 12.2 per cent and 28.9 per cent.

Following most of the literature, Duckett *et al.* (2016) in their SSB tax proposal for Australia assume a one-to-one transmission of the tax to consumers. In their analysis, they use a 0.9 price elasticity to estimate a drop of approximately 15 per cent in SSB consumption.

Several articles such as Valero (2006), Barquera *et al.* (2008), Fuentes and Zamudio (2014), Colchero *et al.* (2015a), Andalón and Gibson (2017), Chapa *et al.* (2017) and Gibson (2019) estimate the price elasticity of demand for soft drinks in Mexico. Valero (2006), Barquera *et al.* (2008), Fuentes and Zamudio (2014) and Colchero *et al.* (2015a) use data – gathered before the approval of the tax – from the households' incomes and expenditures national survey (ENIGH). This database is a cross section. Nevertheless, the results of Valero (2006), Barquera *et al.* (2008) and Colchero *et al.* (2015a) are in line with previous findings. Valero (2006) estimates that own price elasticity of demand for soft drinks in 2002 is 1.4. Barquera *et al.* (2008) calculate it in 1.08 for 2006 and Colchero *et al.* (2015a) in 0.9 for 2010. These elasticities suggest that a 12.8 per cent increase in the price of soft drinks – such as the one that took place in Mexico after the tax – would reduce consumption between 11.5 per cent and 17.9 per cent.

In contrast with most of the international literature, Fuentes and Zamudio (2014), Andalón and Gibson (2017), and Gibson (2019) find relatively small own price elasticity estimates of demand for soft drinks in Mexico. The estimates of Fuentes and Zamudio (2014) are between 0.16 and 0.44, while the estimates of Andalón and Gibson (2017) are between 0.2 and 0.3. It is important to mention that Fuentes and Zamudio (2014) and Andalón and Gibson (2017) use ENIGH which is the same data source used by Valero (2006) and Colchero *et al.* (2015a). However, Fuentes and Zamudio (2014) and Andalón and Gibson (2017) use methods that take into account for certain price policies that are common in the soft drink industry. In particular, they consider price discrimination practices – volume discounts – and product quality differences, respectively. If their price elasticity estimates are correct, and there is a one-to-one transmission of the tax to consumers, then consumption should fall between 2 per cent and 5.6 per cent. Gibson (2019) uses information from *Instituto Nacional de Estadística y Geografía* (INEGI) to show that the average soda prices rise 11.9 per cent after the tax, while the ratio of expenditure to quantities calculated from ENIGH grows 6.3 per cent. Moreover, Gibson (2019) estimates an elasticity of 0.39 using average prices.

A few studies use data gathered around the beginning of the Mexican soft drink tax to estimate its effects on consumption explicitly.[3] For instance, Colchero *et al.* (2016b) use a panel data of household purchases covering two years before the tax and one year after the tax. They estimate that – on average – the tax reduced per-capita consumption by 6 per cent during the first year. Moreover, they argue that the effect of the tax increases with time. More recently, Colchero *et al.* (2017) estimate smaller effects for the same tax. That is, they calculate that per-capita consumption of soft drinks decreased 5.5 per cent during the first year and 9.7 per cent during the second year after the tax. Aguilar *et al.* (2019) develop a regression discontinuity design with panel data consisting of weekly household information of years 2013 and 2014. Their dependent variables are price and calories. They estimate a pass-through of 80 per cent of the tax to consumers and a reduction of 2.7 per cent on calories purchased from SSB. It is important to note that results from the studies above are similar to what we would expect if Fuentes and Zamudio (2014) and Andalón and Gibson (2017) elasticity estimates are correct.

Finally, it is important to mention that Chapa *et al.* (2015), Colchero *et al.* (2016a), Chapa *et al.* (2017) and Aguilar *et al.* (2019) use time-series information from the industry to estimate the effect of the soft drink tax. Chapa *et al.* (2015) and Chapa *et al.* (2017) run regressions on the impact of the tax 8 months after its implementation. Their price elasticity estimates are between 0.25 and 0.36. Aguilar *et al.* (2019) use a time-series approach as a

[3] Similarly, some studies such as Cawley *et al.* (2019), Falbe *et al.* (2016), Debnam (2017) and Taylor *et al.* (2019) evaluate the effects of soda taxes recently imposed in Philadelphia and Berkeley, respectively.

robustness test, particularly to consider both at-home consumption and away-from-home consumption. Under this methodology, they calculate that the tax reduced total consumption of soft drinks in 6.9 per cent. Colchero *et al.* (2016a) obtain similar results using per-capita consumption.

3. Data and econometric model

Unlike most previous studies that use household cross sections or panel data, we use monthly industry time-series data (from January of 2007 to December of 2017) in order to estimate the effect of the Mexican soft drink tax on consumption. The main advantage of using a macroeconomic time-series approach to estimate the effects of the tax, rather than the standard microeconomic-household data approach, is the quality of macro data. That is, industry data are better than household data to calculate soft drink consumption in Mexico. Industry data cover consumption both at-home and away-from-home, while household data only cover the former. Consumption of soft drinks away from home is relatively large in Mexico.[4] For instance, daily per-capita soft drink consumption estimates in Colchero *et al.* (2017) are below 0.2 litres, while industry data – as we will show in a moment – reveal that this figure is well above 0.35 litres. Moreover, consumption away from home may be less sensitive to the tax than consumption at-home.

Using aggregate information obtained from industry sales has certain disadvantages. One of them is that industry (aggregate) data are not useful to distinguish the effects of the tax on different socio-economic and age groups. Therefore, we should recognise that this type of analysis is beyond the scope of our study. Another disadvantage of INEGI industry data – as well as ENIGH household data – is that it mixes taxed and untaxed soft drinks. That is, there is no distinction between regular and diet soft drinks. Nevertheless, this does not seem to be a big limitation considering that consumption of diet soft drinks in Mexico is relatively small.[5]

It is important to mention that we use industry sales data as a proxy for consumption because sales of this product match consumption very closely. A reason for it is that imports and exports are unusual in this market. The trade balance of soft drinks (in conjunction with bottled water because there are no disaggregated series) represents on average about 1.6 per cent of industry sales throughout the 2007–2017 period. Trade of soft drinks is small

[4] This also seems to be the case in Australia. Moreover, according to information presented by Duckett *et al.* (2016), meals out and take away food exhibit an increasing trend in the country.

[5] According to the information provided by Barquera *et al.* (2008), consumption of diet soda by adults (19 years old and over) in Mexico represents about 5.6% of their total consumption of soda, while consumption of diet soda by adolescents (12 to 18 years old) represents about 0.8% of their consumption of soda.

because they are costly to transport. Indeed, soft drink companies in Mexico and many other countries distribute their products through a network of bottlers across the country in order to be close to where demand is located (Henderson and McNamara 2000). Hence, most consumers buy soft drinks that not only are bottled in the country but very likely in their own towns.

The dependent variable in our study is average daily per-capita consumption of soft drinks. We construct this variable by combining soft drink industry sales data from INEGI with population projection data from *Consejo Nacional de Población* (CONAPO). In particular, we use INEGI's monthly manufacturing industry survey (EMIM) to obtain the amount of soft drinks (in litres) sold in the country each month. The soft drinks that we consider are cola and flavour sodas either sold in bottle or sold in can.

In order to collect data from soft drink bottlers, INEGI follows a deterministic sample design that includes as much establishments as necessary to cover at least 80 per cent of total income in the soft drink industry. It is important to mention that INEGI has a confidentiality agreement with these firms (available at https://www.inegi.org.mx/inegi/contenido/confidencialidad.html) in which the institute states the following: 'data provided by the informants for statistical aims are strictly confidential and under no circumstance the data will be used for another aim. The Institute does not provide this information to any person, nor fiscal, judicial, administrative or any other type of authority'.

We also use CONAPO's Mexican population projections for years 1990–2010 and 2010–2030. We assume a constant monthly growth rate during the year to generate a monthly population projection. The average daily per-capita consumption of soft drinks for a given month is the ratio of soft drinks (in litres) sold in the country to the projected population divided by the number of days in the corresponding month.

Figure 1 shows monthly averages of daily per-capita soft drink consumption in Mexico during the last 11 years. Note that during most of the period, daily per-capita consumption of soft drinks in Mexico is between 0.35 and 0.5 litres. Furthermore, note that consumption exhibits large changes within the year depending on weather conditions. It typically increases during the summer and decreases during the winter. For any given year, January is the month in which consumption is the lowest. On the other hand, the month in which consumption is the highest may be between May and August depending on the year. The difference between summer and winter consumption is usually around 0.1 litres, which represents about 22.7 per cent of mean consumption.[6] Figure 1 also shows the price of soft drinks in real terms. We use information from INEGI to construct this variable. For each month, we divide the price index for soft drinks by the national

[6] Analysis of information about monthly sales and production of soft drinks in Mexico for the period 2007-2017 shows that bottlers adjust production to meet sales. Therefore, bottlers produce more in summer and less in winter.

consumer price index (July 2018 is the base period). It is easy to observe that changes in this price between 2007 and 2013 are negligible. However, the price of soft drinks jumps with the introduction of the tax in January of 2014. Since then, the price remains practically unchanged.

It is relatively easy to note that the tax had a large effect on the price of soft drinks, but not on per-capita consumption. Consumption exhibits large changes within the year as well as some apparent trend changes across the years. For instance, the highest per-capita consumption of soft drinks in the series took place in the summer of year 2011. Since then, summer peak consumption of soft drinks has been falling year after year. This reduction in consumption started several years before the introduction of the tax.

Some basic statistics of the monthly averages of daily per-capita soft drink consumption in years 2013 and 2014 can help us to have a first approximation of the effect of the tax. Table 1 shows the mean and standard deviation of daily average per-capita consumption of soft drinks in Mexico during the years immediately before and after the tax. The difference between the two means is 0.0134 litres (about 0.46 ounces). Note that this quantity is about one-half of the standard deviation before the tax. Note also that this change represents about 3 per cent of mean consumption before the tax.

While the simple comparison of average per-capita consumption right before and after the tax is a reasonable approximation of the effect of the tax, it does not take into account the dynamics of the time series or the effect of its price. Although the price of any good may be an important explanatory variable when estimating demands, it may be endogenous. Therefore, it can generate biased and inconsistent estimators. To avoid the latent problem of endogeneity, we estimate a soft drink consumption equation that considers a dummy variable that mimics the behaviour of the real price of soft drinks. We also include a potential trend and a structural break, as well as season effects.

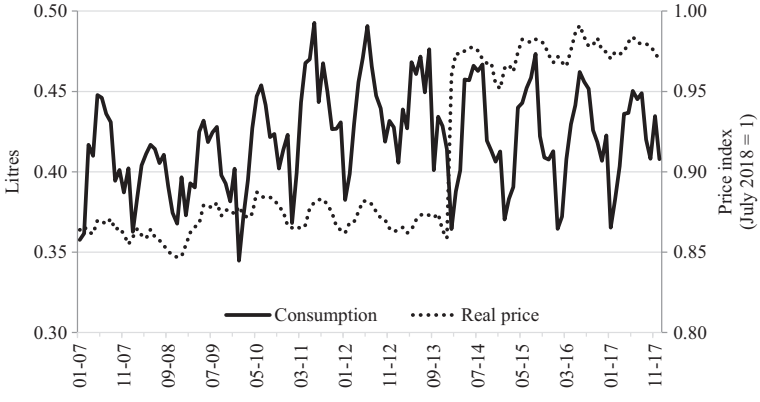


Figure 1 Daily consumption of soft drinks per capita and their prices in Mexico. Source: INEGI and CONAPO.

Table 1 Average of daily per-capita consumption in litres before and after the tax

	Mean	Standard Deviation
2013 (Before the tax)	0.4396	0.026
2014 (After the tax)	0.4262	0.035
Difference	−0.0134	

$$\ln q_t = \beta_0 + \beta_1 trend_t + \beta_2 break_t + \sum_{s=1}^{11} \beta_{s+2} D_{st} + \delta tax_t + \varepsilon_t. \quad (1)$$

The variables in this equation are defined as follows. The dependent variable, $\ln q_t$, is the natural logarithm of average daily per-capita consumption of soft drinks at month t. The independent variables include a deterministic trend ($trend_t$), a dummy variable $break_t$, a set of dummy variables (one for each month but December) D_{st}, a dummy variable tax_t and an error term ϵ_t. The variable $break_t$ takes the value of 1 beginning November 2010, and 0 otherwise.[7] Meanwhile, tax_t is equal to 0 before the tax is implemented and 1 after its implementation (January 2014).

Note that coefficient δ captures the effect of the tax on soft drink consumption. It is worth highlighting that by using the dummy variable tax_t – which is clearly exogenous – instead of the price index of soft drinks, we solve the latent problem of endogeneity between quantity and price in this market.

Even though the Augmented Dickey–Fuller (ADF) unit root test suggests that per-capita consumption of soft drinks is nonstationary, in our equation we include this variable in levels. The reason is that additional tests suggest the variable is stationary. For instance, we employ Phillips-Perron tests as well as other tests that allow the presence of structural breaks such as Zivot and Andrews (1992) and Lee and Strazicich (2013) considering one structural break, and Lee and Strazicich (2003) considering two breaks. All the tests but ADF conclude that the per-capita consumption of soft drink series is stationary (see Table A1 and Table A2 in the appendix).

It is important to make some distinctions between the current analysis and the works of Chapa *et al.* (2015), Colchero *et al.* (2016a), Chapa *et al.* (2017) and Aguilar *et al.* (2019), which are the only studies that have used a time-series approach as far as we know. First, the time series in these studies cover a shorter period after the beginning of the tax. Chapa *et al.* (2015) and Chapa *et al.* (2017) cover 8 months (i.e. 8 observations), while Colchero *et al.* (2016a) and Aguilar *et al.* (2019) 24 months. Our time series spans 4 years after the beginning of the tax (i.e. 48 observations in the time series).

Second, we consider different variables in our analysis. With respect to Chapa *et al.* (2015) and Chapa *et al.* (2017), we exclude price from our

[7] We estimate several regression models changing the date of the structural break. We set it on November 2010 as it has the highest t-statistic value.

regressions to avoid the latent endogeneity problem between price and quantity. For the same reason, we also exclude the economic activity index, which is also considered by Colchero *et al*. (2016a). That is, the economic activity index may be affected by the tax reform that included the soft drink tax. In contrast with Aguilar *et al*. (2019), our dependent variable (consumption of soft drinks) is in daily per-capita terms.

Third, there are some methodological distinctions. We analyse the stationarity properties of the time series. Furthermore, we include a structural break in the estimation, which turns out to be relevant. We investigate whether the tax effect varies within the year. We believe that the demand for soft drinks may be more elastic in the winter than in the summer. Moreover, we evaluate the effect of the tax throughout the years after its implementation.

4. Results

We first estimate the average effect of the tax. We consider several versions of the empirical model trying to take into account that consumption data suggest the presence of a trend, a structural break and a change in trend after the break. The first version includes a trend, a structural break and an interaction between the trend and the structural break. The interaction term attempts to capture a potential change in the trend after the break. The second version excludes the interaction term. The third version excludes the trend but includes the interaction term. The last version excludes both the trend and the interaction term.

Table 2 shows the main results of estimating directly the impact of a soft drink tax on per-capita consumption of these goods in Mexico. It is important to mention that we correct these estimates for heteroskedasticity and autocorrelation following the procedure in Newey and West (1987). Thus, we include heteroskedasticity and autocorrelation consistent standard errors in parenthesis. The results confirm that the series has a structural break at the end of year 2010. Per-capita consumption increases about 8.5 per cent after the break. The coefficients associated with the trend and its interaction with the structural break are not statistically different from zero. However, we still report the results of the different versions of the empirical model. There seems to be a very small positive trend in consumption before the break and a similarly small but negative one afterwards.

It is easy to observe that the inclusion of a trend affects the magnitude of the estimated effect of the tax on per-capita consumption of soft drinks. If we only include a linear trend in the regression, as in column (2), we find that the tax reduces per-capita consumption about 3.9 per cent.[8] However, if we include an interaction term that takes into account for a change in the trend,

[8] According to Kennedy (1981) and van Garderen and Shah (2002), the correct formula for calculating percentage differences in a dummy variable in a semi-log regression is $100\times[e^{\delta-0.5\hat{V}(\delta)}-1]$.

Table 2 Estimated impact of a tax on soft drink consumption in Mexico

Variables	(1)	(2)	(3)	(4)
Intercept	−0.93295***	−0.92899***	−0.92828***	−0.92849***
	(0.01315)	(0.01044)	(0.00733)	(0.00762)
Trend	0.00021	0.00002		
	(0.00040)	(0.00026)		
Break	0.09283***	0.08157***	0.08841***	0.08241***
	(0.02037)	(0.01292)	(0.01884)	(0.00863)
Trend*Break	−0.00030		−0.00009	
	(0.00046)		(0.00028)	
Tax	−0.03499**	−0.03974***	−0.03485**	−0.03887***
	(0.01583)	(0.01398)	(0.01538)	(0.00686)
R^2	0.8643	0.8637	0.8639	0.8637
Adjusted R^2	0.8468	0.8474	0.8476	0.8487
AIC	−4.1006	−4.1113	−4.1124	−4.1264
Schwarz	−3.7511	−3.7837	−3.7848	−3.8206
Observations	132	132	132	132

Note: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. The estimated equation includes a set of 11 seasonal dummy variables. The table does not show their coefficients. *$P < 0.1$, **$P < 0.05$ and ***$P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.

as in columns (1) and (3), then we find that the effect of the tax is about 3.4 per cent. Finally, if we use standard criteria to select the model, then it is better to exclude both the trend and the interaction term as in column (4). This suggests that the effect of the tax is about 3.8 per cent. We also consider other specifications excluding the structural break but results are highly sensitive to the way trends are modelled. Table A3 in the appendix reports these results. It also presents estimations from a specification similar to Aguilar *et al.* (2019) when they use a time-series approach. The estimated impact of the tax is not the same because we use the dependent variable in per-capita terms. Following standard criteria for model selection, specifications from Table 2 are better fits.

Once we control for seasonal dynamics of consumption and the existence of a structural break in the series, it is clear that the tax imposed on soft drinks in Mexico did reduce consumption. More precisely, the tax reduced per-capita consumption of soft drinks 3.8 per cent. This figure is a bit larger than the first approximation of 3 per cent obtained by comparing mean per-capita consumption right before and after the tax. However, the effect of the tax is about a quarter of the size suggested by price elasticity estimates obtained in previous studies such as Valero (2006), Barquera *et al.* (2008) or Colchero *et al.* (2015a), and about two thirds the size of direct estimates of the effect of the tax in Colchero *et al.* (2016b) and Colchero *et al.* (2017). Interestingly, our result is in line with price elasticity estimates obtained by Fuentes and Zamudio (2014), Chapa *et al.* (2017), Andalón and Gibson (2017), and Gibson (2019).

4.1 Tax effects throughout the year

From the analysis of Figure 1, we can establish that consumption exhibits changes throughout a given year depending on weather conditions. Thus, it is worth calculating whether the tax effect also varies throughout the year. In order to do so, we take the version of equation 1 that follows column (4) from Table 2 and include interactions for monthly dummies and the tax dummy. Table 3 shows the relevant results. According to standard criteria, it is not clear whether the model in column (4) from Table 2 or the one in Table 3 is the best fit. The Akaike criterion and adjusted R^2 favour the model in Table 3 but the Schwarz criterion and the Hannan–Quinn criterion (not reported) favour the other.

Results from Table 3 show that the tax effect on soft drink consumption does vary throughout the year. The base category is December. Therefore, due to the tax, daily per-capita consumption of soft drinks reduces about 3.4 per cent in this month. Moreover, the tax interaction coefficients for February, March and August are statistically significant. In particular, the coefficients corresponding to February and March are negative, while the one for August is positive. Thus, the tax reduces consumption during February and March more than in December (7.3 per cent and 8.0 per cent, respectively), but the effect of the tax on consumption is negligible during August.

Figure 2 shows the estimated effect of the tax within the year. We use average daily per-capita consumption of soft drinks for each month of 2013 as a reference. The solid line is consumption in year 2013. The dashed line represents the estimated consumption once we take into account the effect of the tax from Table 3. As we can see, the effect of the tax is not constant throughout the year. Interestingly, the tax seems to have no effect on soft drink consumption during the summer.

4.2 Tax effects for different years

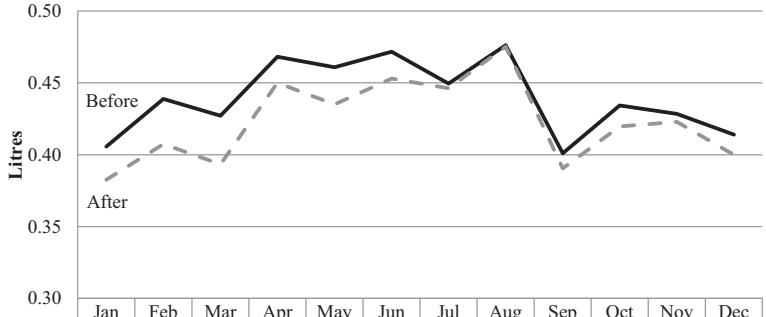
Table 4 shows the main results of estimating directly impact of a soft drink tax on per-capita consumption taking into account that the effect of the tax may change with time. We evaluate the effect of the tax through time with two different specifications. Both versions are based on model (4) in Table 2. Model (4a) includes tax dummies for each year since 2014 instead of a single tax dummy for the whole period. Model (4b) maintains the single tax dummy for the whole period but considers a trend after the tax. This new trend ($trend\_after\_tax_t$) starts in January of 2014.

Model (4a) may suggest that the tax effect of the tax on consumption increases with time as claimed by Colchero *et al.* (2017) and Pedraza *et al.* (2019). In the first year, the tax reduced consumption only about 3 per cent. In the second and third year, the tax reduced consumption about 4 per cent. Finally, in the fourth year the tax reduced consumption about 4.3 per cent.

Table 3 Estimated tax effect throughout the year

Variables	(1)
Tax	−0.03454**
	(0.01120)
January*tax	−0.02389
	(0.01856)
February*tax	−0.03959**
	(0.01970)
March*tax	−0.04752***
	(0.01628)
April*tax	−0.00496
	(0.01799)
May*tax	−0.02297
	(0.01685)
June*tax	−0.00586
	(0.01952)
July*tax	0.02733
	(0.01776)
August*tax	0.03232*
	(0.01870)
September*tax	0.00773
	(0.01887)
October*tax	0.00053
	(0.01411)
November*tax	0.02135
	(0.02504)
R^2	0.8879
Adjusted R^2	0.8628
AIC	−4.1549
Schwarz	−3.6090
Observations	132

Note: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. The estimated equation includes a constant, a set of 11 seasonal dummy variables and a dummy variable for a structural break. The table does not show their coefficients. *$P < 0.1$, **$P < 0.05$ and ***$P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Before	0.406	0.439	0.427	0.468	0.461	0.472	0.449	0.476	0.401	0.434	0.428	0.414
After	0.383	0.407	0.393	0.450	0.435	0.453	0.446	0.475	0.390	0.420	0.423	0.400

Figure 2 Estimated tax impact on daily per-capita soft drink consumption. *Note*: Differences for January–June, October and December are statistically significant at 5%.

Table 4 Estimated impact of a tax on soft drinks through time

Variables	(4a)	(4b)
Intercept	−0.92849***	−0.92821***
	(0.00722)	(0.00737)
Break	0.08241***	0.08239***
	(0.00875)	(0.00869)
Tax		−0.03557***
		(0.01087)
Trend after tax		−0.00013
		(0.00033)
Tax 2014	−0.03035***	
	(0.00871)	
Tax 2015	−0.04027***	
	(0.01057)	
Tax 2016	−0.04079***	
	(0.01121)	
Tax 2017	−0.04407***	
	(0.00997)	
R^2	0.8654	0.8639
Adjusted R^2	0.8467	0.8477
AIC	−4.0935	−4.1128
Schwarz	−3.722	−3.7852
Observations	132	132

Note: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. The estimated equation includes a set of 11 seasonal dummy variables. The table does not show their coefficients. $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.

However, these estimates of the effect of the tax are small and do not change substantially from one year to the next in comparison with what Colchero *et al*. (2017) and Pedraza *et al*. (2019) find. Colchero *et al*. (2017) estimate that the effect of the tax almost doubles from one year to the next (i.e. they find that consumption falls 5.5 per cent and 9.7 per cent, respectively, in the first and second year after the introduction of the tax). Pedraza *et al*. (2019) predict even larger reductions in the average volume of soft drink purchases.

In model (4b), we test formally whether the effect of the tax is changing with time by interacting the tax with a trend that starts with the introduction of the tax. The corresponding parameter is not statistically different from zero. Furthermore, model (4b) fits the data better than model (4a) under standard criteria. Similarly, model (4) is preferred to both models (4a) and (4b). Therefore, contrary to what previous researchers argue, we find that the effect of the tax on consumption is not changing throughout the years.

5. Conclusions

We estimate the average effect of the relatively large excise tax imposed by the Mexican government on the consumption of soft drinks. Unlike most previous studies in the literature that use household survey data, we use a time-series approach and industry data. This is important because industry

data are more comprehensive and accurate than household survey data. We conclude that the tax reduced per-capita consumption about 3.8 per cent. This effect is relatively small in comparison with the effects suggested by most studies that estimate price elasticities using an almost ideal demand system and household survey data.

In terms of the ongoing debate about the potential effects of a SSB tax in Australia, our results support the argument in Pincus (2018) that price elasticities used to calculate the effect of a tax on consumption by Duckett *et al.* (2016) are overestimated. More generally, as expressed by Gibson and Romeo (2017), that price elasticity estimates used by supporters of fat taxes tend to be biased.

We test several econometric models to control for a potential trend and a structural break in the soft drinks' consumption time series. The effect of the tax on per-capita consumption is not sensitive to the inclusion of trends in the regressions as long as we control for a structural break. Standard criteria suggest including a structural break but not the trends. Regardless of whether we include the trends or not, the effect of the tax on consumption is between 3 per cent and 4.3 per cent. Nevertheless, if we exclude the structural break, the effect of the tax on consumption is extremely sensitive to the way trends are modelled.

We find that the effect of the tax varies within the year. In particular, the tax has a larger effect in the winter than in the summer. In terms of calories, the tax reduces consumption of soft drinks about 6.8 calories on average but varies throughout the year between 0.4 (during the summer) and 13.1 (during the winter). These numbers are small in comparison the ones used by Grogger (2017) to estimate the effects of the tax on obesity.

Finally, we test whether the effect of the tax on consumption changes throughout the years. Previous research suggests that the effect of the tax increases with time and that this change is large. However, our results lead us to conclude that the effect of the tax on consumption is not changing significantly throughout the years.

We should point out some limitations of this study. First, the effects of the tax need not be the same for different socio-economic, age or consumer groups. Nevertheless, we cannot address this issue using aggregate data. Second, INEGIs' industry data – as well as household data – mixes taxed and untaxed soft drinks. That is, there is no distinction between regular and diet soft drinks in the Mexican official statistics. Although consumption of diet soft drinks is less than 5.6 per cent of total soft drinks in Mexico (Barquera *et al.* 2008), not being able to measure regular soft drink consumption more accurately may affect – at least marginally – results.

Data availability statement

The data that support the findings of this study are available in the supplementary material of this article.

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Appendix

Table A1 Unit Root Test for lnq_t in levels

Test	Deterministic components	
	Intercept	Intercept and Trend
Augmented Dickey–Fuller	−1.38	−1.28
	(0.58)	(0.88)
Phillips-Perron	−5.50***	−5.56***
	(0.00)	(0.00)

Note: *P*-values are shown in parentheses. $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.

Table A2 Unit Root Test with structural breaks for lnq_t in levels

Test	One structural break	
	Break: Intercept	Break: Intercept and trend
Zivot-Andrews	−8.27***	−8.91***
Critical values		
1%	−5.34	−5.57
5%	−4.8	−5.08
10%	−4.58	−4.82
Lee–Strazicich	−8.19***	−8.78***
Critical values		
1%	−4.23	−5.05
5%	−3 to 56	−4.50
10%	−3 to 21	−4.18
	Two structural breaks	
Lee–Strazicich	−8.45***	−9.30***
Critical values		
1%	−6.43	−6.45
5%	−5.70	−5.67
10%	−5.31	−5.31

Note: $^{*}P < 0.1$, $^{**}P < 0.05$ and $^{***}P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.

Table A3 Estimated impact of a tax on soft drink consumption in Mexico

Variables	(S1)	(S2)	(S3)
Intercept	−0.94400***	−0.96012***	−0.95223***
	(0.01371)	(0.01765)	(0.00733)
Trend	0.00126***	0.00218***	0.00150***
	(0.00024)	(0.00052)	(0.00026)
$Trend^2$		−0.000009**	
		(0.000004)	
Trend*Tax			−0.00161***
			(0.00044)
Tax	−0.07663***	−0.05289***	0.07998*
	(0.01893)	(0.01700)	(0.04140)
R^2	0.7957	0.8131	0.8226
Adjusted R^2	0.7732	0.7907	0.8013
AIC	−3.7217	−3.7952	−3.8472
Schwarz	−3.4159	−3.4676	−3.5196
Observations	132	132	132

Note: Heteroskedasticity and autocorrelation consistent standard errors in parentheses. The estimated equation includes a set of 11 seasonal dummy variables. The table does not show their coefficients. *$P < 0.1$, **$P < 0.05$ and ***$P < 0.01$ indicate level of significance at 10%, 5% and 1%, respectively.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Files that support the findings of this study.