Economics and Human Biology 19 (2015) 129–137

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: http://www.elsevier.com/locate/ehb

Price elasticity of the demand for sugar sweetened beverages and soft drinks in Mexico

M.A. Colchero *, J.C. Salgado, M. Unar-Munguía, M. Hernández-Ávila, J.A. Rivera-Dommarco

Instituto Nacional de Salud Pública, Av. Universidad #655, Col. Santa María Ahuacatitlán, 62508 Cuernavaca, Morelos, Mexico

ARTICLE INFO

Article history:
Received 25 September 2013
Received in revised form 19 August 2015
Accepted 22 August 2015
Available online 5 September 2015

Keywords:
Price elasticity
Obesity
Soft drinks
Sugar sweetened beverages
Mexico

ABSTRACT

A large and growing body of scientific evidence demonstrates that sugar drinks are harmful to health. Intake of sugar-sweetened beverages (SSB) is a risk factor for obesity and type 2 diabetes. Mexico has one of the largest per capita consumption of soft drinks worldwide and high rates of obesity and diabetes. Fiscal approaches such as taxation have been recommended as a public health policy to reduce SSB consumption. We estimated an almost ideal demand system with linear approximation for beverages and high-energy food by simultaneous equations and derived the own and cross price elasticities for soft drinks and for all SSB (soft drinks, fruit juices, fruit drinks, flavored water and energy drinks). Models were stratified by income quintile and marginality index at the municipality level. Price elasticity for soft drinks was −1.06 and −1.16 for SSB, i.e., a 10% price increase was associated with a decrease in quantity consumed of soft drinks by 10.6% and 11.6% for SSB. A price increase in soft drinks is associated with larger quantity consumed of water, milk, snacks and sugar and a decrease in the consumption of other SSB, candies and traditional snacks. The same was found for SSB except that an increase in price of SSB was associated with a decrease in snacks. Higher elasticities were found among households living in rural areas (for soft drinks), in more marginalized areas and with lower income. Implementation of a tax to soft drinks or to SSB could decrease consumption particularly among the poor. Substitutions and complementarities with other food and beverages should be evaluated to assess the potential impact on total calories consumed.

1. Introduction

The prevalence of overweight and obesity has reached alarming rates in Mexico. In 2012, 73% of adult women, 69% of adult men and more than 30% of children and adolescents were overweight or obese (Instituto Nacional de Salud Pública, 2012; Barquera et al., 2013). Mexico ranks second on obesity and first on diabetes prevalence of all country members of the Organization for Economic Co-operation and Development (OECD, 2011; Hernádez-Ávila et al., 2013).

Although the obesity epidemic is caused by multiple and complex factors, there is an increasing and stronger evidence that consumption of sugar-sweetened beverages (SSB) is a risk factor for obesity, type two diabetes and heart disease (Malik et al., 2006; Vartanian et al., 2007). Consumption of sugar in beverages does not produce satiety compared to sugar in a solid form, which tends to stimulate overconsumption of SSB (Willett and Ludwig, 2013). Most systematic reviews of prospective cohorts and randomized trials, show positive associations between the consumption of SSB and adult weight (Malik et al., 2006, 2009; Vartanian et al., 2007; Te Morenga et al., 2013) and risk of type 2 diabetes(Malik et al., 2010; InterAct, 2013).

* Corresponding author.
E-mail address: acolchero@insp.mx (M.A. Colchero).

http://dx.doi.org/10.1016/j.ehb.2015.08.007

Consumption of SSB such as soft drinks, juices, vitamin water, energy drinks and fruit drinks has significantly increased worldwide (Popkin, 2012). In Mexico, average individual consumption of SSB increased 60% between 1989 and 2006 (Barquera et al., 2008). In 2011, Mexico had the largest per capita consumption of soft drinks worldwide estimated at 163 l per capita per year (Euromonitor, 2011). The largest consumption of soft drinks is concentrated in the age range between 12 and 39 and is particularly high in the population aged 19 to 29 (Barquera et al., 2008). Recent evidence from the 2012 National Health and Nutrition Survey shows that caloric beverage represent about 18% of total energy among children and adults (Stern et al., 2014), 71% of the consumption of added sugar in Mexico comes from SSB and at least 66% of the population consumes more than 10% of added sugars – above the WHO recommendation – (Sánchez-Pimienta, 2015). While there is evidence from the National Income and Expenditure Surveys of a slight decrease in the percent of households that report any expenditures on SSB between 2008 and 2010, consumption in the country it is still very high (Euromonitor, 2011).

Fiscal approaches to reduce SSB consumption and the risk of obesity, diabetes and other chronic diseases such as taxation have been implemented or proposed in at least 19 countries around the globe (Jou and Techakehakij, 2012). Three considerations to implement taxes to SSB have been described: externalities related to increased health care costs associated with consumption of unhealthy beverages; information asymmetry in SSB advertisement—particularly among children; and, the use of revenues to benefit groups that are more affected by the health consequences of consuming SSB or to compensate the poor if the tax is regressive (Brownell et al., 2009). At the moment, there is no evidence of the effectiveness of a tax to SSB on consumption in the countries where it has been implemented (such as France or Denmark). The current paper is an estimation of the potential effect of a tax on consumption in Mexico. Taxes to SSB can have a direct effect on consumption and be an effective measure particularly in countries with high rates of obesity and high levels of SSB consumption (Jou and Techakehakij, 2012).

Evidence of the potential effect of a tax on consumption may inform the decision to implement a fiscal policy in the country. Estimation of substitution effects (an increase in the consumption of beverages or high-energy dense food not affected by changes in their own prices in response to the price increase on another – presumably taxed – beverage) are key given that the potential decrease on consumption and its positive effects on health induced by a tax could be offset by an increase in the consumption of other beverages with high sugar content or high-energy food.

Previous estimates in Mexico show price elasticities of the demand for soft drinks ranging between −0.6 and −1.6: a 10% increase in the demand for SSB is associated with a decrease in consumption between 6 and 16% (Valero, 2006; Barquera et al., 2008; Urzúa, 2008; Unar et al., 2013). This wide variation can be partly explained by the year studies were conducted, the type of SSB analyzed (some estimated the price elasticity of soft drinks whereas others mix soft drinks, juices and other SSB), the different empirical models applied as well as the data sets used. Our paper adds to the existing literature the application of a linear approximate almost ideal demand system (LA/AIDS) to derive price elasticities that includes beverages and high-energy foods as potential substitutes. The LA/AIDS model we used is consistent with the economic theory, it allows testing the condition of homogeneity and symmetry through linear restrictions on fixed parameters (Deaton and Muelbauer, 1980) and has more accurate estimations either implementing seemingly unrelated regressions or three stage least square (Alston et al., 1994). A comparison of different demand system models shows that the LA/AIDS model performs as good as other systems when estimating income and price elasticities, and have low standard errors specially when the number of commodities estimated is very large ($n \geq 6$) (Meyer et al., 2011). In addition, we used the most recent data available in the country and provided price elasticities of the demand for soft drinks and SSB stratified by income and marginality level to explore the potential heterogeneous impact of a tax. The rationale for stratifying by marginality index is as follows. The price elasticity of the demand for SSB may vary by marginality area, regardless of household income, as the demand for any food or beverage depends on availability and diversity of brands as well as availability of potential substitutes. The specific aims of this study were to estimate the own and cross price elasticities for soft drinks and for all SSB (soft drinks, fruit juices, fruit drinks, flavored water and energy drinks). The models were stratified by household income quintile and marginality index at the municipality level. Price elasticities were estimated using the 2006, 2008 and 2010 Mexican National Income and Household Expenditure Surveys (MNHIES). Analyzing the potential effect of a tax to soft drinks provides evidence to evaluate the feasibility of fiscal approaches to reduce SSB consumption.

2. Methods

2.1. Data sets

The MNHIES, conducted by the Mexican National Institute of Statistics and Geography (INEGI), is a system of cross-sectional nationally representative surveys with a two stage stratified probabilistic design (Instituto Nacional de Estadística y Geografía, 2011). The surveys are conducted every two years and collect household information on income and expenditures as well as household characteristics and socio-demographic data of their members. The MNHIES gathers daily food and beverage expenditures for one week, including the monetary value of gifts, transfers and consumption of household produced foods. While the individual responsible for reporting the data records every transaction, she or he is also asked to get the information for other members of the households. In this paper, we used the 2006, 2008 and 2010 waves. All the three waves were conducted from the third week of August to the first week of November.

2.2. Empirical model

We estimated a demand system for beverages and food using the Linear Approximation of the Almost Ideal

Demand System (LA/AIDS) developed by Deaton and Muelbauer (1980). The linear model includes a Laspeyres index to obtain linear parameters and other covariates defined below. We used a Laspeyers price index as suggested by Moschini to have linearity in the parameters (Moschini, 1995). This index considers the mean proportion of expenditure in each food group or beverage group in order to avoid a problem of simultaneity in the demand equation. In each equation, the dependent variable is beverage and food expenditure share (proportion of households expenditures on beverage or food group *i* with respect to total expenditures on beverages and food). We classified beverages and foods into eight categories: (1) soft drinks (including diet/low calorie sodas), (2) other SSB: fruit juices, fruit drinks, flavored water and energy drinks, (3) natural and mineral bottled water (4) milk, (5) candies, (6) snacks, (7) sugar, and (8) traditional Mexican snacks. Thus the demand system has 8 equations, one for each group of beverage or food. We also estimated a model merging all SSB (groups 1 and 2) and leaving as described above the other beverages and food items.

Following Zhen's approach for an incomplete demand system, we added a composite numéraire good that includes all other food items purchased by the household, not included as another equation but integrated as a unique price index (Zhen et al., 2013).

The LA/AIDS demand system is laid out as follows:

$$w_{\mathrm{hmit}} = \alpha_i + \sum_{j=1}^{j} \beta_{ij} \log p_{\mathrm{mjt}} + \gamma \log\left(\frac{E}{P}\right) + \sum_{k=1}^{K} \delta_{ik} \eta_{\mathrm{hmtk}} + u_{\mathrm{hmit}}$$

$$h = 1, \ldots, H; \quad m = 1, \ldots, M; \quad i = 1, \ldots, j-1; \quad t = 2006, 2008, 2010$$

where w_{hmit} is the food or beverage expenditure share for food or beverage group *i* for household *h* living in municipality *m* during wave *t*; P_{jt} is the price for food or beverage *j* at municipality level in *wave t* where the *j*th good is the composite numéraire; *E* is total household expenditures on beverages and food, η are variables at household and municipality level, and log *P* is the Laspeyres index price. *H* and *M* represent the number of households and municipalities, respectively; while *K* denotes the number of co-variables at household and municipality level.

The Laspeyres index price is defined as:

$$\log P_{\mathrm{jt}} = \sum_{i=1}^{j-1} \bar{w}_i * \log p_{\mathrm{mjt}}$$

Own and cross price elasticities non-compensated for income of the demand for soft drinks and SSB were derived from the model (see Unar et al., 2013). We estimated a system of structural equations by an equation-by-equation ordinary least squares estimation on the system. We pooled the three cross sectional surveys (2006, 2008 and 2010) to derive price elasticities but also provided results stratified by wave.

We estimated price elasticities by rural and urban settings, total income quintile at the household level and by marginality index at the municipality level.

2.3. Variables and analytical sample

For each of the eight beverage and food categories, we estimated beverage and food expenditure share summing up daily expenditures for one week and expanded it to quarterly expenditures.

Prices were derived from household daily expenditures and quantity spent in liters or kilograms. We averaged prices at the municipality level to reduce the potential measurement error at the household level. To detect and replace outliers we used INEGI methods applied in the collection of prices to estimate the National Consumer Price Index (Instituto Nacional de Estadística y Geografía, 2013). An outlier is detected if the price exceeds the average price at the municipality level plus two standard deviations (2 sd) and it is replaced by the average price at that level plus 2 sd. Prices were deflated using the Consumer Price Index where 2010 was the base year (Banco de México, 2010). We modeled the logarithm of the weighted average price per wave within each group.

The models control for education of the head of the household (last grade completed), round of the survey, urban/rural residence and adult equivalent to reflect household size and household composition based on Engel curves estimated using Mexican data (Teruel et al., 2005).

The models were stratified by total income quintile and marginality index. Total income is quarterly and is estimated at the household level using the MNHIES. The marginality index is a measure of social deprivation that combines in a principal component analysis census data on illiteracy, education, housing conditions (drainage, piped water, electric power, overcrowding, flooring material), population size, employment and income (de la Vega et al., 2011). The index at the municipality level is divided into five categories: very high, high, medium, low and very low levels of marginality.

Our total analytical sample is 73,311 households (19,512 in 2006, 27,994 in 2008, and 25,805 in 2010).

3. Results

The distribution of beverage and food expenditures remained stable between 2006 and 2010 (Table 1). The highest expenditures share was on soft drinks and milk. Except for milk, all beverage prices decreased during the period.

Table 2a shows the estimated own price elasticity of the eight beverage and food categories and cross price elasticities with respect to increases in the price of soft drinks overall and by wave. Overall, for soft drinks a 10% price increase decreases in quantity consumed by 10.6%. Other SSB, natural and mineral water, milk, candies, sugar and traditional snacks were price elastic, i.e., the percent

Table 1
Descriptive statistics of the 73,311 households in the MNHIES.

	ENIGH 2006 (n = 19,512)	ENIGH 2008 (n = 27,994)	ENIGH 2010 (n = 25,805)	All rounds
Percent of households with beverage expenditures >0				
Soft drinks	69.8	71.4	67.6	69.7
Other SSB*	22.8	23.9	21.5	22.8
Water	30.9	33.9	32.8	32.7
Milk	67.3	68.2	63.0	66.1
Sweets	19.7	18.9	17.8	18.7
Snacks	19.2	19.1	16.3	18.1
Sugar	32.6	29.8	31.8	31.2
Traditional snacks	34.9	33.7	33.6	34.0
Distribution of beverage household expenditures (%)				
Soft drinks	27.8	27.7	27.0	27.5
SSB*	4.1	4.3	4.0	4.1
Water	8.2	8.6	9.1	8.7
Milk	29.9	32.1	29.0	30.4
Sweets	2.9	2.7	3.0	2.9
Snacks	2.4	2.4	2.2	2.4
Sugar	9.3	7.0	9.9	8.6
Traditional snacks	15.4	15.0	15.9	15.4
Prices (per kg)**				
Soft drinks	11.3	10.1	9.6	10.2
Other SSB*	21.3	18.4	16.8	18.6
Water	3.9	3.9	2.6	3.5
Milk	12.3	13.0	12.8	12.7
Candies	104.4	110.9	89.0	101.5
Snacks	92.4	91.1	63.3	81.7
Sugar	14.5	11.3	15.3	13.5
Traditional snacks	39.6	49.0	42.4	44.2
Education (head of the household)				
No education	10.9	9.4	9.3	9.8
Primary school	41.1	39.5	38.4	39.6
Secondary school	23.6	25.5	25.8	25.1
High school	10.9	11.8	12.0	11.6
University or higher	13.5	13.8	14.5	14.0
Adult equivalent (mean)	3.7	3.7	3.6	3.7
Urban	73.8	77.8	78.7	77.1

* Other SSB: fruit juices, fruit drinks, flavored water, and energy drinks.
** 2010 Mexican pesos.

quantity decrease is greater than the percent price increase (absolute value price elasticity >1). The estimations show that a price increase in soft drinks is associated with a higher quantity of water, milk, snacks and sugar and a decrease in the quantity of other SSB, candies and traditional snacks.

Table 2b shows the estimated own price elasticities for the seven categories (grouping all SSB together) and cross price elasticities with respect to increases in the price of SSB overall and by wave. Overall, we found that SSB are price elastic: a 10% increase in the price of SSB decrease quantity consumed by 11.6%. The estimations show that a price increase in SSB is associated with a greater consumption of water, milk and sugar and a decrease consumption of candies, snacks and traditional snacks.

Table 3 shows the own price elasticities by wave. For soft drinks, results show elasticities of −1.1 in 2006 and 2008 and of −0.9 in 2010. The price elasticity of SSB were −1.1 in 2006, −1.2 in 2008, and −1.0 in 2010.

Fig. 1 shows the estimated own price elasticity of soft drinks and SSB by income quintile. The demand for soft drinks and for SSB is more elastic for the three lowest quintiles.

Fig. 2 shows the estimated own price elasticity of soft drinks and SSB stratified by marginality index. Price elasticities of the demand for soft drinks and SSB are higher among household living in more marginalized areas.

Table 2a
Own and cross price elasticity of the demand for soft drinks and other.

Beverage	Own price elasticity	Cross price elasticity (1% increase in the price of soft drinks)
Soft drinks	−1.06 [0.02]*	–
Other SSB[a]	−1.17 [0.03]*	−0.21 [0.01]*
Natural and mineral water	−1.32 [0.01]*	0.07 [0.01]*
Milk	−1.65 [0.02]*	0.11 [0.02]*
Candies	−1.13 [0.05]*	−0.32 [0.01]*
Snacks	−0.97 [0.05]*	0.25 [0.01]*
Sugar	−1.49 [0.05]*	0.15 [0.01]*
Traditional snacks	−1.13 [0.01]*	−0.15 [0.01]*

* Significant at 1%. Non-compensated price elasticity, standard errors in brackets.
[a] Other SSB include fruits juices, fruit drinks, flavored water and energy drinks.

Table 2b
Own and cross price elasticity of the demand for SSB and other.

Beverage	Own price elasticity	Cross price elasticity (1% increase in the price of SSB)
SSB	−1.16 [0.02]*	–
Natural and mineral water	−1.32 [0.01]*	0.10 [0.00]*
Milk	−1.67 [0.02]*	0.19 [0.02]*
Candies	−1.15 [0.05]*	−0.44 [0.01]*
Snacks	−0.98 [0.05]*	−0.23 [0.01]*
Sugar	−1.52 [0.05]*	0.46 [0.01]*
Traditional snacks	−1.13 [0.01]*	−0.24 [0.01]*

* Significant at 1%. Non-compensated price elasticity, standard errors in brackets.

Table 3
Own price elasticity of the demand for soft drinks, SSB and others by wave.

Beverage or food	Own price elasticity of the demand for SSB and others			Own price elasticity of the demand for soft drinks and others		
	2006	2008	2010	2006	2008	2010
SSB	−1.1*	−1.2*	−1.0*	–	–	–
Soft drinks	–	–	–	−1.1*	−1.1*	−0.9*
Other SSB[a]	–	–	–	−1.2*	−1.0*	−1.3*
Natural and mineral water	−1.3*	−1.3*	−1.3*	−1.3*	−1.3*	−1.3*
Milk	−1.6*	−1.7*	−1.7*	−1.6*	−1.6*	−1.7*
Candies	−1.2*	−1.1*	−1.1*	−1.2*	−1.1*	−1.1*
Snacks	−0.7*	−1.3*	−0.8*	−0.7*	−1.2*	−0.9*
Sugar	−1.1*	−2.0*	−1.3*	−1.1*	−1.9*	−1.3*
Traditional snacks	−1.1*	−1.3*	−1.0*	−1.1*	−1.3*	−1.0*

* Significant at 1%. Non-compensated price elasticity.
[a] Other SSB include fruits juices, fruit drinks, flavored water and energy drinks.

Finally, the price elasticity of soft drinks is higher among rural dwellers (−1.2) compared to urban (−0.9), and no differences between rural and urban for SSB where elasticities were −1.1 (results not shown).

4. Discussion

We estimated a demand system for beverages and high-energy dense food and derived the own and cross price elasticity of the demand for soft drinks and other beverages. We found that the price elasticity of the demand for soft drinks is −1.06 and higher for SSB (−1.16). The demand for soft drinks and SSB is more elastic among households living in rural areas, those in more marginalized municipalities and those with lower income.

Our price elasticity of the demand for soft drinks and for SSB is in the range of previous estimates for Mexico. Valero's elasticities of −1.6 in 1992 and −1.4 in 2002 (Valero, 2006) were higher than our estimates for soft drinks but similar to SSB because he included fruit juices that have higher price elasticities according to our findings. More recent estimates from Urzúa show elasticities of around −1.1, more similar to our results, although his model includes within the same group fruit drinks and water (Urzúa, 2008). Compared to Barquera et al. (2008) our estimates for soft drinks are similar to their elasticity of −1.0 in 2006, but higher than their 1989 and 2002 estimates of −0.6 and −0.8, respectively. The differences

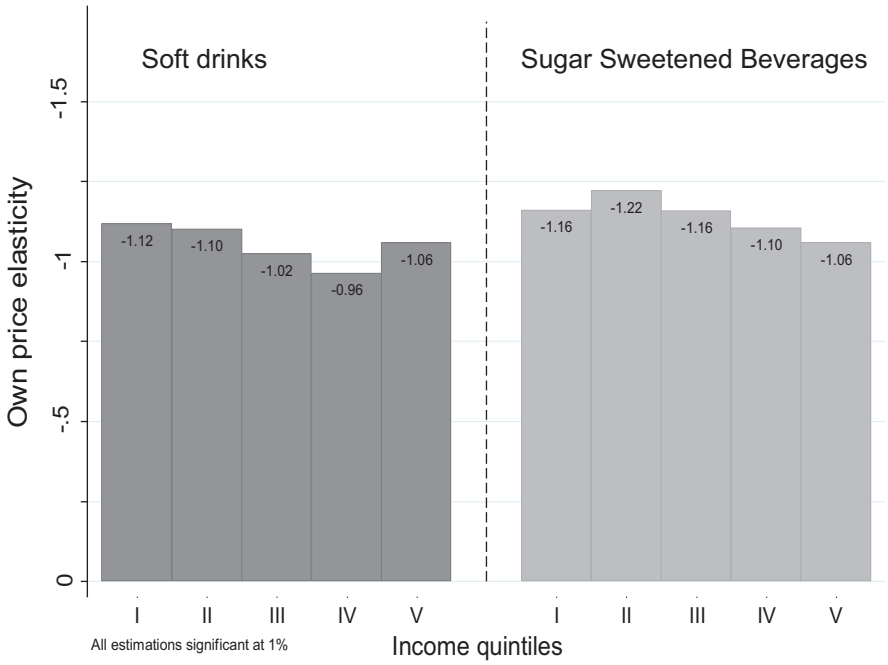

Fig. 1. Own cross price elasticity of the demand for soft drinks and SSB by income quintile.

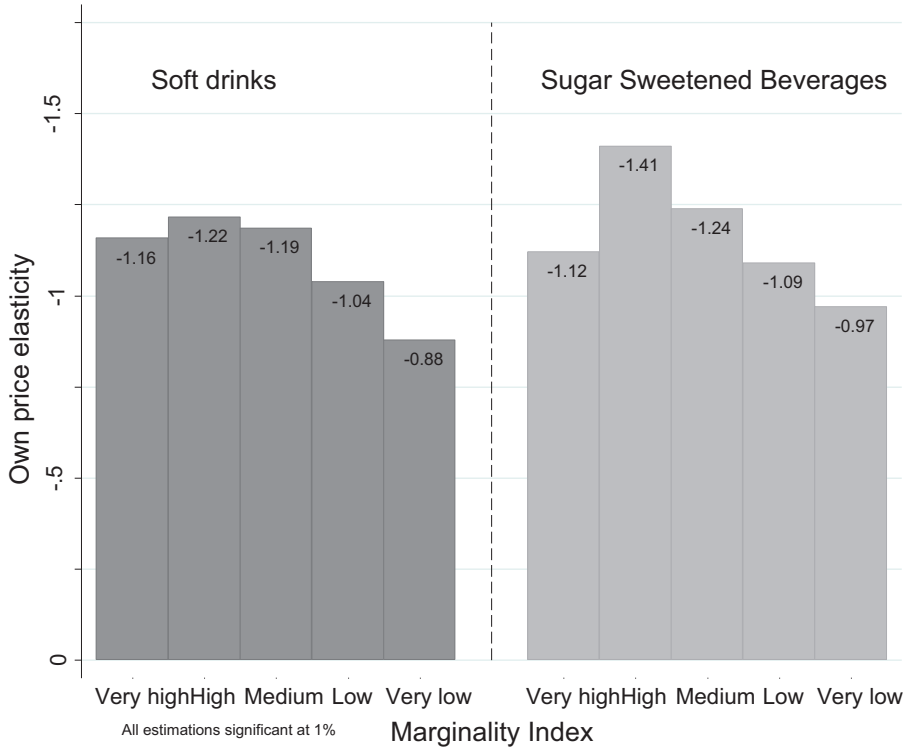

Fig. 2. Own price elasticity of the demand for soft drinks and SSB by marginality index.

could be due to the models used in each study (Barquera applied a two part model in which each beverage group is estimated independently). Another possible reason is that between 1989 and 2002 there were less available substitutes for soft drinks such as bottled water and other SSB (Cahuana et al., 2012). The higher price elasticity of soft drinks of −1.29 in our previous study (Unar et al., 2013) is expected as the Mexican Family Life Survey collects expenditures in only one specific soft drink that is more expensive compared to the wide variety of type of soft drinks and prices reported by the household daily during a week in the MNHIES.

Results show that differences in prices elasticities are greater by marginality area compared to income level. The MNHIES data shows that the difference in the proportion of household expenditures on SSB is greater by marginality index (5% average difference) between the most marginalized areas and the least marginalized areas-compared to the average gap of 3% in SSB expenditure share between the first and fifth income quintile 3%. Given that we can expect higher price elasticities as expenditure share increases, the larger gap in SSB expenditure share by marginality could be an explanation.

Cross price elasticities showed different substitutes and complements. We found that higher prices of soft drinks were associated with increases in water and milk expenditures and lower expenditures in the other groups of sugar sweetened beverages. Barquera et al. found the same substitution effects (Barquera et al., 2008). The substitution for water is very small but may be downward biased as potable water is not reported as expenditure in the MNHIES. Households or communities with higher availability of potable water may have larger elasticities compared to those where potable water is scarce as water represents a substitute. Substitution for water is desirable because it does not contain calories. Substitution for milk is more appropriate than the consumption of other SSB given its nutrient content that are required for children and because milk has a higher satiety (Malik et al., 2006; Runge et al., 2011).

We also found that soft drinks and other SSB are complements. Other SSB in Mexico are significantly more expensive than soft drinks (10.2 pesos per kg vs 18.6 see Table 1) so they would not be an affordable substitute. Another potential explanation is that households facing higher prices of soft drinks and lower expenditures reduce consumption of juices as in supermarkets these beverages are located in the same areas. For instance, evidence shows that sales of unhealthy commodities such as tobacco, alcohol, processed food and beverages are positively correlated (Moodie et al., 2013). Another explanation could be that households living in areas that face higher prices of soft drinks attend less often stores where SSB are available and consume less SSB. However, more research is needed to elucidate the reasons behind these findings.

We estimated uncompensated and compensated elasticities (not presented in the paper) to verify if milk elasticity was higher compared to soft drinks due an expenditure effect. As uncompensated elasticity, the compensated elasticity is higher for milk than for soft

drinks and other SSB. One potential explanation of the higher elasticity of milk is that household beverage expenditures share is higher for milk (30.5%) than for soft drinks (27.5%). Another potential explanation is that milk has more degree of substitution than soft drink (substitution effect is higher for milk than for soft drinks), possibly due to the fact that soft drinks are very common in the Mexican diet and could be seen more as a necessary good instead of milk, since more percentage of households reported an expenditure on soft drinks (69.7% vs 66.1%) or because there are more perceived substitutes of milk in the Mexican market.

Soft drink consumption and the percentage of households that report any consumption slightly decreased between 2008 and 2010. National sales data also show that there was a small decrease of soft drinks in that period along with an increase in sales from bottled water (Euromonitor, 2011).

The price elasticity for the demand for SSB slightly decreased from 1.1 to 1.0 between 2008 and 2010 and for soft drinks from 1.1 to 0.9 which could partly be explained by a decrease in price that went from 11.3 pesos per liter in 2006 to 9.6 in 2010. Another potential explanation of a lower price elasticity of soft drinks in 2010 is the increase in the availability of substitutes such as bottle water as the national consumption went from 155 l per capita per year in 2006 to 246 l in 2010 compared to no changes in water consumption in the United States (Gleick et al., 2012). If the downward trend of the price elasticity continues, the potential effect of a tax to SSB would be reduced.

Our study has some limitations. We were not able to separate diet soft drinks from non-diet soft drinks in the survey but consumption of low calorie SSB and diet soft drinks is still low in Mexico. In 2012, average consumption among adults was estimated at 201 ml for non-diet soft drinks and 34.4 ml of diet soft drinks (Stern et al., 2014).

Estimations from this study come from a pooled analysis of three rounds of the MNHIES that take advantage of price variability between households and over time. The surveys are cross sectional so we do not see changes in purchases within the same individual or the same household over time.

Household beverage expenditures in this survey may be under-reported for several reasons. Based on quantity of beverages purchased in a week as reported in the MNHIES 2010 (5.5 l/household) and an average household size of 3.9 gives a rough estimate of 68 l per capita per year. This estimate is lower than the 160 l per capita estimated using sales data for the same year. We acknowledge that a household expenditure questionnaire in not an instrument suitable to estimate individual consumption compared to a Food Frequency Questionnaire or a 24 h-food recall. In the MNHIES, around 20% of household expenditures on food and beverages were away from home expenditures, but this type of purchases are not specified in the surveys, so it was excluded from the analysis. Individual expenditures, particularly of SSB, may also be under-reported given that the head of the household is responsible for filling out the survey, therefore individual purchases may not be included if the head of the household ignores them. The estimations may be biased if under-reporting is differential, i.e., if individual expenditures are more prevalent among the poorest compared to the richer households which it is likely as richer households could buy larger quantities of soft drinks and store them at home. The bias ultimately depends on the prices faced by individual purchasers from which expenditure is under-reported in the survey versus expenditures reported at the household level.

SSB prices and sales fluctuate during the year due to climate changes (although they are not extreme in the country) and summer vacations. Although the data does not capture the full yearly pattern, the data collection period between August and November captures two months of the peak of SSB sales and prices and two months of a low season (although the lowest season in between January and March).

As Zhen et al. (2014), we acknowledge two potential sources of endogeneity in the model: measurement error in prices and omitted variables if prices are correlated with unobservable variables that influence demand. In our estimations, measurement error could arise as prices were derived from information on quantity of food or beverage expenditures reported by households. To minimize measurement error, we averaged prices at the municipality level, as described in Section 2. We acknowledge that the MNHIES are not representative at the municipality level and aggregating at a higher level could significantly reduce variability but our intention is to reduce the unit value bias. For omitted variables, as explained by Zhen for a model applied in the USA, households with higher preferences for certain foods and beverages may have more tools to find lower prices than others, which could bias the estimation although the direction of the bias is uncertain. Consumers in Mexico face less variability in local prices and brands compared to the USA; however we lack evidence to discard the possibility that certain households may find lower prices, thus we acknowledge this potential bias.

Given the high level of soft drink consumption in the country, the high rates of overweight and obesity and a prevalence of type 2 diabetes that has reached 14% of the adult population (Villalpando et al., 2010), a tax to soft drinks and other SSB could reduce consumption and have a positive effect on health (Jou and Techakehakij, 2012). Taxation has been recommended as a potential policy to diminish the demand for this kind of commodities; however, it should be accompanied with other interventions that have proven to be effective to prevent and reduce the prevalence of obesity and securing the provision of potable water in schools and other public places, particularly in poor communities to guarantee that a healthy substitute to SSB is available.

For the last 70 years, Mexico has had a low overall tax burden (Tello, 2015), the lowest among country members of the Organization of Economic Cooperation and Development: in 2012 revenues represented 19.6% of the gross domestic product compared to average OECD of 33.7% (OECD, 2014). Given the low tax burden in the country, an additional tax to SSB will not be less effective. Assuming an average price per liter of 8.7 pesos from the MNHIES data (around US $0.60) and a price increase of 1.7 pesos with a 20% tax, a population of 110 million (Consejo Nacional de Población, 2012) and an overall reduction in the consumption

of soft drinks from 160 o 126 l per person with no substitutions, as in Andreyeva et al. (2011), total revenues were estimated up to 1663 million dollars per year, which represents about 30% of the total obesity costs in Mexico (Álvarez del Río et al., 2012) and can be used to spend resources on prevention and treatment of chronic diseases.

Taxes to food and beverages are often regressive as the poor pay a higher percent of their income. However, the burden of the tax would be even greater if the own-price elasticity were the same across income quintiles and marginality index levels. Given that the demand for soft drinks is more elastic among lower-income households and more marginalized areas, the financial burden of a tax would be higher among higher socioeconomic households even ignoring how a tax affects the distribution of utilities. Although there is no evidence that in Mexico obesity varies significantly by income level, between 2006 and 2012 diabetes increased more in low versus high socioeconomic groups (Jiménez-Corona et al., 2013). Despite the implementation in 2004 of a voluntary subsidized health insurance for the poor named "Seguro Popular" that aimed to reduce the financial burden of catastrophic expenditures, the country has not reached universal coverage yet (Gutiérrez and Hernández-Ávila, 2013) and the poor still have lower access to health services (Bautista-Arredondo et al., 2014) and have to pay out of pocket for expensive interventions such as hemodialysis for diabetic individuals facing complications that are not covered by Seguro Popular (Comisión Nacional de Protección Social en Salud/Seguro Popular, 2012). If SSB consumption decreases as a result of implementing a tax to SSB and the later has an impact on obesity and diabetes, we may expect to see reductions in health expenditures among the poor.

The effect of a tax on consumption and health can be attenuated if consumers substitute SSB with other high-energy dense foods and if the tax does not pass along to consumers because suppliers decide to absorb the costs. Evidence on the effect of a tax in the future will be crucial to evaluate the effectiveness of such intervention.

Funding source

Funding for this research comes from the Bloomberg Foundation, project "Fighting obesity in Mexico: Supporting the design and evaluation of effective social actions and public policies".

Acknowledgments

We are very grateful with Rajeev Cherukupalli for the insightful comments to our preliminary working paper.

References

Alston, J., Foster, K., Gree, R., 1994. Estimating elasticities with the limear approximate almost ideal demand system: some Monte Carlo Results. Rev. Econ. Stat. 76 (2), 351–356.

Álvarez del Río, F., Gutiérrez-Delgado, C., Guajardo-Barrón, V., 2012. In: Rivera Dommarco, J.A., Hernandez Avila, M., Aguilar Salinas, C.A., Vadillo Ortega, F., Murayama Rendón, C. (Eds.), Costo de la obesidad: las fallas de mercado y las políticas públicas de prevención y control de la obesidad en México. Obesidad en México. Recomendaciones para una política de Estado. Universidad Nacional Autónoma de México, México, Dirección General de Publicaciones y Fomento Editorial, pp. 331–355.

Andreyeva, T., Chaloupka, F.J., Brownell, K., D, 2011. Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue. Prev. Med. 52 (6), 413–416.

Banco de México, 2010. Índice de precios al consumidor y UDIsIn: Principales índices mensuales, From ⟨http://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?.accion=consultarCuadro&idCuadro=CP154&sector=8&locale=es⟩ 4 Diciembre 2012.

Barquera, S., Campos-Nonato, I., Hernández-Barrera, L., Pedroza-Tobías, A., Rivera-Dommarco, J.A., 2013. Prevalence of obesity in Mexican adults, ENSANUT 2012. Salud Publica Mex. 55 (Suppl. 2), S151–S160.

Barquera, S., Hernandez-Barrera, L., Tolentino, M.L., Espinosa, J., Ng, S.W., Rivera, J.A., Popkin, B.M., 2008. Energy intake from beverages is increasing among Mexican adolescents and adults. J. Nutr. 138 (12), 2454–2461.

Bautista-Arredondo, S., Serván-Mori, E., Colchero, M., Ramirez-Rodriguez, B., Sosa-Rubí, S.G., 2014. Analysis of outpatient healthcare utilization in the context on the universal heatlh care coverage reform in Mexico. Salud Publica Mex. 56, 18–31.

Brownell, K.D., Farley, T., Willett, W.C., Popkin, B.M., Chaloupka, F.J., Thompson, J.W., Ludwig, D.S., 2009. The public health and economic benefits of taxing sugar-sweetened beverages. N. Engl. J. Med. 361 (16), 1599–1605.

Cahuana-Hurtado, L., Rubalcava-Peñafiel, L., Sosa-Rubí, S.G., 2012. In: Rivera Dommarco, J.A., Hernandez Avila, M., Aguilar Salinas, C.A., Vadillo Ortega, F., Murayama Rendón, C. (Eds.), Políticas fiscales como herramienta para la prevención de sobrepeso y obesidad. Obesidad en México. Recomendaciones para una política de Estado. Universidad Nacional Autónoma de México, México, Dirección General de Publicaciones y Fomento Editorial, pp. 331–355.

Comisión Nacional de Protección Social en Salud/Seguro Popular, 2012. Catálogo universal de servicios de salud 2012 (CAUSES). Comisión Nacional de Protección Social en Salud/Seguro Popular, Mexico.

Consejo Nacional de Población, 2012. Proyecciones de la Población. Nacional 2010–2050 Retrieved Enero 2013, from ⟨http://www.conapo.gob.mx/es/CONAPO/Proyecciones_de_la_Poblacion_2010-2050⟩

de la Vega, S., Romo Viramontes, R., González Barrera, A.L., 2011. Anexo C Metodología de estimación del índice de marginación Índice de martginación por entidad federativa y municipio 2010. Consejo Nacional de Población, Mexico City, pp. 313–332.

Deaton, A., Muelbauer, L., 1980. An almost ideal demand system. Am. Econ. Rev. 70, 312–326.

Euromonitor, 2011. Euromonitor International's Passport Global Market From http://www.euromonitor.com/⟩ (2013).

Gleick, P., Allen, L., Christian-Smith, J., Cohen, M., Cooley, H., Heberger, J., Palaniappan, M., Schulte, P., 2012. Per-Capita Bottled Water Consumption by Top Countries (1999–2010). The World's Water, Vol. 7. Island Press.

Gutiérrez, J., Hernández-Ávila, M., 2013. Cobertura de protección en salud y perfil de la población sin protección en México, 2000–2012. Salud Publica Mex. 55 (Suppl. 2), 83–90.

Hernández-Ávila, M., Gutiérrez, J., Reynoso-Noverón, N., 2013. Diabetes mellitus in Mexico, Status of the epidemic. Salud Publica Mex. 55 (Suppl. 2), S129–S136.

Instituto Nacional de Estadística y Geografía, 2011. Encuesta Nacional de Ingreso y Gastos de los Hogares Retrieved Noviembre 2012, from ⟨http://www.inegi.org.mx/est/contenidos/Proyectos/encuestas/hogares/regulares/enigh/presentacion.aspx⟩

Instituto Nacional de Estadística y Geografía, 2013. Índice Nacional de Precios al Consumidor: documento metodológico. Instituto Nacional de Estadística y Geografía.

Instituto Nacional de Salud Pública, 2012. Encuesta Nacional de Salud y Nutrición 2012. Estado de nutrición, anemia, seguridad alimentaria en la población mexicana From ⟨http://ensanut.insp.mx/doctos/ENSANUT2012_Nutricion.pdf⟩

InterAct, C., 2013. Consumption of sweet beverages and type 2 diabetes incidence in European adults: results from EPIC-InterAct. Diabetologia 56 (7), 1520–1530.

Jiménez-Corona, A., Aguilar Salinas, C.A., Rojas-Martinez, R., Hernández-Ávila, M., 2013. Type 2 diabetes and frequency of prevention and control measures. Salud Publica Mex. 55 (2 Suppl), S137–S143.

Jou, J., Techakehakij, W., 2012. International application of sugar-sweetened beverage (SSB) taxation in obesity reduction: factors that may influence policy effectiveness in country-specific contexts. Health Policy 107 (1), 83–90.

Malik, V.S., Popkin, B.M., Bray, G.A., Despres, J.P., Willett, W.C., Hu, F.B., 2010. Sugar-sweetened beverages and risk of metabolic syndrome

and type 2 diabetes: a meta-analysis. Diabetes Care 33 (11), 2477–2483.
Malik, V.S., Schulze, M.B., Hu, F.B., 2006. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am. J. Clin. Nutr. 84 (2), 274–288.
Malik, V.S., Willett, W.C., Hu, F.B., 2009. Sugar-sweetened beverages and BMI in children and adolescents: reanalyses of a meta-analysis. Am. J. Clin. Nutr. 89 (1), 438–439, author reply 439–440.
Meyer, S., Yu, X., Abler, D., 2011. Comparison of several demand systemsIn: Agricultural and Applied Economics Association 2011 Annual Meeting 103736, From: http://EconPapers.repec.org/RePEc:ags:aaea11:103736.
Moodie, R., Stuckler, D., Monteiro, C., Sheron, N., Neal, B., Thamarangsi, T., Lincoln, P., Casswell, S., Lancet, N.C.D.A.G., 2013. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet 381 (9867), 670–679.
Moschini, G., 1995. Units of measuremnet and the Stone Index in demand system. Am. J. Agric. Econ. 77 (1), 63–68.
OECD, 2011. Health at a Glance 2011: OEDC Indicators From ⟨http://dx.doi.org/10.1787/health_glance-2011-en⟩
OECD, 2014. Revenue Statistics. OECD Publishing, Paris From http://dx.doi.org/10.1787/rev_stats-2014-en-fr.
Popkin, B.M., 2012. Sugary beverages represent a threat to global health. Trends Endocrinol. Metab. 23 (12), 591–593.
Runge, C.R., Johnson, J., Runge, C.P., 2011. Better milk than cola: soft drink taxes and substitution effects. Choices 26, 3.
Sánchez-Pimienta, T., Batis, C., Lutter, C.K., Rivera-Dommarco, J.A., 2015. Main sources ot total and added sugars intake n the Mexican population. Instituto Nacional de Salud Pública, 16 Congreso de Investigación en Salud Pública. Cuernavaca, Mexico.
Stern, D., Piernas, C., Barquera, S., Rivera, J.A., Popkin, B.M., 2014. Caloric beverages were major sources of energy among children and adults in Mexico, 1999–2012. J. Nutr. 144 (6), 949–956.
Te Morenga, L., Mallard, S., Mann, J., 2013. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ 346, e7492.
Tello, C., 2015. Sobre la baja y estable carga fiscal en México Serie de Estudios y Perspectivas Comisión Económica para América Latina y el Caribe, 163. .
Teruel, G., Ruvalcaba, L., Santana, A., 2005. Escalas de equivalencia para México Secretaría de Desarrollo Social, Serie: Documento de investigacion, 23. .
Unar, M., Colchero, M.A., Teruel, G., Rivera Dommarco, J.A., 2013. The Effect of Food and Beverage Prices on Weight Among Women Participating in the Mexican Family Life Survey. Instituto Nacional de Salud Pública, Cuernavaca.
Urzúa, C., 2008. Evaluación de los efectos distributivos y espaciales de las empresas con poder de mercado en México From ⟨http://www.oecd.org/daf/competition/45047597.pdf⟩
Valero, J.N., 2006. Estimación de las elasticidades e impuestos óptimos a los bienes más consumidos en México. Estudios Económicos 21 (002), 127–176.
Vartanian, L.R., Schwartz, M.B., Brownell, K.D., 2007. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. Am. J. Public Health 97 (4), 667–675.
Villalpando, S., de la Cruz, V., Rojas, R., Shamah-Levy, T., Avila, M.A., Gaona, B., Rebollar, R., Hernandez, L., 2010. Prevalence and distribution of type 2 diabetes mellitus in Mexican adult population: a probabilistic survey. Salud Publica Mex. 52 (1 Suppl), S19–S26.
Willett, W.C., Ludwig, D.S., 2013. Science souring on sugar. BMJ 346, e8077.
Zhen, C., Finkelstein, E.A., Nonnemaker, J., Karns, A.A., Todd, J.E., 2014. Predicting the effects of sugar-sweetened beverage taxex on food and beverage demand in a large demand system. Amer. J. Agric. Econ. 96 (1), 1–25.