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IZA DP No. 10765

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ABSTRACT

The 'Soda Tax' is Unlikely to Make Mexicans Lighter: New Evidence on Biases in Elasticities of Demand for Soda*

Mexico's 'soda tax' has been predicted to reduce average weights by two to four pounds, based on extant estimates of an own-price elasticity of quantity demand for soda of between −1.0 and −1.3. These estimates ignore consumer responses on the quality margin and correlated measurement errors. We use Mexican household budget survey data and city-level soda prices to estimate unrestricted demand models that correct for both errors. The corrected own-price elasticity of quantity demand is just −0.2 to −0.3, so tax-induced soda price increases might cut average weights by less than one pound, which is too small to improve health.

JEL Classification: D12, I10

Keywords: demand, household surveys, quality, price, soda taxes, Mexico

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NON-TECHNICAL SUMMARY

In response to a growing burden of non-communicable diseases such as obesity, several countries have imposed, or are debating, a 'soda tax' on drinks with added sugar. The WHO has called on governments to use such fiscal measures and argues that taxes that raise sugary drink prices at least 20% will lead to proportional reductions in consumption. Discussion of the efficacy of such taxes often alludes to Mexico, which imposed a nationwide tax of one peso per liter (equivalent to about nine percent of pre-tax average prices) on sugar-sweetened drinks from January 2014.

Mexico's one peso per liter tax on sugar-sweetened drinks has been predicted to reduce average weight of Mexicans by two to four pounds, based on extant estimates of an own-price elasticity of quantity demand for soda of between −1.0 and −1.3. These elasticity estimates ignore consumer responses on the quality margin and also are biased by correlated measurement errors. We combine Mexican household budget survey data with city-level soda price data to estimate unrestricted demand models that correct for both errors. If methods from previous Mexican studies are used, the own-price elasticity of quantity demand for soda is between −1.2 and −1.3 but is just −0.2 to −0.3 if more appropriate methods are used. If the corrected elasticities are used, tax-induced soda price increases might cause weight reductions of less than one pound, which is too small to improve health.

I. Introduction

In response to a growing burden of non-communicable diseases, such as diabetes and obesity, several countries have recently enacted a 'soda tax' to be imposed on drinks with added sugar. These countries include France, Ireland, Mexico, South Africa, and the United Kingdom. Similar taxes have been imposed at city or county level in the United States, in Albany, Berkeley, Oakland, and San Francisco in California, Boulder in Colorado, and Cook County in Illinois. The World Health Organization has called on governments to use such fiscal measures, and argues that taxes that lead to at least a 20% increase in the retail price of sugary drinks will result in proportional reductions in consumption of these drinks (WHO 2016).

The discussion of such taxes often alludes to the experience of Mexico, which imposed a nationwide tax of one peso per liter (equivalent to about nine percent of pre-tax average prices) on sugar-sweetened drinks from January, 2014. Several studies, based on different methods such as synthetic controls and time-series intervention analysis, find that the tax more than fully passed through to higher soda prices (Aguilera et al. 2016; Grogger 2016). However, whether higher soda prices will cause demand changes that lead to better health is an open question. Grogger (2016) uses extant estimates of an own-price elasticity of quantity demand for soda in Mexico that range from −1.0 to −1.3 to predict demand changes, and based on this, calculates that the tax could cause a two to four pound (0.9 to 1.8 kg) fall in the average bodyweight of Mexicans – enough to have meaningful health benefits.

The elasticity estimates are the weak link in this chain of reasoning. In common with most demand elasticities from around the world that are estimated with household survey data, they lack plausible estimates of how consumer choices over quality respond to price (Gibson and Kim 2016). The methods used by the authors of these elasticity studies are for a standard, undifferentiated good, and this is not what household survey data provide, as was first noted over sixty years ago, by Prais and Houthakker (1955, p.110):

> "An item of expenditure in a family-budget schedule is to be regarded as the sum of a number of varieties of the commodity each of different quality and sold at a different price."

There are many different brands, package sizes and so forth within survey groups – especially for soda – so a consumer faces two choices: they choose quantity as in the textbook model but they also choose *quality*. If economists forget this point when they estimate demand models from household survey data, quality responses to price differences get conflated with quantity responses, and estimated effects of price on quantity will exaggerate the true effect.

These quality responses may matter especially in Mexico because the price premium for some soda brands and presentations (type and size of beverage container) gives great scope for consumers to buffer quantity by sliding down the quality ladder as prices rise. For example, prior to the soda tax, *Coke* sold at a 15% price premium over *Pepsi* and a 20% premium over some other brands (based on city-level prices for a 600 ml bottle). The gradient due to container size was even steeper, with a 55% premium for buying *Coke* in 355 ml cans rather than in 600 ml bottles and about the same premium for 600 ml bottles over two liter bottles. The soda tax is specific rather than *ad valorem* so it flattened gradients slightly but still leaves great scope for consumers to mitigate effects of price rises by sliding down the quality ladder. Ignoring this quality response will overstate quantity responses and overstate tax effects on bodyweight. Some elasticity estimates for Mexico also are biased by correlated measurement errors since soda quantity is regressed on unit values (expenditures over quantity), creating a spurious negative relationship.

In order to demonstrate the importance of these biases, we combine Mexican household budget survey data with city-level soda price data to estimate unrestricted demand models that allow consumer responses on both the quality and quantity margins. If the methods used in the previous Mexican studies (and typically used in other countries) are applied to these data, we get own-price elasticity of quantity demand for soda estimates of −1.2 to −1.3, which is similar to what the prior studies found. However, these estimates conflate quantity and quality responses to price variation and some are also biased by correlated measurement errors. If more appropriate methods are used with these same data, elasticities are much smaller, with a range from −0.2 to −0.3. Thus, responses of soda quantity to price may have been exaggerated by four-fold or more in the existing literature for Mexico. To illustrate the importance of these elasticity biases to health, if the corrected elasticities are applied to Grogger's results on tax-induced soda price increases, expected bodyweight reductions for Mexicans shrink to less than one pound, which is too small to make much difference to health.

In the next section we provide background information on soda in Mexico, reviewing the literature that has estimated elasticities of demand and also highlighting the quality variation which has been ignored in analyses to date. In Section III we discuss biases in elasticity estimates from household survey data, which stem particularly from a failure to distinguish quality responses from quantity responses. Our database that combines price surveys with household surveys is covered in Section IV, while our empirical results are in Section V. The conclusions are in Section VI.

II. Background on Soda in Mexico

The prevalence of overweight, obesity and type 2 diabetes mellitus in Mexico has risen rapidly in the last two decades (Barquera et al. 2008). By 2012, 26.8% of adult males and 37.5% of females were obese; both rates were up about three percentage points from six years earlier (Bonilla-Chacín et al. 2016). Over 1-in-10 children aged 6-11 are obese. These poor health indicators have been linked to sugar consumption, particularly from soda and other sugary drinks that are calorie-dense but provide few nutrients (Malik, et al. 2006). Mexicans are some of the world's biggest soda drinkers, so Mexico's Congress passed budget legislation in October 2013 to impose a one peso per liter sugar-sweetened beverage (SSB) tax.[1] When implemented on January 1st 2014, the tax was equivalent to about 9% of pre-tax average prices. The specific tax will adjust upwards once the cumulative inflation from January 2014 exceeds 10%.

Aguilera et al (2016) and Grogger (2016) find more than full price pass-through of the tax into SSB prices, with the price of soda rising by about 12 percent. However, these studies differ in their overall conclusions about health effects of the tax, with Aguilera et al (2016) finding no effect on total calories consumed and on body-mass, while Grogger (2016) calculates that the tax could cause a two to four pound (0.9 to 1.8 kg) fall in the average weight of Mexicans. This calculation uses existing elasticity studies from Mexico, where the own-price elasticity of quantity demand for soda ranges from −1.0 to −1.3. These elasticity estimates come from household survey data, using methods typical of how SSB demand elasticities are modelled elsewhere. Indeed, the claim by the World Health Organization that a 20% increase in the retail price of SSBs will result in proportional reductions in consumption implies an own-price elasticity of −1.0.

To highlight key issues in using household survey data to estimate demand elasticities, we summarize six recent studies from Mexico with elasticities for soda, or for a broader soft drinks group, of which soda is the major component (Table 1). Three studies (labeled c, d, and f) are not from the group that Grogger used to form a range of own-price elasticities of −1.0 to −1.3 but that should not matter since these other studies give elasticities of about −1.1 (Urzua 2008; Colchero

[1] A broad definition of sugar (monosaccharides, disaccharides and polysaccharides) including table sugar, high fructose corn syrup, and other high caloric sweeteners was used. The legislation also includes an *ad valorem* 'junk food' tax equivalent to 8% of the value of high-calorie foods of low nutritional value, defined as foods containing 275 kcal or more per 100 grams. This does not apply to soda, since regular soda has less than 50 kcal per 100g.

et al. 2015) or about −1.5 (Bonilla-Chacin et al. 2016). Moreover, the elasticities seem fairly stable across years, so even though we use 2014 data our results should be relevant for evaluating these earlier studies. All six studies in Table 1 use the same household survey data we rely upon but none of them use the market price survey that we use; this is typical of the literature, with unit values (expenditures over quantities) commonly used as a proxy for prices.

Only two studies from Table 1 (Valero 2006; Urzua 2008) allow consumers to respond to price variation by altering both quality and quantity. However, the method they use, due to Deaton (1988, 1990), tends to understate the price elasticity of quality and overstate the price elasticity of quantity (McKelvey 2011; Gibson and Kim 2016). Another study (Bonilla-Chacín et al. 2016) uses a method that attempts to form 'quality-adjusted prices' by following Cox and Wohlgenant (1986), which is shown below to be a misguided approach. These three Mexican studies at least are aware of the quality variation issues first raised by Prais and Houthakker (1955). In contrast, the other studies in Table 1 simply use the wrong framework, which is suitable only for a standardized good for which quality variation is impossible, and in this regard they are typical of many elasticity studies from around the world that use household survey data.

Failure to untangle quality and quantity responses is an important omission because of the big difference in prices across Mexico's soda brands, which give scope for consumers to buffer quantity by sliding down the quality ladder as prices rise. Figure 1 plots the time series of the real price per liter for 600 ml bottles of *Coke* and *Pepsi*, showing that *Pepsi* is significantly cheaper. In December 2013, on the eve of the tax, the price of *Coke* was 15% above the price of *Pepsi*. Since the tax is specific, the percentage increase in price is higher for cheaper brands, so by January 2015, one year after the tax was imposed, the *Coke* price was only 10.8% above the *Pepsi* price. Yet even with this reduction in the price premium a consumer could buffer their quantity of cola consumed by switching from *Coke* to *Pepsi*. The standard demand methods applied to household survey data would not recognize this response on the quality margin, wrongly treating the reduced spending due to brand-switching as reduced spending from cutting the quantity bought.

Even without switching brands, there is scope for Mexicans to cope with the soda tax by switching to cheaper presentations (or presentations whose rate of price increase was lower, as noted by Aguilera et al (2016)). Figure 2 shows the size-related price variation within *Coke*, as of December, 2016 from a supermarket in Guadalajara where one of the author shops. The figure shows that the ratio of price per liter as one slides down the quality ladder from a 235 ml glass bottle of *Coke* to a three-liter plastic bottle varies by a factor of more than three. If a consumer was willing to forego convenience, by buying a larger presentation that is cheaper per liter, they could buffer their quantity consumed even as prices rose. A related switch would be to buy less often, when prices are temporarily reduced, since soda is storable. The data available to us do not let us study storage, although it appears important elsewhere (Wang, 2015).

In addition to price pass-through and elasticities, a focus of other studies is on time trends at the household level. Colchero et al. (2016; 2017) use the Nielsen Mexico Consumer panel of approximately 6,000 households spread over 53 cities to study post-tax changes in the volume of beverages purchased. The household-month observations suggest that purchases of the taxed beverages decreased 5.5% in 2014 and 9.7% in 2015, compared to what the trends from 2012-13 would predict, while purchases of untaxed beverages increased slightly. A more detailed consumer panel with more products, more households, and mores cities shows a 6.7% fall in the volume of SSBs purchased in 2014 compared to 2013 but total calories did not change (Aguilera et al. 2016). Substitution effects may account for this lack of impact, since fat and cholesterol consumption went up even as sugar intake fell, and these effects also occur within categories of food and drink.

For example, consumers switched towards the types of SSBs that experienced lower percentage increases in price, and the *ad valorem* 'junk food' tax on high-calorie foods caused consumers to switch to relatively cheaper products with more calories.

III. Sources of Bias in Quantity Demand Elasticities from Household Survey Data

Price elasticities of quantity demand estimated from household survey data are subject to several biases, which are discussed by Deaton (1987; 1989; 1990) and Gibson and Rozelle (2005; 2011). In this section we use double-log and budget share models to show some of these biases, due to correlated measurement errors and due to conflating consumer adjustment on the quality margin with adjustment on the quantity margin. Both biases are present in the Mexican literature and result in exaggerated estimates of how quantity responds to price.

3.1 Double-log Models

We start with the double-log model, which is easiest to study, even though it is now less popular than are budget share models.[2] This model is used by two of the studies summarized in Table 1. However, instead of a price index for soda, or a price for a representative specification of soda (under Hicksian separability the price of the representative item can proxy for variation in the group-level price index), the studies in Table 1 use the unit value – household's total expenditures on soda divided by the total quantity of soda purchased.

In order to show the biases introduced by using unit values, we consider a model for the log of the quantity of food group G that household i is surveyed as acquiring:[3]

[2] The thousands of citations to Deaton and Muellbauer (1980) are testament to this popularity. Budget share models typically fit the data better than quantity models, since dependent variables are bounded between zero and one, and let theoretical restrictions be imposed (such that budget shares sum to one) that improve estimator efficiency.

[3] We say 'acquiring' rather than 'consuming' because soda is storable and the ENIGH survey does not measure food stocks. The rate that acquisitions respond to price changes overstates consumption responses if consumers buy

$$\ln Q_{Gi} = \phi_G + \lambda_G \ln x_i + \eta_G \ln P_G + \rho_G \cdot z_i + \nu_i \tag{1a}$$

which depends on the log of household total expenditure, x_i, on the log of the price index for food group, P_G and on a vector of control variables, like household size and demographic structure, z_i. We could also include cross-prices, P_H but there is no loss of generality by omitting these when showing the biases we study. Since a food group in a survey – even a narrowly defined one like 'soda' – covers many different varieties and specifications, each sold at a different price, we think of equation (1a) as representing a commodity-wise aggregate.[4]

Importantly, the group-level price, P_G does not have an index i because it does not vary household-by-household even though it is expected to vary over time and space. A consumer may buy a different bundle within the items covered by group G than that bought by their neighbor who shops at the same stores and faces the same price structure, giving a difference in the expenditure per unit (the unit value, E_{gi}/Q_{gi}). However, that difference from their neighbor is the outcome of utility-maximizing choices over quantity and quality, rather than being a constraint (prices) that affect those choices. Yet, the household-specific unit value is exactly what studies (a) and (b) in Table 1 use as their proxy for the group-level price index, giving the following model:

$$\ln Q_{Gi} = \phi_G^* + \lambda_G^* \ln x_i + \eta_G^* \ln\left(\frac{E_{Gi}}{Q_{Gi}}\right) + \rho_G^* \cdot z_i + \nu_{Gi}^* \tag{1b}$$

The (iso-)elasticity of quantity demand with respect to own-price from equation (1b), η_G^*

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when prices are low and then store. Wang (2015) finds that ignoring storage may cause the own-price elasticity of quantity demand for regular soda to be exaggerated by about 60%.

[4] Sufficient conditions for consistent commodity-wise aggregation are the Hicks (Leontief) composite commodity theorem, where prices (quantities) for all items in the group move in exact proportion, or the generalized composite commodity theory where deviations of prices for each individual food in the group are independent of income and of all group-level price indexes, or homothetic separability of the utility function (Shumway and Davis 2001). Along with all demand studies using household survey data, we assume at least one of these conditions holds, since we lack data on individual items within a food group to do the analysis at a more disaggregate level.

will be of larger magnitude (that is, more negative) than the true elasticity, η_G. The first source of exaggeration is that errors in reported quantity cause a spurious negative bias in the regression coefficient in equation (1b) but not in (1a). If the report is $Q_{Gi} \pm \varepsilon_{Q_{Gi}}$, where $\varepsilon_{Q_{Gi}}$ is a random error, then this error is passed into the residuals of equation (1a) but not equation (1b). Instead, for equation (1b) the error is also in the denominator of the unit value (which can be defined as $\ln v_{Gi} \equiv \ln E_{Gi} - \ln Q_{Gi}$) so a common component is on the left-hand and right-hand side. No matter what the true relationship between price and quantity, the estimated relationship will be more negative by construction due to this spurious negative correlation. This correlated errors problem may matter especially for soda, whose survey reports may be quite error-prone because a lot of soda consumption is likely to take place outside of the purview of the household respondent, since soda is often bought with 'walking around money' by children going to and from school or by other householders going about their daily business at some location other than the homestead.[5]

The second reason for an exaggerated elasticity in equation (1b) compared to (1a) is that the unit values will tend to vary less over time and space than do prices if consumers react to high prices in local markets by buying lower quality goods. Thus, the same movement in the left-hand side variable (quantity) is attributed to smaller movement in the right-hand side variable (the unit value) than is the case when prices are on the right-hand side. Consequently, $|\eta_G^*| \geq |\eta_G|$ and since the elasticity is signed negative the bias due to quality substitution will be to make quantity demand appear as more price elastic than it truly is. This bias still occurs even if household-specific unit

[5] Friedman et al (2017) compare a benchmark survey with tightly supervised personal diaries against more typical survey designs where a single respondent reports on behalf of the household. Beverages are the category of consumption with the greatest error when relying on one person to report on others, and the errors are especially large in urban areas, where it is easier for co-residents to consume outside the purview of the survey respondent.

values are replaced with some sort of area-level average unit values, or with regression-adjusted unit values, since in high-priced areas households will slide down the quality ladder as one way to cope with the higher prices, so the average unit value in those areas will be a smaller ratio of the average price than it is in cheaper areas.

3.2 Budget share models

The most common form of demand study with household survey data uses budget share models, and especially the Linear-Approximate Almost Ideal Demand System (LA-AIDS). In these models, the dependent variable is w_{Gi}, the share of the budget devoted to food group G by household i. Budget shares are usually modeled as varying with log total expenditure, ln x_i, the log of the price index for foods in group H (where θ_{GG} is for the own-price effect and θ_{GH} is for the cross-price effect), conditioning variables, z_i, and random noise, u:

$$w_{Gi} = \alpha_G^0 + \beta_G^0 \ln x_i + \sum_{H=1}^{N} \theta_{GH} \ln p_H + \gamma_G^0 \cdot z_i + u_{Gi}^0 \tag{2}$$

The numerator for the budget share is spending on group G, which depends on prices, quantity, and also quality. The unit value, v_{Gi} shows average expenditure per unit, so the total expenditure on the group can be written as $v_{Gi}Q_{Gi}$. Thus, responses of the budget share to price variation potentially involve both quantity adjustments and quality adjustments. Therefore, and in contrast to much of the applied literature that neglects this point, a second equation is needed to model quality choice, which can be indicated by household i's unit value for group G, v_{Gi}:

$$\ln v_{Gi} = \alpha_G^1 + \beta_G^1 \ln x_i + \sum_{H=1}^{N} \psi_{GH} \ln p_H + \gamma_G^1 \cdot z_i + u_{Gi}^1 \tag{3}$$

The variables in equation (3) are as defined for equation (2), with superscripts 0 and 1 used to distinguish parameters on the same variables in each equation. If the logarithm of equation (2) is differentiated to provide budget share elasticities, it gives:

$$\partial \ln w_G / \partial \ln x = \beta_G^0 / w_G = \varepsilon_G + \beta_G^1 - 1 \quad (4)$$

$$\partial \ln w_G / \partial \ln p_H = \theta_{GH} / w_G = \varepsilon_{GH} + \psi_{GH} \quad (5)$$

where ε_G is the elasticity of quantity demand with respect to total expenditure, β_G^1 is the elasticity of the unit value with respect to total expenditure, ε_{GH} is the elasticity of quantity demand with respect to the price of *H*, which is the parameter of interest for considering health effects of the soda tax, and ψ_{GH} is the elasticity of the unit value with respect to the price of *H*.

If equation (5) is rearranged, it becomes clear why one needs an equation like (3), for the household's choice of quality amongst the items within group *G*:

$$\varepsilon_{GH} = (\theta_{GH} / w_G) - \psi_{GH}. \quad (6)$$

Equation (6) shows that if one does not know how quality responds to prices, which can be derived from the ψ_{GH} term, it is impossible to identify the elasticity ε_{GH} that shows how quantity responds to prices. The rate that budget shares vary as prices vary, which θ_{GH} shows, does not by itself identify the quantity response to prices since any quality response also alters spending on group *G*, and thus alters the budget share. However, with data on budget shares, on prices, and on some indicator of quality, such as the unit value, equation (6) can be estimated, with input values from the estimates of equations (2) and (3). This is called the "unrestricted method" by McKelvey (2011) because no restriction is put on how the household's choice of quality responds to price variation. The only published examples of this approach are McKelvey (2011) and Gibson and Kim (2013).

If the typical approach of ignoring price-induced adjustments on the quality margin is used, the formula for the elasticity of quantity with respect to price becomes:

$$\varepsilon_{GH} = (\theta_{GH} / w_G) - \delta_{GH}, \quad (7)$$

(where δ_{GH} equals 1 if G=H, and 0 otherwise). If equation (6) and (7) are compared, it is clear to see that a demand study using household survey data with just has a budget share regression, as in equation (2), but no equation (3) to account for quality choice, imposes an untested restriction of a 1:1 movement of unit values with respect to own-prices.[6] If consumers actually respond to higher own-prices by sliding down the quality scale, $\psi_{GG} < 1$ and quantity will be less own-price elastic than what is estimated.

The studies summarized in Table 1 do not use price survey data, and instead estimate a variant of equation (2) with unit values in place of prices. If equation (3) is rewritten in terms of ln p_H and then substituted into equation (2), the budget share equation that uses unit values rather than using prices has a coefficient of $\psi_{GH}^{-1}\theta_{GH}$ rather than θ_{GH}. Since ψ_{GH} cannot be estimated without prices, the elasticity from equation (7) is unidentified, unless ψ_{GH} is somehow indirectly derived. The typical approach is to assume, implicitly, that $\psi_{GG} = 1$ so that $\psi_{GG}^{-1}\theta_{GG} = \theta_{GG}$; thus, within-group quality substitution is ruled out by this "standard unit value method", as with the "standard price method".[7]

One practical issue for studies using the standard unit value method is that unit values are only available for purchasers (or for acquirers if the survey also covers own-production and gifts) whereas market prices – if a price survey was used – would be available for all households. An advantage of budget share models is that observations on both purchasers and non-purchasers can

[6] This is called the "standard price method" by McKelvey (2011) because it ignores any within-group quality substitution in response to price differences and is only appropriate for a standard, undifferentiated good where quality substitution is impossible.

[7] The coefficients for a budget share equation using unit values on the right-hand side will not be the same as for one using prices, since unit values will vary less than price if there is quality downgrading in higher price areas and also because of measurement errors in the unit values. Compared to the double-log model, there are more complex measurement error effects when unit values are used in budget share equations, which depend on whether expenditure on group G is more reliably measured than is quantity (Gibson and Rozelle 2011).

be used.[8] Thus, to exploit this functional form advantage, studies will typically replace missing unit values with cluster averages, so that the budget share equation can be estimated on all observations. A related approach regresses unit values on household attributes to strip out the variation due to income and demographic factors, with the regression-adjusted unit values then used as a proxy for the prices that all households face (Cox and Wohlgenant 1986); the study by the World Bank (Bonilla-Chacín et al. 2016) of the soda tax in Mexico uses this method.

However, these methods miss the point – even if procedures applied to unit values could make them like prices, in reflecting variation between areas due to transport costs and other spatial factors, and in being available for all households, there is still going to be a bias. One needs two equations to study adjustments that can occur on two margins, so irrespective of adjustments to unit values so they can proxy for prices, a single equation framework will yield biased elasticities. The standard unit value method, the Cox and Wohlgenant method, and the standard price method all force a two-choice problem into a single equation framework that cannot be expected to identify either the price elasticity of quantity or the price elasticity of quality, and instead will yield some unidentified hybrid of these two types of responses.

The only unit value method that allows for consumer's joint choice of quantity and quality and that uses the right elasticity formula (equation (6)) rather than the wrong one (equation (7)) is due to Deaton (1988; 1990).[9] This method allows quality responses to be imputed, so that quantity elasticities can be recovered from observed changes in budget shares. The intuition behind the

[8] This averaging over all households is like an aggregate demand equation and breaks any direct link with utility theory (Deaton, 1997 p.304-5) so efforts to use censored demand approaches with household survey data are probably misplaced. Moreover, for understanding effects of tax-induced price changes on average population health, it is appropriate to average over the purchasers and non-purchasers alike.

[9] Studies (e) and (f) in Table 1 report that they use this method.

method is that under certain weak separability restrictions, ψ_{GH} can be derived from the income elasticity of quality (that is, from β_G^1 which is observable since household incomes and unit values are observed) and from the price and income elasticities of quantity:

$$\frac{\partial \ln v_{Gc}}{\partial \ln p_{Hc}} = \psi_{GH} = \delta_{GH} + \beta_G^1 \frac{\varepsilon_{GH}}{\varepsilon_G} \tag{8}$$

In order to get the parameters needed for equation (8), Deaton's method estimates variants of equations (2) and (3) that use cluster dummy variables instead of the unavailable prices. The bias from measurement error is accounted for in a between-clusters, errors-in-variables framework. Despite the elegance of the method, the limited empirical evidence is that it tends to overstate ψ_{GG} and thus understate the extent of within-group quality substitution, giving elasticities of quantity demand whose magnitude is exaggerated. For example, a study of 45 food and drink items found the unrestricted own-price elasticity of quantity demand averaged −0.20 while the Deaton method gave an average value three times as large, of −0.60 (Gibson and Kim 2016). The inflated quantity demand elasticities from the Deaton method were due to the direct estimates of the price elasticity of quality being much larger than what indirect estimates based on equation (8) suggest.

In Section V we report price elasticities of quantity demand for soda in Mexico that come from each of the methods discussed here. Specifically, by using budget share regressions and unit value equations we derive unrestricted elasticity estimates (based on equation (6)), and these are contrasted with estimates from the standard price method, from the Deaton method, from two variants of the standard unit value method, and from the Cox and Wohlgenant method. For the double-log functional form we contrast results with prices used on the right-hand side with results when unit values are used instead, since using unit values makes the elasticities susceptible to bias from correlated measurement errors and from ignoring quality responses to price variation.

IV. Data Description

We link finely-grained price surveys with an income-expenditure survey, to estimate soda demand models using eight different methods. By comparing the results for these methods we can highlight the importance of allowing for quality responses to price variation and for correlated measurement error. Each month, Mexico's Statistics Institute (INEGI, in Spanish) surveys prices of 282 products and services (with 101 foods and beverages) in 46 cities. Prices are derived from barcode scanning and are collected from a nationally representative sample of vendors several times during each month.[10] Based on this survey, INEGI reports monthly average prices of soda in pesos per liter by specification (combination of size, presentation, and brand) in each city. We average prices across specifications and stores to obtain one price per city and month.[11]

Figure 3 shows cities where the INEGI price survey is fielded. The map denotes cities with higher, medium and lower soda prices, based on the average of the August to November 2012 and 2014 periods that correspond to when the income-expenditure survey is fielded. The cities are spread all over Mexico; each of the 32 Mexican states has at least one city in the survey and no municipality has more than one city surveyed.[12] Generally, the higher priced cities are either big ones (Mexico City and Monterrey) or close to the US border.

The budget shares, quantities, unit values, and covariates other than prices are from microdata from the Mexican Income-Expenditure Household Survey (ENIGH, in Spanish). The ENIGHs are cross-sectional, nationally representative, with a two-stage stratified probabilistic design, and are conducted by INEGI every two years. The expenditure module of this survey asks

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[10] These include street vendors, markets, convenience and specialized stores, supermarkets, and department stores.

[11] The pattern of results across the various methods is robust to using arithmetic, geometric, or harmonic means of the prices. The results reported below are based on arithmetic means for city-level prices.

[12] Municipalities are the administrative level below states, and localities are the next level down. An urban locality is defined by having more than 2,500 people.

the individual responsible for reporting on behalf of the household to record, on a daily basis for a week, purchases and consumption from own-production and gifts of 254 food, drink, and tobacco products, and public transport services used by each household member.[13] The expenditures and quantity of soda purchased, and also otherwise acquired (from gifts and other non-purchases), allow unit values to be calculated, to provide information on the overall quality-mix across the various brands, sizes, and presentations of soda.

We rely mainly on the 2014 ENIGH, whose sample is more than twice as large as that of the 2012 survey. The survey was carried out from 11 August to 18 November, 2014 and we match to city prices based on the household's municipality of residence and month of purchase. The ENIGH collected information on 19,124 households in 2014 but after we restrict to households who live in the municipalities where the INEGI price survey was fielded it reduces the sample size to 12,158 households. The sample further reduces to N=12,087 after trimming outliers (see below) and any observations with missing data. In robustness analysis we further restrict the sample to households who live in urban localities, to be consistent with the urban coverage of the store price surveys, yielding a sample of 9,654 households.

The descriptive statistics for soda expenditures and budget shares, the quantity purchased and acquired, and soda prices and unit values are reported in the top section of Appendix Table 1. We report estimates for the unconditional sample that includes zero purchasers (used in all budget share models) and for the conditional sample that purchased soda (used in double-log quantity demand models). We also report estimates for the urban localities sub-sample that should best

[13] The expenditure module uses a thirty-day recall for 114 frequently purchased nonfood items (e.g. cleaning and personal hygiene products), a quarterly recall for 234 other nonfood products (e.g. clothes and health insurance) and a six-month recall for 145 other items.

match the locations where INEGI surveys prices. The table also has summary statistics for the household-level control variables in our models.

V. Results

We start by using the INEGI price survey and the ENIGH household survey to show how the peso per liter tax on sugar-sweetened drinks altered average prices, unit values and quantities. These averages are at city-level, for the 46 cities where the two surveys can be matched, for the August to November period when the ENIGH survey is fielded, and compare 2012 (pre-tax) with 2014 (post-tax). Since the tax is specific rather than *ad valorem* we examine the effects not only for the all-city average, but also for terciles of cities defined by average prices, since a specific tax should have more effect in lower priced cities than in higher priced cities.

In real terms, average soda prices went up by 11.9% between 2012 and 2014 (Table 2). The rate of price increase in cheap cities (17.7%) was twice that of more expensive ones (8.9%), which is to be expected since a specific tax will reduce price differentials. The average unit values for purchased soda went up by only one-half of the rate of increase in prices, and for all-acquired soda (which includes soda obtained from gifts and other non-market sources) by even less. Moreover, the rate of pass-through from prices to unit values was lowest in the cheaper cities that had the highest percentage increase in prices. These patterns suggest consumer adjustments on the quality margin; as prices rose consumers moved down the quality ladder toward cheaper items, such as switching from *Coke* to *Pepsi* or from expensive presentations of *Coke* to cheaper ones, and Figures 1 and 2 show ample scope for such adjustments.

These quality adjustments matter to the (mis)understanding of soda demand responses for two reasons. First, if a study uses expenditures or budget shares, and rules out any quality response (e.g. by using the equation (7) elasticity formula for the standard price method), the lower spending due to quality downgrading will be mistakenly treated as a lower quantity consumed. Second, even if a study has data on quantities, if unit values are used as a proxy for price, the quantity demand response will seem more elastic than it truly is because the quantity change is related to the smaller movement in unit values rather than to the actual (larger) movement in prices. For example, according to the ENIGH survey data, across all cities the average quantity of soda acquired by households declined 4.6% from 2012 to 2014 and if this is compared with the 5.4% increase in the average unit value, it implies an own-price elasticity of quantity demand of −0.85. Yet the actual increase in real prices was much larger, at 11.9%, and using that figure gives an elasticity of quantity demand for soda with respect to own-price of just −0.39.

In addition to the evidence from temporal price changes in Table 2, the cross-city patterns also show the importance of consumer adjustment on the quality margin. If the cheapest group of cities are compared to the most expensive group, the ratio of the average unit value for soda to the average price varies from 1.0 in the cheapest cities to 0.8 in the dearest. Presumably, where soda is more expensive, consumers, on average, move down the quality ladder as one way to cope with the higher prices. This coping response will bias any elasticity estimates (such as those in Table 1) that use methods that are only appropriate for standard, undifferentiated, goods for which such consumer responses on the quality margin are impossible.

5.1 Household-Level Evidence

In Table 3 we report estimates of the own-price elasticity of quantity demand for soda that come from the eight different methods described in Section III. These estimates are only for households from the 2014 ENIGH sample who live in the municipalities where the INEGI price survey is fielded. Also, in order to ensure that the results are robust to outliers, the estimates use four, successively smaller, samples by trimming observations with prices or unit values more than 5, 4, or 3 standard deviations from the mean. The fourth, and smallest, sample is for households from urban localities within the municipalities where the INEGI price survey is carried out, since these should best match prices that are obtained from urban retail establishments.

A total of 40 equations are estimated to get the elasticities reported in Table 3; budget share and unit value equations for the unrestricted method and for the Deaton method, budget share equations for the standard price method, for two standard unit value methods and for the Cox and Wohlgenant method, and double-log models with prices and with unit values. These equations include 22 control variables other than prices or unit values and total expenditures; household size, five demographic ratios, seven attributes of the household head (age, gender, education, ethnicity and marital status), three area characteristics (altitude, latitude and urbanity) and six regional fixed effects.[14] Since this is too much detail to report here, the full regression results for each method are reported for just one sample (where outlier trimming is at ± 5 SD) in Appendix 2.

When methods based on budget share regressions are used, and quality substitution is ruled out, due to using either the standard price method, or the standard unit value method, or the Cox and Wohlgenant method, the own-price elasticity of quantity demand for soda is estimated to be from −1.25 to −1.30, when we use the largest, least-trimmed sample. The elasticities are very stable across the different samples, and even if we restrict attention just to urban localities there is a similar range of estimated elasticities, from −1.21 to −1.25. When the Deaton method is used, which allows for within-group quality substitution in principle but in practice it seems to understate responses on the quality margin (McKelvey 2011; Gibson and Kim 2016), the results are similar

[14] We include area characteristics and fixed effects in order to provide a short-run interpretation for the elasticities; such elasticities are more appropriate than long-run price ones for considering price reforms (Deaton, 1997, p.323).

to those from the standard price method and to the other unit value methods, with own-price elasticities that range from −1.15 to −1.18.

Thus, using budget share methods like those in some Mexican studies (e.g., Valero, 2006; Colchero et al. 2015), and that also are similar to what is used in other countries with household survey data, we get a similar range of elasticities as the prior estimates. For example, Grogger (2016) summarized the recent Mexican literature as showing own-price elasticities of demand for soda from −1.0 to −1.3. Our estimates with similar methods are from −1.2 to −1.3. Thus, there should be nothing about our sample or about our other procedures that is out of line with these previous studies. In other words, we have a good basis for demonstrating the bias that exists in these previous studies since we can recreate similar estimates to what they report.

The bias in these previous studies appears to be very large, and is consistent with the discussion in Section III. When the unrestricted method is used, with a budget share equation and a unit value equation so as to study consumer responses on two margins, and using INEGI price survey data on the right-hand side of both equations, the own-price elasticity of quantity demand for soda is only −0.3. This elasticity estimate is stable across the various samples and is similar to what the city-level averages in Table 2 showed. Thus it appears that budget share methods used in prior studies, which conflate consumer responses on the quality margin with those on the quantity margin (or which constrain quality responses to be what weak separability allows, as in the Deaton method), lead to elasticities of quantity demand that are overstated by a factor of four.

The double-log quantity demand models show an even larger bias, due to the correlated measurement errors if soda quantity is mis-reported and due to the smaller inter-city variation in unit values than in prices. When log quantity is regressed on log prices, along with all of the control variables, the own-price elasticity is approximately −0.2. Since this elasticity is conditional on a household recording a positive quantity purchased, it is not necessarily comparable to elasticities from budget share methods that average over purchasers and non-purchasers alike. When the household-specific unit values are used, as in Barquera et al. (2008) and Fuentes and Zamudio (2014), the magnitude of the elasticity becomes more than six times larger, and ranges from −1.27 to −1.33. Evidently, it seems that using household-specific unit values on the right-hand side of a double log demand model can induce a very substantial bias in elasticity estimates.

5.2 Including Cross-Price Effects

The elasticities in Table 3 are from models where the only price (or unit value) that is controlled for is soda, and the prices of other beverages are not considered. Since the Mexican studies in Table 1 also include other beverages, such as milk, bottled water, and juice, the results in Table 3 may not be a fair basis for assessing biases in the previous literature. Therefore, in Table 4 we report results where we consider budget share models for four beverages: soda, milk, water, and juice, which depend on prices (or unit values) for the same four beverages.[15] Since the results of the unit value methods were so similar, we only use the standard unit value method based on the all-acquisitions unit values, along with the Deaton method, the standard price method, and the unrestricted method.

The inclusion of the cross-prices in Table 4 makes the own-price elasticity of quantity demand for soda slightly less elastic than was the case in Table 3, for the unrestricted method, the standard price method and the Deaton method. However, including cross-prices does not alter the inference that the standard methods overstate the rate at which soda quantity responds to price. The unrestricted own-price elasticity of demand for soda in Panel A of Table 4 is −0.22, while the

[15] The definitions (and ENIGH commodity codes) for these four beverage groups are as follows: cola and flavoured soda (A220), pasteurized cows' milk (A075), natural bottled water (A215), and bottled juice and nectar (A218).

estimates from the other three methods are between −1.07 and −1.32. In comparison to the models without cross-prices (shown in the first column of Table 3 for the same sample) the degree of bias from using the standard methods is, proportionately, slightly larger with cross-prices included than without. Thus, there is no reason to believe that our evidence on likely bias in the prior elasticity studies for Mexico is sensitive to the use of different (or no) sets of cross-prices.

The bias from conflating consumer adjustment on quality and quantity margins is not confined just to elasticity estimates for soda demand. If the own-price elasticities for milk, water, and juice from Panel A are compared with the elasticities in the other three panels of Table 4, the overstatement of quantity responses to own-price is also apparent, albeit not as marked as for soda. For milk, water and juice the unrestricted method gives own-price elasticities that are from 40-50% of the magnitude of what the standard (and Deaton) methods say, while the unrestricted elasticity for soda is only about 20% of what the other methods suggest. The greater range of qualities within soda should give more scope for adjustment on the quality margin, and therefore more potential for bias when this adjustment is ignored, than is the case for the other beverages.

The cross-price elasticities in Table 4 are not subject to any homogeneity or symmetry constraints, in order to let the data speak most freely about the effects of not allowing for quality substitution. Based on these unconstrained cross-price elasticities, it appears that soda demand is affected by the price of bottled water. The reverse effect of soda prices on the demand for water highlights sensitivity to the different methods; the standard price method and the Deaton method show no effect, the standard unit value method suggests a positive effect and the unrestricted method shows a negative effect. The effect of soda prices on water demand with the unrestricted method operates through qualities, with higher unit values for bottled water (conditional on bottled water prices) in places where soda prices are higher (giving a positive ψ_{GH} term to subtract from an effect of soda prices on bottled water budget shares that is almost zero). The standard unit value method also differs from the other three methods in its estimates of the effect of milk prices on water demand, and the reverse, and the effect of juice prices on milk and water demand. While various hypotheses could be formed about these patterns, the key message is that there are likely to be more complicated relationships between the quantity, quality and price of related items than what is shown by the standard methods.

VI. Conclusions

Taxes on drinks with added sugar are being imposed in a growing number of countries, and are often driven by concerns about disorders like diabetes and obesity. The proponents of these taxes assume that quantity demand for sugar-sweetened beverages is fairly responsive to price. The empirical estimates of demand elasticities that applied economists have published over several decades undoubtedly contribute to this view. Yet evidence in many of these countries is from household surveys, and the data from these surveys are not like the standard, undifferentiated, good in the textbook depiction of a demand curve. Instead, expenditures and budget shares in household survey data vary with choices that consumers make on both the quantity and quality margins. If the quality responses to price are ignored, the estimated price elasticities of quantity demand will wrongly include quality responses, overstating the likely effects that taxes may have in moderating intake of unhealthy items like sugary drinks. A further problem with household survey data is that researchers often use unit values from these surveys as a proxy for price, and this makes elasticities susceptible to correlated measurement error, especially if demand models are in terms of quantities.

In this paper we show that these biases matter very much for Mexico, where effects of the soda tax are closely studied. The own-price elasticity of quantity demand for soda is overstated by a factor of four when we use standard budget share methods that rule out any possible consumer adjustment on the quality margin in response to price variation. There is a similar overstatement when Deaton's method, that constrains the quality responses to be what weak separability allows, is used. A somewhat idiosyncratic feature of the Mexican literature is a continued reliance on double-log models, and when these are used with household unit values on the right-hand side, the bias in the own-price elasticity of demand for soda is even larger – with a six-fold exaggeration compared to when market prices are used on the right-hand side. These biases are inherent in elasticity estimates from household survey data when responses on the quality margin are ignored (Gibson and Kim 2016) but may be especially important for soda in Mexico because of the large brand-related and presentation-related price gradients. Once these biases are accounted for, the two to four pound reduction in bodyweight that Grogger (2016) predicts, based on the impacts of the Mexican soda tax, reduces to less than one pound ($\approx$ 0.4 kg), which is too small to make much difference to health.

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Figure 1: Brand-Related Quality Premium for Soda
(Based on 2800 city-month price survey observations by INEGI)

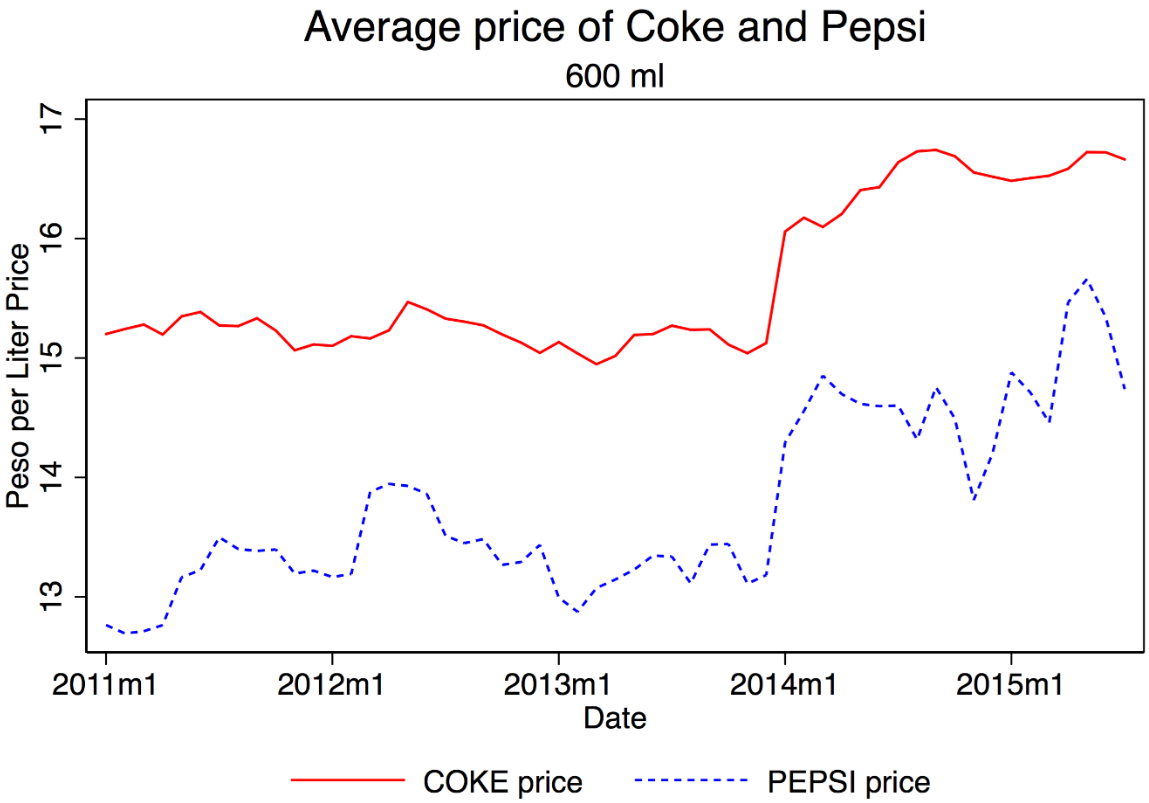

Figure 2: Size-Related Quality Premium for Soda (*Coke* in Different Presentations)

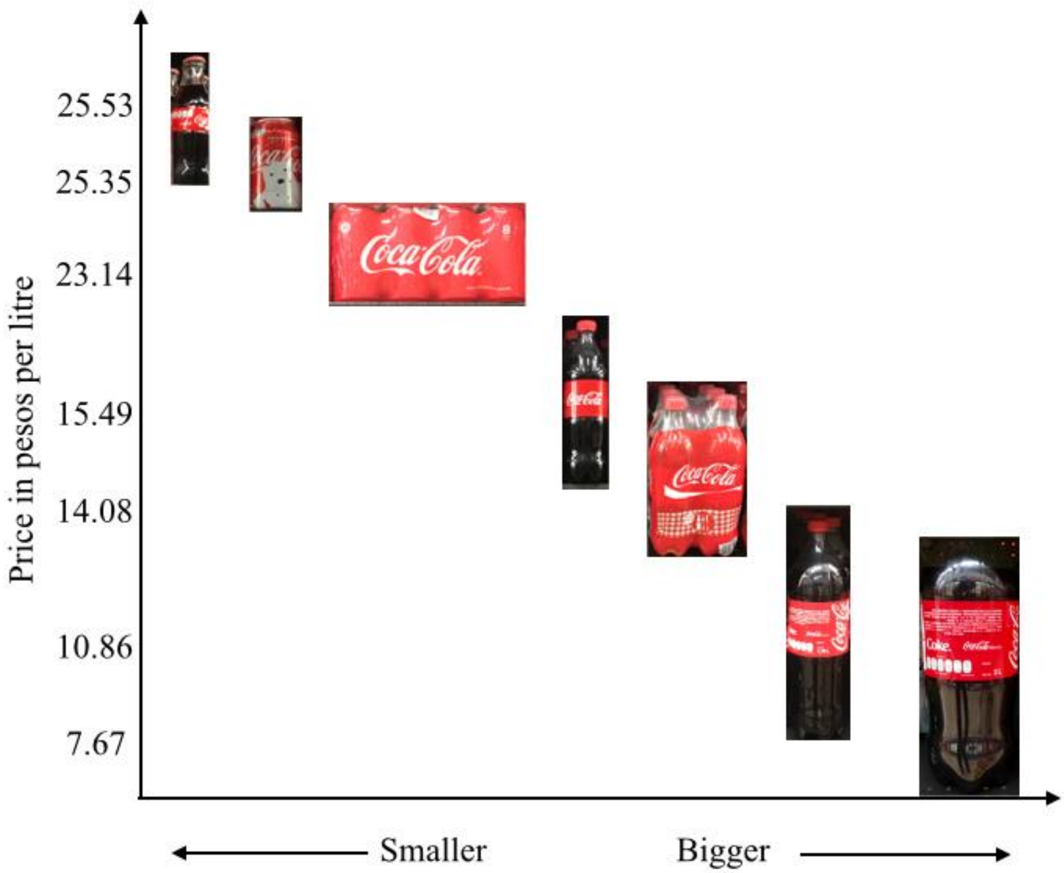

Figure 3: Cities Where INEGI Surveys Retail Prices for Basic Goods Every Month

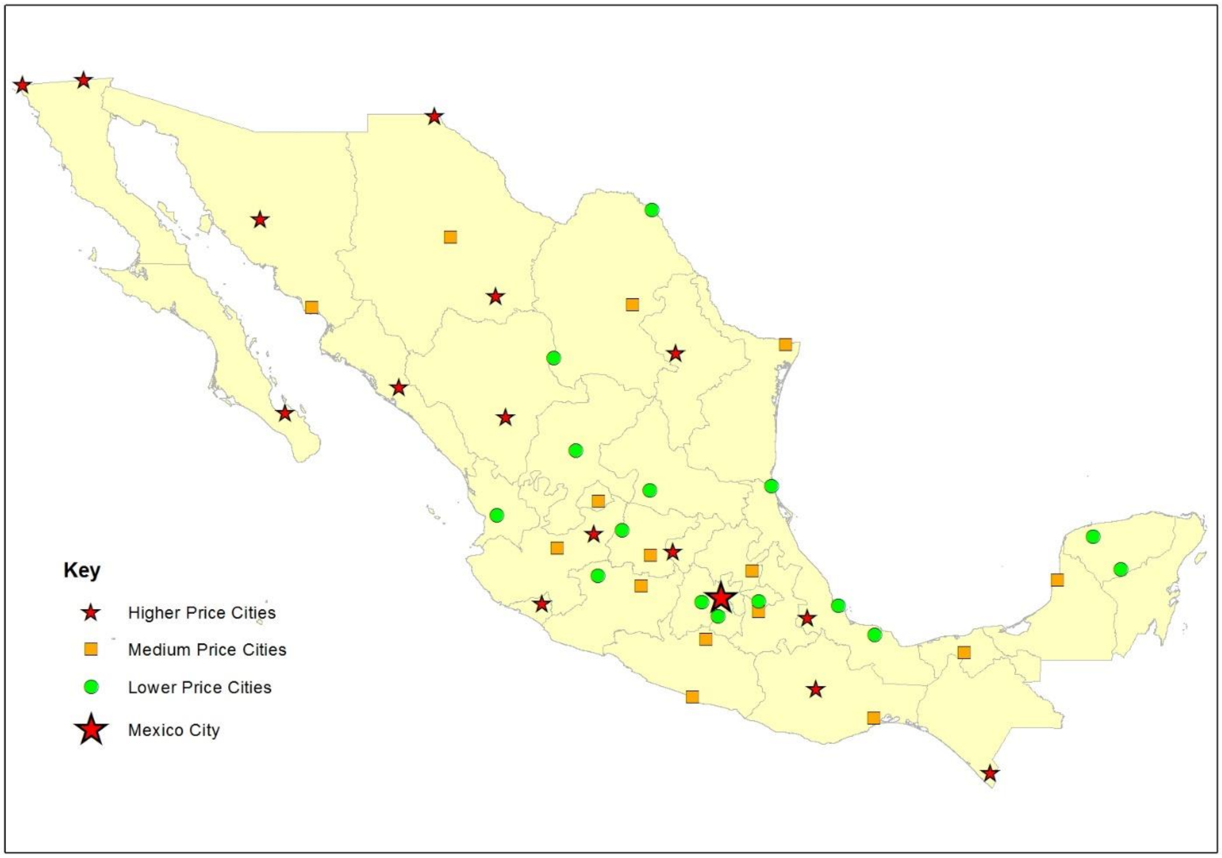

Table 1: Summary of Recent Estimates of The Price Elasticity of Demand for Soda in Mexico

A. Data and Methods

Author(s), year	**Method**	**Price measure**	**Beverages included**	**Foods included**	**Survey**	**Zero expenditure**
(a) Barquera et al., 2008	Double-log model	HH unit value	Soda; sweet drinks; whole milk; juice; bottled water		ENIGH	Included (Two part model)
(b) Fuentes and Zamudio, 2014	Double-log model	HH unit value	Soda; water; juice		ENIGH	Excluded
(c) Colchero et al., 2015	Budget shares (standard unit value method)	Municipality unit value	Soda; other SSB (juices, fruit drinks, flavoured water and energy drinks); bottled water; milk	Candies, snacks, sugar and traditional snacks.	ENIGH	Included
(d) World Bank: Bonilla-Chacin et al., 2016	Budget shares (Cox & Wohlgenant)	Regression-adjusted unit value	Soda; milk; water	Vegetables; fruits; high calorie food	ENIGH	Included
(e) Valero, 2006	Deaton method (budget shares & unit values)	Cluster dummy variables	Soda and juice; water; milk	Tortilla; beef; chicken; eggs; tomato; onion and chili; beans	ENIGH	Included
(f) Urzua, 2008	Deaton method (budget shares & unit values)	Cluster dummy variables	Soda, juice and water; beer; milk	Tortilla; Processed meats (ham, salami etc.); chicken and eggs; medicine	ENIGH	Included

B. Own price elasticities from studies in panel A

	2002	2006	2008	2010	2012	2014
Soda		-1.1(a), -1.1(c)	-1.1(c), -1. 2(b)	-0.9(c), -1.2(b)	-1.3(b)	-1.5(d)
Soda and juice	-1.4(e) -1.6(e)*					
Soda, juice and water		Rural: -1.0(f), Urban: -1.1(f)				

Notes: * is the quality-corrected elasticity based on the Deaton method.

Table 2: City-Level Changes in Soda Prices, Unit Values and Quantity

	City Terciles Based on Soda Prices			All cities
	Lower	Medium	Higher	
Percentage change in average soda price from Aug-Nov 2012 to Aug-Nov 2014 (a)	17.7%	9.5%	8.9%	11.9%
Percentage change in average unit values for purchased soda (b)	8.2%	5.8%	4.8%	6.3%
Share of price increase reflected in unit value increase (b)÷(a)	0.46	0.61	0.55	0.52
Percentage change in average unit values for all acquired soda (c)	5.8%	5.2%	5.2%	5.4%
Share of price increase reflected in unit value increase (c)÷(a)	0.32	0.62	0.54	0.45
Percentage change in average soda quantity acquired (Aug-Nov, 2012 to Aug-Nov, 2014)	−13.2%	0.2%	−0.9%	−4.6%
Average unit value for all acquired soda as a fraction of average price (Aug-Nov, 2014)	1.02	0.89	0.80	0.89
Average soda price, Aug-Nov 2012 and 2014 (peso/ℓ)	10.61	12.06	14.20	12.33

Notes: The calculations are based on 2900 city-month-presentation soda price survey observations by INEGI. The soda category includes cola and flavoured soft drinks. We calculated real prices (in pesos of August 2014) using the National Consumer Price Index. The price data were merged to ENIGH records based on the city and month of purchase. We matched 5190 households to price data in 2012 and 12,214 households to price data in 2014. We divide the 46 cities into terciles based on the average of their August to November 2012 and August to November 2014 real soda prices. These months are when the ENIGH household budget survey is fielded.

Table 3: Estimates of the Own-Price Elasticity of Quantity Demand for Soda

	Price or Unit Value Outliers Trimmed			Only urban households
	± 5 SD	± 4 SD	± 3 SD	
Methods based on budget share regressions				
Unrestricted method	**−0.31**	**−0.30**	**−0.28**	**−0.28**
	(0.12)	**(0.12)**	**(0.10)**	**(0.13)**
Standard price method	−1.25	−1.25	−1.23	−1.22
	(0.13)	(0.13)	(0.14)	(0.15)
Deaton method	−1.18	−1.18	−1.17	−1.15
	(0.11)	(0.11)	(0.09)	(0.12)
Standard unit value method – purchases	−1.28	−1.27	−1.29	−1.22
	(0.06)	(0.06)	(0.06)	(0.06)
Standard unit value method – acquisitions	−1.30	−1.29	−1.29	−1.25
	(0.06)	(0.06)	(0.06)	(0.06)
Cox and Wohlgenant method	−1.26	−1.26	−1.29	−1.21
	(0.06)	(0.06)	(0.06)	(0.07)
Methods based on log quantity regressions				
Log quantity on log prices	**−0.19**	**−0.18**	**−0.17**	**−0.16**
	(0.09)	**(0.09)**	**(0.09)**	**(0.10)**
Log quantity on log unit values	−1.29	−1.29	−1.33	−1.27
	(0.04)	(0.04)	(0.04)	(0.04)
Sample size – budget share methods	12087	12050	11907	9654
Sample size – log quantity methods	7983	7946	7810	6514

Notes: Clustered standard errors in ( ). In addition to prices or unit values, the regressions used to calculate these elasticities include 23 control variables, for household total expenditure and size, 5 demographic ratios, 7 attributes of the household head (age, gender, education, ethnicity and marital status), 3 area characteristics (altitude, latitude and urbanity) and 6 regional fixed effects. Full results of the regressions are in Appendix 2.

Methods in **bold** plausibly deal with quality responses to price changes and with correlated measurement error, while methods not in bold do not.

Table 4: Own- and Cross-Price Elasticities of Demand for Beverages in Mexico

A. Unrestricted Method

Demand for:	Elasticity of quantity demand with respect to the price of:			
	Soda	Milk	Water	Juice
Soda	−0.22	0.03	0.30	0.06
	(0.13)	(0.18)	(0.09)	(0.10)
Milk	−0.08	−0.45	−0.27	−0.38
	(0.11)	(0.22)	(0.09)	(0.10)
Water	−0.63	−1.42	−0.34	−0.65
	(0.17)	(0.26)	(0.13)	(0.18)
Juice	−0.33	0.45	−0.05	−0.71
	(0.24)	(0.39)	(0.22)	(0.19)

B. Standard Price Method

Demand for:	Elasticity of quantity demand with respect to the price of:			
	Soda	Milk	Water	Juice
Soda	−1.13	−0.07	0.30	0.07
	(0.15)	(0.24)	(0.10)	(0.13)
Milk	0.03	−1.24	−0.24	−0.35
	(0.14)	(0.21)	(0.09)	(0.12)
Water	0.02	−1.07	−0.85	−0.17
	(0.22)	(0.33)	(0.14)	(0.20)
Juice	−0.33	0.49	0.13	−1.53
	(0.29)	(0.48)	(0.18)	(0.21)

C. Deaton Method

Demand for:	Elasticity of quantity demand with respect to the price of:			
	Soda	Milk	Water	Juice
Soda	−1.07	−0.07	0.28	0.06
	(0.12)	(0.17)	(0.09)	(0.09)
Milk	0.03	−1.19	−0.23	−0.33
	(0.11)	(0.21)	(0.09)	(0.09)
Water	0.02	−0.89	−0.71	−0.14
	(0.14)	(0.21)	(0.09)	(0.14)
Juice	−0.32	0.48	0.12	−1.49
	(0.24)	(0.38)	(0.21)	(0.19)

D. Standard Unit Value Method

Demand for:	Elasticity of quantity demand with respect to the price of:			
	Soda	Milk	Water	Juice
Soda	−1.32	0.13	0.09	−0.02
	(0.06)	(0.04)	(0.02)	(0.04)
Milk	0.01	−0.48	−0.01	−0.01
	(0.06)	(0.06)	(0.02)	(0.04)
Water	0.30	−0.03	−1.16	0.10
	(0.07)	(0.07)	(0.03)	(0.05)
Juice	0.27	0.01	0.12	−1.10
	(0.12)	(0.11)	(0.04)	(0.12)

Notes: See Table 3 for details on the other variables included in the regressions. *N*=12,087. The standard unit value method uses unit values based on all acquisitions. Clustered standard errors in ( ).

Appendix Table A1: Descriptive Statistics

	Mexico		Urban localities	
	Unconditional	Conditional	Unconditional	Conditional
HH monetary exp. on soda (%)	0.02	0.03	0.02	0.03
	(0.03)	(0.03)	(0.03)	(0.03)
HH monetary exp. on soda (pesos)	139.54	211.27	146.69	217.40
	(174.34)	(175.68)	(178.72)	(178.79)
Price of soda (pesos per liter)	13.30	13.34	13.30	13.33
	(1.66)	(1.65)	(1.67)	(1.65)
Quantity of soda purchased (liters)	14.16	21.45	14.86	22.02
	(19.53)	(20.53)	(20.21)	(21.16)
Unit value of soda purchased (pesos)	10.89	10.89	10.91	10.91
	(3.29)	(3.29)	(3.24)	(3.24)
Quantity of soda acquired (liters)	14.92	22.59	15.53	23.02
	(20.11)	(20.96)	(20.68)	(21.47)
Unit value of soda acquired (pesos)	10.92	10.92	10.95	10.95
	(3.33)	(3.33)	(3.27)	(3.27)
HH monetary expenditure (pesos)	9534.41	9798.70	10288.23	10426.38
	(9967.74)	(9440.45)	(10645.25)	(10020.09)
Household size	3.71	3.81	3.63	3.75
	(1.83)	(1.83)	(1.78)	(1.78)
Share are female children (0 to 11)	0.09	0.09	0.08	0.08
	(0.14)	(0.14)	(0.14)	(0.14)
Share are male children (0 to 11)	0.09	0.09	0.09	0.09
	(0.15)	(0.15)	(0.14)	(0.15)
Share are female adult (12 to 64)	0.37	0.37	0.37	0.37
	(0.24)	(0.22)	(0.24)	(0.23)
Share are male adult (12 to 64)	0.36	0.37	0.36	0.37
	(0.25)	(0.25)	(0.26)	(0.25)
Share are female old (65+)	0.06	0.04	0.06	0.05
	(0.18)	(0.15)	(0.19)	(0.16)
Share are male old (65+)	0.04	0.04	0.04	0.04
	(0.15)	(0.14)	(0.15)	(0.14)
Head age	47.65	46.69	47.96	46.98
	(15.18)	(14.73)	(15.12)	(14.72)
Head female	0.27	0.25	0.28	0.26
	(0.44)	(0.43)	(0.45)	(0.44)
Head education is grades 0 to 8	0.39	0.37	0.34	0.33
	(0.49)	(0.48)	(0.47)	(0.47)
Head education is 9 to 11 grades	0.30	0.32	0.30	0.32
	(0.46)	(0.47)	(0.46)	(0.47)
Head education is grades 12 or more	0.32	0.31	0.36	0.35
	(0.46)	(0.46)	(0.48)	(0.48)
Head is indigenous	0.05	0.05	0.03	0.03
	(0.22)	(0.21)	(0.18)	(0.17)
Head is married/partnered	0.70	0.72	0.68	0.71
	(0.46)	(0.45)	(0.47)	(0.46)

Head is single	0.09	0.08	0.09	0.09
	(0.28)	(0.27)	(0.29)	(0.28)
Head is divorced/widowed	0.22	0.20	0.23	0.21
	(0.41)	(0.40)	(0.42)	(0.41)
HH is in urban locality	0.80	0.82	1.00	1.00
	(0.40)	(0.39)	(0.00)	(0.00)
Observations	12087	7983	9654	6514

Notes: Standard deviations in ()

Appendix Table 2a: Regression Results for Four Budget Share Models
(Sample With Trimming of Prices and Unit Values ± 5 Standard Deviations from Means)

	Standard price method	Standard UV method - purchases	Standard UV method - acquisitions	Cox and Wohlgenant method
Log of soda price (INEGI city data)	-0.005			
	(0.003)			
Log of purchase unit values		-0.006		
		(0.001)		
Log of acquisition unit values			-0.006	
			(0.001)	
Log of regression-adjusted unit values				-0.005
				(0.001)
Log of household total expenditure	-0.009	-0.009	-0.009	-0.023
	(0.001)	(0.001)	(0.001)	(0.001)
Log of household size	0.003	0.002	0.002	0.004
	(0.001)	(0.001)	(0.001)	(0.001)
Share of female children (0 to 11)	-0.008	-0.008	-0.008	-0.014
	(0.004)	(0.004)	(0.004)	(0.006)
Share of male children (0 to 11)	-0.004	-0.004	-0.004	-0.015
	(0.004)	(0.004)	(0.004)	(0.006)
Share of female adult (12 to 64)	-0.007	-0.007	-0.007	-0.013
	(0.004)	(0.004)	(0.004)	(0.005)
Share of male adult (12 to 64)	0.004	0.004	0.004	-0.004
	(0.004)	(0.004)	(0.004)	(0.005)
Share of female old (65+)	-0.011	-0.011	-0.011	-0.017
	(0.004)	(0.004)	(0.004)	(0.007)
Household head age	-0.011	-0.011	-0.011	-0.000
	(0.003)	(0.003)	(0.003)	(0.004)
Head is female	-0.002	-0.002	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Head education is grades 9 to 11	-0.002	-0.002	-0.002	-0.003
	(0.001)	(0.001)	(0.001)	(0.001)
Head education is grades 12 or more	-0.006	-0.006	-0.006	-0.003
	(0.001)	(0.001)	(0.001)	(0.001)
Head is indigenous	0.001	0.001	0.001	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Head is married/cohabiting	-0.001	-0.002	-0.002	-0.003
	(0.001)	(0.001)	(0.001)	(0.002)
Head divorced/widowed	0.001	0.000	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)
Log of municipality altitude	-0.001	-0.001	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Log of municipality latitude	0.036	0.035	0.035	0.019
	(0.004)	(0.004)	(0.004)	(0.004)
Urban locality	0.002	0.002	0.002	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Region is Mexico City	-0.001	-0.002	-0.002	-0.008
	(0.001)	(0.001)	(0.001)	(0.002)

Region is North-Central	0.002	0.002	0.002	-0.004
	(0.001)	(0.001)	(0.001)	(0.002)
Region is South-Central	-0.004	-0.004	-0.004	-0.009
	(0.001)	(0.001)	(0.001)	(0.001)
Region is Northern border	-0.007	-0.006	-0.006	-0.005
	(0.002)	(0.002)	(0.002)	(0.002)
Region is Northeast	0.006	0.006	0.006	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Region is Northwest	-0.005	-0.004	-0.005	-0.005
	(0.002)	(0.002)	(0.002)	(0.002)
Constant	0.019	0.022	0.023	0.189
	(0.014)	(0.013)	(0.013)	(0.017)
R-squared	0.128	0.129	0.130	0.292

Notes: The dependent variable is the budget share for soda. Cluster standard errors in ( ). *N*=12087 urban and rural households in municipalities with INEGI price surveys. These regressions provide the parameters used for four of the own-price elasticities of quantity demand for soda that are reported in column (1) of Table 3.

Appendix Table 2b: Regression Results for Unrestricted and Double Log Models
(Sample With Trimming of Prices and Unit Values ± 5 Standard Deviations from Means)

	Unrestricted method		Double log method	
	Budget share equation	Unit value equation	City-level prices	Household-level unit values
Log of soda price (INEGI city data)	-0.005	0.063	-0.189	
	(0.002)	(0.023)	(0.090)	
Log of purchase unit values				-1.290
				(0.036)
Log of household total expenditure	-0.009	0.030	0.165	0.223
	(0.000)	(0.004)	(0.016)	(0.014)
Log of household size	0.003	-0.088	0.395	0.221
	(0.001)	(0.005)	(0.025)	(0.023)
Share of female children (0 to 11)	-0.008	0.050	-0.360	-0.280
	(0.004)	(0.023)	(0.114)	(0.104)
Share of male children (0 to 11)	-0.004	0.001	-0.240	-0.212
	(0.004)	(0.026)	(0.113)	(0.103)
Share of female adult (12 to 64)	-0.007	-0.009	-0.114	-0.120
	(0.004)	(0.019)	(0.090)	(0.083)
Share of male adult (12 to 64)	0.004	-0.002	0.113	0.102
	(0.004)	(0.015)	(0.080)	(0.074)
Share of female old (65+)	-0.011	-0.004	-0.164	-0.152
	(0.004)	(0.023)	(0.102)	(0.095)
Household head age	-0.011	0.016	-0.097	-0.077
	(0.003)	(0.021)	(0.098)	(0.086)
Head is female	-0.002	0.006	-0.023	-0.019
	(0.001)	(0.006)	(0.032)	(0.029)
Head education is grades 9 to 11	-0.002	-0.012	0.000	-0.025
	(0.001)	(0.006)	(0.024)	(0.022)
Head education is grades 12 or more	-0.006	0.006	-0.156	-0.148
	(0.001)	(0.007)	(0.028)	(0.025)
Head is indigenous	0.001	-0.023	0.056	0.034
	(0.001)	(0.011)	(0.046)	(0.041)
Head is married/cohabiting	-0.001	-0.044	0.107	0.017
	(0.002)	(0.009)	(0.041)	(0.036)
Head divorced/widowed	0.001	-0.032	0.079	0.014
	(0.002)	(0.010)	(0.041)	(0.037)
Log of municipality altitude	-0.001	-0.013	-0.020	-0.034
	(0.000)	(0.002)	(0.007)	(0.006)
Log of municipality latitude	0.036	-0.008	0.770	0.733
	(0.003)	(0.025)	(0.127)	(0.116)
Urban locality	0.002	-0.008	0.073	0.052
	(0.001)	(0.006)	(0.028)	(0.025)
Region is Mexico City	-0.001	-0.095	-0.084	-0.245
	(0.001)	(0.012)	(0.054)	(0.046)
Region is North-Central	0.002	0.048	-0.175	-0.102
	(0.001)	(0.009)	(0.043)	(0.038)
Region is South-Central	-0.004	-0.011	-0.252	-0.263
	(0.001)	(0.009)	(0.043)	(0.038)

Region is Northern border	-0.007	0.112	-0.370	-0.221
	(0.002)	(0.012)	(0.063)	(0.058)
Region is Northeast	0.006	0.088	-0.041	0.076
	(0.001)	(0.012)	(0.056)	(0.051)
Region is Northwest	-0.005	0.097	-0.356	-0.206
	(0.001)	(0.012)	(0.058)	(0.053)
Constant	0.019	2.113	-0.799	1.644
	(0.012)	(0.085)	(0.437)	(0.377)
R-squared	0.128	0.124	0.133	0.304

Notes: The unrestricted method has two dependent variables, the budget share for soda and the unit value for soda. The dependent variable for the double log method is the log quantity of soda acquired. Cluster standard errors in ( ). *N*=12087 for the unrestricted method and *N*=7983 for the double log models. These regressions provide the parameters used for four of the own-price elasticities of quantity demand for soda that are reported in column (1) of Table 3, with results for the Deaton method derived by imposing restrictions on the coefficients from the unrestricted method.