Elasticity of Demand for Sweetened and Unsweetened Drinks: The Case of Argentinian Households

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Abstract:

Argentina is the fourth highest consumer of sweetened drinks, and the first consumer of soda in the world. In this paper we estimate a quadratic almost ideal demand system (QUAIDS) to explore demand for a number of sweetened and unsweetened beverages in Argentina. We use two household surveys: the last one available, performed in 2012-2013, and the previous one, carried over in 2004-2005. We explore expenditure shares and own and cross price elasticities. These results can shed light on a discussion that was held in 2017 in Congress towards the design of a tax reform on sweet beverages that will affect consumers, farmers, and the retail and food industries. Our results support the notion that a tax applied to highly sweetened beverages will affect consumption: for every 1% increase in price there will be a 1.32% drop in quantity purchased. In addition,we find that for every 1% price increase in highly sweetened beverages there will be a 1.12% increase in the amount of dairy beverages purchased.

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THE CASE OF ARGENTINEAN HOUSEHOLDS

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1. Introduction

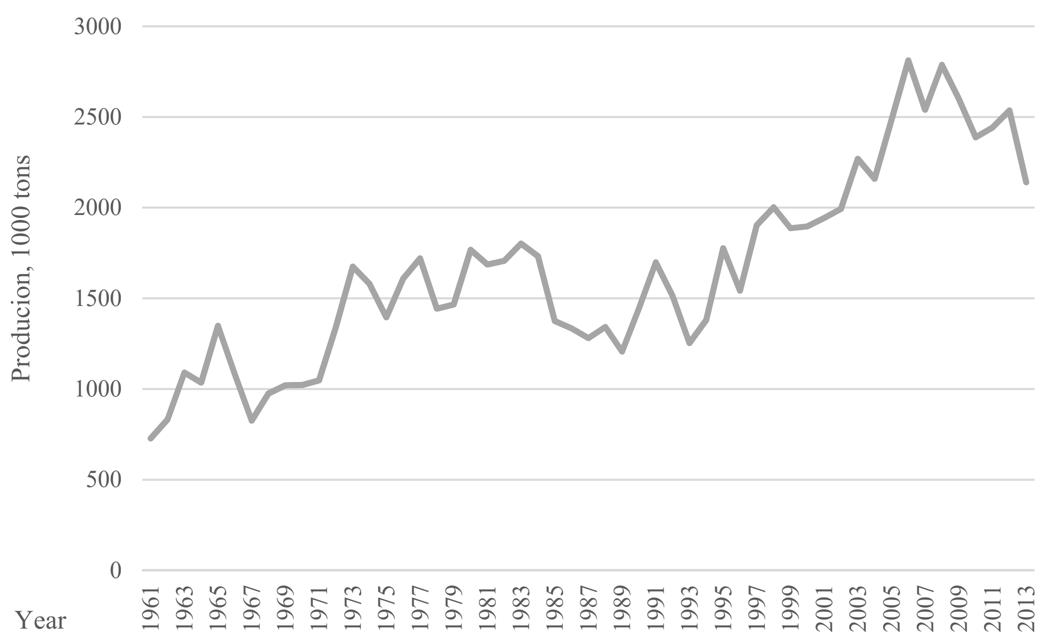
In December 2015 a new government administration took office in Argentina, announcing reforms that would range from social security to taxes and the labor market. In November of 2017, after a year of debates around a tax reform, a bill was proposed to the Congress ("News report 1," 2017). One of the biggest points of discussion in this bill was whether to tax or not to tax sweetened drinks – and how to do it. The goal of this paper is to shed light on consumer demand for sweetened beverages (SB) and their relevant complements and substitutes, in order to make effective policy recommendations.

There is increasing evidence that consumption of sugar-sweetened beverages (SSB) is a risk factor for obesity, type two diabetes and heart disease (Malik, Schulze, & Hu, 2006; Vartanian, Schwartz, & Brownell, 2007). Several reviews note that there are positive associations between the consumption of SSB and adult weight (Malik et al., 2006; Malik, Willett, & Hu, 2009; Vartanian et al., 2007; Morenga, Mallard, & Mann, 2013), and risk of type 2 diabetes (Malik, Popkin, Bray, Després, & Hu, 2010; Consortium, 2013). According to Jou and Techakehakij (2012), fiscal measures have been implemented or proposed in at least 19 countries around the globe with the aim of reducing SSB consumption and the risk of obesity, diabetes and other chronic diseases, with substantial effects on consumption particularly in countries with high rates of obesity and high levels of SSB consumption.

Argentina is the 4th largest consumer of daily calories/capita/day in SSB in the world, after Chile, Mexico and the USA according to 2014 data from Guerrero-López, Unar-Munguía, & Colchero (2017). Specifically, Argentina is the first consumer of soda in the world ("Euromonitor," 2014). Overweight and obesity rates are high for both the county's young (34,5%) and adult population (57,9%) ("Argentinean Health Department," 2013 and

"Argentinean Health Department," 2012). Argentinean production of sweeteners – i.e. sugar plus other sweeteners, except honey – has increased in the past 50 years, as shown in Figure 1 ("FAO," 2013).

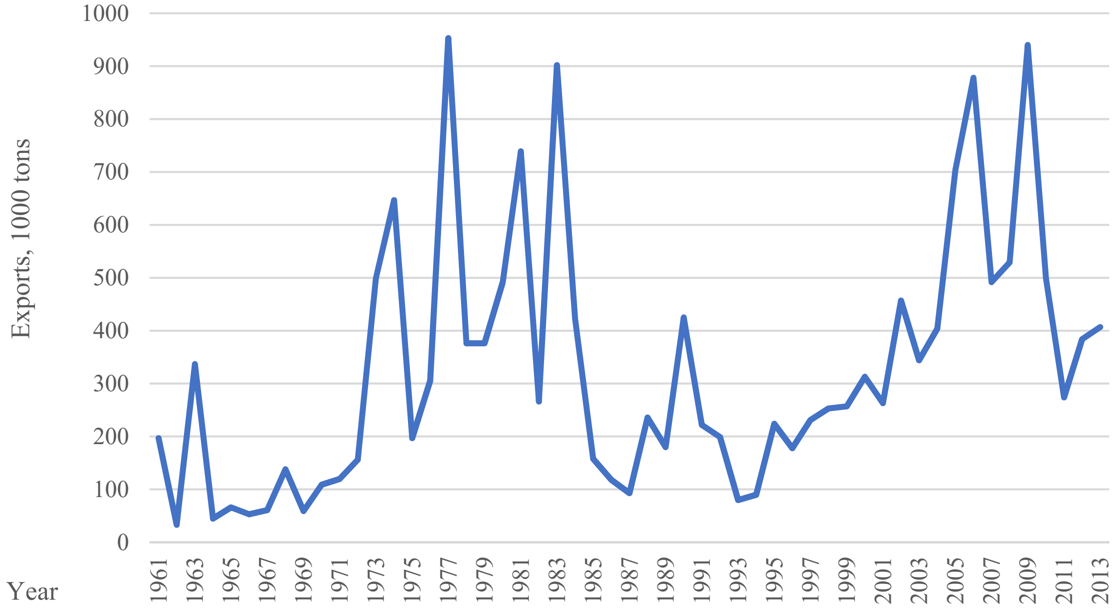
Figure 1: Argentinean production of sweeteners



Source: Elaborated with data from FAO, 2013

Argentinian exports of sweeteners ranked 34th out of 168 countries reported by FAO for 2013, presenting an increasing trend as shown in Figure 2. Argentinean imports of sweeteners, in contrast, are very low, averaging 33,000 tons in the period 2003-2013 ("FAO," 2013). This amount represents 1.5% of the domestic supply, while exports were around 25% of the domestic supply for that period ("FAO," 2013). This suggests strong reliance from the industry in the domestic market.

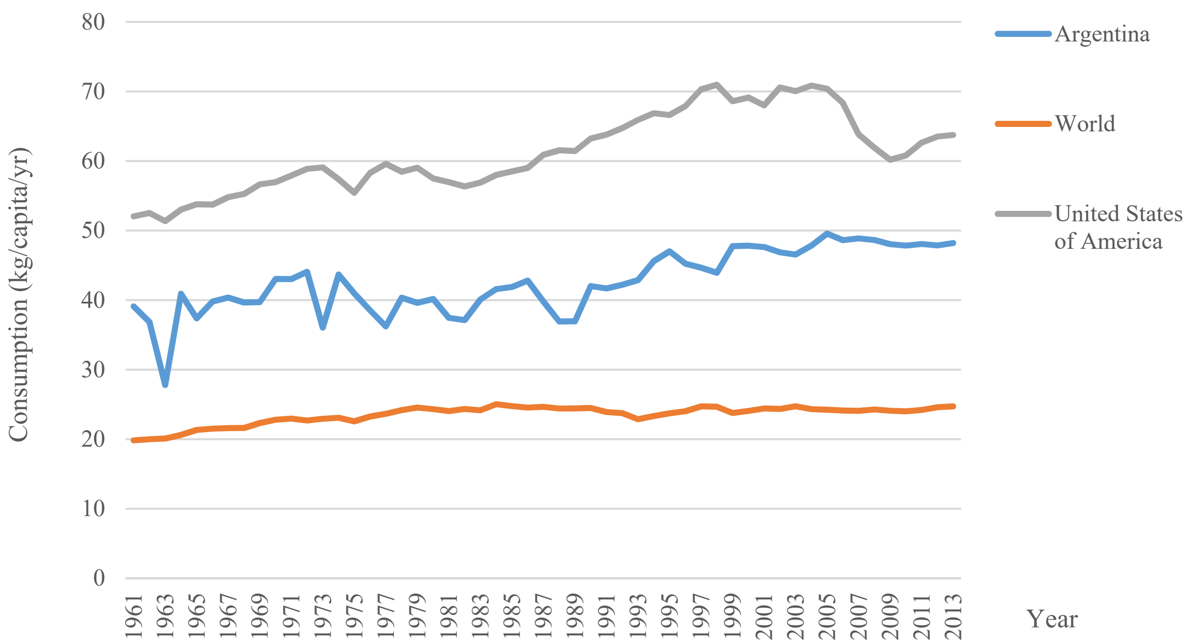
Figure 2: Argentinean exports of sweeteners



Source: Elaborated with data from FAO, 2013

Out of 175 countries reported by FAO for 2013, Argentina is the 21^{st} greatest consumer of sweeteners, with 48 kg/capita/yr. The first consumer of sweeteners is the USA, with 64 kg/capita/yr (“FAO,” 2013). Other countries with high consumption of sweeteners are Germany, Switzerland, New Zealand, the Russian Federation, Canada, Mexico and other Caribbean countries (“FAO,” 2013). Figure 3 shows sweetener consumption in the world – calculated as total kg consumed in the world divided by the world population each year – with respect to Argentina and the USA.

Figure 3: Consumption of sweeteners in the world, Argentina and the USA



Source: Elaborated with data from FAO, 2013

The decrease in the USA's consumption of sweeteners after 2006 that can be noted at the right hand of Figure 3 was analyzed by Welsh, Sharma, Grellinger, & Vos (2011), who found that it was driven by a reduction in soda consumption as compared to other sweet food products.

The bill introduced to the Congress in Argentina in 2017 was designed with the Pan American and World Health Organizations' (PAHO and WHO, respectively) sweetener consumption recommendations in mind. The WHO and PAHO suggest implementing fiscal measures to discourage the consumption of foods and beverages that can harm health. For instance, the Plan of Action for the Prevention of Obesity in Children and Adolescents in the Americas, presented by PAHO in 2014, advises taxing SSB and high-energy dense products in order to stop the increase in the prevalence of obesity in children and adolescents ("PAHO," 2014). The WHO recommendation is to not go over 50 grams per day for a 2,000 kcal diet

(“WHO,” 2015). The bill in discussion intends a tax proportional to the content of sweeteners in a drink, applicable to SB with over 40 grams per liter, except for those containing over 20% of natural juice, in which case the tax starts applying once the amount of sweetener exceeds 50 grams per liter.

Cabrera Escobar, Veerman, Tollman, Bertram, & Hofman (2013) analyzed nine articles from the USA, Mexico, Brazil and France to assess the potential impact of taxes or price increases on SB on consumption levels. They report that all the studies reviewed showed negative own-price elasticity, and that the mean value is −1.2, implying that higher prices are associated with a lower demand. Zhen, Wohlgenant, Karns, & Kaufman (2011) found that in the USA a half-cent per ounce tax on SSB results in a moderate reduction in consumption in the short run, but a 15 to 20% higher reduction in the long run due to habit formation. Dharmasena & Capps (2012) looked into the consequences of a tax on SSB to combat the U.S. obesity problem. They found that consumption of isotonics, regular soft drinks and fruit drinks is negatively impacted by the tax, while consumption of fruit juices, low-fat milk, coffee, and tea is positively affected. They suggest considering interrelationships among non-alcoholic beverages in assessing the effect of a tax. Another study, performed by Pou et al. (2016), highlights that in Argentina obesity is a recognized public health issue. However, this study could not confirm that consumption of SSB is significantly linked to overweight and obesity. Another developing country (neighbor to Argentina) where the demand for SSB was studied is Chile, the world second largest per capita consumer of caloric beverages. In this study, Guerrero-López, Unar-Munguía, & Colchero (2017) found that other food and beverages behave as substitutes for soft drinks and that the demand for soft drinks is price sensitive. Therefore, an incentive system with subsidies and/or taxes could lead to substitutions. Colchero, Salgado, Unar-Munguía, Hernández-

Ávila, & Rivera-Dommarco (2015) analyzed the demand for beverages and high-energy food in Mexico, and found that a price increase in soft drinks is associated with greater consumption of water, milk, snacks and sugar; and a decrease in the consumption of other SB, candies and traditional snacks. The same was found for the SB group except that an increase in price of SB was associated with a decrease in snack consumption. They estimated the price elasticity of SB in −1.16, and between −1.06 and −1.29 for soft drinks. They found higher elasticities among lower income households, and they point out that the implementation of a tax could decrease consumption particularly among the poor. They also note that substitutions and complementarities with other food and beverages should be evaluated to assess the potential impact on total calories consumed. In Ecuador, the price elasticity of SSB was reported to be between −1.17 and −1.33 depending on the socioeconomic group (Paraje, 2016). Demand in Argentina has been studied for meat (Monzani and Robledo, 2011; Pace Guerrero, Berges, & Casellas, 2015), dairy (Rossini, Guiguet, & Villanueva, 2008) and food in general (Rossini & Guiguet, 2008; Berges & Casellas, 2007; Lema et al., 2008); but as far as we know demand for SB in comparison to other drinks has not been analyzed yet.

During the discussion on the bill that motivated this study, sugarcane producers and representatives from the soda and juice industry stated that this tax would disproportionately affect them. Fruit and corn producers were also concerned given their relationship to the juice industry. This led to several representatives from different regions bringing the matter up in Congress. Furthermore, Coca-Cola announced it would reverse planned investments for one thousand million dollars along with juice purchases for another 250 million ("News report 2," 2017). In a sensitive context, policymakers' decisions must be informed. Assessing whether the consumption of certain drinks or food products will change in response to variations in prices is valuable information. The goal of this study is to analyze the potential effect of a tax to SB in the consumption of related products. Some questions we answer are: is the demand for various beverages different across groups? What are the compensated and uncompensated demand cross and own-price elasticities? Are these products substitutes or complements? What are the expenditure elasticities of these products? Are they considered necessities or luxury goods? What are their expenditure shares?

The rest of the paper is organized as follows: section 2 presents the methodology, section 3 describes de data, section 4 presents the results, and section 5 presents the main conclusions and policy implications.

2. Methods

We use the quadratic almost ideal demand system (QUAIDS) developed by Blundell et al. (1993) and Banks et al. (1997). The QUAIDS takes into account linear models such as the AIDS by Deaton and Muellbauer (1980) or the Translog by Jorgenson and Lau (1975) but unlike them, and by virtue of including a quadratic expression for the income variable, it fits the existence of goods that behave as luxury goods at lower levels of income, and as necessities at higher ones. The QUAIDS model also preserves all the qualities of the AIDS model, such as flexibility and consistency in the aggregation of consumers.

The system is estimated using the expenditure/budget share for each good (w_i), its price (p_i) and the income or total expenditure (m). The parameters to be estimated are α_i , γ_{ij}, β_i and λ_i. We assume weak separability of preferences. This means that preferences for products in a group are independent from consumption of products in other groups, and the marginal rate of substitution between two products in one group is independent from quantities of goods consumed in other groups (Deaton & Muellbauer, 1980). Therefore, we incorporate the total expenditure in order to obtain a complete system of equations (i.e., to make the system reach the budget restriction). In this paper, these separable groups are formed based on the type of drink, as will be described in section 3. The QUAIDS system for n goods is given by:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{m}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 + \varepsilon_i \quad (1)$$

where $\ln a(p)$ and $b(p)$ are translog and Cobb–Douglas price aggregator functions respectively. The translog price aggregator is written as:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j \quad (2)$$

and the Cobb–Douglas price aggregator is written:

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad (3)$$

The AIDS model is a particular case of the QUAIDS model, in which $\lambda_i = 0$.

Theoretical restrictions of adding up, homogeneity and Slutsky symmetry are imposed on the demand system in order to ensure consistency with the theory of demand, as described below.

Adding up:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad ; \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad ; \quad \sum_{i=1}^{n} \beta_i = 0 \quad ; \quad \sum_{i=1}^{n} \lambda_i = 0 \quad (4)$$

Homogeneity:

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \tag{5}$$

Symmetry:

$$\gamma_{ij} = \gamma_{ji} \tag{6}$$

To calculate QUAIDS elasticities we derive equation 1 with respect to $\ln m$ and $\ln p_i$ respectively, following Banks et al. (1997):

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\} \tag{7}$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum\nolimits_k \gamma_{jk} \ln p_k\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2 \tag{8}$$

The expenditure elasticities are then given by:

$$e_i = \frac{\mu_i}{w_i} + 1 \tag{9}$$

And the uncompensated price elasticities are given by:

$$e_{ij} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \tag{10}$$

where $\delta_{ij} = 0 \;\forall\; i \neq j$ and $\delta_{ij} = 1 \;\forall\; i = j$.

Finally, the set of compensated elasticities are calculated using the Slutsky equation:

$$e_{ij}^{*} = e_{ij} + e_i w_j \tag{11}$$

3. Data

The National Household Expenditure Survey (NHES) is conducted by the Argentinean Institute of Statistics and Census (AISC). We use data from the last two surveys: 2004/05 (NHES1) and 2012/13 (NHES2).

The surveys collect household information on daily food and beverage quantities purchased and expenses incurred during one week, as well as household socio-demographic data. Since prices are not recorded directly, they are derived from household daily expenditures and quantities purchased in liters. Prices are also deflated using the Consumer Price Index (CPI) reported by AISC, using as base period the last month of data collection for each survey.

We look into 5 groups of goods: highly sweetened beverages (HSB), lightly sweetened beverages (LSB), water, dairy beverages (DB) and infusions. Drinks with sweetener concentrations such that the recommendations of the WHO are reached with less than 3 glasses are considered HSB in this study. This comprises sodas and juices, according to the Inter-American Heart Foundation (2014). LSB are those of which 3 to 5 glasses per day can be consumed safely, according to WHO recommendations. In this group there are flavored waters, isotonic drinks, herbal beverages and soybean drinks ("Inter-American Heart Foundation," 2014). In the water group we include sparkling and plain water, mineral or not. In the DB group we include milk and yoghurt drinks. In the infusions group we include coffee, tea, malt, cocoa and yerba mate, a traditional local infusion.

3.1 Adjusting data for price quality

We calculate implicit prices, i.e. the ratio between the total expenditure and the purchased quantity for each good or group of products. The introduction of these prices, however, poses additional problems due to the fact that they reflect “quality effects” that should be corrected before the estimation. Variation of cross-sectional prices can be driven by differences in the regions and price discrimination (changes in the supply); services acquired with the commodities; seasonal effects and differences in the quality due to the aggregate of non-homogeneous goods (Cox & Wohlgenant, 1986). Following Cox and Wohlgenant (1986), we include these differences by adjusting the prices for each one of the groups to variables that fit the appropriate “quality effect” for each household. The selected explanatory variables − following Berges and Casellas (2007) − are shown in the following expression:

$$P_i = \beta_0 + \beta_1 age + \beta_2 gender + \beta_3 DhsE + \beta_4 DcE + \beta_5 size + \beta_6 income + \beta_7 income^2 + \beta_8 income * size + \beta_9 Dact + \beta_{10} Dsreg2 + \cdots + \beta_{11} Dsreg12 + \varepsilon_i \quad (12)$$

where P_i indicates the implicit price for each group i of goods; age indicates the head of household’s age; $gender$ is a dummy variable that represents the gender of the head of household (equals 1 if the head of household is a woman); $DhsE$ and DcE are dummy variables that equal 1 if the head of household has a high school degree and college degree respectively; $size$ refers to the number of members in the household; $income$ represents the total household income, which is also included squared and multiplied by the size of the household; $Dact$ represents the activity of the head of household (it is 1 if the head of household is employed); and $Dsreg2$ to $Dsreg12$ are dummy variables, one for each sub-region. The quality-adjusted price is then $\widehat{P_i}$ for households that reported expenditure in the goods considered, and $\widehat{\beta_0}$ plus the estimated coefficient of the dummy variable indicating the sub-region ($Dsreg2$ to $Dsreg12$) for households with zero consumption.

3.2 Correcting data for selection bias

Zero expenditure on one or more commodities is a common phenomenon in household survey data, and our study is no exception. Lack of consumption may result from infrequency of purchase, a short data collection period, consumer preferences, or the fact that consumers do not purchase certain goods at current prices and income levels (Davidson & MacKinnon, 1993). In Table 1 we provide the amount and percentage of households that reported consuming beverages during the survey period, total and per beverage.

Table 1: Quantity and percentage of households with positive expenditures on beverages

	NHES1		NHES2	
	quantity	%	quantity	%
Total households in NHES	28,796	100	20,960	100
Reporting positive expenditures in beverages	25,740	89.39	18,581	88.65
Reporting positive expenditures in HSB	19,293	67	13,329	63.59
Reporting positive expenditures in LSB	1,337	4.64	2,978	14.21
Reporting positive expenditures in water	4,949	17.19	3,689	17.6
Reporting positive expenditures in DB	17,687	61.42	12,980	61.93
Reporting positive expenditures in infusions	12,109	42.05	8,509	40.6

Given the high prevalence of zeroes for all beverages, we adopt a two-step approach for censored demand system estimation following Shonkwiler and Yen (1999). The system has latent variables q_{ij}^* and d_{ij}^* that correspond with observed variables q_{ij} and d_{ij} for commodity i and household j, where

$$d_{ij} = \begin{cases} 1 & \text{if } d_{ij}^* > 0 \\ 0 & \text{if } d_{ij}^* \leq 0 \end{cases} \tag{13}$$

$$q_{ij} = q_{ij}^* d_{ij} \tag{14}$$

and

$$d_{ij}^{*} = z'_{ij}\,\theta_i + v_{ij} \tag{15}$$

$$q_{ij}^{*} = f(X_{ij}, \eta_i) + \omega_{ij} \tag{16}$$

Variable d_{ij} represents the probability of household j purchasing good i, and takes the form of a dichotomous variable that is equal to one if consumption is different from zero, and zero if consumption is zero. Variable q_{ij} indicates the actual quantity consumed by those who chose to consume. The observed quantity consumed will equal the latent quantity if the consumer is actually purchasing the item ($d_{ij} = 1$), and zero if not. $f(.)$ is an indicator function, z'_{ih} and X_{ij} are vectors of observables, θ_i and η_i are parameter vectors, and v_{ij} and ω_{ij} are random error terms. This model is a generalization of Amemiya's (1974) system in which the censoring of each dependent variable is governed by a separate stochastic process. Years later, Yen (2005) and Yen and Lin (2006) suggested a censored two-step multivariate procedure that improved the efficiency of the estimator. We use this two-step procedure in which the first stage is modeling the probability of positive consumption using a Probit model and obtaining $\phi(.)$ − the probability density function − and $\Phi(.)$ − the cumulative distribution function. If we assume that the error terms $[v_{ij}, \omega_{ij}]'$ follow a bivariate normal distribution with $cov(v_{ij}, \omega_{ij})$, then the conditional mean of q_{ij} is (Wales and Woodland, 1980):

$$E\left(q_{ij} \middle| x_{ij}, z_{ij}; v_{ij} > -z'_{ij}\theta_i\right) = f(X_{ij}, \eta_i) + \delta_i \frac{\phi(z'_{ij}\theta_i)}{\Phi(z'_{ij}\theta_i)} \tag{17}$$

And because $E(q_{ij}|x_{ij}, z_{ij}; v_{ij} \leq -z'_{ij}\theta_i) = 0$, the unconditional mean of q_{ij} is:

$$E(q_{ij}|x_{ij}, z_{ij}) = \Phi(z'_{ij}\theta_i)f(X_{ij}, \eta_i) + \delta_i\phi(z'_{ij}\theta_i) \quad (18)$$

Based on equation 18, the system of equations 13 to 16 can be rewritten as:

$$q_{ij} = \Phi(z'_{ij}\theta_i)f(X_{ij}, \eta_i) + \delta_i\phi(z'_{ij}\theta_i) + \xi_{ij} \quad (19)$$

where $\xi_{ij} = qi - E(q_{ij}|x_{ij}, z_{ij})$. We then obtain ML probit estimates $\hat{\theta}_i$ of θ_i, using the binary outcome d_{ij} for each i. To do this, we use the same variables used in the estimation of implicit quality-adjusted prices plus dummy variables for presence of people younger than 14 and older than 65 in the household. Estimation of separate probit models instead of one multivariate probit implies the restriction $E(v_{ij}v_{kj}) = 0 \; \forall \; i \neq k$. With some loss in efficiency relative to the multivariate probit, the separate probit estimates are nevertheless consistent.

In the second step we calculate $\Phi(z'_{ij}\hat{\theta}_i)$ and $\phi(z'_{ij}\hat{\theta}_i)$, and estimate η_i, a vector of the parameters in the QUAIDS $(\alpha_i, \beta_i, \gamma_{ij}, \lambda_i)$, and δ_i:

$$q_{ij} = \Phi(z'_{ij}\hat{\theta}_i)f(X_{ij}, \eta_i) + \delta_i\phi(z'_{ij}\hat{\theta}_i) + \xi_{ij} \quad (20)$$

Because the ML probit estimators $\hat{\theta}_i$ are consistent, applying ML or SUR estimation to equation 20 produces consistent estimates in the second step.

According to Shonkwiler and Yen's (1999) method, the QUAIDS corrected for zero consumption is then:

$$w_i = \Phi(z'_{ij}\hat{\theta}_i)\left[\alpha_i + \sum_{j=1}^{n}\gamma_{ij}\ln p_j + \beta_i \ln\left(\frac{m}{a(p)}\right) + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2\right] + \delta_i\phi(z'_{ij}\hat{\theta}_i) + \varepsilon_i \quad (21)$$

To allow for the possibility of endogeneity (Coelho, 2006), expenditure was instrumented by total household income and total household income squared, household size and region, and head of household's age, employment activity, gender and educational level. In addition, a robust estimation of parameters is carried out in order to deal with a possible heteroscedasticity in the errors of the model.

Correcting for bias modifies the elasticity equations that result from the system. The new expressions for expenditure elasticities are:

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \Phi\left(z'_{ij}\hat{\theta}_i\right)\left[\beta_i + \frac{2\lambda_i}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}\right] \tag{22}$$

$$e_i \equiv \frac{\mu_i}{w_i} + 1 \tag{23}$$

And the expressions for uncompensated price elasticities are:

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \Phi\left(z'_{ij}\hat{\theta}_i\right)\left[\gamma_{ij} - \mu_i\left(\alpha_j + \sum\nolimits_k \gamma_{jk}\ln p_k\right) - \frac{\lambda_i\beta_j}{b(p)}\left\{\ln\left[\frac{m}{a(p)}\right]\right\}^2\right] \tag{24}$$

$$e_{ij} \equiv \frac{\mu_{ij}}{w_i} - \delta_{ij} \tag{25}$$

where $\delta_{ij} = 0 \;\forall\; i \neq j$ and $\delta_{ij} = 1 \;\forall\; i = j$. The compensated price elasticities are obtained using the Slutsky equation:

$$e^*_{ij} = e_{ij} + e_i w_j \tag{26}$$

4. Results

We consider the two last NHES, 2004/2005 (NHES1) and 2012/2013 (NHES2). Since the socio-economic context and inflation rates were very different between them, we report separate results for each survey period and refrain from making statistical comparisons.

Table 2 shows QUAIDS parameter estimates for NHES1 and NHES2.

Table 2: QUAIDS parameter estimates for NHES1 and NHES2

	NHES1		NHES2	
Parameter	Coef.	Std. Err.	Coef.	Std. Err.
α_1	0.439***	0.018	0.507***	0.025
α_2	0.603***	0.022	0.488***	0.125
α_3	0.085***	0.024	-0.169	0.164
α_4	0.438***	0.023	0.139**	0.044
α_5	-0.564***	0.022	0.035	0.087
β_1	0.133***	0.015	0.098***	0.009
β_2	-0.081***	0.016	-0.008	0.033
β_3	0.178***	0.016	-0.039	0.024
β_4	-0.066***	0.018	-0.154***	0.023
β_5	0.103**	0.036	0.299***	0.041
γ_{11}	-0.281***	0.008	-0.519***	0.017
γ_{12}	0.179***	0.005	-0.02	0.012
γ_{13}	-0.064***	0.006	0.196***	0.015
γ_{14}	0.385***	0.009	0.422***	0.018
γ_{15}	-0.218***	0.006	-0.078***	0.014
γ_{21}	0.179***	0.005	-0.02	0.012
γ_{22}	0.111***	0.016	-0.114	0.109
γ_{23}	-0.139***	0.016	0.035	0.072
γ_{24}	-0.044***	0.010	0.066	0.066
γ_{25}	-0.106***	0.014	0.033	0.109
γ_{31}	-0.064***	0.006	0.196***	0.015
γ_{32}	-0.139***	0.016	0.035	0.072
γ_{33}	0.12***	0.018	-0.102	0.040
γ_{34}	0.072***	0.011	-0.021	0.067
γ_{35}	0.011	0.012	-0.107	0.117
γ_{41}	0.385***	0.009	0.422***	0.018
γ_{42}	-0.044***	0.010	0.066	0.066

γ_{43}	0.072***	0.011	-0.021	0.067
γ_{44}	-0.456***	0.012	-0.492***	0.033
γ_{45}	0.043***	0.012	0.024	0.026
γ_{51}	-0.218***	0.006	-0.078***	0.014
γ_{52}	-0.106***	0.014	0.033	0.109
γ_{53}	0.011	0.012	-0.107	0.117
γ_{54}	0.043***	0.012	0.024	0.026
γ_{55}	0.27***	0.018	0.129***	0.025
λ_1	0.012***	0.003	0.011***	0.002
λ_2	-0.016***	0.003	-0.007	0.006
λ_3	0.026***	0.002	0	0.004
λ_4	-0.005	0.003	-0.019***	0.005
λ_5	-0.016***	0.002	0.015	0.007
δ_1	0.417***	0.005	0.462***	0.009
δ_2	-0.197***	0.007	-0.319***	0.014
δ_3	0.161***	0.007	0.181***	0.019
δ_4	0.521***	0.004	0.731***	0.008
δ_5	0.671***	0.016	0.354***	0.014

*** Denotes significance at the .01 level, ** Denotes significance at the .05 level, * Denotes significance at the .1 level.
Estimated using Stata.
The standard errors were not corrected by the two-step estimation of Shonkwiller and Yen (1999).
1: HSB, 2: LSB, 3: Water, 4: DB, 5: Infusions.

The fact that parameters λ_i are statistically significant in at least one of the surveys for all goods denotes that expenditures in these products do not present a linear relationship with income. In addition, our tests rejected the hypothesis of linearity ($\lambda_i = 0 \ \forall \, i$) for both NHES1 and NHES2. We conclude that including a quadratic term was the appropriate method for studying demand for beverages. The fact that parameters δ_i are statistically significant supports the need of adjustment for zero observations in the data set used. β_i parameters show the behavior of the linear term for income in each equation, while parameters λ_i are associated with the quadratic term for income. This means that an increase in the real expenditure on beverages results in an increase ($\beta > 0$) in the participation in the budget of HSB, water and infusions, at increasing rates for HSB and water ($\lambda_i > 0$) and decreasing rates for infusions ($\lambda_i < 0$). On the other hand, the participation in the budget of LSB and DB will be reduced ($\beta < 0$, at decreasing rates $\lambda_i < 0$). The signs of the β_i and λ_i parameters stand during the two periods analyzed for all the goods. The importance (in absolute value) of the linear term for income decreases from the first to the second period for HSB, LSB and water, and increases for DB and infusions. The quadratic term remains steady for HSB, increases for DB and decreases for LSB, water and infusions.

Table 3 presents the estimated expenditure and price elasticities (compensated and uncompensated) within the system for the two periods, calculated at the mean point of all the variables in the system.

Table 3: QUAIDS elasticities for NHES1 and NHES2

	NHES1		NHES2	
Parameter	Coef.	Std. Err.	Coef.	Std. Err.
e1	1.195***	0.015	1.141***	0.012
e2	0.85***	0.037	1.015***	0.084
e3	1.361***	0.034	0.873***	0.060
e4	0.898***	0.020	0.733***	0.031
e5	1.37***	0.083	1.734***	0.081
e11u	-1.603***	0.016	-1.966***	0.032
e12u	0.265***	0.009	-0.088***	0.021
e13u	-0.13***	0.012	0.378***	0.025
e14u	0.702***	0.017	0.75***	0.032
e15u	-0.391***	0.012	-0.181***	0.026
e21u	0.695***	0.020	-0.069	0.042
e22u	-0.585***	0.060	-1.409***	0.384
e23u	-0.507***	0.063	0.125	0.255
e24u	-0.172***	0.041	0.23	0.238
e25u	-0.393***	0.055	0.129	0.399
e31u	-0.261***	0.021	0.642***	0.046
e32u	-0.479***	0.053	0.127	0.228
e33u	-0.636***	0.062	-1.338***	0.127
e34u	0.231***	0.037	-0.066	0.217
e35u	0.034	0.041	-0.34	0.385

e41u	0.793***	0.020	1.001***	0.043
e42u	-0.051*	0.019	0.241	0.146
e43u	0.146***	0.023	-0.101	0.149
e44u	-1.886***	0.024	-2.073***	0.074
e45u	0.074**	0.023	0.132	0.064
e51u	-0.621***	0.030	-0.347***	0.041
e52u	-0.37***	0.038	-0.087	0.298
e53u	0.042	0.032	-0.19	0.320
e54u	0.068	0.028	0.054	0.072
e55u	-0.271***	0.047	-0.779***	0.077
e11c	-1.131***	0.014	-1.506***	0.030
e12c	0.281***	0.009	-0.037	0.021
e13c	-0.06***	0.012	0.448***	0.025
e14c	1.118***	0.019	1.115***	0.034
e15c	-0.17***	0.010	0.014	0.026
e21c	1.031***	0.025	0.34***	0.056
e22c	-0.573***	0.061	-1.364***	0.387
e23c	-0.457***	0.062	0.187	0.251
e24c	0.124	0.049	0.554	0.259
e25c	-0.236***	0.051	0.303	0.389
e31c	0.276***	0.025	0.994***	0.059
e32c	-0.461***	0.053	0.166	0.229
e33c	-0.556***	0.061	-1.284***	0.125
e34c	0.705***	0.044	0.213	0.232
e35c	0.286***	0.037	-0.191	0.377
e41c	1.147***	0.018	1.297***	0.039
e42c	-0.039	0.019	0.274	0.146
e43c	0.198***	0.022	-0.056	0.148
e44c	-1.574***	0.028	-1.838***	0.078
e45c	0.24***	0.021	0.257***	0.061
e51c	-0.081***	0.013	0.353***	0.035
e52c	-0.351***	0.038	-0.009	0.298
e53c	0.122***	0.032	-0.084	0.319
e54c	0.545***	0.044	0.609***	0.083
e55c	-0.018	0.049	-0.483***	0.072

*** Denotes significance at the .01 level, ** Denotes significance at the .05 level, * Denotes significance at the .1 level.
Estimated using Stata.
The standard errors were calculated through the delta method.
ei = expenditure elasticity; eiju = uncompensated (Marshallian) price elasticity; eijc = compensated (Hicksian) price elasticity.
1: HSB, 2: LSB, 3: Water, 4: DB, 5: Infusions.

The expenditure elasticities (e1-e5) are positive for all types of drinks in both periods. The fact that all of the chosen drinks have positive expenditure elasticities means that when Argentinean income increases, the demand for them will continue to grow. The expenditure elasticity is elastic in both periods for HSB and infusions, and inelastic in both periods for DB, while it changes from elastic to inelastic between the first and the second period for water, and from inelastic to elastic for LSB. This means that DB are considered necessities within the beverage budget allocation, while HSB and infusions are considered luxury goods. LSB became luxury goods in the second period considered, while water became a necessity.

As expected, the compensated (Hicksian) own-price elasticities were found to be higher than the uncompensated figures (Marshallian). Own-price compensated elasticities are negative in all cases, except for infusions in the first survey, indicating that consumption of goods in this group is not very responsive of changes in price. Next, we look into own and cross-price compensated elasticities. HSB and DB are elastic, while infusions are inelastic in both the first and second samples, with slight increases in the coefficients in the second one. LSB and water go from being inelastic in the first survey to being elastic in the second one. This means that consumers are very responsive to changes in HSB and DB prices, while they are not very responsive to changes in prices of infusions. Consumer responsiveness to changes in LSB and water prices increased in the last period. HSB are a substitute for all goods in the basket, except for infusions in the first survey, in which case they act as a complement. They are especially strong as substitutes of DB, and LSB in the first survey and water in the second one. The magnitude of HSB's complementarity with infusions is small. LSB are substitutes for HSB in the first survey, and complements of water and infusions. Water is a substitute for HSB in the second survey and for DB and infusions in the first one, and a complement of HSB and LSB in the first one. DB are a very strong substitute for HSB and, to a lesser extent, infusions, and for water in the first survey. DB do not act as complements of any of the goods considered. Infusions are a substitute of DB and water in the first survey, and complements of HSB and LSB, although the elasticity values are not high.

In Table 4 we show expenditure elasticities (again), along with expenditures shares and marginal expenditure shares for the different goods in the system. In order to calculate marginal expenditure shares, the estimated expenditure elasticities were multiplied by the expenditure shares.

Table 4: Expenditure elasticities, shares and marginal shares for NHES1 and NHES2

	NHES1			NHES2		
Goods	Expenditure Elasticity	Expenditure Share (%)	Marginal Expenditure Share (%)	Expenditure Elasticity	Expenditure Share (%)	Marginal Expenditure Share (%)
1	1.2	39.48	47.18	1.14	40.33	46.02
2	0.85	1.37	1.16	1.02	4.47	4.54
3	1.36	5.86	7.98	0.87	6.14	5.36
4	0.9	34.81	31.26	0.73	31.98	23.44
5	1.37	18.47	25.3	1.73	17.08	29.62

1: HSB, 2: LSB, 3: Water, 4: DB, 5: Infusions.

These results show that the expenditure share is highest for HSB, followed by DB and infusions. For any increase in future expenditures, the largest share of that increase will be allocated to even more HSB (approximately 46%), and then infusions and DB (approximately 25%). It is worth noting that the marginal expenditure share of DB is for both periods lower than its current expenditure share, while for infusions the marginal expenditure share is in both cases higher than the expenditure share.

5. Conclusions

It is crucial to design tax policies based on quality information, especially when they affect specific food groups. In this paper we estimate a quadratic almost ideal demand system (QUAIDS) for a group of sweetened and unsweetened drinks in Argentina. To do so, we use the last two National Household Expenditure Surveys (NHES), carried over in 2004/05 and 2012/13, and we estimate expenditure and price elasticities.

Our results tell us that that as long as income increases, the demand for all of the goods considered will grow. Marginal increases in expenditure will translate mainly in increased expenditures on highly sweetened beverages (HSB) and infusions, while the proportion of expenditure on dairy beverages (DB) will fall.

Quantities purchased will decrease with price increases for all of the goods considered. Consumers will be especially responsive to changes in HSB and DB prices, while not as much so to changes in prices of infusions. As HSB prices increase, demand for DB will increase, and the other way around.

Comparing our results to those in other studies, we find that they are comparable to Cabrera Escobar, Veerman, Tollman, Bertram, & Hofman's (2013), who report a mean value of own-price elasticity for SB of −1.2. The average of own-price elasticities for SB in our study is −1.14. Our results are also equivalent to those found by Colchero, Salgado, Unar-Munguía, Hernández-Ávila, & Rivera-Dommarco (2015), who reported that own-price elasticity of SB is −1.16, and between −1.06 and −1.29 for soft drinks. The average own-price elasticity for HSB (the group that includes sodas) in our study was −1.32, a bit higher than theirs, perhaps closer to what Paraje (2016) reports (between −1.17 and −1.33).

These results support the notion that a tax applied to HSB will affect consumption. For every 1% increase in price there will be a 1.32% drop in quantity purchased. Likewise, for every 1% price increase in HSB there will be a 1.12% increase in DB purchased. Infusions seem to behave differently, they act as a luxury good and they are not very responsive to changes in price, behaving mostly as complements of other goods. These results are of interest to policymakers, health specialists, representatives from the beverage industry, sweetener producers and consumers.

Future research should look into demand according to different consumer profiles and contexts, such as in the midst of an economic or socio-political shock (see Zurawicki & Braidot, 2005). Another strand of research could be looking into other food groups, such as sweets and snacks and their relationship with sweet beverage consumption. And finally, we think that research should dig deeper in consumer behavior with respect to infusions in Argentina, specifically with respect to traditional yerba mate.

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