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The effects of different types of taxes on soft-drink consumption

Abdulfatah Sheikhbihi Adam and Sinne Smed[1]

Abstract

Monthly data from GfK Consumerscan Scandinavia for the years 2006 – 2009 are used to estimate the effects of different tax scenarios on the consumption of sugar sweetened beverages (SSB's). Most studies fail to consider demand interrelationships between different types of soft-drinks when the effects of taxation are evaluated. To add to the literature in this aspect we estimated a two-step censored dynamic almost ideal demand system where we include the possibilities that consumers have to substitute between diet and regular soft-drinks, between discount and non-discount (normal) brands as well as between different container sizes. Especially the large sizes and discount brands provide considerable value for money to the consumer. Three different type of taxes is considered; a tax based on the content of added sugar in various SSB's, a flat tax on soft-drinks alone and a size differentiated tax on soft-drinks that remove the value for money obtained by purchasing large container sizes. The scenarios are scaled equally in terms of obtained public revenue. Largest effect in terms of reduced intake of calories and sugar are obtained by applying the tax on sugar in all beverages, even though detrimental health effects in terms of increased intake of diet soft-drinks has to be considered. A flat tax on soft-drinks decreases the intake of sugar, but implies a small increase in total calorie intake due to substitution with other SSB's. A tax aimed at removing the value added from purchasing large container sizes increase sugar and total calorie intake due to substitution towards discount brands. Hence the results show the importance of considering substitution between different sizes, brands and discount versus normal brands when simulating the effects of soft-drinks taxation and point toward a tax on the sugar content of SSB's as the most effective in the regulation of obesity.

1. Background and introduction

Obesity is one of the main causes of preventable death (Barness *et al*., 2007) and it could well become the most common health challenge of the 21st century (Palou *et al.*, 2000) and as such this has become a major health policy issue in many countries in the world. This is especially due to the huge personal as well as social costs implied by obesity, mainly in terms of increased health care costs (Sturm, 2010). Although many countries in the OECD have higher obesity rate than Denmark (OECD health data

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2011), we still have to be highly concerned by both the increase in the rate of extreme overweight, as well as the social bias in the prevalence of obesity. Obesity is mainly due to unbalanced energy intake (Bray *et al*., 2004; Malik *et al*., 2006) and particularly, the increased intake of sugar sweetened soft-drinks, have been blamed to be associated with the increase in obesity (see, for instance, Ludwig *et al*., 2001, Brownell *et al.*, 2009). For instance in the US there is evidence that during the same time-period that US citizens have experienced increased prevalence of obesity, the proportion of soft-drink consumed as part of their diet was also increasing (Putnam *et al*., 2002). Sugar sweetened soft-drinks were reported to be the single largest contributor to energy input in the USA over the last decade (7%) (Block, 2004) and the consumption increased by nearly 500% during the past 50 years (Putnam and Allshouse, 1999). Also in Denmark there has been a sharp increase in the consumption of sugar sweetened drinks over the recent decades, and according to Mattiassen *et al.* (2002) this consumption has increased with up to 50% since the 1970s. Moreover, in the US, container size of soft-drinks increased significantly (Nielsen *et al.*, 2002). Similar trends are found in Denmark (Mattiessen *et al.*, 2003). Various studies were initiated to investigate the impact of portion size on energy intake of consumers (Wansink, 1996; Wansink and Park, 2000; Diliberti *et al.*, 2004; Steenhuis and Vermeer, 2009). Their general conclusion is that significantly increased energy intake is a result of increasing portion sizes of foods. Despite this fact, and although there are several studies on portion size effect on energy intake (see above), only a few are found that focus on beverages (Matthiassen *et al*., 2002; Young, 2002, Nestle, 2003). Furthermore, the above studies do not, however, consider demand for various container sizes and brands as well as diet versus regular soft-drinks and the associated impact on energy intake and thereby on obesity.

Economic instruments in form of taxes on energy-dense goods, such as soft-drinks, cab be used to deter consumers from consuming higher amounts than is recommended; or in the form of subsidies to encourage people to consume more healthy foods such as fruits and vegetables. There have been several studies on the possible impact of economic instruments on the consumption of healthy versus unhealthy foods. Smed *et al.* (2007) investigated the effect of possible price instruments on consumption of saturated fats, fibres and sugar. They found that the impact of economic instruments is stronger for lower social classes than in other social classes of the population. Furthermore Jensen and Smed (2007) have evaluated different scenarios to investigate the most cost-effective scenario in terms of possible government policy. They conclude that average cost-effectiveness with regard to changing the intake of selected nutritional variables can be improved by 10–30% if taxes/subsidies are targeted against these nutrients, compared with targeting selected food categories. Soft-drinks are not directly addressed in the above papers, but as the link between soft-drink consumption and obesity have become more evident, some economic studies have emerged focusing particularly on taxes on soft-drinks and how they influence consumer behaviour.[2] Jacobson and Brownell (2000) were among the first that analysed the effect of taxation on the consumption of soft-drinks. However, the focus of this study was how to raise funds intended at promoting unfunded public health programs rather than curbing soft-drink consumption. But in a later study (Brownell *et al.*, 2009) have linked soft-drink consumption to obesity and thus reiterated the need to tax soft-drinks, a tax that they conclude would promote reduction of soft-drink consumption while at the same time generating revenue for the government. Since then several studies have emerged. Fletcher *et al.* (2009) have estimated the impact of hypothetical soft-drink tax on the US obesity rate and conclude that soft-drink taxes influence BMI, but that the effect is small in magnitude.[3] In another study, Fletcher *et al.* (2010), show that although soft-drink taxation brings about a moderate reduction in the consumption of soft-drink by children and adolescents in the US, this reduction is, however, totally offset by increases in consumption of other calorie-rich drinks. Nevertheless, this tax also induces consumers to substitute more nutritious whole milk with soft-drinks. In a later study Zhen *et al.* (2011) estimate that based on price elasticity calculations of nine non-alcoholic beverages, a half-cent per ounce tax on sugar sweetened beverages would reduce consumption of these beverages moderately. Smith *et al.* (2010) and Dharmasena and Capps, (2011) are the only studies that take both own and cross-price elasticities into account when estimating the impact of a tax on non-alcoholic beverages. The former study find that, on average, a reduction of 3.8 pounds of body weight per year for adults would be the result of a 20 % price increase of SSB’s. The latter study concludes that the same price increase would result in a reduction of body weight that ranges between 1.54 pounds and 2.55 pounds per person per year. The above mentioned

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[2] Although there have been taxes on soft-drinks in many countries, these taxes were mainly intended to raise revenue for the state. Recently, countries and states have imposed or increased already existing taxes on soft-drinks to address the obesity problem. For instance, the current government in Denmark has in 2010, in a move intended to limit sugar intake of citizens, increased tax on sugary substances, including soft-drinks (see e.g. http://www.skm.dk/public/dokumenter/engelsk/Danish%20Tax%20Reform_2010.pdf).

[3] But since obesity is not the only health cost associated with soft-drink consumption, the impact could be higher if other benefits would be accounted in this study. Dental costs are one example of such other costs.

study by Fletcher *et al.* (2010) uses both own-price and cross-price elasticities of soft-drinks in a single-equation fixed effects model while the studies by Smith *et al.* (2010), Zhen *et al.* (2011) and Dharmasena and Capps, (2011) are recent papers that use both demand system approaches and own and cross-price elasticity. Finally there is one Norwegian study by Gustavsen and Rickertsen (2009) that looked into the effects of taxes on purchases of sugar-sweetened carbonated soft-drinks. This study is unique in that it implements a quantile regression approach. They conclude that an increased VAT could be an efficient policy in reducing the growth of obesity although their result also suggests that light and moderate drinkers are more responsive to price and income changes than heavy drinkers in relative terms.

The above studies fail to consider the substitution possibilities between soft-drinks with different container sizes. As far as the authors are aware, the only paper that investigates possible effects of container size on consumption of soft-drinks is Stockton and Capps (2005). This study, which focuses on milk and other non-alcoholic beverages, is the first of its kind to explore the impact of container size on consumer behaviour finding very different price elasticities for non-alcoholic beverages with different container sizes. They further conclude that, products, that are normally considered to be substitutes for one another, were complementary for some sizes and substitutes for other sizes. Our paper distinguishes itself from most of the papers mentioned above in several important ways. First we acknowledge that soft-drinks are sold in different container sizes and secondly in different brand types (discount versus normal). This is an important issue since a potential tax might lead to substitution from normal brands to the cheaper discount brands. This is important information that can help to design good tax policies directed to reduce soft-drink consumption. Finally due to the detail of our data we distinguish between consumption of diet soft-drinks and their non-diet counterparts. To the best of our knowledge the two latter issues has not earlier been considered in a demand study of soft-drinks.

The rest of this paper is organized as follows. Section 2 is devoted to a description of the market for soft-drinks and the value for money when purchasing larger size containers. Section 3 describes the empirical model, estimation issues and data. Section 4 the results of the demand system estimation. Section 5 is devoted to a description of the tax simulation model and the results of this simulation. Finally section 6 gives a discussion and conclusion of the paper

2. The market for soft-drinks and value for money

In the last decades firms in the food business have, significantly increased container size of the foods they sell to their customers (Young and Nestle, 2002). Consumers respond positively to the changes in container sizes (*ibid*) and this response can partly be explained by economic reasoning as consumers take advantage of the lower per unit costs and buy goods which are packed in larger containers (Steenhuis and Vermeer, 2009; Wansink, 1996; Vermeer *et al.*, 2010). This might lead to increased consumption. Mattiessen *et al.* (2003) have compiled trends in container size of some popular sugar-sweetened foods in Denmark, including beverages. The result of this study shows increasing container sizes for many types of food. As an example table 1 shows a significant increase over a period of more than 4 decades, for the container size of Coca-Cola with the largest increases taking place after 80'ies.

Table 1: Development in container size of Coca Colas over time

Volume (ml)	Year of introduction-termination
190	1959–1972
250	1972–
350	1961–1988
500	1980–
1000	1971–1994
1500	1991–
2000	2004–

Source: (Matthiessens *et al.*, 2003)

Figure 1 shows volume shares of different main container sizes aggregated across discount versus normal brands for all soft-drinks based on data from GfK consumerscan Scandinavia.[4] The nine types of container sizes originally included in the dataset are aggregated to 2 litres, 1.5 litres and smaller sizes. Together, the 1.5 litres accounted for more than 65% of the market between 2001 and 2004, with discount brands dominating. In 2004 the 2 litres container size was introduced into the market. This was a success for the beverage industry since the 2 litre container size soon got a dominating position on the market. In the beginning of 2006 the 2 litre container size had approximately 33% of the market as did also the 1.5 litres and the smaller sizes. From 2007 and onwards the 2 litres, discount brands became dominating in the market. Within the same period diet soft-drinks have captured around 12% of the market for soft-drinks.

[4] For a description of the dataset see the data section below. Remark that throughout the paper we will name non-discount brands as normal.

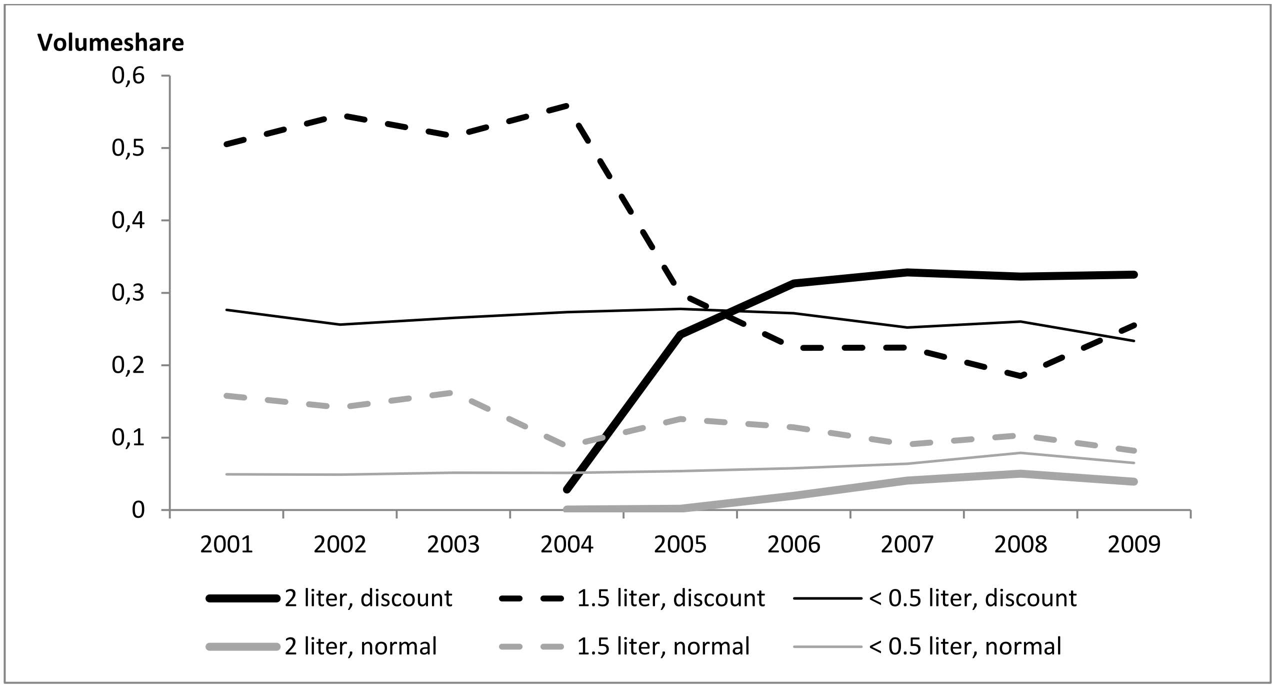


Figure 1: Volume shares of discount and regular for different container sizes, 2001 – 2009
Source: GfK Consumertracking Scandinavia

One reason for the success of the 2 litres container sizes are the value for money associated with buying larger sizes. In table 2 we present the prices of different container sizes in DKK per litre. If we as an example compare a small size diet discount brand with the same brand, but in a 2 litre container 1.38 DKK are to be saved per litre. For the non-discount (normal) counterpart 10.78 DKK are to be saved per litre if a 2 litre container is chosen instead of a small size. More money is to be saved if the discount counterpart is purchased. For example 16.52 DKK are to be saved per litre if a discount version of a small diet soft-drink is purchased compared to a normal type and 13.62 DKK per litre if a regular type are purchased. There are almost no price differences between diet and non-diet soft-drinks, even though for 1.5 liters and smaller sizes regular brands a little more than 2 DKK are saved per liter if a regular is chosen instead of a diet version.

Table 2: Unit price (DKK/litres) **of different types of soft-drinks, average for 2007**

	Mean	Std	Deviation from		
			2 litre alternative (DKK/litre)	Discount alternative (DKK/litre)	Regular alternative (DKK/litre)
Price, 2 l. discount, diet	5.06	0.30	0.00	0.00	0.57
Price, 1,5 l. discount, diet	6.70	0.28	1.64	0.00	0.16
Price, < 1.5 l. discount, diet	6.44	0.38	1.38	0.00	-0.09
Price 2 l. normal, diet	12.18	1.52	0.00	7.12	-0.63
Price, 1,5 l. normal, diet	15.10	6.09	2.92	8.4	2.6
Price < 1.5 l. normal, diet	22.96	2.69	10.78	16.52	2.81
Price, 2 l. discount, regular	4.49	0.28	0.00	0.00	0.00
Price, 1,5 l. discount, regular	6.54	0.28	2.05	0.00	0.00
Price, < 1.5 l. discount, regular	6.53	0.45	2.04	0.00	0.00
Price 2 l. normal, regular	12.81	1.57	0.00	8.32	0.00
Price, 1,5 l. normal, regular	12.50	0.45	-0.31	5.96	0.00
Price < 1.5 l normal, regular	20.15	1.42	7.34	13.62	0.00

3. Empirical model

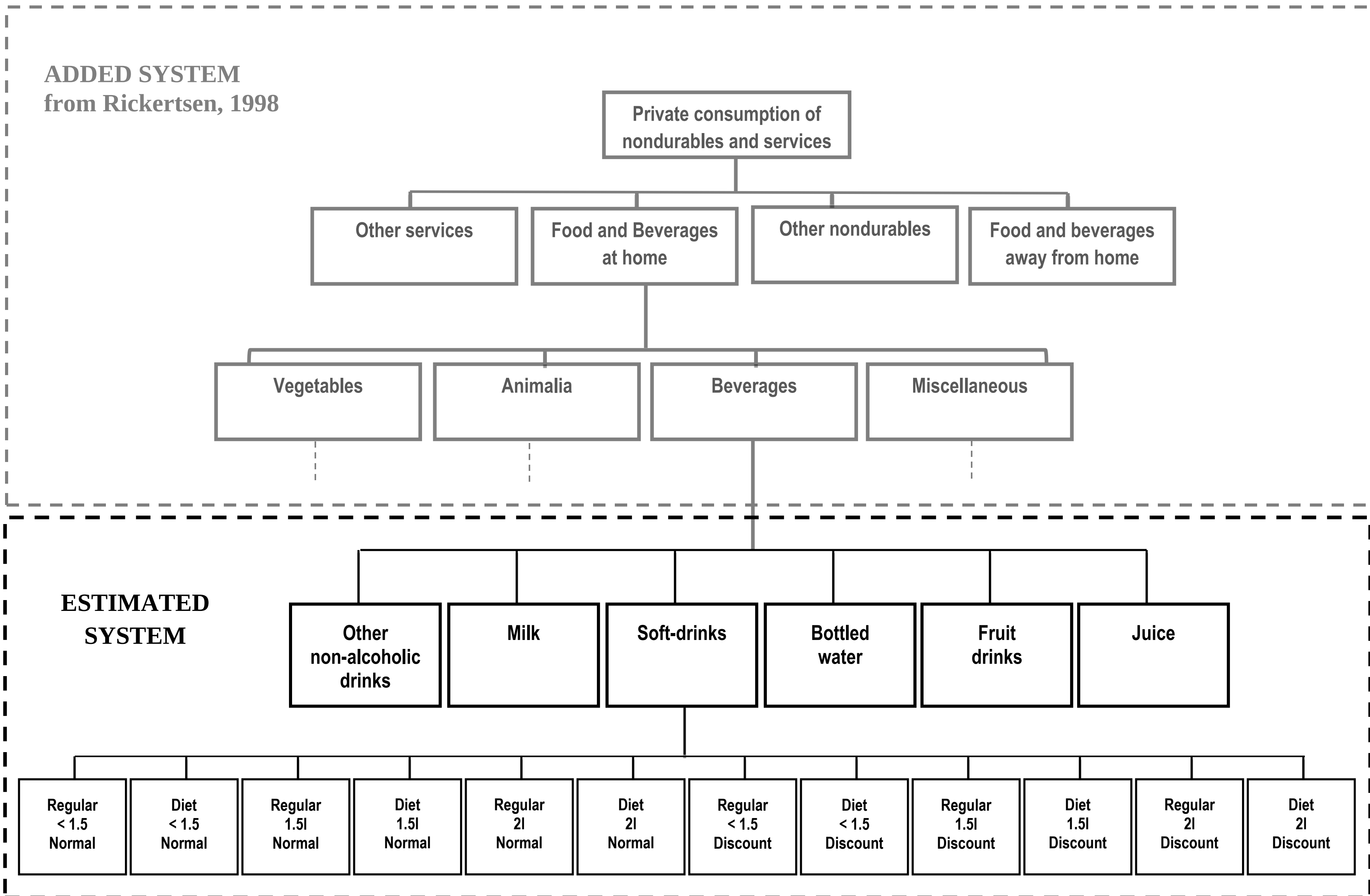
3.1 Two-step budgeting

We base our estimated demand system on multistage budgeting where households in the first stage decide what kind of beverage to buy, hence choose between several non-alcoholic beverages and allocate their budget accordingly; and in the second stage decide which type of soft-drinks to buy, hence choose between container sizes, brand types and regular versus diet. The prices used in the second step are calculated as average unit prices whereas the prices in the first step are based on Törnquist price indices. This multistage system implies that we assume weak separability between different types of non-alcoholic beverages. However, it has to be noted that weak separability does not conclude that price changes for goods in different groups do not affect each other, but just that such effects are channelled through the group expenditures Edgerton, (1997). Price changes in one good (say in group r) will not only affect other goods in the same group but also other goods in another group (say group s). The effect on the latter is channelled through the price index of the group, P_r (Edgerton *et al*., 1996, Edgerton, 1997). This has implications for calculated elasticities because these are affected not only by first stage budgeting elasticities but also the second stage elasticities.

Furthermore within the estimated system it is assumed that the budget for non-alcoholic beverages is constant which might be an important limitation of the simulated effects of a tax on e.g. soft-drinks or sugar. To correct this we faced two alternative solutions, i.e. either to get more data on household consumption to enable us directly to model multistage demand elasticities or use already published elasticities of the upper stages, particularly, unconditional elasticities of non-alcoholic beverages. As far as the authors know, there are no published studies of beverage consumption in Denmark except Edgerton *et al*. (1996). However, in their utility tree, Edgerton *et al*. (1996) place milk under the animalia food group while we prefer to use elasticities from a system that place milk under beverages as we do in the present study. Therefore, we used elasticities from Rickertsen (1998) in our effort to recover unconditional elasticities since this study group milk under the beverage group. It has to be noted though that the data used by Rickertsen (1998) is not from Denmark, rather it is. Nonetheless, we assume consumer preferences in both countries could be similar in that they are two very closely related countries in terms of culture, economic growth and geography. In his paper, Rickertsen (1998) estimates a three-stage complete demand model of food and beverages in Norway by using a dynamic almost ideal demand system (AIDS). The utility tree used by Rickertsen (1998) is shown in figure 2. We take the mean unconditional own price elasticity of -0.85 for beverages and use it[5] to calculate our system's unconditional elasticities by the formula put forward by Edgerton (1997) and presented in (21) – (22). After these adjustments, our utility tree is partly a replica of Rickertsen (1998) and partly different. In the stages until the beverage groups we are similar to Rickertsen (1998) since we, as mentioned above, use their beverage elasticities; and in the stages below we depend on our own data. The separation strategy for the estimated system and for the system on which the elasticities used for calculating the final unconditional elasticities are shown in figure 2 below.

[5] We could not use the standard errors of the unconditional own price elasticity of beverages in this paper since Rickertsen (1998) does not report them. Therefore we rely on standard errors based on the conditional part of the formula when we calculating the standard errors for the unconditional elasticities of the various non-alcoholic beverages.

Figure 3: Utility-tree for estimated demand system of non-alcoholic beverages



3.2 The AIDS model

To estimate the demand system we use a linear version of Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) with lagged expenditure shares to control for habit formation as previous studies have shown strong evidence for habit formation of non-alcoholic beverages (see e.g. Zhen *et al*., 2011).[6] The model has the following derived equations:

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} ln\ p_{jt} + \beta_i ln\ \frac{X_t}{P_t} + \sum_j \theta_{ij} w_{jt-1} + \varepsilon_{it} \qquad (1)$$

for all *i*, where w_i is the expenditure share of good *i*, p_j are prices for good *j*, and X_{it} represents the total expenditure on all goods in the system and w_{jt-1} is lagged expenditure share of all goods *j* and P_t is a price index for all goods. Equation (1) is the dynamic version of the AIDS model modified to account for dynamics in consumer behaviour (e.g. habit formation or storage effects) by introducing lagged expenditure shares in the model as suggested by, for example, Alessie and Kapteyn (1991) and Assarson (1991).

In the original model the price index *P* is not linear in the parameters, hence the model may be difficult to estimate. An alternative approach suggested by Deaton and Muellbauer is to use a linear price index that can be an approximation of the non-linear translog index. The original linear index used by Deaton and Muellbauer is the Stone index where P_t^* is given by:

$$\ln\ P_t^* = \sum_i w_i \ln(p_{it}) \quad \mathrm{i} = 1, \ldots, \mathrm{n} \qquad (2)$$

[6] The AIDS model satisfies the axioms of choice exactly; it is possible to aggregate over consumers; it has a functional form which is consistent with known household-budget data; it is simple to estimate, has linear versions (LA-AIDS) that avoid the need for non-linear estimation and most importantly it is flexible. Last but not least, it can be used for testing the restrictions of homogeneity and symmetry. Translog (Christensen *et al.*, 1975) and Rotterdam (Theil, 1965, 1975; Barten, 1964, 1968, 1977) models also have similar properties but not all of the properties that AIDS model exhibits. AIDS is a price independent generalized logarithmic PIG-LOG class model implying that price is independent from expenditure in the log form. PIG-LOG are preferences and are represented via the cost or expenditure function which defines the lowest expenditure required to attain a specific utility level at given prices

w_i is the expenditure share. From these, the modified model with the stone index can be written as follows:

$$w_{it} = \alpha_i^* + \sum_j \gamma_{ij} ln \; p_{jt} + \beta_i ln \; \frac{X_t}{P_t^*} + \sum_j \theta_{ij} w_{jt-1} + \varepsilon_{it}^* \qquad 3$$

where $\alpha_i^* = \alpha_i - \beta_i \alpha_i$ and $\varepsilon_{it}^* = \varepsilon_{it} - \beta_i (\ln \; \varphi \; - E \; \ln \; \varphi$.

Equation (3) is known as the Linear Almost Ideal Demand System or LA-AIDS in the literature and is easier to estimate. Therefore, most empirical studies follow Deaton and Muellbauer in favoring LA-AIDS owing to its simplicity. However, lately, some authors have criticized it for using the Stone index (Moschini, 1995; Pashardes, 1993). Moschini (1995), for instance, argues that the Stone index results in biased estimates of the parameters. Solutions suggested to this caveat include correcting the units of measurement error by scaling prices by their sample mean. Moschini (1995) has suggested the use of the Laspeyres price index to remedy this measurement error.

This can be achieved by replacing w_i in equation (2) with w_i. Note that w_i is the mean expenditure share. Then we can rewrite equation (2) as:

$$\ln \; P_t{}^L \; = \sum_i w_i \ln(p_{it}) \;\; \mathrm{i} = 1, \ldots, \mathrm{n} \qquad 4$$

Therefore, the Laspeyres price index is a geometrically weighted average of prices. Equation (4) is then inserted in (1) to get LA-AIDS with Laspeyres price index as follows:

$$w_{it} = \alpha_i^{**} + \sum_j \gamma_{ij} ln \; p_{jt} + \beta_i (ln \; x_t \; - \sum_{\mathrm{j}} w_i \ln(p_{it})) + \sum_j \theta_{ij} w_{jt-1} + \varepsilon_i^{**} \qquad 5$$

where $\alpha_i^{**} = \alpha_i - \beta_i (\alpha_0 - \sum_{\mathrm{j}} w_j \ln \; p_j$

Finally, we note that there are basic restrictions in consumer theory that should be satisfied. These are adding up, symmetry and homogeneity and they are expressed in terms of the coefficients.
Homogeneity: $\sum_j \gamma_{ij} = 0$; Adding up: $\sum_{\mathrm{i}} \alpha = 1$, $\sum_{\mathrm{i}} \beta_i = 0$, $\sum_j \gamma_{ij} = 0$, $\sum_j \theta_{ij} = 0 \; \forall \mathrm{j}$; Symmetry: $\gamma_{ij} = \gamma_{ji}$.

3.3 Two-step estimation of censored LA-AIDS

Due to the nature of our data we have a considerable amount of 0's in the dataset. We use the Shonkwiler and Yen (hereafter abbreviated as SY) two-step approach to correct for these zero-expenditures (Shonkwiler and Yen, 1999). The system of equations is a generalization of Amemiya (1974) approach:

$$w_{it}^{*} = f(\mathrm{x}_{it}, \beta_i) + \epsilon_{it}, d_{it}^{*} = z_{it}'\alpha_i + \upsilon_{it}, \tag{6}$$

$$d_{it} = \begin{cases} 1\ if\ d_{it}^{*} > 0 \\ 0\ if\ d_{it}^{*} \leq 0 \end{cases} \quad w_{it} = d_{it}\, w_{it}^{*} \quad (i = 1,2, \ldots, m; t = 1,2, \ldots, T)$$

where w_{it} and d_{it} are the observed dependent variables of the i^{th} equation and t^{th} observation, w_{it}^{*} and d_{it}^{*} are corresponding latent variables where x_{it} and z_{it} are vectors of exogenous variables, β_i and α_i are vectors of parameters, and ϵ_{it} and υ_{it} are random errors. The SY approach assumes that the error terms ϵ_{it} and υ_{it} are distributed as bivariate normal with $cov(\epsilon_{it},\upsilon_{it}) = \delta_i^2$. Furthermore the unconditional expectation of w_{it} is:$\mathrm{E}(\mathrm{w_{it}} | \mathrm{x_{it}}, \mathrm{z_{it}}) = \Phi(z_{it}'\alpha_i) f(\mathrm{x}_{it}, \beta_i) + \delta_i \varphi(z_{it}'\alpha_i)$

Equation (6) can then be written as:

$$\mathrm{w_{it}} = \Phi(z_{it}'\alpha_i) f(\mathrm{x}_{it}, \beta_i) + \delta_i \varphi(z_{it}'\alpha_i) + \xi_{it} \quad (i = 1,2, \ldots, m; t = 1,2, \ldots, T) \tag{7}$$

where $\xi_{it} = w_{it} - E(w_{it} | x_{it}, z_{it})$. Finally with (7) it is now straightforward to estimate a two-step estimation procedure by using all available observations (Shonkwiler and Yen, 1999). In the first step a maximum likelihood (ML) probit is estimated to obtain $\alpha_i$of $\alpha_i$using the binary outcome of whether a household had expenditures for a certain good or not at time *t* (i.e. $d_{it} = 1\ and\ d_{it} = 0$ for each *i*). In the second step, the $\Phi(z_{it}'\alpha_i)$ and $\delta_i \varphi(z_{it}'\alpha_i)$ are calculated to finally estimate $\beta_1, \beta_2, \ldots, \beta_{m,} \delta_1, \delta_2, \ldots, \delta_m$ in the system where $f(\mathrm{x}_{it}, \beta_i)$ is estimated within the AIDS system:

$$\mathrm{w_{it}} = \Phi(\boldsymbol{z}_{it}' \boldsymbol{\alpha}_i) f(\mathbf{x}_{it}, \boldsymbol{\beta}_i) + \delta_i \varphi(\boldsymbol{z}_{it}' \boldsymbol{\alpha}_i) + \xi_{it} \tag{8}$$

by ML or Seemingly Unrelated Regression (SUR), where

$$\xi_{it} = \epsilon_{it} + [\Phi(z_{it}'\alpha_i) - \Phi(z_{it}' \alpha_i)] f(\mathrm{x}_{it}, \beta_i) + \delta_i [\varphi(z_{it}'\alpha_i) - \varphi(z_{it}' \alpha_i)] \tag{9}$$

With $E(\xi_{it}) = 0$ and $Var(\xi_{it}) = \sigma_i^2 \Phi(z_{it}'\alpha_i) + [1 - \Phi(z_{it}'\alpha_i)] \times \{[f(\mathrm{x}_{it}, \beta_i)]^2 \Phi(z_{it}'\alpha_i) + 2f(\mathrm{x}_{it}, \beta_i) \delta_i \varphi(z_{it}'\alpha_i)\} - \delta_i^2 \{z_{it}'\alpha_i \varphi(z_{it}'\alpha_i) + [\varphi(z_{it}'\alpha_i)]^2$

Moreover, the parameters obtained in the second step are consistent because the ML probit estimators $\boldsymbol{\alpha}_i$ in the first step are consistent. On the other hand, the disturbance term in equation (9) is heteroskedastistic. To mitigate this problem, heteroskedasticity robust standard errors are used.

3.4. Calculation of elasticities

The elasticities in the AIDS system are calculated as:

$$E = 1 + \frac{\beta_i}{wi} \qquad 10$$

$$\varepsilon_{ij} = \frac{\gamma_{ij} + \beta_i . [\beta_j \ln \frac{y}{P} \; - w_j - \frac{1}{2} . \quad _k \; \gamma_{kj} - \gamma_{jk} \;\; lnp_k}{w_i} - \delta_{ij} \qquad (11)$$

where the parameters γ_{ij} and β_i represent the changes in the expenditure shares caused by the change in prices and real expenditure respectively and where δ_{ij} is the Kronecker delta (Edgerton *et al*., 1996).

Some adjustments have to be done when the calculation of the price elasticities are based on parameters obtained in the SY approach. Here we present elasticity formulas from Jonas and Roosen (2008) who in turn follow the approach by Chalfant (1987).

Expenditure elasticity: $$\eta_i = \Phi_i . \frac{\beta_i}{w_i} + 1 \qquad (12)$$

Uncompensated own price elasticity: $$\varepsilon_{ii} = \Phi_i \;\; \frac{\gamma_{ii}}{w_i} - \beta_i \;\; - 1 \qquad (13)$$

Uncompensated cross price elasticities: $$\varepsilon_{ij} = \Phi_i \;\; \frac{\gamma_{ij} - \beta_i w_j}{w_i} \qquad (14)$$

Since the elasticities in (12-14) are short run elasticities that do not take into account the dynamics of consumption and because the long run effects of taxes may be of more interest for policy makers, we also calculate the long run elasticities as in Larivière *et al*. (2000):

For the first stage that do not have any censoring:

$$\eta_i = \frac{\beta_i + w_i}{w_i - \;\; \Omega_\iota \times Q_i} \qquad (15)$$

$$\varepsilon_{ii} = \frac{\gamma_{ii} - w_i - (\beta_i \times w_i)}{w_i - \ \Omega_i \times Q_i} \tag{16}$$

$$\varepsilon_{ij} = \frac{\gamma_{ij} - (\beta_i \times w_j)}{w_i - \ \Omega_i \times Q_i} \tag{17}$$

And for the second stage: Uncompensated own price elasticity:

$$\eta_i = \Phi_i \ \ \frac{\beta_i + w_i}{w_i - \ \Omega_i \times Q_i} \tag{18}$$

$$\varepsilon_{ii} = \Phi_i \ \ \frac{\gamma_{ii} - w_i - (\beta_i \times w_i)}{w_i - \ \Omega_i \times Q_i} \tag{19}$$

$$\varepsilon_{ij} = \Phi_i \ \ \frac{\gamma_{ij} - (\beta_i \times w_j)}{w_i - \ \Omega_i \times Q_i} \tag{20}$$

Where where Ω_i is a coefficient associated with habit formation and Q_i is the mean of per capita consumption for beverage *i*.

Furthermore as we estimate a two-step system we have to calculate unconditional elasticities as derived in Edgerton (1997):[7]

$$E_i = E_{\ r} \ E_{\ ri} \tag{21}$$

$$e_{ij} = \delta_{rs} e_{\ r \ ij} + E_{\ r \ i} w_{\ s \ j} \ \ \delta_{rs} + e_{\ r \ \ s} \tag{22}$$

where E_i is the unconditional expenditure elasticity, $E_{(r)}$ group expenditure elasticity, $E_{(ri)}$ denotes within group expenditure elasticity, e_{ij} is the uncompensated price elasticities. δ_{rs} is the Kronecker delta equal to 1 if $r = s$ and zero otherwise. The final elasticities unconditional on the total budget are calculated based on elasticities from Rickertsen (1998) and are likewise based on the equations (21) – (22).

[7] We also used calculated unconditional elasticities based on the formulas in Carpenter and Guyomard (2001), but got unrealistic results for the cross price elsticities

3.5 Data

The data used in this paper originates from Scandinavian Consumer tracking (GfK) that among other things maintains a demographically representative consumer panel from all the different regions of Denmark. The data covers at-home purchases of food and beverage items. The data covers the years 2006-2009 and is an unbalanced panel that contains approximately 3000 households. The households report types of food purchased as well as, day, week and month of each purchase activity. Due to the frequency of zero purchase in the data and the issue of storage in relation to soft-drinks consumption, we aggregated each household’s consumption over months. In total this leads to 91105 observations.
The data has rich information including purchase details in terms of beverage type, value and volume, container size etc. As we follow a multistage budgeting approach, two sub datasets are derived. The first dataset contained all types of non-alcoholic beverages. As can be seen in table 3 below, households spend most of their budget on milk which accounts 60% of all expenditure allocated to consumption of non-alcoholic beverages. Soft-drinks come in second with almost 20% of beverage expenditure while third most popular beverage is juice with roughly 15% of the all beverage expenditure. This data is supplemented with a Tornqvist price index to represent prices for each composite group based on calculated unit prices and expenditure shares.

Table 3: Summary of expenditure shares for beverages in the first step

Variable	Mean	Std. Dev.
Expenditure share, Soft-drinks	0.18	0.27
Expenditure share, Milk	0.60	0.33
Expenditure share, Other Non-alcoholic (ONA)	0.03	0.10
Expenditure share, Fruit drinks	0.04	0.12
Expenditure share, Bottled Water	0.01	0.06
Expenditure share, Juice	0.15	0.23

N = 65068, T= 2006-2009

The second dataset contains different types of soft-drinks. These were divided into three sizes, the 2 litres, the 1.5 litres and the remaining smaller sizes aggregated as one small size these are shown in table 4 below. We choose to model the 2 litres, the 1.5 litres and the smaller sizes accordingly since we want to specifically consider the substitution patterns between the 2 litres sizes and compare with the remaining sizes and furthermore to consider the substitution effects of discount soft-drink types with their normal counterparts. Therefore, we made a distinction between discount soft-drinks and normal soft-drinks based on the idea that anything below the average price of soft-drink is considered as discount soft-drink whereas the opposite is a normal soft-drink. Last but not least we acknowledged the importance of distinguishing the between diet and regular soft-drinks.

Table 4: Summary statistics of expenditure shares for soft-drinks

Variable	Mean	Std. Dev.
Expenditure share, 2 l. discount, diet	.08	0.24
Expenditure share 2 l. normal, diet	.02	0.12
Expenditure share, 1.5 l. discount, diet	.07	0.21
Expenditure share, 1.5 l. normal, diet	.04	0.17
Expenditure share, < 1.5 l. size, discount, diet	.05	0.19
Expenditure share, < 1.5 l. size normal, diet	.04	0.18
Expenditure share, 2 l. discount, regular	.19	0.35
Expenditure share 2 l. normal, regular	.02	0.13
Expenditure share, 1.5 l. discount, regular	.12	0.28
Expenditure share, 1.5 l. normal, regular	.08	0.23
Expenditure share, < 1.5 l. size, discount, regular	.18	0.35
Expenditure share < 1.5 l. size normal, regular	.11	0.28

Note. The source of these data is GfK Household Panel 2006–2009 (n=27445) . The data shown in the table consider only households that are consumers of soft-drinks. For a more precise description of the data that are used in the estimation see the data-section below.

The same data also contains information about socio-economic status of the households. Household income, education, age and gender of the diary keeper, age and number of children in the household are among these variables. In line with past literature (e.g. Gould and Dong, 2000) we find it important to account for household heterogeneity when using micro-data. Therefore socio-demographic variables are included in the model to acknowledge household-specific heterogeneity. We also acknowledge the need to account for the dependence of current utility evaluations on past choices and therefore we add past consumption as a supplementary method of accounting for heterogeneity.

Table 5: Summary statistics of the socio-demographic variables used in the estimation

Variable	Mean	Std. Dev.
Age (Years)		
25 or below	0.01	0.10
26-29	0.03	0.16
30-39	0.11	0.32
40-49	0.19	0.39
50-59	0.21	0.41
60-69	0.26	0.44
70 or above	0.19	0.39

Education		
Vocational training	0.38	0.49
Short higher education	0.17	0.38
Medium higher education	0.19	0.39
Long higher education	0.06	0.23
No education	0.20	0.40
Number of Kids in the households		
No Kids	0.76	0.43
Share of Households with kids between 0-6	0.08	0.27
Share of Households with kids between 7-14	0.12	0.33
Share of Households with kids between 15-20	0.10	0.30
Income		
Share of Low income families	0.38	0.49
Share of Middle income families	0.60	0.49
Share of High income families	0.02	0.12

Note. The source of these data is GfK Household Panel 2006–2009.

3.6 Estimation procedure

The two-stage budgeting process system is estimated by iterative feasible generalized on-Linear system (IFGNLS) with the help of STATA version 11.2. This is equivalent to maximum likelihood (ML) estimation. First a 6 good system is estimated using equation (5) and expenditure, own-price and cross-price demand elasticities were calculated for the 6 beverage categories in the first step using equations (15) - (17) and (21) - (22). The two-step estimation of a censored system of equations method suggested by Shonkwiler and Yen (1999) are used for the second step estimation. We note that demand restrictions are not necessarily imposed on observed expenditure shares but on latent expenditure shares.[8] First a maximum likelihood probit model is estimated. Then the univariate standard normal cumulative distribution function (cdf) and the probability density function (pdf) are calculated from the probit regression and these are used as weights in the demand system estimation in equations that have zero expenditures. Therefore, we first estimate the probability that a household will consume soft-drink with a specific container size as:

[8] When estimating the system on *n-1* equations, the results may not be invariant to the equation deleted. Therefore the robustness of the elasticity estimates is checked by changing the type of soft-drink excluded. Generally the elasticities of the estimated equations were stable after the tests.

$$d_{ih}^{*} = Z_{ih}'a_i + v_{ih} \qquad d_{ih} = \begin{cases} 1\ if\ d_{it}^{*} > 0 \\ 0\ if\ d_{it}^{*} \leq 0 \end{cases} \tag{23}$$

Where Z_{ih}' is a vector of household socio-demographic variables such as age of the household diary keeper, education of the dairy keeper, number children in the family, gender of the dairy keeper and household income. Secondly the final model estimated is:

$$w_{iht} = \Phi_{iht}\left(\alpha_{i0} + \sum_{k} \rho_{ik} d_{kh} + \sum_{j=1}^{n} \gamma_{ij} lnp_{jht} + \beta_i (lnx_{ht}/P_{ht})\right) + \delta_i \varphi_{iht} \tag{24}$$

where α_{i0} is a constant and d_{kht} are household specific socio-demographic variables. Note that P_{ht} is the Laspeyres price index. Furthermore, heteroskedasticity robust standard errors were used in the estimation, since the two-step estimation method of Shonkwiler and Yen (1999) is heteroskedastic by construction. Because of the adding-up property the variance-covariance matrix of the error terms for the complete *n* system of equations becomes singular. Therefore, to avoid this singularity problem one equation has to be dropped in the demand system and parameters of the dropped good can be recovered afterwards. The good dropped in the beverage system is the juice category whereas in the second step system the category excluded in the estimation is the small container size discount soft-drinks. However, adding up as well as invariance to which equation is omitted from estimation does not necessarily hold in the SY two-step method. Therefore robustness test of the results was carried out by omitting a different equation in the second stage. The delta method was used to calculate the variance of the elasticity estimates.

4. Estimation results

As there was censoring in the second step budgeting, but not in the first, probit estimates are only available for the second step. These are provided in appendix A. Based on the model described in the foregoing sections, we calculated long run as well as short run conditional own and cross-price elasticities for both the first and second step budgeting choices. The long run unconditional elasticities are shown in appendix B (table B1 and B2) and the short run elasticities are shown in the appendix C (table C1 and C2 respectively). Furthermore the calculated short run unconditional elasticities are calculated and shown in table C3.

As shown in table 6 below most of the price elasticities are significant at conventional levels and all own price elasticities have expected signs (negative). From long run conditional elasticities for beverages (table B1 in appendix B) we see that milk, other non-alcoholic beverages and bottled water are the least elastic while soft-drinks are most elastic of the six beverages. Soft-drink has an own-price elasticity of -1.23 which are somewhat in line with Andreyeva *et al.*, (2010) who conducted a literature survey on the matter and report own-price elasticity of soft-drinks to be between −0.8 and −1.0 while Zheng and Kaiser (2008) find an elasticity which is less responsive i.e. −0.15. More recently a relatively high elasticity of -1.90 has been found by Dharmasena and Capps, (2009). The observed differences can to some extend be based on cultural differences in how soft-drinks are considered to be a part of the diet. Furthermore, table B1 also shows cross price elasticities which also convey important information about price responsiveness of the various beverages with regard to a change in other beverages' prices. For example the cross-price relationships indicate that all the beverages are substitutes to soft drinks with the exception of bottled water and juice. Fruit drinks and other non-alcoholic drinks which also contain a lot of sugar are the most responsive. The fact that milk is a substitute to soft drinks is in accordance with previous findings by Pofahl *et al*., 2005. The size differences in the elasticities of our study and the Pofahl *et al.*, 2005 paper can be explained by the differences in the cultures of the two samples for the two studies. In Denmark there is a long tradition of high consumption of milk and milk products, which might not necessarily be similar in the US. The interesting part here in relation to taxation of soft-drinks is to what extent other sugar sweetened beverages are substitutes to soft-drinks.

Table 6 below reports unconditional long run elasticities for the complete beverage demand model i.e. we see own and cross price elasticities for the five main beverages and the twelve soft-drink categories. The lower right side of the table presents elasticity results for soft-drinks with specific container sizes, regular versus diet type as well as discount versus normal brands (second step budgeting). Here too, own price elasticities have expected negative sign. What is quite interesting here is that the own- price elasticities are highest for discount brands with 1.5 litre container sizes; whereas the least inelastic are the 2 litre discount brands. The opposite is true for the normal brands, hence consumers are less price responsive when it comes to large container size discount brands and small size normal brands. There are no systematic differences found between diet and regular brands. Turning to cross-price elasticities we find that there are no significant substitutes for the least price elastic brands, i.e. small size normal brand diet soft drinks has only its counterpart, small size diet discount brand as a substitute whereas the 2 litres discount regular and diet types has no significant substitutes. The reason for this might be that the 2 litres discount are found to be the “everyday” soft-drink, hence the cheapest version, whereas the small size are purchased on “the run”, hence you buy it to consume it outdoor or to satisfy immediate cravings. This implies that for both these types no close substitutes exist. The 2 litre and smaller sizes normal brand regular soft-drinks are substitutes for the diet 1.5 litre normal brands while the remaining categories are its complements.

Table 6: Unconditional long run elasticities on non-alcoholic beverage consumption (Standard errors in parenthesis)

	Milk	ONA	Fruit drinks	Water	Juice	Price of Diet Discount 2l	Diet Discount 1.5l	Diet Discount <1.5	Diet Normal 2l	Diet Normal 1.5l	Diet Normal <1.5	Regular Discount 2l	Regular Discount 1.5l	Regular Discount <1.5	Regular Normal 2l	Regular Normal 1.5l	Regular Normal <1.5
Milk	-0.801***	0.007	-0.005	-0.017***	0.086***	0.027***	0.007***	0.021***	0.013**	0.017***	0.014***	0.061**	0.008***	0.037***	0.025**	0.060***	0.037**
	(0.014)	(0.008)	(0.013)	(0.0064)	(0.013)	(0.0001)	(0.0001)	0.0001	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)
ONA	0.009	-0.792***	0.055	-0.100*	-0.106*	.029***	0.007***	0.023***	0.014***	0.018***	0.015***	0.067***	0.009***	0.041***	0.027***	0.065***	0.040***
	(0.097)	(0.107)	(0.159)	(0.054)	(0.064)	(0.001)	(0.0002)	(0.001)	(0.0003)	(0.0004)	(0.0004)	(0.002)	(0.0002)	(0.001)	(0.001)	(0.002)	(0.001)
Fruit drinks	-0.143	0.032	-1.082***	0.049	0.030	0.037***	0.009***	0.030***	0.018***	0.023***	0.019***	0.084***	0.011***	0.052***	0.034***	0.082***	0.051***
	(0.094)	(0.099)	(0.254)	(0.064)	(0.056)	(0.001)	(0.0001)	(0.001)	(0.0003)	(0.0004)	(0.0003)	(0.001)	(0.0002)	(0.001)	0.001	(0.0013)	(0.001)
Bottled Water	0.0004***	.0002*	-.0002	-0.709***	-0.0001	0.0004***	0.0001***	0.0001***	0.0001***	0.0003***	0.0002***	0.001***	0.0001***	0.0001	0.0001***	0.0001***	0.0004***
	(0.0002)	(0.0001)	(.0002)	(0.178)	(0.0001)	(0.00002)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.00001)	(0.001)	(0.0003)
Juice	0.0001***	-0.0003*	0.000	0.0003	-0.900***	0.0002***	0.0005***	0.0002***	0.001***	0.001***	0.001***	0.001***	0.00012	0.00003	0.001***	0.0001***	0.0003***
	(0.0001)	(0.00002	(0.000)	(0.0001)	(0.008)	(0.0001)	(0.0004)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0003)	(0.0001)	(0.0004)	(0.0002)
Diet Discount 2l	0.087***	.009	.017***	.0004***	.008***	-0.312*	0.0103	0.014	-0.022***	-0.003	-0.012	-0.004	0.016	0.025	-0.031***	-0.044**	-0.035*
	(0.002)	(0.0002)	(0.001)	(0.00001)	(0.0002)	(0.183)	(0.0133)	(0.021)	(0.010)	(0.009)	(0.016)	(0.028)	(0.012)	(0.025)	(0.0120)	(0.0201)	(0.022)
Diet Discount 1.5l	.112***	.012***	.022	0.001***	.011	0.236	-1.489***	-0.587***	-0.267***	-0.067	-0.224*	0.361	0.007	-0.594***	0.364***	0.027	0.387**
	(0.003)	(0.0004)	(0.001)	(0.00001)	(0.0003)	(0.213)	(0.267)	(0.211)	(0.089)	(0.072)	(0.134)	(0.241)	(0.152)	(0.234)	(0.117)	(0.183)	(0.194)
Diet Discount <1.5	0.117	.012	.023	.001***	.011	0.016	0.032	-0.914***	0.009	-0.035***	0.031*	-0.057*	-0.064***	-0.030	-.003	0.029	-0.054**
	(0.003)	(0.0003)	(0.001)	(0.00001)	(0.0003)	(0.026)	(0.026)	(0.201)	(0.010)	(0.009)	(0.018)	(0.031)	(0.018)	(0.029)	(0.016)	(0.025)	(0.027)
Diet Normal 2l	.137	.015	.027***	.001***	.013	-0.081	-0.113***	0.103*	-0.869***	-0.237***	0.034	0.105	0.140***	0.200***	-0.050	0.004	0.059
	(0.004)	(0.0004)	(0.001)	(0.0001)	(0.0004)	(0.067)	(0.038)	(0.055)	(.084)	(0.036)	(0.047)	(0.076)	(0.038)	(0.071)	(0.052)	(0.071)	(0.067)
Diet Normal 1.5l	.092	.010**	.018***	.0005	.009	0.350	-0.134	-0.579**	-1.191***	-1.08***	0.164	0.086	-0.016	1.089***	-0.429***	-0.549*	1.278***
	(0.003)	(0.0003)	(0.001)	(0.0001)	(0.0003)	(0.305)	(0.154)	(0.247)	(0.182)	(0.060)	(0.217)	(0.356)	(0.141)	(0.321)	(0.224)	0.305	(0.282)
Diet Normal <1.5	.066***	.007	.013	.0003	.006**	0.551	2.342*	-5.327**	-0.664	-0.588	-0.706***	3.535	-1.724	3.857	-4.795***	0.005	0.125
	(0.003)	(0.0003)	(0.001)	(0.00002)	(0.0003)	(2.705)	(1.383)	(2.387)	(1.139)	(1.038)	(0.151)	(2.871)	(1.423)	(2.848)	(1.626)	(2.540)	(2.483)
Regular Discount 2l	.060*	.006	.0120	.0003	.006***	-0.366	-0.229	.131	-0.118	0.037	0.233	-0.588***	-0.322**	-0.278	-0.035	0.200	-0.388
	(0.001)	(0.0002)	(0.002)	(0.001)	(0.0001)	(0.295)	(0.161)	(0.265)	(0.119)	(0.110)	(0.186)	(0.112)	(0.153)	(0.312)	(0.163)	(0.261)	(0.271)
Regular Discount 1.5l	.100***	.011***	.0200***	.0005	.010***	0.128	-0.020	-0.585***	0.171***	-0.073*	0.064	0.109	-1.504***	-1.012***	0.030	0.239**	0.034
	(0.005)	(0.015)	(0.060)	(0.045)	(0.094)	(0.135)	(0.103)	(0.154)	(0.060)	(0.045)	(0.094)	(0.156)	(.186)	(0.152)	(0.080)	(0.118)	(0.133)
Regular Discount <1.5	.074***	.008	.015	.0004***	.007***	0.051	-0.055***	-0.017	0.029**	.029**	-0.040*	.002	-0.131***	-1.178***	-0.015	-0.076**	-0.040
	(0.001)	(0.0001)	(0.003)	(0.013)	(0.0001)	(0.034)	(0.020)	(0.032)	(0.014)	(0.013)	(0.024)	(0.040)	(0.019)	(0.156)	(0.020)	(0.034)	(0.031)
Regular Normal 2l	.124***	.013	.025	.001**	.0120***	-0.062	0.160***	0.103	-0.042	-0.076*	0.216***	0.113	0.031	0.050	-0.927***	-0.294***	0.182**
	(0.004)	(0.0003)	(0.001)	(0.0001)	(0.0003)	(0.081)	(0.050)	(0.084)	(0.051)	(0.044)	(0.067)	(0.103)	(0.050)	(0.101)	(0.085)	(0.094)	(0.095)
Regular Normal 1.5l	.069	.007***	.0138	.0004**	.007***	0.011	-0.011	-.372***	0.009	.119**	-0.013	.049	-0.150**	0.159	0.010	-0.914***	-0.336**
	(0.001)	(0.0001)	(0.002)	(0.056)	(0.0001)	(0.126)	(0.072)	(0.123)	(0.065)	(0.056)	(0.097)	(0.155)	(0.068)	(0.155)	(0.126)	(0.078)	(0.127)
Regular Normal <1. 5	-.001***	.003	-.008***	-.001***	-.006***	-0.003	-0.008**	0.001	-0.005*	-.013***	-0.003	-.024	-0.001	-0.005	-0.011***	-0.026***	-0.328***
	(0.003)	(0.006)	(0.003)	(0.002)	(0.004)	(0.006)	(0.003)	(0.006)	(0.003)	(0.002)	(0.004)	(0.007)	(0.003)	(0.006)	(0.004)	(0.005)	(-2.89)
	1.190***	0.800***	0.990***	1.083***	0.942***	1.101***	1.420***	1.482***	1.739***	1.169	0.841***	0.759***	1.269***	0.934***	1.568***	0.875***	0.432**
	(0.011)	(0.004)	(0.022)	(0.017)	(0.052)	(0.026)	(0.043)	(0.034)	(0.052)	(0.034)	(0.038)	(0.014)	(0.062)	(0.017)	(.033)	(0.015)	(0.022)

Notes: Standard errors in parentheses; ***, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively.

5. Simulation model

5.1. Analytical framework

The analyses of the effects of taxes on soft-drinks are carried out by using the model described in Smed *et al.*, (2007) illustrated in fig. 3. We combine the long run price elasticities calculated as described in the section above, [9] with beverage/added sugar/caloric tables. The latter is basically matrices of technical conversion coefficients reflecting the sugar and caloric content of the various SSB's considered in the estimation model and are equivalent to the consumption technology matrices in characteristics models.

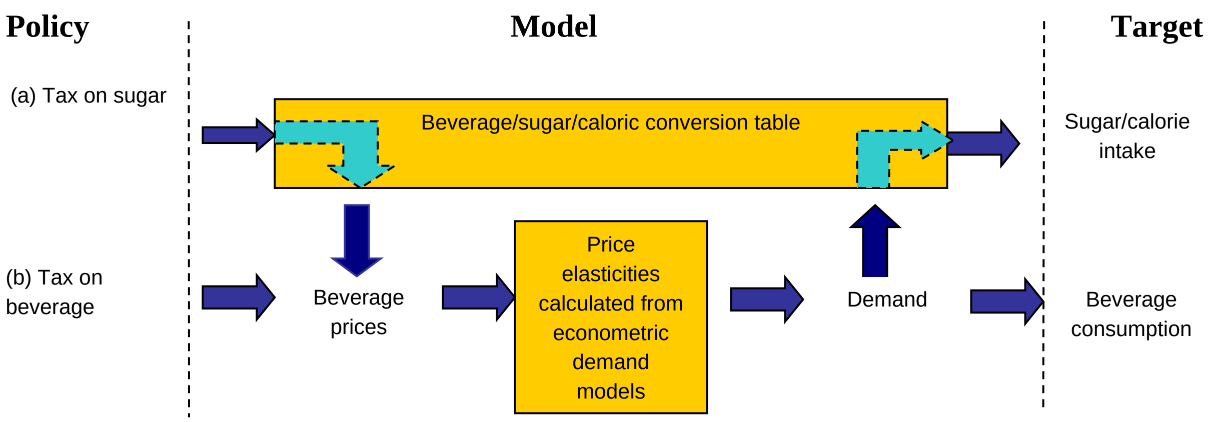


Figure 3: Simulation model

As in Huang (1999) we assume that the total quantity of a sugar consumed can be expressed as the sum of sugar consumed from the various SBB's: $\theta_k = \sum_i a_{ki} q_i$, where θ_k is the total amount of calories or added sugar consumed in the diet, a_{ki} is the amount of either added sugar or calories per unit contained in each beverage q_i. The figure illustrates the operation of a tax instrument on two different levels: *a*) taxes levied on the sugar content in each beverage which implies that prices changes according to the amount of added sugar in each beverage *b*) a tax levied directly on different types of beverages. The resulting change in demand is thereafter predicted using the estimated price elasticities. The change in the quantities demanded can thereafter be converted into changed beverage consumption or changed added sugar or caloric consumption. As we have estimated the elasticities based on household data it is not possible to predict the consumption of nutrients on individual level, but throughout this paper we will assume that household purchases are equal to household consumption. We assume thus that it is reasonable, provided that there are no

[9] We consider only the long run effects of the considered tax scenarios since this is what is of main interest in terms of the considered health effects.

waste, since we estimate demand at a monthly level, storage will be a minor problem.[10] Most "sin" taxes like a tax on cigarettes, alcohol, sugar etc. is based, not on health reasons, but based on that they are part of negotiations over the annually financial law. Therefore we scale the considered scenarios, not to be comparable in terms of welfare economic costs, but to be comparable in terms of how much extra revenue the authorities will gain from the considered tax. All three scenarios are scales so that the gives rise to extra revenue at 478 million DKK per year. Up and downscaling is of course easily possible.

The first scenario in table 7 considers a tax on added sugar at 12.25 DKK/kg in all type of beverages. This implies, as it is obvious from table 7, that the price of all SSB increases proportionally to their content of added sugar[11] and hence that diet soft-drinks, juice and milk are not taxed. Other non-alcoholic drinks and fruits drinks have the largest content of added sugar due to that these are supposed to be mixed with water before drinking. Most of them will have a content of added sugar similar to soft-drink after mixing. The second scenario considers a tax on all types of soft-drinks on 1.78 DKK/litre[12], hence soft-drinks, including diet soft-drinks, have a considerable price increase whereas other SSB's will have the same price as before and finally the third scenario equalize out the value for money difference between soft-drinks with various container sizes within each discount/normal diet/regular category. This implies that the price for soft-drinks within each category (discount versus normal and diet versus regular) ends up being the same in DKK per litre. In terms of taxes this gives a tax at 1.41 DKK/litres for the diet 2 litres discount, 10.22 DKK/litres for the diet 2 litres normal, 9.44 DKK/litres for the diet 1.5 litres normal and so forth.

[10] This also implies that we assume that there is no waste. This might be reasonable concerning soft-drinks, but less reasonable when concerning the consumption of e.g. milk.
[11] This is additional to the existing tax at 14.2 DKK/kg sugar
[12] This is additional to the existing tax at .0.93 DKK/liter

Table 7: Overview of tax scenarios

	Prices	Consump.	Sugar content	Caloric content	1. Sugar tax		2.Soft-drink tax		3.Size adj. tax	
	(Monthly average 2009)				New price	Change	New price	Change	New price	Change
	kr/l.	*l./pers*	*g/l.*	*KJ/l.*	*kr/l.*	*%*	*kr/l.*	*%*	*kr/l.*	*%*
2 l. discount, diet	5.30	0.496	0	0	5.30	0.0%	7.09	33.6%	6.72	26.7%
2 l. normal, diet	12.14	0.057	0	0	12.14	0.0%	13.92	14.7%	22.36	84.2%
1.5 l. discount, diet	6.67	0.449	0	0	6.67	0.0%	8.46	26.7%	6.72	0.7%
1.5 l. normal, diet	12.92	0.120	0	0	12.92	0.0%	14.70	13.8%	22.36	73.1%
< 1.5 l. discount, diet	6.72	0.120	0	0	6.72	0.0%	8.50	26.5%	6.72	0.0%
< 1.5 l. normal, diet	22.36	0.081	0	0	22.36	0.0%	24.14	8.0%	22.36	0.0%
2 l. discount, reg	4.69	0.981	98	1680	5.89	25.6%	6.47	38.0%	6.79	44.8%
2 l. normal, reg	12.49	0.136	98	1680	13.69	9.6%	14.27	14.3%	20.25	62.1%
1.5 l. discount, reg	6.57	0.633	98	1680	7.77	18.3%	8.35	27.1%	6.79	3.3%
1.5 l. normal, reg	13.00	0.249	98	1680	14.20	9.2%	14.78	13.7%	20.25	55.8%
< 1.5 l. discount, reg	6.79	0.629	98	1680	7.99	17.7%	8.57	26.2%	6.79	0.0%
< 1.5 l. normal, reg	20.25	0.255	98	1680	21.45	5.9%	22.03	8.8%	20.25	0.0%
Milk	6.39	10.922	4.5	1900	6.44	0.9%	6.39	0.0%	6.39	0.0%
Other non-alcoholic	16.25	0.249	624	10710	23.89	47.0%	16.25	0.0%	16.25	0.0%
Fruit syrops	24.78	0.301	414	7500	29.85	20.5%	24.78	0.0%	24.78	0.0%
Juice	10.75	2.311	0	2000	10.75	0.0%	10.75	0.0%	10.75	0.0%
Botteled water	9.06	0.318	0	0	9.06	0.0%	9.06	0.0%	9.06	0.0%

5.2 Results from simulation model

Two issues are of basic interest concerning health when we consider the results from the simulation scenarios. The first is the change in sugar consumption and the second issue is the change in total caloric consumption. The results from the different scenarios are shown in table 8. Largest decrease in sugar intake from beverage consumption is found for scenario 1 with a tax based on sugar content in SSB's (decrease in sugar intake from SSB's of 17.3%) compared to the two scenarios where the tax is levied on soft-drinks, either a flat tax (decrease in sugar intake from SSB's at 10.2%) or a size differentiated tax (increase in sugar intake from SSB's at 0.7%). Theoretically it makes sense that a tax differentiated according to sugar content is more efficient than a product based tax when it comes to reduction of sugar intake. Furthermore this result is in line with Jensen and Smed (2007) who show that taxes and subsidies levied directly on either saturated fat, fibres or fat are more efficient than when the tax is levied on a product group.

The remarkable reduction in sugar intake from scenario 1 is mainly due to reductions in the consumption of all types of soft-drinks as well as a reduction in the consumption of other SSB's. The reduction in the monthly consumption of soft-drinks with added sugar from 2.88 l. to 2.33 l. per person is however partly off-set by an increase in the consumption of diet soft drinks from 1.32 to 1.46 litres per person. Total soft drinks consumption therefore decrease with approximately 9.8%. A minor increase in the consumption of milk is observed while there are no changes observed for juice and bottled water. The smaller decrease in consumption of sugar that are observed in scenario 2, where a tax is levied on soft-drinks, compared to scenario 1, is mainly due to an increase in the consumption of other sugar sweetened beverages in scenario 2, especially other non-alcoholic and fruit syrups. This is also reflected in the observed changes in total calories consumed as a decrease of 3.7% is observed in scenario 1 whereas there is a small increase in scenario 2. Compared to scenario 1 reductions in the consumption of diet soft-drinks are observed in scenario 2. Total soft drink consumption therefore decrease with 26.4% (-1.11 litres per person per month) in scenario 2, which is considerable more than in scenario 1. The decrease in consumption of diet soft drinks does not have any influence on either added sugar or total caloric consumption, but in many other ways consumption of diet soft-drinks has adverse health effects (Mattes and Popkin, 2008; Creanor *et al*., 1995; Baelocher *et al*., 1994; Stegink *et al*., 1998). An interesting element of the taxation scenarios is that the tax aimed at removing the size induced price difference of soft-drinks in scenario 3 actually leads to an increase in the total consumption of sugar at 0.7%. This is due to that, the large decreases observed on the consumption of especially 2 and 1.5 litres normal brand regular and diet soft-drinks are off-set by large increases in the consumption of especially small and 1.5 litres discount soft-drinks. In total soft-drink consumption decreases with 0.48 litres per month while the consumption of milk and especially other non-alcoholic beverages and fruit syrups increases. This leads to an increase in the total amount of calories consumed from non-alcoholic beverages at 5.3%. The large contribution from milk to the change in total calories consumed is due to, not that milk is very price responsive, but more that Denmark is a nation of heavy milk drinkers. Average monthly consumption is almost 11.0 litres per month per person hence an increase of 8.9%, is equal to almost a liter per person per month. When considering the effect of the taxes we have to consider, not only the change in total caloric and sugar intake, but also the potential health improvements from the increase in milk consumption. The consumption of milk increases in all the three scenarios, with scenario 3 resulting in the largest increase in consumption of milk.

Table 8 : Scenario results based on long run elasticities

	Consumption (%)			Sugar consumption (g/pers/month)			Total calories (KJ/pers/month)			Total tax paid* (kr/pers/month)		
	Scenario			Scenario			Scenario			Scenario		
Drink categories	1	2	3	1	2	3	1	2	3	1	2	3
2 l. discount, diet	0.4%	-8.9%	-11.7%	0	0	0	0	0	0	0.45	1.34	1.15
2 l. normal, diet	9.5%	-5.8%	-48.3%	0	0	0	0	0	0	0.05	0.15	0.64
1.5 l. discount, diet	5.6%	-34.3%	18.3%	0	0	0	0	0	0	0.41	1.21	0.43
1.5 l. normal, diet	20.7%	-9.4%	-80.9%	0	0	0	0	0	0	0.11	0.32	1.24
< 1.5 l. discount,	-1.9%	-21.8%	-2.1%	0	0	0	0	0	0	0.11	0.32	0.11
< 1.5 l. normal, diet	105.1%	29.3%	-80.7%	0	0	0	0	0	0	0.07	0.22	0.07
2 l. discount, reg	-21.0%	-37.3%	-25.7%	-20	-36	-25	-347	-614	-423	2.07	2.64	2.95
2 l. normal, reg	-4.9%	-4.4%	-46.0%	-1	-1	-6	-11	-10	-105	0.29	0.36	1.18
1.5 l. discount, reg	-30.1%	-46.8%	11.9%	-19	-29	7	-320	-498	126	1.34	1.70	0.71
1.5 l. normal, reg	-7.8%	-18.0%	-26.9%	-2	-4	-7	-33	-75	-112	0.52	0.67	2.03
< 1.5 l. discount,	-19.5%	-27.2%	0.1%	-12	-17	0	-206	-288	1	1.33	1.69	0.57
< 1.5 l. normal, reg	-2.9%	-4.6%	-3.6%	-1	-1	-1	-12	-20	-15	0.54	0.69	0.23
Milk	2.6%	6.5%	8.9%	1	3	4	544	1346	1846	0.60	0.00	0.00
Other non-	-23.0%	7.1%	9.7%	-36	11	15	-613	189	258	4.11	2.21	2.21
Fruit syrops	-13.7%	9.2%	12.4%	-17	11	15	-310	208	279	3.29	1.77	1.77
Juice	0.0%	0.1%	0.1%	0	0	0	0	3	4	0.00	0.00	0.00
Botteled water	0.0%	0.2%	0.3%	0	0	0	0	0	0	0.00	0.00	0.00
Total change (year)				-106	-62	4	-1307	241	1858	15.29	15.29	15.29
Percentage (year)				-17.3%	-10.2%	0.7%	-3.7%	0.7%	5.3%			

*Some tax is already levied on soft-drinks hence the tax paid here is the original tax + the new tax, but excluding VAT. Total tax is equal to 975 mill. DKK, the new tax is equal to 478 mill DKK

6. Discussion and conclusion

In this paper we calculate short and long run own and cross price elasticities of non-alcoholic beverages with specific focus on soft-drinks with varying container sizes, discount versus normal brand as well as diet versus regular types based on an estimated model of a two stage budgeting process. Censored demand was a problem in the second step budgeting and the two step approach by Shonkwiler and Yen was implemented to avoid bias. Finally elasticities are made unconditional using top stage elasticities from a similar Norwegian study (Rickertsen, 1998).

A general conclusion of this paper is that studies estimating elasticities of aggregate soft-drink consumption could give a misleading picture since soft-drinks is a broad category that contains a plethora of differentiated products with different own and cross-price elasticities. Substitution between these has to be taken into account when designing tax policies aimed at changing sugar and caloric consumption. Apart from container size which was our main objective in this paper due to the relationship between container/portion size and obesity rate, we have also looked into whether differences in elasticities is observed between discount and normal brands as well as between diet and regular types. A somewhat surprising finding is the low price elasticity of 2 litres discount brands of diet and regular types, as well as normal brand regular small sizes. Each of these soft-drink types represents a different "type" of good and at it appears from the results in this paper that they do not have any substitutes. 2 litres discount are viewed as kind of "everyday" soft-drinks whereas small size normal are often consumed "on the go", and as such cannot be substituted with e.g. larger container sizes. Considering the short run elasticities from appendix C is appears that diet and regular soft –drink types are complements, but according to the long run elasticities in table 6 these are in several cases substitutes. This implies that a tax on sugar sweetened beverages will to some extent, as feared, increase the consumption of diet soft-drinks, whereas the substitution towards cheaper alternatives has to be taken into account when a tax on soft-drinks is levied. Even though not always significant the substitution between discount and normal brands are in some cases substantially.

We have used the calculated elasticities to look into the effects of levying different taxes on soft-drinks based on their container size, their content of sugar compared or a flat tax on all types of soft-drinks. The most desired outcome in terms of sugar and caloric consumption is achieved if a tax based on sugar content in SSBs is levied (scenario 1) rather than a flat tax on soft-drinks (scenario 2) or a tax that equalize the value for money effect of larger container sizes (scenario 3). However what has to be considered in scenario 1 is the increase in the consumption of diet soft-drinks which might have other adverse health effects than obesity related. While it was expected to find that a tax on the sugar content of SSB's are more efficient than a tax directly on soft-drinks in terms of reducing sugar consumption due to the results in Jensen and Smed (2007) it was expected to find that proportional pricing of container sizes of high caloric food would reduce the consumption of sugar and calories (Vermeer *et al.* 2009). But according to the results in this paper a tax equalizing the value for money effect of large container sizes will have detrimental effects on sugar and total caloric consumption. The reason for this is basically due to huge increases in the consumption of especially discount brands soft-drinks of both regular and diet types. Hence in terms of regulating obesity this scenario will have no effect. In terms of e.g. increased dental health this scenario might be promising due to a large increase in the consumption of milk.

However the data is limited to at-home consumption alone and we may not feel comfortable to generalize the results to include consumption away from home. However, Danes traditionally consume a high amount of their food at home and therefore the result might within reasonable standard deviations be generalized for average Danish consumption. Furthermore soft-drinks, and particularly those with bigger container sizes, are not the only cause of overweight. Therefore, policies directed towards combating this will surely be beneficial but need to be supplemented with other aspects of addressing the most important factors identified to contribute to obesity i.e. subsidizing healthy choices such as vegetables and physical exercises along with rising awareness would probably achieve a desired result.

7. References

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Appendix A

Table A1: First Step Probit Estimation

	Diet						Regular					
	Discount			Normal			Discount			Normal		
Variable	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.
Age												
40-49[a]												
< 25	-0.143	-0.323*	-0.322*	-0.163	0.111	0.102	0.395***	0.195*	-0.121	-0.087	0.02	0.181
	(-1.26)	(-2.25)	(-2.13)	(-0.88)	(-0.85)	(-0.82)	(-4.33)	(-2.02)	(-1.20)	(-0.56)	(-0.17)	(-1.85)
26-29	0.1	-0.048	-0.14	0.013	0.190**	0.238***	0.103	-0.002	-0.006	0.141	0.058	0.07
	(-1.60)	(-0.69)	(-1.75)	(-0.14)	(-2.63)	(-3.46)	(-1.91)	(-0.03)	(-0.11)	(-1.83)	(-0.89)	(-1.18)
30-39	0.091*	0.110**	-0.031	0.107*	0.222***	0.266***	-0.195***	-0.119**	-0.207***	0.056	0.053	0.091*
	(-2.37)	(-2.77)	(-0.69)	(-2.03)	(-4.93)	(-5.99)	(-5.62)	(-3.20)	(-5.53)	(-1.10)	(-1.30)	(-2.48)
50-59	-0.104**	-0.084*	0.039	-0.156**	-0.075	-0.037	-0.106***	-0.052	0.056	-0.145**	-0.054	-0.026
	(-3.18)	(-2.44)	(-1.08)	(-3.26)	(-1.85)	(-0.95)	(-3.77)	(-1.74)	(-1.94)	(-3.25)	(-1.59)	(-0.84)
60-69	-0.258***	0.018	-0.009	-0.193***	-0.018	-0.216***	-0.139***	-0.056	0.071*	-0.218***	-0.018	-0.205***
	(-7.45)	(-0.52)	(-0.24)	(-3.91)	(-0.43)	(-5.19)	(-4.76)	(-1.80)	(-2.39)	(-4.66)	(-0.52)	(-6.34)
>70	-0.488***	-0.245***	0.033	-0.471***	-0.135**	-0.212***	-0.340***	-0.160***	0.205***	-0.303^{**v}	0.05	0.054
	(-12.03)	(-5.91)	(-0.80)	(-7.50)	(-2.87)	(-4.55)	(-10.38)	(-4.60)	(-6.35)	(-5.64)	(-1.33)	(-1.57)
Educ												
No Educ.[a]												
Voc. Edu	-0.063*	0.060*	-0.112***	0.158**	0.079*	-0.053	-0.017	0.084**	-0.086***	-0.03	0.072*	-0.014
	(-2.21)	(-2.00)	(-3.79)	(-3.20)	(-2.23)	(-1.57)	(-0.70)	(-3.24)	(-3.69)	(-0.75)	(-2.47)	(-0.54)
Short HE	-0.04	0.120***	-0.103**	0.284***	0.049	-0.042	0.037	0.087**	-0.106***	0.027	0.107**	-0.002
	(-1.17)	(-3.39)	(-2.89)	(-5.19)	(-1.15)	(-1.03)	(-1.28)	(-2.82)	(-3.77)	(-0.58)	(-3.10)	(-0.05)
Medium HE	-0.084*	0.082*	-0.174***	0.312***	0.147***	0.022	0.018	-0.018	-0.199***	-0.001	0.101**	-0.049
	(-2.42)	(-2.3)	(-4.77)	(-5.69)	(-3.59)	(-0.55)	(-0.62)	(-0.57)	(-6.94)	(-0.01)	(-2.93)	(-1.55)
Long HE	-0.093	0.053	-0.295***	0.555***	0.104	0.069	-0.04	0.006	-0.345***	0.141*	0.148**	0.264***
	(-1.80)	(-1.01)	(-5.02)	(-8.15)	(-1.75)	(-1.22)	(-0.91)	(-0.12)	(-7.52)	(-2.23)	(-2.97)	(-6.04)
Household type												
Zero Children[a]												
Children <6yrs	-0.141***	-0.056	-0.123*	-0.175**	-0.110*	-0.083	0.045	0.152***	0.035	0.095	0.023	-0.082*
	(-3.35)	(-1.30)	(-2.44)	(-3.02)	(-2.26)	(-1.78)	(-1.22)	(-3.95)	(-0.90)	(-1.82)	(-0.53)	(-2.07)
Children btw 7-14yrs	0.195***	0.244***	0.145***	0.091*	0.062	-0.03	0.250***	0.123***	0.069*	-0.06	-0.042	0.052
	(-6.10)	(-7.43)	(-3.93)	(-1.98)	(-1.56)	(-0.76)	(-8.83)	(-4.11)	(-2.32)	(-1.35)	(-1.17)	(-1.67)
Children btw 15-20yrs	-0.043	-0.119**	-0.224***	-0.228***	-0.226***	-0.263***	0.136***	0.132***	-0.039	0.028	-0.081*	-0.067
	(-1.19)	(-3.09)	(-5.22)	(-3.97)	(-4.70)	(-5.43)	(-4.48	-4.17	(-1.24)	-0.58	(-2.09)	(-1.95)
HH_income												
High income[a]												
Medium income	0.141	-0.023	-0.187*	0.688***	-0.057	0.437***	0.173*	0.379***	0.04	0.331*	0.015	0.327***
	(-1.60)	(-0.28)	(-2.21)	(-3.90)	(-0.64)	-3.6	(-2.28	-4.28	-0.53	-2.48	-0.17	-3.94
Low income	0.200*	-0.07	-0.316***	0.599***	-0.185*	0.330**	0.285***	0.319***	0.022	0.306*	-0.022	0.238**
	-2.21	(-0.83)	(-3.60)	(-3.34)	(-1.98)	(-2.66	(-3.67)	-3.53	-0.29	-2.24	(-0.26)	-2.8
Gender												
Female[a]												

Male	0.100***	0.026	0.01	-0.005	-0.122***	-0.036	0.087***	0.077**	-0.037	0.079*	0.026	0.005
	-3.77	-0.94	-0.36	(-0.13)	(-3.67)	(-1.14)	-3.91	-3.23	(-1.62)	-2.24	-0.97	-0.21
$W_{(t-1)}$	1.783***	1.374***	1.381***	1.678***	1.394***	1.648***	1.374***	0.948***	1.107***	1.703***	1.123***	1.197***
	-51.59	-36.28	-32.33	-22.15	-28.1	-35.2	-58.42	-34.29	-48.99	-25.66	-33.01	-41.72
Constant	-1.293***	-1.333***	-1.059***	-2.574***	-1.499***	-1.847***	-0.969***	-1.418***	-0.801***	-1.989***	-1.356**	-1.328***
	(-14.01)	(-15.26)	(-11.78)	(-14.05)	(-15.58)	(-14.64)	(-12.17)	(-15.33)	(-10.04)	(-14.33)	(-15.35)	(-15.28)

Notes: ***, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively.

The probability of buying all soft-drink categories except small container soft-drinks with discount (SD) decreases for households where the age of the main shopper is greater than 50 years as compared to the base group of age 40-49. Households between the ages of 30-39 have significantly higher probability of buying soft-drinks with no discounts; they are also more likely to buy diet soft-drinks than regular ones. Age group 26-29 have significantly positive probabilities of purchasing the diet soft-drinks with 1.5 litres normal and smaller sizes normal, whereas households where the main shopper is under the age of 25 have significantly higher probability of buying diet soft-drinks that are discount, particularly those with the 2 litre and 1.5 litre container sizes. When considering households' education, all households have negative probabilities of purchasing small soft-drink category with discounts, but the higher the level of the household education, the larger was this negative probability. The probability of consuming the normal version of the same category increases for people with long higher education compared to those with no education, although this is only significant in the case of the regular soft-drinks. Moreover, the higher the level of education of the household, the higher the probability of purchasing the 1.5 litres soft-drinks (both diet and regular) with non- discount prices. Furthermore, only households with vocational and short higher education have significant positive probability of consuming the discount type of the 1.5 litres regular soft-drinks. Whereas the 2 litre regular soft-drinks are insignificant for all households except for those with higher education category who have positive probability for the normal version, the diet counterpart of the same size has significant an positive probability for all households and increases with households' education. Generally households with higher education tend to purchase diet soft-drinks more likely. Families with children under the age of 6 years and families with those with children between 15-20 years old are less likely to buy diet soft-drinks and more likely to purchase regular soft-drinks except normal versions of smaller size and 1.5 liters respectively compared to those with no children. Households with children between 7 and 14 years old are generally like to but both diet and regular soft-drinks but they are particularly highly likely to choose soft-drinks with discount prices in both categories.

Compared to high income families, both low and middle income households have generally higher probability of consuming both diet and regular drinks. However, they are less likely to consume the diet versions of 1.5 litre discount and small size normal and small size normal for low income families and middle income families respectively. Last but not least, households where the main shopper is male have significant increase in their probability of buying the 2 litres discount in both diet and regular categories, however, they are less likely to buy diet type of normal 1.5 litre soft-drinks.

Appendix B: Long Run conditional elasticities

Table B1: Long run conditional price elasticities of various types of beverages (Standard errors in parenthesis)

	Price 0f					
	Soft Drink	**Milk**	**Other non-alc beverages**	**Fruit drinks**	**Bottled Water**	**Juice**
Soft Drink	-1.232*** (0.060)	-0.024*** (0.005)	-0.006** (0.003)	-0.012*** (0.005)	-0.005*** (0.002)	-0.010*** (0.003)
Milk	0.199*** (0.022)	-0.801*** (0.014)	0.007 (0.008)	-0.005 (0.013)	-0.017*** (0.0064)	0.086*** (0.013)
Other non-alcoholic beverages	0.337** (0.139)	0.009 (0.097)	-0.792*** (0.107)	0.055 (0.159)	-0.100* (0.054)	-0.106* (0.064)
Fruit drinks	0.420*** (0.158)	-0.143 (0.094)	0.032 (0.099)	-1.082*** (0.254)	0.049 (0.064)	0.030 (0.056)
Bottled Water	-0.001*** (0.0002)	0.0004*** (0.0002)	.0002* (0.0001)	-.0002 (.0002)	-0.709*** (0.178)	-0.0001 (0.0001)
Juice	0.0002*** (0.0001)	0.0001*** (0.0001)	-0.00003* (0.00002)	0.00002 (0.00002)	0.0003 (0.0001)	-0.900*** (0.008)

Notes: *, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively.**

Table B2: Long run conditional price elasticities of the various types of soft drinks (Standard errors in parenthesis)

			Price of											
			Diet						**Regular**					
			Discount			**Normal**			**Discount**			**Normal**		
			2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.
Diet	Discount	2l	-0.312* (0.183)	0.0103 (0.0133)	0.014 (0.021)	-0.022*** (0.010)	-0.003 (0.009)	-0.012 (0.016)	-0.004 (0.028)	0.016 (0.012)	0.025 (0.025)	-0.031*** (0.0120)	-0.044** (0.0201)	-0.035* (0.022)
		1.5l	0.236 (0.213)	-1.489*** (0.267)	-0.587*** (0.211)	-0.267*** (0.089)	-0.067 (0.072)	-0.224* (0.134)	0.361 (0.241)	0.007 (0.152)	-0.594*** (0.234)	0.364*** (0.117)	0.027 (0.183)	0.387** (0.194)
		< 1.5 l.	0.016 (0.026)	0.032 (0.026)	-0.914*** (0.201)	0.009 (0.010)	-0.035*** (0.009)	0.031* (0.018)	-0.057* (0.031)	-0.064*** (0.018)	-0.030 (0.029)	-.003 (0.016)	0.029 (0.025)	-0.054** (0.027)
	Normal	2l	-0.081 (0.067)	-0.113*** (0.038)	0.103* (0.055)	-0.869*** (.084)	-0.237*** (0.036)	0.034 (0.047)	0.105 (0.076)	0.140*** (0.038)	0.200*** (0.071)	-0.050 (0.052)	0.004 (0.071)	0.059 (0.067)
		1.5l	0.350 (0.305)	-0.134 (0.154)	-0.579** (0.247)	-1.191*** (0.182)	-1.08*** (0.060)	0.164 (0.217)	0.086 (0.356)	-0.016 (0.141)	1.089*** (0.321)	-0.429*** (0.224)	-0.549* 0.305	1.278*** (0.282)
		< 1.5 l.	0.551 (2.705)	2.342* (1.383)	-5.327** (2.387)	-0.664 (1.139)	-0.588 (1.038)	-0.706*** (0.151)	3.535 (2.871)	-1.724 (1.423)	3.857 (2.848)	-4.795*** (1.626)	0.005 (2.540)	0.125 (2.483)
Regular	Discount	2l	-0.366 (0.295)	-0.229 (0.161)	.131 (0.265)	-0.118 (0.119)	0.037 (0.110)	0.233 (0.186)	-0.588*** (0.112)	-0.322** (0.153)	-0.278 (0.312)	-0.035 (0.163)	0.200 (0.261)	-0.388 (0.271)
		1.5l	0.128 (0.135)	-0.020 (0.103)	-0.585*** (0.154)	0.171*** (0.060)	-0.073* (0.045)	0.064 (0.094)	0.109 (0.156)	-1.504*** (.186)	-1.012*** (0.152)	0.030 (0.080)	0.239** (0.118)	0.034 (0.133)
		< 1.5 l.	0.051 (0.034)	-0.055*** (0.020)	-0.017 (0.032)	0.029** (0.014)	.029** (0.013)	-0.040* (0.024)	.002 (0.040)	-0.131*** (0.019)	-1.178*** (0.156)	-0.015 (0.020)	-0.076** (0.034)	-0.040 (0.031)
	Normal	2l	-0.062 (0.081)	0.160*** (0.050)	0.103 (0.084)	-0.042 (0.051)	-0.076* (0.044)	0.216*** (0.067)	0.113 (0.103)	0.031 (0.050)	0.050 (0.101)	-0.927*** (0.085)	-0.294*** (0.094)	0.182** (0.095)
		1.5l	0.011 (0.126)	-0.011 (0.072)	-.372*** (0.123)	0.009 (0.065)	.119** (0.056)	-0.013 (0.097)	.049 (0.155)	-0.150** (0.068)	0.159 (0.155)	0.010 (0.126)	-0.914*** (0.078)	-0.336** (0.127)
		< 1.5 l.	-0.003 (0.006)	-0.008** (0.003)	0.001 (0.006)	-0.005* (0.003)	-.013*** (0.002)	-0.003 (0.004)	-.024 (0.007)	-0.001 (0.003)	-0.005 (0.006)	-0.011*** (0.004)	-0.026*** (0.005)	-0.328*** (-2.89)
			1.101*** (0.026)	1.420*** (0.043)	1.482*** (0.034)	1.739*** (0.052)	1.169 (0.034)	0.841*** (0.038)	0.759*** (0.014)	1.269*** (0.062)	0.934*** (0.017)	1.568*** (.033)	0.875*** (0.015)	0.432** (0.022)

Notes: *, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectiv**

Appendix C: Short Run Elasticities

Table C1: Short run conditional price elasticities of various types of beverages (t-values in parenthesis)

	Price of					
	Soft Drink	Milk	Other non-alc beverages	Fruit drinks	Bottled Water	Juice
Soft Drink	-1.360***	-0.091	0.034	0.078**	0.034**	0.013
	(-22.53)	(-2.30)	(1.65)	(2.08)	(2.29)	(0.52)
Milk	0.050	-0.888***	-0.004	-0.015**	-0.012***	-0.0003
	(4.21)	(-64.89)	(-1.02)	(-2.19)	(-3.35)	(-0.05)
Other non-alcoholic	0.274**	-0.221**	-0.899***	0.041	-0.103*	-0.166***
	(1.93)	(-2.21)	(-8.37)	(0.25)	(-1.86)	(-2.54)
Fruit drinks	0.387**	-0.410***	0.025	-1.200***	0.050	-0.030
	(2.21)	(-3.93)	(0.23)	(-4.72)	(0.71)	(-0.48)
Bottled Water	0.788**	-0.916***	-0.320*	0.240	-0.811***	-0.005
	(2.43)	(-3.71)	(-1. 85)	(0.73)	(-4.55)	(-0.04)
Juice	0.068	-0.080	-0.027	-0.001	-0.0001	-1.009***
	(2.32)	(-2.85)	(-2.36)	(-0.06)	(-0.1)	(-127.43)
Expenditure	1.293***	0.869***	1.074***	1.177***	1.024***	1.101***
	(109.06)	(206.70)	(44.38)	(63.39)	(18.03)	(117.35)

Notes: *, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively**

Table C2: Short run conditional price elasticities of various types of soft drinks (t-values in parenthesis)

			Price of											
			Diet						Regular					
			Discount			Normal			Discount			Normal		
			2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.	2l	1.5l	< 1.5 l.
Diet	Discount	2l	-.297* (-1.62)	-0.164 (-1.44)	-0.055 (-1.14)	-0.084 (-1.15)	0.063 (1.19)	0.009 (0.10)	-0.244 (-1.62)	-0.291* (-2.15)	-0.014 (-0.12)	-0.119* (-1.76)	0.063 (0.96)	0.033 (0.27)
		1.5l	-0.234* (-1.66)	-0.894*** (-4.44)	0.094** (1.93)	0.238*** (2.67)	-0.116** (-2.14)	-0.245*** (-2.50)	-0.042 (-0.25)	-0.050 (-0.32)	-0.491*** (-2.72)	0.299*** (3.14)	-0.120 (-1.42)	0.080 (0.55)
		< 1.5 l	-0.094 (-1.22)	0.141** (2.25)	-1.087*** (-18.18)	0.033 (0.84)	0.298*** (6.51)	-0.045 (-0.82)	-0.034 (-0.38)	-0.281*** (-3.48)	0.125 (1.63)	0.003 (0.08)	0.104* (1.85)	-0.330*** (-4.66)
	Normal	2l	-0.361 (-1.25	0.771*** (2.68)	0.068 (0.70)	-1.466*** (-5.51)	0.344*** (2.84)	0.286 (1.57)	-0.573* (-1.74)	0.753* (2.37)	-0.117 (-0.47)	-0.021 (-0.10)	-0.532*** (-3.33)	-0.571** (-2.17)
		1.5l	0.075 (0.70)	-0.209** (-2.33)	0.352*** (6.05)	0.170*** (2.73)	-0.848*** (-10.14)	-0.080 (-1.05)	-0.295* (-2.37)	-0.392*** (-2.42)	-0.130 (-1.14)	-0.244*** (-3.95)	0.030 (0.36)	-0.170 (-1.57)
		< 1.5 l	0.038 (0.22)	-0.333*** (-2.32)	-0.037 (-0.57)	0.147* (1.70)	-0.040 (-0.56)	-0.684*** (-4.55)	.226 1.26	.242 1.36	.002 0.01	-.108 -1.21	-.299*** -2.94	.005 0.03
Regular	Discount	2l	-0.090 (-1.22)	0.035 (0.53)	0.011 (0.41)	-0.056 (-1.39)	-0.028 (-0.94)	0.061 (1.31)	-0.565*** (-5.06)	-0.065 (-0.83)	0.059 (0.91)	-0.080* (-2.10)	-0.005 (-0.12)	-0.091 (-1.34)
		1.5l	-0.206** (-2.01)	0.008 (0.08)	-0.120*** (-2.16)	0.152*** (2.55)	-0.111*** (-2.62)	0.092 (1.30)	-0.130 (-1.09)	-1.161*** (-7.41)	0.109 (1.09)	0.377*** (6.62)	-0.006 (-0.10)	0.044 (0.47)
		< 1.5 l.	0.013 (0.24)	-0.154*** (-2.92)	0.055* (2.32)	-0.003 (-0.08)	0.006 (0.23)	-0.002 (-0.05)	0.039 (0.58)	0.079 (1.19)	-0.892*** (-11.44)	-0.062* (-2.13)	0.148*** (3.90)	-0.163*** (-2.99)
	Normal	2l	-0.390* (-1.83)	0.776*** (3.19)	0.000 (0.00)	-0.014 (-0.08)	-0.361*** (-3.70)	-0.198 (-1.33)	-0.606*** (-2.45)	1.549*** (6.45)	-0.462*** (-2.49)	-1.480*** (-7.99)	-0.086 (-0.68)	0.049 (0.02)
		1.5l	0.030 (0.42)	-0.111 (-1.49)	0.051 (1.33)	-0.148*** (-2.37)	0.024 (0.54)	-0.203*** (-2.45)	-0.159* (-1.74)	-0.081 (-0.92)	0.197** (2.40)	-0.037 (-0.83)	-0.905*** (-10.69)	-0.194** (-2.33)
		< 1.5 l	0.080 (0.88)	0.119 (1.35)	-0.118*** (-2.53)	-0.088* (-1.77)	-0.010 (-0.24)	0.018 (0.30)	-0.076 (-0.73)	0.102 (1.09)	-0.119 (-1.46)	0.022 (0.45)	-0.046 (-0.81)	-0.319*** (-2.81)
Exp. elasticity			1.100*** (41.68)	1.481*** (43.92)	1.167*** (34.83)	1.419*** (32.98)	1.741*** (33.12)	0.841*** (22.36)	0.759*** (53.32)	0.935*** (55.35)	0.874*** (59.97)	1.267*** (20.59)	1.569*** (47.40)	0.435**** (19.96)

Notes: *, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively**

Table C3: Short run unconditional elasticities on non-alcoholic beverage consumption (t-values in parenthesis)

	Milk	ONA	Fruit drinks	Water	Juice	Diet Discount 2l	Diet Discount 1.5l	Diet Discount <1.5	Diet Normal 2l	Diet Normal 1.5l	Diet Normal <1.5	Regular Discount 2l	Regular Discount 1.5l	Regular Discount <1.5	Regular Normal 2l	Regular Normal 1.5l	Regular Normal <1.5
Milk	-0.775*** (-56.68)	0.108*** (25.15)	0.098*** (14.31)	0.101*** (28.98)	0.112*** (16.01)	.011*** (206.7)	.009*** (206.70)	.007*** (206.70)	.003*** (206.7)	.005*** (206.70)	.005*** (206.70)	.024*** (206.70)	.015*** (206.70)	.024*** (206.70)	.003*** (206.70)	.010*** (206.70)	.015*** (206.70)
ONA	-0.129 (-1.29)	-0.807*** (-7.52)	0.133 (0.82)	-0.011 (-0.19)	-0.074 (-1.13)	.030*** (44.38)	.024*** (44.38)	.018*** (44.38)	.007*** (44.38)	.014*** (44.38)	.015*** (44.38)	.068*** (44.38)	.042*** (44.38)	.067*** (44.38)	.009*** (44.38)	.028*** (44.38)	.041*** (44.38)
Fruit drinks	-0.328*** (-3.15)	0.107 (0.97)	-1.117*** (-4.40)	0.132* (1.87)	0.052 (0.84)	.042*** (63.39)	.034*** (63.39)	.026*** (63.39)	.010*** (63.39)	.020*** (63.39)	.021*** (63.39)	.095*** (63.39)	.058*** (63.39)	.093*** (63.39)	.012*** (63.39)	.039*** (63.39)	.058*** (63.39)
Bottled Water	-0.819*** (-3.31)	-0.223 (-1. 29)	0.337 (1.03)	-0.714*** (-4.01)	0.092 (0.68)	.069*** (18.03)	.055*** (18.03)	.043*** (18.03)	.016*** (18.03)	.033*** (18.03)	.035*** (18.03)	.157*** (18.03)	.096*** (18.03)	.153*** (18.03)	.020 *** (18.03)	.063*** (18.03)	.095*** (18.03)
Juice	0.010 (0.34)	0.062*** (5.33)	0.088*** (5.45)	0.089*** (11.58)	-0.920*** (-116.2)	.013*** (117.35)	.011*** (117.35)	.008*** (117.35)	.003*** (117.35)	.006*** (117.35)	.007*** (117.35)	.030*** (117.35)	.018*** (117.35)	.029*** (117.35)	.004*** (117.35)	.012*** (117.35)	.018*** (117.35)
Diet Discount 2l	-.009*** (-41.76)	.002*** (-41.76)	.004*** (-41.76)	.001*** (-41.76)	.009*** (-41.76)	-0.317* (-1.73)	-0.187 (-1.64)	-0.072 (-1.48)	-0.089 (-1.23)	0.052 (0.97)	-0.006 (-0.06)	-0.30** (-1.98)	-0.332** (-2.43)	-0.074 (-0.68)	-.127* (-1.88)	0.038 (0.58)	-0.006 (-0.05)
Diet Discount 1.5l	-.012*** (-43.70)	.003*** (-43.70)	.006*** (-43.70)	.001*** (-43.70)	.012*** (-43.70)	-0.272** (-1.93)	-0.920*** (-4.57)	0.073 (1.50)	0.230*** (2.58)	-0.140*** (-2.46)	-0.263*** (-2.69)	-0.121 (-0.72)	-0.998 (-0.63)	-0.572*** (-4.33)	0.288*** (3.02)	-0.153* (-1.82)	0.032 (0.22)
Diet Discount <1.5	-.009*** (-34.72)	.002*** (-34.72)	.004*** (-34.72)	.001*** (-34.72)	.009*** (-34.72)	-0122 (-1.59)	0.119* (1.91)	-1.103*** (-18.41)	0.026 (0.67)	0.284*** (6.21)	-0.058 (-1.07)	-0.098 (-1.09)	-0.322*** (-3.97)	0.064 (0.82)	-0.006 (-0.17)	0.077 (1.37)	-0.368*** (-5.19)
Diet Normal 2l	-.011*** (-32.80)	.003*** (-32.80)	.005*** (-32.80)	.001*** (-32.80)	.011*** (-32.80)	-0.394 (-1.35)	0.745*** (2.59)	0.048 (0.49)	-1.475*** (-5.53)	0.332*** (2.72)	0.270 (1.47)	-0.655** (-1.99)	0.713** (2.23)	-0.195 (-0.78)	-0.030 (-0.15)	-0.563*** (-3.51)	-0.626** (-2.37)
Diet Normal 1.5l	-.01*** (-33.19)	.003*** (-33.19)	.007*** (-33.19)	.001*** (-33.19)	.014*** (-33.19)	0.035 (0.32)	-0.243*** (-2. 27)	0.325*** (5.59)	0.160*** (2.59)	-0.867*** (-10.37)	-0.103 (-1.35)	-0.387*** (-3.13)	-0.457*** (-3.97)	-0.219* (-1.92)	-0.255*** (-4.14)	-0.007 (-0.08)	-0.226** (-2.10)
Diet Normal <1.5	-.007*** (-22.21)	.002*** (-22.21)	.003*** (-22.21)	.001*** (-22.21)	.007*** (-22.21)	0.015 (0.09)	-0.349** (-2.33)	-0.049 (-0.75)	0.142 (1.64)	-0.051 (-0.71)	-0.694*** (-4.61)	0.178 (0.99)	0.215 (1.21)	-0.423 (-0.27)	-0.114 (-1.27)	-0.320*** (-3.12)	-0.019 (-0.12)
Regular Discount 2l	-.006*** (-53.18)	.001*** (-53.18)	.003*** (-53.18)	.000*** (-53.18)	.006*** (-53.18)	-0.106 (-1.44)	0.021 (0.32)	0.0002 (0.01)	-0.061 (-1.50)	-0.036 (-1.22)	0.051 (1.10)	-0.607*** (-5.44)	-0.90 (-1.15)	0.018 (0.27)	-0.085** (-2.22)	-0.022 (-0.54)	-0.117* (-1.72)
Regular Discount 1.5l	-.007*** (-55.29)	.002*** (55.29)	.004*** (55.29)	.001*** (55.29)	.008*** (55.29)	-0.228** (-2.24)	-0.010 (-0.11)	-0.134*** (-3.53)	0.147*** (2.47)	-0.123*** (-2.93)	0.080 (1.14)	-0.179 (-1.51)	-1.187*** (-7.59)	0.058 (0.58)	0.367*** (6.47)	-0.026 (-0.43)	0.015 (0.16)
Regular Discount <1.5	-.001*** (-59.02)	.002*** (59.02)	.003*** (59.02)	.001*** (59.02)	.007*** (59.02)	-0.009 (-0.17)	-0.170*** (-3.24)	0.042* (1.78)	-0.008 (-0.25)	-0.003 (-0.09)	-0.012 (-0.30)	-0.010 (-0.16)	0.049 (0.73)	-0.938*** (-12.03)	-0.068*** (-2.35)	0.129*** (3.40)	-0.191*** (-3.52)
Regular Normal 2l	-.010*** (-20.40)	.002*** (20.40)	.005*** (20.40)	.001*** (20.40)	.010*** (20.40)	-0.424** (-1.98)	0.754*** (3.09)	-0.020 (-0.28)	-0.020 (-0.12)	-0.376*** (-3.92)	-0.214 (-1.43)	-0.674*** (-2.71)	1.511*** (6.25)	-0.533*** (-2.85)	-1.491*** (-8.01)	-0.111 (-0.87)	-0.041 (-0.19)
Regular Normal 1.5l	-.012*** (-47.43)	.003*** (47.43)	.006*** (47.43)	.001*** (47.43)	.013*** (47.43)	-0.009 (-0.13)	-0.141* (-1.90)	0.027 (0.70)	-0.155*** (-3.56)	0.007 (0.15)	-0.222*** (-3.78)	-0.244*** (-2.69)	-0133 (-1.51)	0.115 (1.40)	-0.046 (-1.05)	-0.939*** (-11.10)	-0.247*** (-2.98)
Regular Normal <1.5	-.003*** (-19.72)	.001*** (19.72)	.002*** (19.72)	.000*** (19.72)	.004*** (19.72)	0.068 (0.75)	0.112 (1.26)	-0.125*** (-3.71)	-0.091* (-1.84)	-0.014 (-0.36)	0.015 (0.24)	-0.101 (-0.97)	0.089 (0.95)	-0.143* (-1.74)	0.018 (0.37)	-0.057 (-0.99)	-0.328*** (-2.89)
Exp. elasticity	0.800*** (206.70)	0.988*** 44.38)	1.083*** (63.39)	0.942*** (18.03)	1.013*** (117.4)	0.717*** (41.76)	0.965*** (43.70)	0.761*** (34.72)	0.924*** (32.80)	1.132*** (33.19)	0.547*** (22.21)	0.494*** (53.18)	0.608*** (55.29)	0.570*** (59.02)	0.826*** (20.40)	1.021*** (47.43)	0.281*** (19.72)

Notes: *, ** and * indicate the elasticity is significant at the 1%, 5% and 10 % levels respectively**