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Consumer demand for alcoholic beverages in Switzerland: a two-stage quadratic almost ideal demand system for low, moderate, and heavy drinking households

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Abstract

In this study, we estimate final demand for beverages with a particular focus on alcoholic beverages and calculate elasticities using microdata from the Swiss household expenditure survey from 2000 to 2009, which containsdata from more than 34,000 households. We estimate price and income responses for three household segments – light, moderate, and heavy drinking households – to assess whether higher alcohol consumption could be described by different price and income elasticities in comparison to lower alcohol consumption. We obtain unconditional estimates by applying a two-stage budgeting quadratic almost ideal demand system. To generate missing price data, we used the recently proposed quality adjusted price approach. Due to a high share of zero consumption for some beveragescategories,we correct the model with a two-step estimation procedure. Estimation results show that heavy drinking households are much less price elastic with respect to wine and beer in comparison to moderate or light drinking households, while the price response for spirits is almost constant over the three segments. Before implementing a new tax for alcoholic beverages in Switzerland, the social, health, and economic effects of a rather small decrease in alcohol consumption among heavy drinking households must be weighed against possible negativeconsequences of a sharp decline in light or moderate drinking households.

Keywords: Demand alcoholic beverages; QUAIDS; Household segments

Introduction

Knowledge about the determinants of consumption of alcoholic beverages and the price and income elasticity of different consumer segments is highly relevant to policy decisions. Alcohol consumption is a public health priority. Following for example Wakabayashi (2013) and Corrao et al. (2000), a regular but moderate consumption of alcohol in general can have a positive effect on health by increasing the level of HDL cholesterol and reducing the risk of heart and vascular diseases, though other studies do not report positive health effects of low or moderate alcohol consumption (Estruch et al. 2014, WHO 2007). The discussion is complex and still ongoing. However, there is consensus that excessive alcohol consumption can be detrimental to health in that it can lead to liver cancer, liver disease, higher blood pressure, stroke, or mental decline

(Rehn et al. 2001; Schwartz et al. 2013; Sabia et al. 2014). In addition, excessive alcohol consumption can also have negative psychological and behavioral consequences. It can lead to higher rates of crime or violence (Jacobs and Steyn 2013; Fergusson et al. 2013) and have negative economic effects, leading to substantial higher state costs (Sacks et al. 2013).

Policy measures have been shown to reduce alcohol consumption and to be a cost effective health care intervention (Xuan et al. 2013; Doran et al. 2013). Nevertheless, alcohol taxation and its effectiveness is still a controversial discussion point in Switzerland and other European countries (for an overview of the different alcohol policy regulations in Europe see e.g., FOPH, 2014a). While total alcohol consumption in Switzerland has been decreasing slightly since 1990, with a current per capita consumption of about 8.5 liters of pure alcohol per year (SAB 2013), excessive forms of alcohol drinking like binge drinking have been increasing, especially among young people (FOPH 2013; Annaheim and Gmel 2004). Therefore, Switzerland is currently debating a tightening of alcohol legislation. While wine is excluded from the alcohol tax, beer and spirits are heavily taxed. The current legislation has the purpose of a positive health effect on one hand and a fiscal benefit on the other, with annual tax revenue of about 440 million Swiss francs (FDF 2009).

In order to assess the effect of a new tax on consumption, especially in the case of heavy drinkers, the estimation of price elasticities is crucial. However, price policies may be superfluous if changing income level affects consumption (Aepli and Finger 2013; Gallet 2010). Therefore, an estimation of income elasticities as a supplement to price elasticities is necessary. An additional tax burden to reduce light or moderate drinkers' consumption levels may not be desirable with respect not only to social aspects but also concerning health effects, depending on which assumptions are made with respect to the health effects of low or moderate alcohol consumption. In the case of heavy drinkers it is clear that a reduction in consumption would reduce public health costs and decrease social problems. To address the question of how price and income affect demand for alcoholic beverages in Switzerland, we estimate final demand price and income elasticities separately for light, moderate, and heavy drinking households based on a repeated cross-sectional household expenditure survey. We combine several recently used methods into one demand system, expecting that price and income responses are not constant among the three segments. Switzerland is a particularly interesting case due to its comparatively high purchasing power. Findings from the Swiss case can also be transferred to a considerable extent to other European countries.

Elasticity estimates based on household data are scarce. Most studies rely on time-series data (Gallet 2007), which limits the ability to estimate elasticities for different household segments. Furthermore, most studies did not investigate possible substitution effects between alcoholic and non-alcoholic beverages. Our study contributes to filling this gap and allows a more detailed understanding of alcohol demand with respect to the demand response of different household segments.

We apply a two-stage quadratic almost ideal demand system (QUAIDS) (Banks et al. 1997 [for application see e.g., Abdulai 2002; Jithitikulchai 2011]). It uses cross-sectional data from the Swiss household expenditure survey from 2000 to 2009, which contains data from more than 34,000 households. Final demand elasticities are estimated for

food, beverages, and other products and services at the first stage and for wine, beer, spirits, and several non-alcoholic beverages at the second stage. Due to a high zero consumption for some product groups, we modified the QUAIDS using Shonkwiler and Yen's approach (1999) (for application see e.g., Thiele 2008; Tafere et al. 2010) and corrected for possible heteroscedasticity by applying a parametric bootstrap. We received missing price data by using the method recently proposed by Majumder et al. (2012), further developed by Aepli and Finger (2013), and by introducing a variable for seasonality and trend applied by Aepli and Kuhlgatz (2014) for the same expenditure survey. Furthermore, we corrected for endogeneity of the expenditure variable in the model by using the augmented regression technique.

Heeb et al. (2003) analyzed the effect in Switzerland of a price reduction on spirits in 1999. The reduction was due to a tariff reduction under the WTO agreement and they focused on heavy drinkers using a longitudinal survey. Overall, spirits are rated as inelastic, whereas low volume drinkers are more elastic than high volume drinkers are. This would mean that taxes should reduce light or moderate drinkers' level of consumption more than the heavy drinkers' levels (Manning et al. 1995). Kuo et al. (2003) used the same period as Heeb et al. (2003) with the price reduction due to the WTO agreement to estimate demand reaction to the price decrease. They found that young people in particular responded with higher demand, whereas people aged 60 or older did not respond at all to the price change.

The paper is structured as follows. In Section Theoretical framework and two-stage budgeting, we describe the theoretical framework and the two-stage budgeting system, and in Section Data description and price computation, we present the descriptive statistics and indicate how price data are generated. Section Estimation procedure and elasticity calculation summarizes the estimation procedure and the elasticity calculation. The income and price responses are discussed in Section Results and discussion, while Section Conclusions and policy implications concludes.

Background
Theoretical framework and two-stage budgeting
Theoretical framework of the QUAIDS

Equation systems have been widely used in demand analysis. The most frequently applied models are: the almost ideal demand system (AIDS) or the linearized AIDS (Deaton and Muellbauer 1980a, 1980b; Akbay et al. 2007; Mhurchu et al. 2013); the quadratic version of the AIDS (QUAIDS) (Banks et al. 1997; Abdulai 2002; Dey et al. 2011; see Stasi et al. 2010 and Cembalo et al. 2014 for wine in particular); the Rotterdam model (Barten 1964; Theil 1965; Barnett and Seck 2008; Barnett and Kanyama 2013); the Translog (Christensen et al. 1975; Holt and Goodwin 2009); and the linear and quadratic expenditure systems (Pollak and Wales 1978; De Boer and Paap 2009). One of the most important criteria is the approximation of non-linear Engel curves, which is best satisfied by the QUAIDS and allows general income responses that are not captured by the AIDS or many other models. The QUAIDS model is a rank three demand system and satisfies the axioms of choice. It allows exact aggregation over consumers due to underlying preferences that are of the generalized Gorman polar form (Banks et al. 1997; Blackorby et al. 1978). The recently proposed EASI demand system (Lewbel and Pendakur 2009; for application see e.g., Stasi et al.

2011) would have been an alternative due to its flexibility with respect to the approximation of Engel curves. But Cranfield et al. (2003) noted that the QUAIDS is especially suitable in the case of a disaggregated analysis, as in this study. Furthermore, the QUAIDS has already been successfully applied to the Swiss household expenditure survey (see e.g., Abdulai 2002).

Following Banks et al. (1997) the indirect utility function of the QUAIDS is given by:

$$\ln V = \left(\left[\frac{\log m - \log a(p)}{b(p)} \right]^{-1} + \lambda(p) \right)^{-1} \tag{1}$$

where m is total expenditure and p are prices, $a(p)$ is the translog price aggregator, and $b(p)$ is the Cobb-Douglas price aggregator. The term $\frac{\log m - \log a(p)}{b(p)}$ is the indirect utility function of a PIGLOG demand system and $\lambda(p)$ is a differentiable, homogeneous function of degree zero of prices. $a(p)$ and $b(p)$ are defined as follows:

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

$$b(p) = \beta_0 \prod_{i=1}^{n} p_i^{\beta_i} \tag{3}$$

where i and j are specific goods and n is the number of goods.

The Marshallian demand function in budget shares is obtained by applying Roy's identity to the indirect utility function:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log \left[\frac{m}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \log \left[\frac{m}{a(p)} \right] \right\}^2 + \varepsilon_i \tag{4}$$

where w_i is the budget share for product category i, and α_0, α_i, γ_{ij}, β_i and λ_i are parameters to be estimated. The residuals ε_i are assumed to be multivariate normal distributed with zero mean and a finite variance-covariance matrix.

To meet utility maximization theory, the restriction of adding-up (5), of homogeneity of the Marshallian cost function in prices and total expenditure (6), and of symmetry of the Slutsky matrix (Young's theorem) (7) are implemented:

$$\text{Adding-up: } \sum_{i}^{n} \alpha_i = 1; \; \sum_{j}^{n} \gamma_{ij} = 0; \; \sum_{i}^{n} \beta_i = 0; \; \sum_{i}^{n} \lambda_i = 0 \tag{5}$$

$$\text{Homogeneity: } \sum_{i=1}^{n} \gamma_{ij} = 0 \tag{6}$$

$$\text{Symmetry: } \gamma_{ij} = \gamma_{ji} \tag{7}$$

Theoretical restrictions allow us to reduce the number of estimated parameters as well as improve the efficiency of the estimated model (Barnett and Seck 2008). To avoid singularity in the variance-covariance matrix and to satisfy the condition of adding-up, one equation is dropped and an n-1 equation system is estimated. The parameters of the n th equation are obtained from the restriction and the parameters of the n-1 equations.

In addition to the economic determinants, we take household characteristics and a variable for seasonality and time trend into account using the demographic translation approach by Pollak and Wales (1978) (applied e.g., by Abdulai 2002; Bopape and Myers 2007), modifying the intercept α_0 in equation (4) to

$$\alpha_i = \rho_{i0} + \sum_{j=1}^{S} \rho_{ij} d_j \qquad (8)$$

Where d_f is the fth variable of a total number of S variables including household characteristics and a variable for month and year.

Two-stage budgeting design

To obtain unconditional elasticities for alcoholic beverages, which are more suitable for policy recommendations than conditional elasticities (Abdulai 2002, Klonaris and Hallam 2003), we adopt a two-stage budgeting system, assuming separability of the utility function (for further explanations see e.g., Moschini et al. 1994 or Brehe 2007)[a]. First, we assume that the household allocates its budget on the three aggregated product groups at stage 1: food, beverages, and other products and services. At stage 2, the total expenditure for beverages is allocated to the disaggregated product categories: wine, beer, spirits, coffee, tea, cocoa beverages, mineral water, non-alcoholic soft drinks, and fruit and vegetables juices. We estimate income and price response at both stages, while the elasticity at stage 2 is conditional with respect to total expenditure for beverages. Unconditional elasticities for stage 2 could be obtained using the elasticity estimates at stage 1 (see Section Elasticity estimates).

Method and data

Data description and price computation

Summary statistics and definition of the household segments

For our study, we used data collected by the Swiss Federal Statistical Office from 2000 to 2009 for the Swiss household expenditure survey , a national representative survey that consists of cross-sectional data with a periodicity of one month. Almost 3,000 households participate in the survey every year. We can base our estimates on more than 34,000 households over a period of 10 years. Households are chosen randomly from the register or private telephone lines (see SFSO 2011 for details). The sample is stratified with respect to the seven major regions in Switzerland and the distribution of households is calibrated to the distribution of households in the Swiss population (SFSO 2011). For every household, data on expenditure and quantity bought (in liters per month) for all products and services, household income, and detailed information on household characteristics were gathered. To increase the explanatory power of the model and to test whether household characteristics have an influence on alcohol demand, we introduced the following criteria into the model: household size in terms of adult equivalents, a dummy variable for the presence of young children (<5 years), the age of the household's reference person, and a dummy variable for whether the household's reference person has a university degree. Household size is calculated following the OECD-modified equivalence scale (Hagenaars et al. 1994). Following Angulo et al. (2001) we expect a decreasing expenditure share as the number of equivalence

increases and the household's reference person's age decreases. With respect to education and the presence of young children there are either contradictory or no clear findings in the literature (see e.g., Van Oers et al. 1999; Reavley et al. 2011; Rice et al. 1998).

The sample is divided into three segments: light drinking households, moderate drinking households, and heavy drinking households. We provide elasticities for the entire sample as well as for the three household segments. The classification is constructed based on the recommendations for Switzerland in Annaheim and Gmel (2004). These are the official recommendations for Switzerland from the Swiss Institute for the Prevention of Alcohol and Drug Problems. Table 1 summarizes the class boundaries in pure alcohol per person and day.

According to FOPH (2014b), we assume the following levels of pure alcohol for each beverage category: 86.9 g pure alcohol per liter for wine, 37.9 g pure alcohol per liter for beer, and 316.0 g pure alcohol per liter for spirits. We calculated the amount of pure alcohol bought per month for every household based on data from the household expenditure survey. We divided the total amount of pure alcohol by the adult equivalent for every household[b] and classified the households according to the class boundaries (Table 1) based on Annaheim and Gmel's recommendations (2004).

Tables 2, 3 and 4 present summary statistics for stage 1, stage 2, and the household characteristics considered in the model. Furthermore, we provide the share of zero consumption for every product group. Given that some households did not buy beverages during the collection period, the sample for stage 2 declines to 33,364 households.

As Table 2 demonstrates, Swiss households spend only 1.4% of their budget on beverages, with 0.8% on alcoholic beverages and 0.7% on non-alcoholic beverages (Table 3). This is much lower than the European Union average values of about 1.5% and 1.2% of household budgets spent on alcoholic and non-alcoholic beverages, respectively (Eurostat 2013). Within alcoholic beverages, the highest share of the Swiss budget is spent on wine, followed by spirits and then beer. Table 3 clearly delineates the differences among the three household segments. Moderate drinking households spend on average four to five times more on wine, beer, or spirits than light drinking households, whereas heavy drinking households spend about twice as much or more in comparison to moderate drinking households. On average, the light drinking household consumes 49.3 g of pure alcohol per month, the moderate drinking household 864.5 g, and the heavy drinking household consume 1890.0 g.

The share of zero consumption is a point of particular interest. Zero consumption means that the left side of equation (4) (budget share) is left censored at zero in the case of demand systems. Besides a short collection period, which may play a special role in the context of beverages, there are other determinants for zero consumption like income restrictions that force households into a corner solution or forgoing

Table 1 Class boundaries in pure alcohol per person and day

	Pure alcohol (in g per day)
Light drinkers	<20
Moderate drinkers	20-39
Heavy drinkers	>40

Table 2 Summary statistics for the stage 1 model, total number of households and expenditure per month

Total number of households	34,176		
	Mean	Standard deviation	Percentage of zero consumption
Total expenditure (in Swiss Francs)	8,432.70	5,132.24	0.00
Expenditure on food (in Swiss Francs)	616.63	354.78	0.14
Expenditure on beverages (in Swiss Francs)	121.63	186.97	2.38
All other expenditure (in Swiss Francs)	1395.42	4933.60	0.00

preferences for certain products (see e.g., Perali and Chavas 2000; Thiele 2008). On the aggregated level (stage 1), zero consumption is low, but at the stage 2 level, a large proportion of households did not consume at all during the collection period. This has serious implications for the model specification. Censoring of the expenditure data should therefore be considered, in particular at stage 2, to avoid biased parameter estimates.

Quality-adjusted prices

Only a few household expenditure surveys collect price data. In the literature, there are two main methods for retrieving price data from expenditure and quantity variables: using unit values as proxy for market prices, as Abdulai (2002) or Akbay et al. (2007) did by dividing the expenditure by the quantity consumed. The other method of quality-adjusted unit values was originally introduced by Cox and Wohlgenant (1986) and is frequently applied in the literature (e.g., in Lazaridis 2003; Thiele 2010; Zheng and Henneberry 2010). Despite the nomenclature, unit values still have a quality aspect, because of the heterogeneity of products within a given category (e.g., wine). The consumer can select between different quality levels, leading to different unit values among households; differences in unit values can be attributed to quality and price variations (Chung et al. 2005). An increase in the unit value could be induced by a price increase or by a shift in the household's demand for more expensive products within this particular product category. Thus, taking unit values as proxies for market prices could lead to biased parameter estimates. This is particularly true for composite commodities (Chung et al. 2005), such as the beverage product groups used in this study, which contain products of varying qualities. As McKelvey (2011) notes, unit values will be an "error-ridden indicator of prices".

Cox and Wohlgenant (1986) proposed correcting the unit value for every household and product group by regressing proxies for quality variations (e.g., education or household size) on the unit value. This leads to quality-adjusted prices that vary between household. Majumder et al. (2012) criticized this approach, stating that households should face the same price at least in the same regional market and proposed a new method to calculate quality-adjusted prices per region. Aepli and Finger (2013) expanded it by a variable for month and year and adapted it for the Swiss household expenditure survey.

We give a short overview of the method (for further details, see Majumder et al. (2012) and Aepli and Finger (2013)). As noted in Majumder et al. (2012), household characteristics and income are good proxies for quality preferences. For instance,

Table 3 Summary statistics for the stage 2 model, sample sizes (reduced samples)[j] and expenditure per month

	Mean (all households)	Standard deviation (all households)	Percentage of zero consumption (all households)	Mean (only light drinking households)	Standard deviation (only light drinking households)	Mean (only moderate drinking households)	Standard deviation (only moderate drinking households)	Mean (only heavy drinking households)	Standard deviation (only heavy drinking households)
Number of households		33,364			25,699		4,152		3,513
Expenditure on beverages (in Swiss Francs)	124.59	188.25	2.38	79.28	69.85	192.70	128.76	375.54	444.81
Expenditure on alcoholic beverages (in Swiss Francs)	67.57	175.72	32.09	23.93	39.15	131.25	109.74	311.51	435.48
Expenditure on non-alcoholic beverages (in Swiss Francs)	57.02	53.95	1.61	55.35	53.30	61.45	53.57	64.03	58.19
Wine (in Swiss Francs)	48.31	162.57	49.10	15.57	34.37	91.17	114.12	237.16	425.85
Beer (in Swiss Francs)	8.23	20.55	69.52	4.36	11.18	17.23	26.65	25.87	41.73
Spirits, sweet wines, etc. (in Swiss Francs)	11.03	32.44	71.33	4.00	13.47	22.85	34.81	48.48	72.84
Coffee (in Swiss Francs)	14.46	31.21	44.66	13.49	30.03	17.23	31.81	18.32	37.81
Tea (in Swiss Francs)	3.87	8.83	59.92	3.91	9.09	3.88	7.76	3.57	8.05
Cocoa beverages (in Swiss Francs)	1.92	6.36	85.05	2.03	6.61	1.64	5.45	1.48	5.45
Mineral water (in Swiss Francs)	10.89	19.33	39.88	10.33	19.17	12.46	19.28	13.10	20.26
Non-alcoholic soft drinks (in Swiss Francs)	15.87	25.01	32.62	15.67	24.64	16.17	25.77	17.02	26.68
Fruit juices and vegetable juices (in Swiss Francs)	10.01	19.81	38.50	9.92	20.65	10.06	15.62	10.54	17.89

Table 4 Summary statistics for the household characteristics

Household characteristics	Mean	Standard deviation
Household size in adult equivalents	1.63	0.52
Young children (<5 years, yes or no)	0.14	0.35
Age of the household's reference person	49.69	15.22
University degree with respect to the household's reference person (yes or no)	0.13	1.27

households with less income tend to choose less expensive goods within a product group. A separate regression is run for each product category i. Following Aepli and Finger (2013), the unit value and the proxy variables are related as follows:

$$v_i^{hlym} - \left(v_i^{lym}\right)_{median} = \alpha_i D_l + \beta_i D_y + \gamma_i D_m + \delta_i x^{hlym} + \eta_i x^{2hlym} + \theta_i e^{hlym} + \omega_i f_i^{hlym}$$
$$+ \sum_{j=1}^{n} b_i Z_{ij}^{hlym} + \varepsilon_i^{hlym}$$

(9)

where v_i^{hlym} is the unit value paid by household h for item i in its region l, year y, and month m. The deviation of the household's unit value from the median is explained by household characteristics, income, and expenditure variables, which capture the quality effect. The part of the deviation that cannot be explained by quality is captured by the error term ε_i^{hlym}. Furthermore, x denotes income and x^2 the square of income, e is the household total expenditure for beverages, and f is the household total expenditure for food and beverages consumed away from home. Z_{ij} denotes the j th of n household characteristics, which are household size, a binary dummy variable for having children, and a dummy variable for having a university degree. D_l, D_y, and D_m are dummies for region, year, and month, respectively. To manage possible outliers more successfully, we decided to follow the suggestions in Aepli and Finger (2013) and to estimate the equations using a robust M-estimator using only those households that consumed the good.

To obtain regional, monthly, and yearly quality adjusted market prices p_i^{lmy} we add the median unit value v_i^{lym}median to the corresponding median of item i of the estimated residuals from equation (9).

$$\left(p_i^{lmy}\right)_{median} = \left(v_i^{lmy}\right)_{median} + \left(\varepsilon_i^{lmy}\right)_{median}$$

(10)

The prices are then assigned to all households in the sample according to region, month, and year. Due to a low number of households consuming tea and cocoa beverages in the Italian-speaking part of Switzerland in some months, we took the corresponding consumer price index for those product categories, as well as for all product categories at stage 1.

Estimation procedure and elasticity calculation

Censoring

Table 3 shows that the share of zero consumption is relatively high for all beverage product categories at stage 2. This fact has some major consequences on the estimation procedure and must be taken into account to avoid self-selection and resulting biased

parameter estimates. As Deaton (1990) states, deleting the zero-consumption points only allows for estimating conditional effects. The most popular model for coping with censored data is the Tobit approach (Tobin 1958; Amemiya 1984), which is widely used for single-equation demand models. Heien and Wessels (1990) proposed a new approach for equation systems based on Heckman (1979) (for its application see e.g., Dey et al. 2011; Lazaridis 2003). Their approach was criticized by Shonkwiler and Yen (1999) and later by Vermeulen (2001), who showed that the revised procedure leads to inconsistent estimates. As an alternative, Shonkwiler and Yen (1999) proposed another frequently used approach (e.g., in Thiele 2008; Su and Yen 2000; Zheng and Henneberry 2011; for wine in particular, see e.g., Stasi et al. 2011) that is applied in this study.

In the first step, a multivariate probit is estimated (unlike Shonkwiler and Yen (1999), who estimated a univariate probit). We suppose that one household's purchase of a particular beverage product category is not independent of purchase decisions for other beverage product categories due to substitution effects. The model to be estimated is:

$$w_i^* = f\left(x_{ij}\beta_{ij}\right) + \varepsilon_i, \; g_i^* = z_{ik}'\gamma_{ik} + v_i \; i = 1, ..., \; n \; i = 1, ..., \; m \; k = 1, ..., f \qquad (11)$$

$$g_i = \begin{cases} 0 \; if \; g_i^* \leq 0 \\ 1 \; if \; g_i^* > 0 \end{cases} \; w_i = g_i w_i^* \, i = 1, ..., \; n \qquad (12)$$

where w_i and g_i are the observed dependent variables for the food product groups, g_i^* and w_i^* are the correspondent latent variables, g_i is a binary variable representing the decision of the household to consume or not, and x_{ij} and z'_{ik} are explanatory variables such as income, logarithmic prices, and household characteristics. All these variables are presumed to be important determinants with respect to the decision of the household to consume or not (in this context we refer also to Thiele 2008 and Zheng and Henneberry 2011). The error terms ε_i and v_i are assumed to have a multivariate normal distribution, each with a mean of zero and a variance-covariance matrix V with diagonal elements of 1 and off-diagonal elements of $\rho_{rl} = \rho_{lr}$.

Based on the estimated parameters, we calculate the standard normal cumulative distribution function $\Phi(\;)$ (cdf) and the standard normal probability density function $\phi(\;)$ (pdf) for every household and each product category; cdf and pdf are used to correct the budget share equation (4) for a censoring of the budget share variables as follows:

$$w_i = \Phi\left(z_{ik}'\gamma_{ik}\right)f\left(x_{ij}\beta_{ij}\right) + \delta_i\phi\left(z_{ik}'\gamma_{ik}\right) + \varepsilon_i, \; \varepsilon_i \sim MVN(0, \sigma) \; i = 1, ..., \; n \qquad (13)$$

Following Zheng and Henneberry (2010), the parameter for the pdf δ_i represents the covariance between the error term in the budget share equation (4) and the error term of the multivariate probit model. Equation (13) is applied only to stage 2. At stage 1, there is no need for the two-step estimation procedure due to the low level of zero consumption. We dropped the equation for expenditure on other products and services as described in Section Theoretical framework of the QUAIDS. For the two-step estimation procedure, the right hand side generally no longer adds up to one, so we estimate the full equation system following Yen et al. (2002) or Ecker and Qaim (2010)[d].

Despite the advantages of Shonkwiler and Yen's (1999) procedure, Tauchmann (2005) draws attention to the problem of heteroscedasticity. By expanding the budget

share equation cdf and pdf, heteroscedasticity is implicitly introduced into the model (for further explanations, see Tauchmann 2005). To avoid this problem and to estimate a heteroscedasticity robust covariance matrix, we apply the parametric bootstrap.

Expenditure endogeneity

Assuming weak separability and applying a two-stage budgeting model could lead to problems with respect to the endogeneity of the expenditure variable in the budget share equation, because the expenditure variable could be correlated with the equation errors (Attfield 1985). To account for endogeneity, Blundell and Robin (1999) proposed the augmented regression technique. In a first step, we regress all the price variables, the household characteristics, and the variable for month and year of the budget share equation on the expenditure variable for every product category. On the right hand side, we further include income and its square as instruments as proposed by Bopape (2006). In contrast to other studies, where the equations are estimated using OLS (e.g., Fashogbon and Oni 2013), we use a robust M-estimator to account for possible outliers. Residuals are then included in every budget share equation as additional right hand side variables. Testing the parameter of the residuals for significance allows us to check whether endogeneity is present or not.

Elasticity estimates

Income elasticities for stage 2, where censoring is an issue, are derived using the formula proposed by

$$e_i = \frac{\Phi(z'_{ik}\gamma_{ik})\mu_i}{w_i} + 1 \tag{14}$$

which reduces to $e_i = \frac{\mu_i}{w_i} + 1$ (Banks et al. 1997) for stage 1, where μ_i is the differentiation of equation (4) with respect to $\log m^e$. For the Marshallian price elasticity ε_{ij}^M, we follow Zheng and Henneberry (2010) and calculate the full effect of a price change on demand based on the effect of the budget share equation and the effect of the multivariate probit model for stage 2:

$$\varepsilon_{ij}^M = \frac{\Phi(z'_{ik}\gamma_{ik})\mu_{ij}}{w_i} + \phi * \tau_{ij} * \left(1 - \frac{\delta_i}{w_i}\right) - \delta_{ij} \tag{15}$$

where μ_{ij} is the differentiation of equation (4) with respect to $\log p_j$. [f] τ_{ij} is the estimated parameter for price j with respect to product category i in the multivariate probit model and δ_i is defined as above. δ_{ij} denotes the Kronecker delta, which is equal to one when $i = j$ and otherwise is zero. For stage 1, the formula for the Marshallian price elasticity reduces to $\varepsilon_{ij}^M = \frac{\mu_{ij}}{w_i} - \delta_{ij}$.

The Slutsky equation is applied to get the Hicksian price elasticities:

$$e_{ij}^H = e_{ij}^M + e_i w_j \tag{16}$$

For stage 2, we first estimate conditional elasticities with respect to total expenditures on beverages. Unconditional elasticities are derived following Edgerton (1997). The formula for the income elasticity (unconditional) e_i^{uc} is:

$$e_i{}^{uc} = e_{(r)i}{}^c * e_{(r)}{}^{uc} \tag{17}$$

where $e^c_{(r)i}$ is the expenditure elasticity (conditional) for item i within the r th product group and $e^{uc}_{(r)}$ the income elasticity for the r th product group (unconditional). The unconditional Marshallian price elasticity $\varepsilon_{ij}^{M,\,uc}$ is calculated by:

$$\varepsilon_{ij}^{M,\,uc} = \varepsilon_{(r)ij}^{H,\,c} + e_{(r)i}{}^c * w_{(r)j}\varepsilon_{rr}{}^{M,\,uc} \tag{18}$$

where $\varepsilon_{(r)ij}^{H,\,c}$ is the conditional Marshallian price elasticity for item i and j, $w_{(r)j}$ the budget share of item j within the r th product category, and $\varepsilon_{rr}^{M,uc}$ the uncompensated Hicksian own-price elasticity of product category r.

The unconditional, Hicksian price elasticity $\varepsilon_{ij}^{H,\,uc}$ is derived analogously using $\varepsilon_{(r)ij}^{H,\,c}$ and the Hicksian own-price elasticity (unconditional) of product category r $\varepsilon_{rr}^{H,uc}$:

$$\varepsilon_{ij}^{H,\,uc} = \varepsilon_{(r)ij}^{H,\,c} + e_{(r)i}{}^c * w_{(r)j}\varepsilon_{rr}{}^{H,uc} \tag{19}$$

Results and discussion

Overall, the variables in the model explain between 0.47% and 0.86% of total variance at stage 1 and between 0.06% and 0.80% of total variance at stage 2. For the sake of brevity, we report the parameter estimates of stages 1 and 2, the coefficients of determination, and X^2 -test statistics for the entire model in the Additional file 1: Appendix. While prices and socio-demographic variables do explain a part of the variance in consumption, the rest is determined by other factors such as lifestyle or psychographic or behavioral aspects, which are not considered further in this study (for determinants of Swiss wine demand see e.g., Brunner and Siegrist 2011). While household size is mostly negatively correlated with budget share, the age of the households' reference person shows a positive correlation which is in line with the findings of previous studies. For the presence of young children and education, we could not show a clear relationship with respect to the budget share. The sign of the parameters varies depending on the household segment.

To verify the model specification with respect to the implementation of household characteristics and the quadratic income term, we carried out Wald-tests for every model. The test statistics reject clearly the null-hypothesis of no household characteristics for all models (Additional file 1: Appendix), which can also be derived from the estimation results for the parameter estimates in Tables 24 to 28 (in the Additional file 1: Appendix). The hypothesis that Engel curves for beverages in Switzerland are often of a nonlinear form is supported by the test results. The QUAIDS specification is therefore superior to the AIDS specification for stage 1 and stage 2, except for the models for light drinking and moderate drinking households (Additional file 1: Appendix). These findings are consistent with other findings for food demand in Switzerland (Abdulai 2002; Aepli and Kuhlgatz 2014). Furthermore, we tested for endogeneity of the expenditure variable in the model. The hypothesis of no endogeneity is clearly rejected for all models and confirms the importance of a correction for endogeneity (Additional file 1: Appendix), which we achieved by applying the augmented regression technique.

Unconditional Hicksian price and income elasticities for beverages are reported in Tables 5, 6, 7, 8, 9, 10, 11 and 12 for all households and the three segments. We provide

Table 5 Unconditional, Marshallian price and income elasticities at stage 2, all households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.986 (0.208)***	−0.177 (0.142)	0.046 (0.097)	−0.141 (0.181)	−1.328 (0.325)***	0.353 (0.248)	0.354 (0.203)	−0.256 (0.296)	0.054 (0.135)	1.288 (0.182)***
Beer	0.188 (0.139)	−0.634 (0.242)***	0.100 (0.093)	0.153 (0.112)	0.571 (0.260)**	−1.260 (0.238)***	−1.036 (0.180)***	0.002 (0.109)	0.296 (0.153)*	0.096 (0.085)
Spirits	0.397 (0.146)***	−0.164 (0.072)**	−0.950 (0.043)***	−0.082 (0.122)	0.565 (0.357)	0.519 (0.215)**	0.132 (0.116)	−0.070 (0.209)	0.003 (0.069)	0.918 (0.101)***
Coffee	0.055 (0.088)	0.185 (0.084)**	0.098 (0.077)	−0.786 (0.081)***	−2.436 (0.256)***	−1.508 (0.158)***	−0.320 (0.136)**	−0.126 (0.110)	0.172 (0.079)**	0.350 (0.132)***
Tea	−0.157 (0.114)	0.007 (0.108)	−0.030 (0.089)	−0.143 (0.128)	−4.638 (0.506)***	−2.442 (0.294)***	0.300 (0.218)	−0.045 (0.180)	0.030 (0.097)	0.419 (0.160)***
Cocoa beverages	0.443 (0.242)*	−0.593 (0.219)**	−0.138 (0.100)	0.028 (0.207)	−3.365 (0.679)***	−0.753 (0.484)	1.175 (0.236)***	−0.305 (0.330)	−0.267 (0.167)	1.441 (0.106)***
Mineral water	−0.068 (0.182)	−0.416 (0.115)***	−0.106 (0.066)	0.016 (0.166)	−2.969 (0.273)***	−0.064 (0.229)	−0.186 (0.148)	−0.213 (0.262)	0.058 (0.110)	1.156 (0.107)***
Non-alcoholic soft drinks	−0.011 (0.094)	0.054 (0.076)	0.099 (0.034)***	−0.031 (0.076)	−0.406 (0.148)***	−0.565 (0.124)***	−0.403 (0.079)***	−1.169 (0.122)***	0.226 (0.065)***	0.518 (0.044)***
Fruit juices and vegetables juices	0.033 (0.073)	0.318 (0.109)***	0.164 (0.046)***	−0.253 (0.074)***	−1.933 (0.210)***	−1.279 (0.167)***	−0.745 (0.124)***	−0.053 (0.101)	−0.757 (0.086)***	0.363 (0.057)***

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 6 Unconditional, Hicksian price and income elasticities at stage 2, all households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.983 (0.208)***	−0.176 (0.142)	0.046 (0.097)	−0.138 (0.181)	−1.324 (0.325)***	0.356 (0.248)	0.355 (0.203)*	−0.252 (0.295)	0.055 (0.135)	1.288 (0.182)***
Beer	0.188 (0.139)	−0.634 (0.242)***	0.100 (0.093)	0.153 (0.112)	0.571 (0.260)**	−1.260 (0.238)***	−1.036 (0.180)***	0.002 (0.109)	0.296 (0.153)*	0.096 (0.085)
Spirits	0.399 (0.146)***	−0.163 (0.072)**	−0.950 (0.043)***	−0.080 (0.122)	0.567 (0.357)	0.520 (0.215)**	0.133 (0.116)	−0.067 (0.209)	0.004 (0.069)	0.918 (0.101)***
Coffee	0.056 (0.088)	0.185 (0.084)**	0.098 (0.077)	−0.785 (0.081)***	−2.435 (0.256)***	−1.507 (0.158)***	−0.320 (0.136)**	−0.125 (0.110)	0.172 (0.079)**	0.350 (0.132)***
Tea	−0.156 (0.113)	0.008 (0.108)	−0.030 (0.089)	−0.142 (0.128)	−4.637 (0.506)***	−2.442 (0.294)***	0.300 (0.218)	−0.044 (0.180)	0.031 (0.097)	0.419 (0.160)***
Cocoa beverages	0.446 (0.242)*	−0.592 (0.219)***	−0.138 (0.100)	0.031 (0.207)	−3.361 (0.679)***	−0.751 (0.484)	1.176 (0.236)***	−0.300 (0.330)	−0.266 (0.167)	1.441 (0.106)***
Mineral water	−0.066 (0.182)	−0.415 (0.115)***	−0.106 (0.066)	0.018 (0.166)	−2.966 (0.273)***	−0.062 (0.229)	−0.185 (0.148)	−0.209 (0.262)	0.059 (0.109)	1.156 (0.107)***
Non-alcoholic soft drinks	−0.010 (0.094)	0.054 (0.076)	0.099 (0.034)***	−0.030 (0.076)	−0.404 (0.148)***	−0.564 (0.124)***	−0.402 (0.079)***	−1.167 (0.122)***	0.226 (0.065)***	0.518 (0.044)***
Fruit juices and vegetables juices	0.034 (0.073)	0.318 (0.109)***	0.164 (0.046)***	−0.252 (0.074)***	−1.932 (0.210)***	−1.278 (0.167)***	−0.744 (0.124)***	−0.052 (0.101)	−0.757 (0.086)***	0.363 (0.057)***

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.
Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 7 Unconditional, Marshallian price and income elasticities at stage 2, light drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−1.275 (0.247)***	−0.144 (0.141)	0.038 (0.203)	−0.156 (0.161)	−0.801 (1.050)	0.172 (0.718)	0.450 (0.348)	−0.484 (0.177)***	0.003 (0.595)	0.620 (0.366)*
Beer	0.679 (0.707)	−1.216 (0.457)***	0.000 (0.265)	0.550 (0.226)**	−1.892 (2.355)	−2.940 (1.576)*	−1.056 (1.363)	0.480 (0.545)	1.082 (0.874)	0.469 (0.534)
Spirits	0.363 (0.400)	−0.011 (0.151)	−0.859 (0.220)***	0.109 (0.152)	2.874 (1.163)**	0.317 (1.276)	−0.760 (0.730)	0.429 (0.235)*	0.417 (0.703)	0.666 (0.408)
Coffee	0.365 (0.348)	0.165 (0.151)	0.036 (0.163)	−0.729 (0.134)***	−3.209 (1.311)**	−1.825 (0.721)**	−0.431 (0.667)	0.192 (0.240)	0.708 (0.527)	0.569 (0.307)*
Tea	−1.000 (0.580)*	−0.438 (0.245)*	−0.070 (0.430)	−0.606 (0.297)**	−4.656 (2.844)	−0.586 (1.466)	2.528 (1.147)**	−0.721 (0.343)**	−1.146 (1.403)	0.875 (0.845)
Cocoa beverages	0.635 (0.564)	−0.332 (0.627)	0.014 (0.403)	−0.006 (0.446)	−4.249 (1.628)***	−1.244 (1.244)	−0.807 (0.915)	0.375 (0.610)	−0.574 (0.825)	1.489 (0.668)**
Mineral water	−0.193 (0.831)	−0.854 (0.670)	−0.099 (0.316)	−0.710 (0.445)	−6.929 (2.611)***	0.722 (1.186)	0.490 (1.599)	−0.193 (0.653)	−1.239 (0.819)	2.068 (0.403)***
Non-alcoholic soft drinks	−0.282 (0.255)	0.100 (0.230)	−0.011 (0.100)	0.074 (0.154)	−0.168 (0.348)	−0.422 (0.339)	0.141 (0.437)	−1.062 (0.256)***	0.384 (0.129)***	0.464 (0.109)***
Fruit juices and vegetables juices	0.171 (0.275)	0.388 (0.273)	0.111 (0.163)	0.025 (0.138)	−0.812 (1.077)	−1.558 (0.458)***	−0.262 (0.753)	0.025 (0.251)	−0.206 (0.465)	0.220 (0.248)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 8 Unconditional, Hicksian price and income elasticities at stage 2, light drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−1.273 (0.246)***	−0.143 (0.141)	0.039 (0.203)	−0.155 (0.161)	−0.799 (1.049)	0.174 (0.718)	0.450 (0.348)	−0.483 (0.176)***	0.004 (0.595)	0.620 (0.366)*
Beer	0.680 (0.707)	−1.216 (0.457)***	0.001 (0.265)	0.551 (0.225)**	−1.890 (2.355)	−2.938 (1.576)*	−1.056 (1.363)	0.480 (0.545)	1.082 (0.874)	0.469 (0.534)
Spirits	0.365 (0.400)	−0.010 (0.151)	−0.858 (0.220)***	0.111 (0.152)	2.877 (1.163)**	0.319 (1.276)	−0.760 (0.730)	0.430 (0.235)*	0.417 (0.703)	0.666 (0.408)
Coffee	0.367 (0.347)	0.165 (0.151)	0.036 (0.163)	−0.728 (0.133)***	−3.207 (1.311)**	−1.823 (0.721)**	−0.431 (0.667)	0.193 (0.240)	0.708 (0.527)	0.569 (0.307)*
Tea	−0.998 (0.579)*	−0.437 (0.245)*	−0.070 (0.430)	−0.604 (0.296)**	−4.653 (2.843)	−0.584 (1.466)	2.529 (1.147)**	−0.720 (0.342)**	−1.146 (1.403)	0.875 (0.845)
Cocoa beverages	0.639 (0.564)	−0.330 (0.627)	0.014 (0.403)	−0.003 (0.446)	−4.244 (1.627)***	−1.240 (1.244)	−0.806 (0.915)	0.377 (0.609)	−0.573 (0.825)	1.489 (0.668)**
Mineral water	−0.188 (0.831)	−0.852 (0.670)	−0.098 (0.316)	−0.705 (0.445)	−6.923 (2.611)***	0.727 (1.186)	0.491 (1.599)	−0.189 (0.653)	−1.238 (0.819)	2.068 (0.403)***
Non-alcoholic soft drinks	−0.280 (0.254)	0.100 (0.230)	−0.010 (0.100)	0.075 (0.154)	−0.166 (0.348)	−0.421 (0.339)	0.141 (0.437)	−1.061 (0.256)***	0.384 (0.129)***	0.464 (0.109)***
Fruit juices and vegetables juices	0.171 (0.275)	0.388 (0.273)	0.112 (0.163)	0.026 (0.137)	−0.812 (1.077)	−1.558 (0.458)***	−0.262 (0.753)	0.026 (0.251)	−0.206 (0.465)	0.220 (0.248)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.
Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 9 Unconditional, Marshallian price and income elasticities at stage 2, moderate drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.665 (1.419)	0.194 (1.155)	0.236 (0.606)	−0.029 (0.554)	0.186 (0.614)	−0.183 (0.548)	−0.362 (0.450)	−0.562 (0.563)	−0.088 (0.232)	1.077 (0.355) ***
Beer	0.639 (1.230)	−0.825 (1.186)	0.365 (0.535)	−0.049 (0.699)	1.096 (1.289)	−0.893 (0.554)	−0.301 (0.450)	−0.317 (0.704)	−0.137 (0.266)	0.877 (0.867)
Spirits	0.305 (0.954)	0.166 (0.453)	−0.799 (0.351)**	−0.093 (0.249)	−0.877 (0.514)*	−0.479 (0.304)	−0.143 (0.310)	−0.423 (0.390)	−0.144 (0.145)	0.636 (0.355) *
Coffee	0.034 (1.414)	0.015 (1.579)	0.077 (0.686)	−0.828 (0.611)	−1.718 (1.648)	−0.250 (1.180)	0.173 (0.473)	−0.096 (0.479)	0.105 (0.361)	0.058 (0.436)
Tea	0.264 (2.398)	0.005 (1.583)	0.043 (0.960)	−0.237 (0.757)	−1.360 (1.488)	−1.367 (1.008)	0.524 (0.685)	0.069 (0.714)	−0.170 (0.403)	0.241 (0.613)
Cocoa beverages	0.337 (2.472)	−1.143 (2.480)	−0.097 (1.039)	−0.063 (1.441)	−2.195 (3.197)	1.858 (3.379)	−0.087 (1.077)	−0.129 (1.496)	0.389 (0.857)	−0.186 (1.539)
Mineral water	−0.293 (1.706)	−0.021 (0.873)	−0.033 (0.561)	−0.212 (0.523)	−0.716 (0.757)	−0.136 (0.620)	−0.512 (1.234)	−0.211 (0.704)	0.316 (0.563)	0.632 (0.509)
Non-alcoholic soft drinks	0.145 (1.497)	−0.034 (0.870)	0.009 (0.553)	−0.004 (0.435)	−0.724 (0.605)	−0.053 (0.577)	0.023 (0.547)	−1.141 (0.550)**	−0.051 (0.286)	0.489 (0.420)
Fruit juices and vegetables juices	0.362 (0.973)	−0.058 (0.937)	0.007 (0.384)	−0.041 (0.452)	−2.267 (0.857)***	0.265 (0.457)	0.175 (0.638)	−0.419 (0.417)	−0.947 (0.356)***	0.503 (0.329)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.
Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 10 Unconditional, Hicksian price and income elasticities at stage 2, moderate drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.663 (1.419)	0.194 (1.155)	0.236 (0.606)	−0.028 (0.554)	0.188 (0.614)	−0.182 (0.548)	−0.360 (0.450)	−0.556 (0.563)	−0.087 (0.232)	1.077 (0.355)***
Beer	0.640 (1.230)	−0.825 (1.186)	0.365 (0.535)	−0.048 (0.699)	1.098 (1.289)	−0.892 (0.554)	−0.299 (0.449)	−0.312 (0.701)	−0.135 (0.265)	0.877 (0.867)
Spirits	0.306 (0.954)	0.166 (0.453)	−0.799 (0.351)**	−0.093 (0.249)	−0.876 (0.514)*	−0.479 (0.304)	−0.141 (0.310)	−0.420 (0.389)	−0.143 (0.145)	0.636 (0.355)*
Coffee	0.034 (1.414)	0.015 (1.579)	0.077 (0.686)	−0.828 (0.611)	−1.717 (1.648)	−0.250 (1.180)	0.173 (0.473)	−0.095 (0.478)	0.105 (0.361)	0.058 (0.436)
Tea	0.265 (2.398)	0.006 (1.583)	0.043 (0.960)	−0.237 (0.757)	−1.360 (1.488)	−1.367 (1.008)	0.525 (0.685)	0.070 (0.712)	−0.170 (0.402)	0.241 (0.613)
Cocoa beverages	0.336 (2.472)	−1.143 (2.480)	−0.097 (1.039)	−0.063 (1.441)	−2.195 (3.197)	1.857 (3.378)	−0.088 (1.076)	−0.130 (1.491)	0.389 (0.856)	−0.186 (1.539)
Mineral water	−0.292 (1.706)	−0.021 (0.873)	−0.033 (0.561)	−0.212 (0.523)	−0.715 (0.757)	−0.135 (0.620)	−0.511 (1.233)	−0.207 (0.703)	0.317 (0.563)	0.632 (0.509)
Non-alcoholic soft drinks	0.146 (1.497)	−0.034 (0.870)	0.009 (0.553)	−0.003 (0.435)	−0.723 (0.604)	−0.052 (0.577)	0.024 (0.547)	−1.139 (0.549)**	−0.050 (0.286)	0.489 (0.420)
Fruit juices and vegetables juices	0.362 (0.973)	−0.057 (0.937)	0.007 (0.384)	−0.040 (0.452)	−2.266 (0.857)***	0.265 (0.457)	0.176 (0.638)	−0.416 (0.416)	−0.947 (0.356)***	0.503 (0.329)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 11 Unconditional, Marshallian price and income elasticities at stage 2, heavy drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.519 (0.319)	0.573 (0.557)	0.251 (0.204)	0.178 (0.119)	1.533 (1.075)	−1.456 (0.803)*	−0.641 (0.295)**	−0.673 (0.516)	0.543 (0.325)*	1.009 (0.172)***
Beer	0.800 (1.210)	−0.244 (2.026)	0.289 (0.671)	0.498 (0.604)	4.057 (5.212)	−3.259 (4.122)	−1.306 (1.427)	−0.684 (0.987)	1.419 (1.960)	1.412 (0.768)**
Spirits	0.336 (0.512)	−0.684 (0.897)	−0.919 (0.315)***	−0.260 (0.221)	−3.335 (1.771)*	1.735 (1.339)	0.494 (0.451)	−0.284 (0.372)	−1.095 (0.566)*	0.357 (0.240)
Coffee	0.066 (0.451)	−0.451 (0.819)	0.237 (0.275)	−0.997 (0.318)***	−3.220 (2.295)	1.173 (1.721)	0.408 (0.586)	−0.296 (0.402)	−0.898 (0.855)	0.488 (0.338)
Tea	0.230 (0.830)	−1.307 (1.232)	0.199 (0.522)	−0.319 (0.416)	−2.582 (3.903)	3.393 (2.865)	1.149 (0.799)	−0.631 (0.674)	−0.859 (1.050)	0.258 (0.503)
Cocoa beverages	0.131 (0.873)	−0.429 (1.159)	0.100 (0.569)	−0.285 (0.655)	−6.955 (5.165)	−1.639 (3.760)	0.055 (1.388)	−0.274 (0.790)	−0.864 (2.016)	0.426 (0.634)
Mineral water	0.079 (0.468)	−0.442 (0.783)	−0.055 (0.343)	−0.374 (0.457)	−2.208 (2.190)	1.556 (1.655)	−0.686 (0.775)	−0.591 (0.491)	0.007 (1.110)	0.398 (0.350)
Non-alcoholic soft drinks	0.483 (0.545)	−0.193 (1.027)	0.069 (0.333)	−0.255 (0.329)	−2.633 (2.429)	1.908 (1.947)	0.308 (0.649)	−1.702 (0.421)***	−0.931 (0.951)	0.389 (0.378)
Fruit juices and vegetables juices	0.233 (0.826)	−0.969 (1.339)	−0.082 (0.410)	−0.691 (0.622)	−2.330 (3.855)	1.553 (3.069)	1.517 (1.340)	−0.160 (0.623)	−2.154 (1.735)	0.395 (0.601)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.

Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

Table 12 Unconditional, Hicksian price and income elasticities at stage 2, heavy drinking households (at sample means)

	Win	Bee	Sp	Cof	Tea	CBe	MWa	NaS	FJVJ	Income
Wine	−0.518 (0.319)	0.574 (0.557)	0.251 (0.204)	0.179 (0.119)	1.535 (1.075)	−1.455 (0.803)**	−0.639 (0.295)**	−0.666 (0.516)	0.545 (0.325)*	1.009 (0.172)***
Beer	0.801 (1.210)	−0.244 (2.026)	0.289 (0.671)	0.499 (0.604)	4.059 (5.212)	−3.258 (4.122)	−1.303 (1.426)	−0.674 (0.984)	1.420 (1.960)	1.412 (0.768)**
Spirits	0.337 (0.512)	−0.684 (0.897)	−0.919 (0.315) ***	−0.260 (0.221)	−3.334 (1.771)*	1.735 (1.339)	0.495 (0.451)	−0.281 (0.371)	−1.094 (0.566)*	0.357 (0.240)
Coffee	0.067 (0.451)	−0.451 (0.819)	0.237 (0.275)	−0.996 (0.318)***	−3.219 (2.295)	1.173 (1.721)	0.409 (0.586)	−0.292 (0.400)	−0.897 (0.855)	0.488 (0.338)
Tea	0.231 (0.830)	−1.307 (1.232)	0.199 (0.522)	−0.319 (0.416)	−2.582 (3.903)	3.393 (2.865)	1.150 (0.799)	−0.629 (0.671)	−0.859 (1.050)	0.258 (0.503)
Cocoa beverages	0.131 (0.873)	−0.429 (1.159)	0.100 (0.569)	−0.284 (0.655)	−6.954 (5.165)	−1.639 (3.760)	0.056 (1.388)	−0.271 (0.787)	−0.863 (2.016)	0.426 (0.634)
Mineral water	0.079 (0.468)	−0.442 (0.783)	−0.055 (0.343)	−0.373 (0.457)	−2.207 (2.190)	1.556 (1.655)	−0.685 (0.775)	−0.588 (0.489)	0.007 (1.110)	0.398 (0.350)
Non-alcoholic soft drinks	0.484 (0.545)	−0.193 (1.027)	0.069 (0.333)	−0.255 (0.329)	−2.633 (2.429)	1.908 (1.947)	0.309 (0.649)	−1.699 (0.419)***	−0.931 (0.951)	0.389 (0.378)
Fruit juices and vegetables juices	0.234 (0.826)	−0.969 (1.339)	−0.082 (0.410)	−0.691 (0.622)	−2.330 (3.855)	1.553 (3.069)	1.518 (1.340)	−0.157 (0.620)	−2.154 (1.735)	0.395 (0.601)

*, ** and *** denote significance at 10%, 5% and 1% level, respectively.
Note: Win: Wine, Bee: Beer, Sp: Spirits, Cof: Coffee, Tea: Tea, CBe: Cocoa beverages, MWa: Mineral Water, NaS: Non-alcoholic soft drinks, FJVJ: Fruit juices and vegetables juices.

standard errors and the significance level, which are computed by the delta method discussed in Oehlert (1992). We provide the conditional elasticities for stage 2 in the Additional file 1: Appendix. The elasticities for stage 1 can be obtained from the author on request.

General price and income responses for beverages and for the three household segments are discussed in terms of elasticities. Due to the cross-sectional structure of the data set, elasticities should be interpreted as short-term reactions of households to price and income changes.

Income elasticities for alcoholic beverages are all positive in the model for all households. Wine is found to be a luxury good and spirits and beer are found to be necessity goods, though spirits is very closed to the luxury goods. The findings for beer are in line with previous studies (see e.g. Nelson 1997 and Selvanathan and Selvanathan 2005). With respect to wine and spirits the findings in the literature are partially contradictory. In most studies wine and spirits are found to be luxury goods or have an elasticity which is smaller but close to one (Fogarty 2008). Therefore our findings are in the range of variability of the results of previous studies.

Looking at the income elasticities of the three segments, alcoholic beverages are a necessity good for light drinking households, as well as for moderate drinking households, except for wine. For heavy drinking households, beer and wine are luxury goods, while spirits are necessity goods[g]. Light drinking households are clearly less income-elastic for wine and beer than moderate and heavy drinking households, and heavy drinking households are much more income-elastic with respect to beer than moderate drinking households.

Almost all own-price elasticities for alcoholic and non-alcoholic beverages are negative for the three household segments as well as for the model with all households. Therefore, the negativity condition is mostly fulfilled. For wine and beer, our findings show a clear decrease in the magnitude from light drinking households to heavy drinking households. Looking at the Hicksian demand elasticities, an additional 1% decrease in beer price would result in an increase of the light drinking household demand by 1.21%, while moderate drinking households would increase their consumption by 0.83% and heavy drinking households even less by 0.24%. This shows that light drinking households are relatively price elastic while heavy drinking households are inelastic. Beer is of special interest because it is the favorite beverage for young people in Switzerland. A recently study published by Dey et al. (2013) shows that those who practice binge drinking or other risky drinking behavior in Switzerland have a high penchant for beer. The authors (Dey et al. 2013) suggest the relatively low price of beer in comparison to other alcoholic beverages explains these findings. The price argument likely also applies to middle-aged or older people in terms of risky drinking behavior and could be a reason why own-price elasticities for spirits, which are more expensive than beer, are almost constant between the three segments with a range from 0.83 and 0.92[h]. These results are in contrast to Kuo et al. (2003), who found that moderate drinkers show relatively higher price responses than heavy drinkers in relation to spirits.

Looking at the model for all households, non-alcoholic beverages are mostly substitutes for wine and beer. In the case of spirits, tea, cocoa beverages, and mineral water are slight complements, while coffee, non-alcoholic soft drinks, and fruit and vegetables juices are substitutes. With respect to the substitution effects between alcoholic and non-alcoholic beverages among the three households segments, we did not find a clear structure. There are substitutes as well as complementary goods depending on the household segment.

The own-price elasticities for non-alcoholic beverages for the three segments are all negative except for mineral water for light drinking households and cocoa beverages for moderate drinking households. The magnitude of the Hicksian own-price elasticities shows a tendency for higher price sensitivity from light to heavy drinking households, indicating that heavy drinking households are price-sensitive to non-alcoholic beverages in contrast to alcoholic beverages.

Conclusions and policy implications

This paper reports on the income and price elasticities for different alcoholic and non-alcoholic beverage product categories with respect to light, moderate, and heavy drinking households in Switzerland. It is based on microdata of the Swiss household expenditure survey from 2000 to 2009, containing data from more than 34,000 households. We applied a two-stage quadratic almost ideal demand system, correcting for the high share of zero consumption for some product categories at stage 2 and for endogeneity of the expenditure variable. Missing price data were received by adjusting unit values for quality as recently proposed by Aepli and Finger (2013) and Majumder et al. (2012). We tested the model specification with respect to household characteristics as well as the quadratic income term, which distinguishes the QUAIDS from the AIDS. Testing for the overall significance of the household characteristics and the quadratic income terms confirms the model specification. With respect to wine and beer, moderate and heavy drinking households are less price-sensitive than light drinking households are, while for spirits we did not find a difference among the three household segments.

Our findings have major policy implications with respect to the alcohol tax. In general, the higher the negative effects of alcohol consumption and the lower the elasticity, the higher the tax should be set and vice versa. This only holds if we assume a constant elasticity function. By dividing the sample into three segments, we have shown that this does not hold for Swiss households and heavy drinking households are less price-sensitive, in particular with respect to wine and beer, than moderate or light drinking households. To fix the optimal level of a tax on alcohol, the different responses of households to price changes should be considered. As already noted by Manning et al. (1995), the optimal level for an alcohol tax is a trade-off between economic, public health, and social gains due to a reduction in consumption of heavy drinkers and the possible adverse social or even health effects[i] on light or moderate drinkers due to the additional tax burden. Our findings clearly show that the assumption of a constant elasticity function with respect to the three defined segments is violated and that households do not respond similarly to price changes in wine and beer. A tax on those products will therefore lead to a decrease in consumption, especially in light drinking households, and to a lesser extent in moderate drinking households. The effect on heavy drinking households is minimal. From a social and health perspective, this may not be a desirable development. Therefore, before implementing a new tax on alcoholic beverages in Switzerland or in other European countries, the social and health externality costs and the economic effects of a rather small decrease in alcohol consumption among heavy drinking households must be weighed against possible adverse health or economic consequences of a sharp decline in light or moderate drinking households. To a certain extent, our findings for Switzerland can be transferred to other high-income countries and contribute to a differentiated discussion on alcohol tax.

In addition to estimating of the negative external effects of alcohol consumption, a topic for further research will be the estimation of elasticities for different household types with respect to the age of the households' reference person. As Kuo et al. (2003) has already noted, the price response for spirits depends on age. While younger or middle-aged people react more to price changes in spirits, older people are quite inelastic. Our findings show that households react differently to spirits than to wine and beer. Therefore, the findings of Kuo et al. (2003) will probably not hold for wine and beer and a further study should shed valuable light on this question.

Another point of interest is the substitution within a product category, such as shifting from more expensive alcoholic beverages to cheaper ones of lower quality due to a higher tax. Although we were not able to show this effect in our analysis, it is possible that people would buy cheaper products which are likely more risky. Gruenewald et al. (2006) show that consumers respond to price increases by altering their consumption, varying their brand choices as well as substituting between quality classes. This finding has consequences for a tax increase. For example, a tax increase on only high quality alcohol beverages could lead to substitution towards lower quality products and operate as a positive income effect, probably associated with higher consumption of alcoholic beverages in total (Gruenewald et al. 2006). This possibility illustrates the need for research focused on quality substitution.

From a methodological perspective, further research should be conducted on the estimation of price and income for different household segments within a single QUAIDS by introducing cross-terms into the budget share equation, to estimate possible interaction effects between household types and price or income parameters.

Endnotes

[a]After Klonaris and Hallam (2003) conditional elasticities contain only direct effects on demand in comparison to unconditional elasticities, which contain direct and indirect effects. The latter are therefore more relevant in welfare analysis and for policy purposes (Klonaris and Hallam 2003). The reason lies in multistage budgeting; a change in the price for one beverage category at the second stage within beverages (first stage) has a direct effect on the demand of all beverage categories (second stage) but has also an effect on the price index for beverages (first stage) and therefore will influence the allocation at the first stage (beverages and other commodity groups). This could have a further indirect effect on the demand for beverage categories at the second stage.

[b]Adult equivalent is a better proxy for the number of alcohol consuming people in a household than the number of adults because of the relatively high alcohol consumption among people 15 years old or younger in Switzerland (Annaheim and Gmel 2004).

[c]Shonkwiler and Yen's (1999) two-step estimation procedure of does not allow for the incorporation of the adding-up restriction into the model.

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

[e]$\mu_{ij} \equiv \frac{\partial w_i}{\partial \log p_j} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_k \gamma_{jk} \log P_k \right) - \frac{\lambda_i \beta_j}{b(p)} \left\{ \log \left[\frac{m}{a(p)} \right] \right\}^2$

[f]A good is called a luxury good if demand increases more than proportionally as income rises ($e_i > 1$). If demand increases less than proportionally, the good is called a necessity good ($e_i > 1$).

[g]The quality adjusted price for beer (3.00 CHF/Liter) is much lower than the price for wine (10.20 CHF/Liter) or spirits (15.18 CHF/Liter). This supports the interpretation proposed by Dey et al. (2013) that the low price for beer plays an important role with respect to drinking behavior.

[h]The health effects depend on the assumptions made with respect to low or moderate alcohol consumption.

[i]The reduction in sample size in comparison to Table 1 arises due to the deletion of households without consumption of beverages during the data collection period.

Additional file

> **Additional file 1: Appendix. Table S1.** Wald tests for household characteristics. **Table S2.** Wald tests for the quadratic term in the QUAIDS. **Table S3.** Wald tests for endogeneity of the expenditure variable. **Table S4.** Conditional, Marshallian price and income elasticities at stage 2, all households (at sample means). **Table S5.** Conditional, Hicksian price and income elasticities at stage 2, all households (at sample means). **Table S6.** Conditional, Marshallian price and income elasticities at stage 2, light drinking household (at sample means). **Table S7.** Conditional, Hicksian price and income elasticities at stage 2, light drinking household (at sample means). **Table S8.** Conditional, Marshallian price and income elasticities at stage 2, moderate drinking household (at sample means). **Table S9.** Conditional, Hicksian price and income elasticities at stage 2, moderate drinking household (at sample means). **Table S10.** Conditional, Marshallian price and income elasticities at stage 2, heavy drinking household (at sample means). **Table S11.** Conditional, Hicksian price and income elasticities at stage 2, heavy drinking household (at sample means). **Table S12.** Parameter estimates of the budget share equation, Stage 1. **Table S13.** Parameter estimates of the budget share equation, Stage 2, all households. **Table S14.** Parameter estimates of the budget share equation, Stage 2, light drinking household. **Table S15.** Parameter estimates of the budget share equation, Stage 2, moderate drinking households. **Table S16.** Parameter estimates of the budget share equation, Stage 2, heavy drinking households.

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