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MASTER'S THESIS

Sin Tax on Soft Drinks: Possible Impacts in the Czech Republic

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Declaration of Authorship

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Prague, January 5, 2017

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Abstract

Overweight and obesity are a global problem, especially in the developed countries such as the Czech Republic. A sin food tax on products contributing to the creation and expansion of this problem, is a measure which many states have chosen. In the Czech Republic, any sin food tax has never been implemented. The aim of the thesis is to evaluate possible impact of such tax on soft drinks. The key indicator which must be estimated is the own-price elasticity of demand for soft drinks. The data used for the thesis are provided by Czech Statistical Office and contains Household Budget Survey Data from years 2002-2007. Almost Ideal Demand System with the implementation of Shonkwiller and Yen's estimator is evaluated as the most suitable model. The final own-price elasticity is -1.3580, which suggests that the possible increase in Value Added Tax for soft drinks may be efficient. Moreover, it was simulated that there would be a stronger effect in case of lower-income households, where higher prevalence of overweight and obesity is proven.

JEL Classification D11, D12, H31, I18
Keywords overweight, obesity, soft drinks, demand, AIDS, VAT

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Abstrakt

Nadváha a obezita jsou globálním problémem, zejména pak v rozvinutých státech jako je Česká republika. Zvláštní daň na potraviny, které způsobují a prohlubují tento problém, je opatřením, které již zvolilo mnoho států. V České republice ještě nikdy nebyla zvláštní daň na potraviny zavedena. Cílem této práce je vyhodnotit případný dopad zvláštní daně na slazené nápoje na poptávku po nich. Klíčovým indikátorem, který je třeba odhadnout, je vlastní cenová elasticita poptávky po slazených nápojích. Poskytovatelem dat pro tuto práci je Český statistický úřad. Konkrétně byly použity Potravinové deníky domácnosti z let 2002-2008. Jako nejvhodnější model pro tuto práci byl vybrán Skoro ideální poptávkový systém (Almost Ideal Demand System) s implementací Shonkwilerova a Yenova estimátoru. Výsledná vlastní cenová elasticita je -1.3580, což naznačuje, že zvýšení daně z přidané honodty na slazené nápoje by mohlo být účinné. Navíc jsme pomocí simulace zjistili, že efekt by byl silnější v případě domácností s nižšími příjmi, u kterých je prokázaný vyšší výskyt obezity.

Klasifikace JEL	D11, D12, H31, I18
Klíčová slova	nadváha, obezita, slazené nápoje, poptávka, AIDS, DPH

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Acronyms

AIDS Almost Ideal Demand System

CSO Czech Statistical Office

CZK Czech crown

EASO European Association for the Study of Obesity

EU European Union

EURO-PREVOB Prevention of Obesity in Europe - Consortium obesity prevention actions through effective nutrition and physical activity

FAO Food and Agriculture Organization of the United Nations

FBS Family Budget Statistics

ISAO International Association for the Study of Obesity

LES Linear Expenditure System

MLE Maximum Likelihood Estimation

PIGLOG Price-independent generalized linear preferences

QES Quadratic Expenditure System

QUAIDS Quadratic Almost Ideal Demand System

SUR Seemingly Unrelated Regressions

UNICEF The United Nations Children's Fund of the United Nations

VAT Value Added Tax

WHO World Health Organization

Master's Thesis Proposal

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Proposed topic	Sin Tax on Soft Drinks: Possible Impacts in the Czech Republic

Motivation Diabetes is a very serious problem in the Czech Republic. In the year 2000, as many as 6% of citizens suffered from type 2 of diabetes. When measuring the new cases, we are on the first place among all European countries (500 new cases per 100 000 citizens in 2000). Furthermore, $80-90\%$ of diabetes patients suffer from obesity as well. The medical costs of treating diabetes are very high. It is estimated that expenses (including diabetes and other issues connected to it) are between $5-10\%$ of total expenses on health care (Diabetická asociace ČR). Beside diabetes, excessive consumption of sugar leads to overall poorer health (Mytton, 2007). Employing a higher tax burden on soft drinks, which contain sugar or other sweeteners could be a way how to tackle this problem. Several countries managed to introduce tax on sweetened soft drinks in order to reduce the rate of obesity and diabetes. The successful case of such a tax is Mexico where 10% tax on sweetened soft drinks as levied in 2014. In the first year of its existence, the bill managed to cut sales of sweetened soft drinks sugary drinks by 6%. On the contrary, we can observe an example from Denmark where sin tax on saturated fat was introduced in October 2011. It was abandoned 15 months later when it became clear that it had a bad impact on the economy. Instead of changing dining habits the Danish started shopping abroad (Snowdon, 2013). The explanation of this phenomenon lies in the Laffer curve; a concave function that represents the rate of taxation at which maximal revenue is generated. The taxation in Denmark was too high resulting in lower revenue for government. These examples show, that a very careful evaluation of consequences is needed before introducing a new taxation. In this thesis, we want mainly focus on the relationship between price and demand for soft drinks, i.e. the price elasticities of demand. There is a proven relationship between consuming sweetened beverages and poor health (Harnack, 1999), so we will assume that reduction in the demand for soft drinks may lead to a better health status. The core of the thesis will be then a deep evaluation of possible impacts that a soft drink taxation might have in the Czech Republic.

Hypotheses

Hypothesis #1: Taxes are likely to shift consumption in the desired direction.

Hypothesis #2: The effect will be most significant in the short run, decreasing in the long run.

Hypothesis #3: The most affected group will be the poor one, due to larger price sensitivity and poor diet.

Methodology We will analyze Household Budget Survey (Statistika rodinnych uctu) created by the Czech Statistical Office in the period 1998-2007. The survey contains data about income and expenses of Czech households, including socio-demographic data about the respondents. The expenses are divided into various categories, so the data contains information about the amount spent on a specific food category and the quantity of food purchased for that amount. Specifically, we will use the amount spent on syrups, concentrates and other soft drinks together with the quantity bought.

For our thesis, we decided to include beverages that are sweetened with non-caloric sweeteners. No adverse health effects of non-caloric sweeteners have been consistently demonstrated, but there are concerns that diet beverages may increase calorie consumption by justifying consumption of other caloric foods or by promoting a preference for sweet tastes. Since we believe that beverages with non-caloric sweeteners may thus lead to poorer health, we decided to include them in our analysis.

We will first create a probit model to estimate the characteristics of households that buy sweetened soft drinks. This model will help us to determine the characteristics which increase or decrease the probability that a given household buys sweetened soft drinks. To create the model we will use various socio-demographic data about the respondents. The model will be constructed in the following way: $purchase = \alpha + \sum_{i=1}^{n} \beta_i x_i$, where purchase represents if a household exhibits expenses on sweetened beverages and various socio-demographic information about the households are used as explanatory variables.

Using the results from the probit model, we will create an AIDS model to estimate the price elasticities of demand. Specifically we will use the LA/AIDS model, thus a linear approximation of an AIDS model. With such model will we be able to predict changes in the quantity of consumed sweetened soft drinks caused by changes in the explanatory variables. The model will be constructed in the following way:

$w_i = \alpha_i + \sum_j \gamma_{ij} lnPj + \beta_i ln\frac{X}{P}$, where X is the total expenditure on the group analyzed and P is the price index for the group (Deaton and Muellbauer, 1980). The price index is then calculated as follows: $lnP = \sum_k w_k lnPk$(Blanciforti and Green, 1983).

With the knowledge of the price elasticities we will be able to apply different taxation scenarios and to compare their impacts on the consumption of sweetened soft drinks. Since our model will include among other the socio-demographic data about the income of the households, we will observe effects of taxation on various income groups.

Expected Contribution In some countries various sin taxes on food have been introduced and their impacts are mixed. That implies that every country is specific and the impacts of such tax need to be modeled properly. Our goal is to model effects of sin tax on soft drinks in the Czech Republic under different taxation scenarios. Such model could have important policy implications, since some kind of food sin tax was considered by Czech politicians as a solution to worsening health status of Czech citizens.

Outline

1. Literature Review.
2. Data Description.
3. Methodology.
4. Results.
5. Conclusion.

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Chapter 1

Introduction

Worldwide, countries are struggling with the problems of obesity and diet-related chronic disease. A recent study estimated that between 1975 and 2014 the worldwide incidence of obesity rose from 4.8 % to 12.9 % (NCD Risk Factor Collaboration and others 2016). The occurrence is much higher in the developed nations; for example, in the U.S., the incidence of adult obesity is 37.7% as of 2013-2014 (Flegal *et al.* 2016). The annual deaths due to high blood pressure total 7.5 million, high blood glucose (diabetes) 3.4 million, overweight and obesity 2.8 million, and high cholesterol 2.6 million (WHO, 2009). In Mexico, which has the highest per capita consumption of carbonated beverages in the world, the number one cause of death is diabetes. In the U.S., 37% percent of the adult population suffers from cardiovascular disease, 16% has high total blood cholesterol, 34% has hypertension, and 11% has diabetes (USDA, 2010). In the Czech Republic 63% of inhabitants suffer from overweight and 27% from obesity. The circulatory system diseases are the most frequent cause of death (51.1% of cases).

Because of this situation there have been several recommendations to tax energy-dense (i.e. high-calorie), less-nutritious foods; see, e.g. WHO (2015), Brownell & Frieden (2009), Jacobson & Brownell (2000). Probably the most frequent advice is to tax sugar-sweetened soft drinks, which are high in calories and low in nutrient. Consumption of soft drinks does not cause feelings of satiety, so people tend not to reduce the intake of other calories, which leads to an increase in overall calorie consumption and contributes to overweight and obesity (Malik & Hu 2011). Based on these recommendations, several countries have recently levied an extra taxation on sugar-sweetened soft drinks, including Mexico (2014), France (2012), Finland (2011), Hungary (2011), Nauru (2007), Fiji (2006), and Australia (2000). Also, majority of U.S. states tax soft drinks on local level.

In the Czech Republic, any sin food tax was never implied. Our goal is to estimate the possible impact of tax on soft drinks, because of the reasons descibed above. The research questions are: the value of the own-price elasticity of demand for soft drinks, simulated impacts on demand under different Value Added Tax (VAT) rates and the influence of higher VAT rates on different income groups. The elasticity of demand expresses the sensibility of a consumer to the changes on the market, such as an increase in price. To obtain the elasticities, we decided to estimate the demand for all beverages through a demand system. From the various demand systems, which have been studied and improved since 1940's, we chose the Almost Ideal Demand System. For this thesis, we use data from the budget survey collected by the Czech Statistical Office between the years 2002-2007.

The theoretical part of this thesis has two principal goals. Firstly, we aim to describe the situation in the world and in the Czech Republic concerning the obesity and diet-related chronic disease and the possible solution by imposing a sin tax on demonstrably unhealthy food and beverage items. Secondly, we describe the demand systems which are commonly used to analyze the food demand. The empirical goal is to estimate the demand for all beverage categories in Czech households using the most fitting model and proper censoring technique. As a result of this estimation we get, among others, the own-price elasticity of demand for soft drinks. The demand is estimated to be elastic suggesting the effectiveness of taxation. The elasticity is then used to simulate the possible impacts of imposing a higher VAT on soft drinks in the Czech Republic.

The thesis is organized as follows. The next chapter brings the background information about various soda taxes around the world and about the current situation in the Czech Republic. The Chapter 3 contains the literature review, which focuses on the models used for demand estimation and on the research undertaken on the Czech data. The Chapter 4 describes the methodology, including the treatment of censored data and estimation of standard errors. In the Chapter 5 the dataset is described, together with the way of collecting the budget survey data. The results of the empirical part are provided in the Chapter 6. The Chapter 7 discusses the results in the context of other similar studies and the Chapter 8 concludes the thesis.

Chapter 2

Background

2.1 Soda sin taxes around the world

An increasing number of countries are introducing sin taxes on food and drinks. From the policy makers' point of view, it is a way how to correct marker failure when overconsumption of certain goods leads to health problems which are costly to the state's economy. The question of real effects of food sin taxes is still not completely answered. The list of food taxes which have been introduced so far can be found in the Table 2.1.

In some countries, the sin taxes seem to be successful so far such as in Hungary, which introduced a tax on sweetened beverages but also on energy drinks, salted snacks, condiments, fruit preserves, and pre-packaged sweetened products in September 2011. According to the National Institute of Pharmacy and Nutrition in Budapest, 30% of the Hungarian households have reduced their consumption of pre-packaged sweets, 22% of energy drinks, and 19% of sugar-sweetened soft drinks.

In 2011 a tax on products with saturated fat was introduced in Denmark. It was canceled a year later together with the old soft drinks tax from 1930's. The tax on products including saturated fat was a reaction of the Danish government to the growing numbers of obese patients in the country. However, the tax did not reach the goal, mainly because the Danish started to shop groceries abroad, namely in Germany and Sweden, and Danish producer complained about decreasing profits. Moreover, an analysis showed that the demand for products containing fat did not decrease. Customers only switched to cheaper and less quality products (Smed 2012). The Danish Medical Association proclaimed that the government prefers short-term economic benefits

Table 2.1: Various food taxes

Country	Year of Introduction	Food taxed	Tax rate
US	Various	Sugar sweetened drinks (in 23 states)	1-8%
Norway	1981	Sugar, chocolate, and sugary drinks	Variable
Samoa	1984	Soft drinks	0,18$/L
Australia	2000	Soft drinks, confectionery, biscuits, and bakery products	10%
French Polynesia	2002	Sweetened drinks, confectionery, and ice cream	0,66$/L for imported drinks
Fiji	2006	Soft drinks	5% for imported drinks
Nauru	2007	Sugar, confectionery, carbonated drinks, cordial and flavored milks	30% import levy
Finland	2011	Soft drinks and confectionery	Soft drinks 0,075EUR/L; confectionery 0,75EUR/kg
Hungary	2011	Food high in sugar, fat, or salt and sugary drinks	0,05$ per item
Denmark	2011	Products with more than 2,3% of saturated fat: meat, dairy products, animal fats, and oils	2,84$/kg of saturated fat
France	2012	Drinks containing added sugar or sweetener	0,72EUR/L
Mexico	2013	Soda,junk food	0,08USD/L;5% for junk food
St. Helena	2014	Sugar-sweetened carbonated drinks with more than 15g of sugar per liter	0,75 GBP/L

Source: Mytton, 2012 and author's own research

over long-term health benefits for Danish population and that one year is a too short time to evaluate the situation.

France introduced a tax on all drinks with added sugar or sweetener in 2012 in the amount of 7.16 cents per liter. In the analysis of the impacts of the tax Berardi *et al.* (2016) examined the shifting of the tax into the prices of three beverage categories. Six months after the introduction, the tax fully shifted to soda prices and almost fully shifted to prices of fruit drinks, while the pass-through for flavored waters was only partial. There were also differences among brands and retailing groups. The private brands and small producers experienced an over-shifting, while large producers experienced under-shifting. Also, the two main retailing groups in France passed-through the soda tax less than the other ones, meaning that the prices did not rise as much as the tax.

Mexico is currently a country with the most obese inhabitants per capita in the world. As many as 70% of adults suffer from overweight or obesity. Children represent the riskiest group, where obesity rates tripled in the recent years (Barquera *et al.* 2009). In 2004, obesity-related non-communicable diseases caused 75% of total deaths and 68% of total disability-adjusted life years in Mexico (Stevens *et al.* 2008). The government started to fight this problem in 2013 when they introduced a tax on soda drinks and various kinds of junk food. Moreover, the Mexican president Peña Nieta started a campaign to fight obesity and appealed on the citizens to exercise more. It is still too early to evaluate the impacts of the tax, but Rtveladze *et al.* (2014) tried to project the situation without any intervention from the state, using Mexican Health and Nutrition Surveys from 1999 and 2002 and Mexican Health and Nutrition Survey from

2006. The authors projected that by 2050 the proportion of normal weight will decrease to 12% for males and 9% for females respectively (compared to 32% and 26% in 2010). They also projected that 1% reduction in BMI prevalence could save $US 43 million in health-care costs in 2030 and $US 85 million in 2050.

The United States do not have a nation-wide soda tax, but many states impose a tax on soft drinks. However, the taxes are largely for revenue generation rather than for public health purposes; diet versions are taxed the same as caloric soft drinks (Fletcher *et al.* 2015). Yet, several of the US cities introduced their own tax on sugary drinks. Berkley was the first one with imposing a tax of one cent per ounce on the distributors of specified sugar-sweetened beverages at the beginning of 2015. In a recent study, Cawley & Frisvold (2015) estimated that, across all brands and sizes of products examined, 43.1% of the Berkeley tax was passed on to consumers. Interestingly, for Coca-Cola and Pepsi only 22.1% of the tax was passed on to consumers. Later study showed that consumption of sugary drinks decreased by 21% in Berkeley with the most significant effect on low-income families (Falbe *et al.* 2016). The city of Philadelphia approved a similar tax of 1.5-cents-per-ounce effective from January 2017.

2.2 Current situation in the Czech Republic

The rising epidemic of obesity has become one of the biggest problems of public health next to smoking and mental health, discussed within the EU. Policy makers, governmental, and non-governmental organizations are trying to respond to this growing trend by using decrees, laws, and other initiatives aiming to reverse it. The United Nations is a major player in international public policy. It includes WHO, FAO, UNICEF, Standing Committee on Nutrition, Commission on Macroeconomics & Health. Since 2002, the international scene has also ISAO (International Association for the Study of Obesity). The European Commission, which is currently working closely with the WHO (its European Office) and EASO (European Association for the Study of Obesity) in fighting the obesity, plays a major role in Europe. At the national level, it is all about individual ministries (health, education, transport, culture, agriculture, and industry), parliaments, civil society organizations and other institutions.

According to Central Intelligence Agency (2016) in 2014 63% of Czechs suffered from overweight and 27% from obesity. This was an increase compared to the year 2010, when 61% of inhabitants suffered from overweight and 25% from obesity. In 2013 STEM/MARK, a.s. agency conducted a research of obesity in the Czech Republic. Among other alarming results, it showed that 20-30% of children are overweight or obese. When studying their preferred consumption choices, it appeared that 25% prefer hamburgers, hot-dogs, chips, and sweets and 55% prefer a sweet drink if given a free choice. The overview of the overweight and obesity in the Czech Republic, Europe and World can be seen in the Figure 2.1.

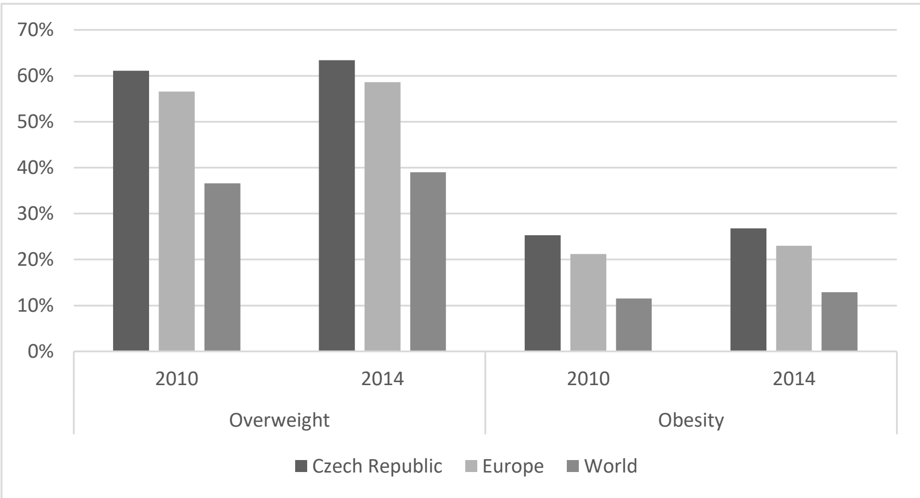

Figure 2.1: Overweight and Obesity (%)

Although obesity is among major factors which are involved in the occurrence and development of several serious diseases, the Czech Republic has not yet developed any specific strategy in the fight against obesity epidemic. In 1991 a short-term strategy of the National Health Programm(Government Resolution no. 247/1991) was approved and in 1993 a medium-term strategy of the National Health Programmed (Government Resolution no. 273/1992) was approved. The long-term strategy of the National Health Program was negotiated in 1995. This strategy primarily aimed at increasing people's knowledge about healthy way of life and the possibilities for disease prevention, encouriging changes in behavior and creating coalitions for the realization of health promotion in the community. In 2002, the Czech government signed the Declaration of the WHO Health for All in the 21st Century (Health 21) as a long-term program for improving health (Government Resolution no. 1046/2002). The program, approved in 1998 at the 51th World Health Assembly, aimed to improve the health status of the population in the 21st century and provided 21 specific measures to implement those objectives. Health 21 followed all previously approved documents which dealt with public health.

In 2004 when the Czech Republic became a member of the European Union the National Council for Obesity was established as a permanent specialized advisory institution for the Ministry of Health. Its task was to design and implement the National Action Plan to combat obesity, which is based on the WHO Global Strategy on Diet, Physical Activity, and Health. This Council is composed of ministers of various ministries (Health, Agriculture, Interior, Education) and representatives from specialized institutions, health insurance companies, and voluntary organizations. In 2005, the Ministry of Health founded a specialized group to implement the Children's Environment and Health Action Plan for Europe (CEHAPE). This action plan focuses on environmental risk factors that most affect the health of European children. Between 2007-2010 the Czech Republic participated in the project EURO-PREVOB (Prevention of Obesity in Europe - Consortium obesity prevention actions through effective nutrition and physical activity). This project was funded by the European Commission and its aim was to promote and to support cooperation within existing networks to meet social and economic factors of obesity in Europe. The latest activities of the EU including the Czech Republic focus on awareness. According to EU Regulation no. 1169/2011 on the provision of food information to consumers, all packed food products have to state the information about nutrition contained in the product since December 2016.

Recently, Czech government focuses on fighting childhood overweight and obesity. Vyhláška o požadavcích na potraviny, pro které je přípustná reklama a které lze nabízet k prodeji a prodávat ve školách a školských zařízeních[1] apllies since September 2016 (282/2016 Sb.). According to the decree all food containing sweeteners, trans-fatty acids and all energy drinks are forbidden for advertising and sale in school premises, where children with compulsory school attendance occur.

Several marginal taxes exist in the Czech Republic, like excise taxes on alcoholic and cigarettes. However, no taxation that would fight and prevent overweight and obesity has ever been introduced. The estimation of the impact of raising VAT on soft drinks could serve as a proxy for impact of raising VAT on all products containing sugar. To the best knowledge of the author no food-related taxation bill is currently being prepared. For a better overview of the

[1] The Decree on Requirements for Food, which is Allowable for Advertising and for Sale in Schools.

current situation we list the groups of food products taxed by different VAT rates.

- VAT 10%: baby food and food for young children, cereal products, malt, starches, wheat gluten, modified cereal products and ready-mix for the preparation of food for people intolerant to gluten.
- VAT 15%: Food and beverages (excluding alcohol), including catering services.
- VAT 21%: Alcoholic beverages, which are also subject to excise duty.

Chapter 3

Literature review

3.1 Analysis of consumer behavior through demand systems

Economists have always been interested in examining consumer behavior, since it is a key factor in market based system. The choices a consumer makes and the preferences which he shows through his choices are the determinants of the behavior of the whole economy. Therefore, there are many models providing information about consumer behavior and the whole demand system.

The models can be divided into two categories, single- and multi-equation systems (Anwar *et al.* 2012). The single-equation models were frequently used in the past. Their main aim was to estimate the elasticities and they did not consider the consumer theory sufficiently (Lee *et al.* 1994). The partial isolation of these models from some important theoretical relationships may cause their inaccuracy and distortion (Syrovátka 2006). On the contrary the multi-equation models are able to capture the complexity of all demand functions, which shape the scope and structure of monitored consumer baskets (Syrovátka 2006). The current models aim at estimating the whole demand systems through the system of simultaneous equations. Thus, the models manage to consider interdependence among commodities in the consumer basket. The specific form of the model than influences the way of estimating the price and income elasticities.

Kumar *et al.* (2011) claims that there are two requirements for building the models which study the demand for food commodities. First, the model should be flexible enough to allow income elasticities to differ across income groups. This is important as income elasticities of food demand generally fall with rise in income. Second, the model should be able to include the cases of zero consumption of a specific food commodity by a household. The extraction of these households may lead to bias.

There is no general rule that states which model is the best for a specific dataset and situation. The researcher must consider the type of the data and what exactly he wants to examine and then determine the most suitable model for his analysis. As Syrovátka (2006) claims the researchers must realize that they are still working with theoretical models of real demand systems and that the results are just approximations of real consumer behavior. Moreover, the quality of accuracy of achieved results is always influenced by the choice of the model.

Currently, the most popular model is Almost Ideal Demand System (AIDS) developed by Deaton & Muellbauer (1980). The authors of the studies which use this model claim that it is simple, clear, consistent with consumer theory and easy to apply on time series data. According to Davis *et al.* (2009) the AIDS is an almost perfect demand system. Studies applying AIDS or its modification: Romero-Jordán *et al.* (2010), Janda *et al.* (2009), Li *et al.* (2006).

We chose the AIDS model as well. Mainly for its simplicity and it is one of the most widely used models for examining the consumer demand through budget survey data in the last three decades. We will describe models which preceded the AIDS, namely the Linear Expenditure System (LES) and the Quadratic Expenditure System (QES) in the following sections. Also, we will describe the Rotterdam model and the Translog model, which estimate the demand system in a different way that the AIDS model.

3.1.1 LES and QES

The crucial paper in the development of estimating demand system was written by Stone (1954). As a first economist Stone (1954) used LES developed by Klein & Rubin (1947) to estimate the whole demand system. Stone (1954) sets five objectives to his research. The first one is to: "derive a practical system of demand equations which possess properties usually considered desirable from the standpoint of elementary economics" (Stone (1954), pp. 2). In other words, he wanted to develop a system of equations which will be able to describe demand system properly and be consistent with microeconomic theory at the same time. To obey the later requirement, he set to himself three conditions.

- Additivity: The sum of the individual expenditures in the system must be equal to the total expenditure. Mathematically it can be described as: $\sum_{j=1}^{n} p_j q_j \equiv \mu$, where p and q are price and quantity and μ stands for total expenditure.

- Homogeneity: This means that for each commodity the sum of total expenditure elasticity and all the price elasticities equals zero.

- Symmetry of the substitution matrix: This is basically Slutsky equation, which must be valid in cross-relations, i.e. for good ij as well as for ji. In other words, the demand effects must be symmetric to both sides.

Under these conditions, Stone derived the system of equations which must be estimated simultaneously. The name of the model comes from the fact, that expenses on single commodities are expressed as linear functions of total expenditures and prices. LES, linear expenditure system, is determined by the equation:

$$p_i q_i = p_i \gamma_i + \beta_i (w - \sum_{j=1}^{n} p_j q_j) \tag{3.1}$$

where

$$x_i - \gamma_i > 0, 0 < \beta_i < 1, \sum_i \beta_i = 1$$

In the equation p stands for price, q for quantity. The equation contains two unknown parameters: β_i and γ_i, where β_i - marginal share of i-th good on expenditure - is temporarily estimated and consequently used for estimation of γ_i-quantity of good i. With the estimated γ_i, β_i can be reestimated more precisely. This process is then repeated until the parameters are stable. The estimation is made for n commodities. Stone (1954) analyses the problems which may occur while using this model. One of the main issues is that the three conditions stated above are fulfilled by the model by definition. Thus it cannot be verified if a specific system would truly fulfill them. The next objective of his paper (after deriving a system of equations) was to apply his system to data from Great Britain from the years 1920-1938. He compared his estimations with real data and within the most groups he achieved a correlation coefficient over 0.9.

The LES model has some limitations. Together with its extensions like QES it assumes that utility function has an additive form and that all goods are net substitutes. Therefore, it allows little flexibility in the price coefficient. Moreover, the model does not allow inferior goods. It cannot deal with long range of variation of income and implies linear Engel functions. The existence of linear Engel functions was never empirically supported.Also, it is appropriate only for short term predictions. Therefore it is mostly suitable for analysis of broad aggregate groups.

Despite these limitations LES can still be used in specific situation as an appropriate model. Pollak & Wales (1978) for example used LES and QES to estimate the complete demand systems from household budget data. According to the paper the authors opted for this model because they had a small number of budget studies and therefore limited price variation. Also, it was suitable for their objective to incorporate any set of demographic variables into the complete system of demand equations. Their empirical results were generally good: regularity conditions were almost always satisfied, and there was significant improvement of the results connected with transition from the LES with no family size effects to the QES with family size effects. The LES model was also used in the more recent studies. For example in the study from Berges & Casellas (2002) which works with Argentinian data. They defend their choice of the model by stressing its simple and straightforward interpretation and its automatic fulfillment of microeconomic conditions set by Stone. Nevertheless, the authors adjusted the model to the modern econometric theory. For the estimation they used Seemingly Unrelated Regression (SUR) to be able to express price and income elasticities precisely.

3.1.2 Rotterdam demand system

The Rotterdam model was firstly used by Theil (1965) and shortly after by Barten (1977). Their approach is similar to Stone (1954) by using the method of linear expenditure system, but it uses differentials instead of logarithms. Another difference is that the Rotterdam model is defined directly by Marshallian demand function. Expenditure and indirect utility function are not specified. Therefore, the model is more general and does not require the definition of price index function like LES and AIDS models do. The demand function has the following form:

$$\frac{w_i + (w_i)_{-1}}{2} \Delta(log(q_i)) = A_i + B_i \Delta(log(\bar{\mu})) + \sum_j C_{ij} \Delta(log(\bar{p}_j)) + u_i, \quad (3.2)$$

where $\bar{\mu}$ is real income and $\bar{p}_j$ is the deflated price of the jth commodity:

$$\bar{\mu} = \frac{\mu}{p}, \qquad \bar{p}_j = \frac{p_j}{p^*}, \qquad \Delta(log(p^*) = \sum_i B_i \Delta(log(p_i)). \tag{3.3}$$

Lately, the model has been used by Anwar *et al.* (2012). He applied the Rotterdam model on the set of nine major commodities (wheat, rice, chicken, mutton, milk, apple, mango, potato, onion) of Pakistan. The model was calculated by employing SUR estimation method on budget survey data from 2007-2008. Own-price, cross-price and income elasticities were calculated.

Another study was conducted by Svensson (2013). Since the Swedish consumers have decreased the budget share spent on food commodities during the end of the 20th century he decided to analyze the Swedish demand for food over the period 1980-2011. By estimating the price and income elasticities he confirmed his hypothesis that the Swedish demand is insensitive to price changes.

3.1.3 Translog demand system

Since the beginning of the 70s the concept of flexible functional form is known to mathematical economics and econometrics. Its main feature is the presence of flexible explanatory variables, which relate to a relatively large number of parameters of any flexible shape. One and perhaps the most typical representative of flexible shapes is called Transcendental logarithmic function (translog). It was used by Christensen *et al.* (1975) to create the Translog demand system, which is a combination of two dual systems. In the first one the direct translog utility functions are used to describe the system of indirect demand functions and in the second one indirect translog utility functions describe the system of direct demand functions. The direct translog utility function has the form:

$$lnU = lnU(x_1, x_2, ..., x_m), \tag{3.4}$$

which can be transformed to

$$-lnU = \alpha_0 + \sum_i \alpha_i lnx_i + \frac{1}{2} \sum_i \sum_j \beta_{ij} x_i x_j. \tag{3.5}$$

The indirect traslog utility is derived as:

$$lnV = lnV\left(\frac{p_1}{\mu}, \frac{p_2}{\mu}, ..., \frac{p_m}{\mu}\right), \tag{3.6}$$

which can be transformed to:

$$lnV = \alpha_0 + \sum_i \alpha_i ln\frac{p_i}{\mu} + \frac{1}{2}\sum_i\sum_j \beta_{ij}\frac{p_i}{\mu}\frac{p_j}{\mu} \tag{3.7}$$

.

Applying the logarithmic version of Roy's identity to the utility function brings share equations of the form:

$$w_j = \frac{p_j x_j}{\mu} = \frac{\alpha_j + \sum \beta_{ij} ln x_i}{\sum \beta_{ki} ln x_i} \tag{3.8}$$

for the direct translog utility function and

$$w_j = \frac{p_j x_j}{\mu} = \frac{\alpha_j + \sum \beta_{ij} ln\frac{p_i}{\mu}}{\sum(\alpha_k + \sum \beta_{ki} ln\frac{p_i}{\mu}} \tag{3.9}$$

for the indirect translog utility function. The aim of Christensen *et al.* (1975) was to test the theory of demand without imposing the assumptions of additivity and homotheticity as part of the maintained hypothesis for individual commodities or for commodity groups. They tested it on time series data for U. S. personal consumption expenditures for 1929-72. The $(K-1)$ equations were estimated by Maximul Likelihood Estimation (MLE). After the series of tests the authors concluded that the theory of demand is inconsistent with the evidence.

The translog model can be also used on censored data as showen by Yen *et al.* (2002). They estimated household demand for fat and oil. Their prediction was based on cross-sectional data from the 1987-1988 US Nationwide Food Consumption Survey. The two-step procedure was conducted using the Shonkwiler & Yen (1999) estimator. Own price, total expenditure and compensated elasticities were estimated.

3.1.4 AIDS

Deaton & Muellbauer (1980) introduced a completely new model for estimating consumer demand in article: *"An Almost Ideal Demand System"*. As we mentioned before, after introduction of Stone's work (1954) many new models were proposed. When AIDS was introduced, the Rotterdam and the translog models already existed. Deaton & Muellbauer (1980) claim, that their model is of "comparable generality", but has some advantages over both of them. In that matter they highlight simplicity of estimation which avoids the need for non-linear estimation and flexibility of its application. They also say, that it is consistent with consumer theory and known household-budget data. Deaton & Muellbauer (1980) build on preference model PIGLOG (Price-independent generalized linear preferences), which allows to put all households togehther into one representative. The basic equation of the AIDS model looks as following:

$$w_i = \alpha_i + \sum_j \gamma_{ij} ln(p_j) + \beta_i ln\left(\frac{x}{p}\right), \tag{3.10}$$

where

$$lnP = \alpha_0 + \sum_k \alpha_k ln(p_k) + \frac{1}{2}\sum_j \sum_k \gamma_{kj} ln(p_k) ln(p_j) \tag{3.11}$$

The variables are defined as: w_i is the share of expenditures spent on good i, p are prices, x is total expenditure, P is a price index and α, β and γ are the coefficients. If all β coefficients are zero than all income elasticities are equal to one. Negative β stands for necessary good, positive for luxury one. Then the model contains restrictive conditions:

$$\sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \gamma_{ij} = 0, \sum_{i=1}^{n} \beta_i = 0 \tag{3.12}$$

$$\sum_j \gamma_{ij} = 0 \tag{3.13}$$

$$\gamma_{ij} = \gamma_{ji} \tag{3.14}$$

At the beginning of describing Stone's model we stated his three necessary conditions for a demand system to be consistent with microeconomic theory. By the restrictive conditions, additivity (3.12), homogeneity (3.13) and Slutsky equation (3.14) all are satisfied. The derivation of the model is based on the utility maximization. In case that the maximization is not consistent with reality it is enough not to obey conditions (3.13) and (3.14). The authors themselves suggest to estimate the equations by MLE. However they also suggest that if price index P is known, the equations may be estimated by OLS method. To estimate the price index, the so called Stone's index can be used: $lnP^* = \sum w_k ln(p_k)$. If we imply that $P \simeq \phi P^*$, the equation transforms to:

$$w_i = (\alpha_i - \beta_i ln\phi) + \sum_j \gamma_{ij} ln(p_j) + \beta_i ln\left(\frac{x}{P^*}\right) \tag{3.15}$$

This specific version of AIDS model is called LA/AIDS. Similarly to Stone (1954), Deaton & Muellbauer (1980) deeply discuss all characteristics and possible limitations of their model. For that purpose, they directly tested their model on yearly data form Great Britain from period 1954-1974. Their parameter estimations are consistent with results from other papers. Later, they tested the homogeneity and symmetric conditions and declined them both. It is one of the advantages of the AIDS model over LES, that these conditions can be tested and are not explicitly given.

Blanciforti & Green (1983) reacted to the AIDS model three years later after its introduction. They go back to the findings from AIDS model with aim to create the dynamic version of the original model, which will contain the consumers' customs. Their adjustment is based on single equation:

$$\alpha_i = \alpha_i^* + \alpha_i^* q_{it-1} \tag{3.16}$$

By this equation they involved the custom as a quantity consumed in the previous periods q_{it-1}. They tested the model on time series data from the USA from period 1948-1978. The model for 11 commodity groups like food, alcohol, tobacco, clothes and transport were estimated by OLS and 4 special food groups - meat, fruit, vegetables and others were estimated by MLE. Their results indicate that the AIDS model incorporating habits and allowing for autocorrelation is closer to the reality that the original one. Therefore, they find it more appropriate for modeling consumers' behavior.

The estimation of the elasticities is an integral part of creating the AIDS model. Green & Alston (1990) and Green & Alston (1991) are examining this problem in their work. They point out that specific equations for estimating the elasticities are not used in many studies and show how the final results can vary if the way of elasticity calculation differs. Mostly they focus on differences between AIDS and LA/AIDS model. According to Green and Alston the elasticities should be calculated in the following way:

- AIDS - income elasticity $e_M^i = 1 + \frac{\beta_1}{w_i}$
- AIDS - uncompensated price elasticity $e_{pj}^i = -\delta_i j + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i \alpha_i}{w_i} - \frac{\beta_i}{w_i} \sum_k \gamma_{kj} lnp_k$
- LA/AIDS - income elasticity $e_M^i = 1 + \frac{\beta_i}{w_i}\left[1 - \sum_j w_j lnp_j \left(e_M^j - 1\right)\right]$

- LA/AIDS - uncompensated price elasticity $e^i_{pj} = -\delta_i j + \frac{\gamma_{ij}}{w_j} - \frac{\beta_i w_i}{w_i} - \frac{\beta_i}{w_i}\left[\sum_k w_k lnp_k \left(e^k_{pj} - \delta kj\right)\right]$,

where δ_{ij} is Krockner's delta, which is equal to 1 for $i = j$ and to 0 for $i \neq j$. It is important to mention that in different studies the formulas for calculating elasticities may differ (simple versions are used in several of them) but Green & Alston (1990) consider them to be correct only under additional restrictions.

In reaction to above mentioned papers Hahn (1994) claims, that all AIDS model adjustments (including LA/AIDS) do not completely satisfy required theoretical conditions for all combinations of prices and expenditures and are threatened by estimation bias while using proxy for price index. Therefore he recommends, if possible, to use the original model without linear or any other adjustments. He proves his theory by mathematical transformations of the models.

3.1.5 QUAIDS

The most recent version of the AIDS model is quadratic AIDS (QUAIDS), which assumes the relationship between income and expenditure to be non-linear. It was developed by Banks *et al.* (1997) during their examination of the impacts of indirect taxes. They found out that for some goods the current versions of the model are not accurate enough. It was an impulse for them to create an alternative version of the AIDS model which will be more suitable for their purposes. In their words they derived the complete series of integratable quadratic logarithmic systems of expenditure shares. It means, that they included a natural logarithm as a variable of income and a quadratic natural logarithm as a variable of total expenditure. QUAIDS allows the goods to be necessary for some levels of income and luxury for the others, which is an important feature of this model.

The basic equation of the model can be written as:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} lnp_j + \beta_i ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left[ln\left[\frac{m}{a(p)}\right]\right]^2, \qquad (3.17)$$

where $a(p)$, $b(p)$ and $\lambda(p)$ are differentiable functions of price vector p. Banks *et al.* (1997) then applied their model to cross-sectional data from Great Britain from years 1970-1986. The results were found consistent.

3.2 Studies on Czech data

This section is divided into two parts. In the first one, we discuss the existing articles estimating demand systems on the Czech data. In the second one, we provide an overview of the literature on impacts of VAT in the Czech Republic.

3.2.1 Estimation of demand using Czech data

The demand for various food groups in the Czech Rebublic has been estimated for years. One of the early works dealing with price and income elasticities of food demand was written by Ratinger (1995) and expanded by Janda & Rausser (1998). The aim was to apply Deaton & Muellbauer's (1980) AIDS model on the Czech data. Ratinger (1995) used a linear version of the model to estimates the Czech domestic food demand and Janda & Rausser (1998) added a non-linear model and estimated food import demand elasticities. They confirmed the hypothesis that the past values of import prices do not determine the level of domestic prices. Janda *et al.* (2000) continued with the study of food import demand aiming to create *"a set of import demand elasticity estimates which could be used in economic analysis and in building structural models of the Czech economy or which could be used as an approximation of import demand elasticities in modelling other Central European transition economies"* (Janda *et al.*, 2000, pp.21). They discovered that all commodity groups tend to be normal goods with positive income elasticities and almost all of them to be Hicksian substitutes. There were even studies focused on some specific food groups - like alcoholic beverages. Janda *et al.* (2010) not only deal with estimation of demand elasticities but also consider possible taxation of the alcoholic beverages. They claim that due to the different elasticities and substitutional relationships among alcoholic beverage cathegories (beer, wine, spirits) an optimal tax solution does not mean tax hamonization, rather an individial treatment of every cathegory. There are also foreign researches, who used Czech data like Crawford *et al.* (2003). In their research they try to come up with a new approach to the estimation of demand systems on the basis of unit values. They apply this estimation on the Czech budget survey data, using 8 goods cathegories out of which 6 are food.

3.2.2 Impacts of VAT in the Czech Republic

The Czech Republic introduced VAT in 1993. It applies to most of household expenditures in the form of its three rates. Since 2016 the VAT rates in the Czech Republic are 10%, 15% and 21%. VAT and its changes in the Czech Republic have been studied by Schneider (2005), who analysed tax burden of households and found VAT in the Czech Republic to be relatively regressive. The negative effect is mostly felt by the by the low income households, where VAT consumes 15-25% of their market income. There is no significant progressivity in the upper half of income distribution. Then Slintáková *et al.* (2010) focused on the impacts of VAT harmonization connected with the accession of the Czech Republic to the EU. They follow Schneider (2005) in claiming that VAT is relatively regressive under annual income analysis, but concurrently detect that under lifetime income analysis VAT is progessive, due to the tendency of lower-income households to consume less-taxed products and of higher-income households to consume more taxed products. In accordance with this finding Slintáková *et al.* claim that in the long-run a shift from the income taxation towards the consumption taxation would lead to improved economic efficiency. Dušek & Janský (2012a) then used a micro-simulator to provide estimates of the impact of the then proposed VAT rates changes in the Czech Republic on the living standards of households and tax revenues. In 2011 it was proposed at first to raise reduced rate from 10% to 14% and then to unite the rate to 17,5%. Dušek & Janský's (2012a) findings generally support the previous ones that the VAT raising has regressive impact, althoug its very moderate. For example the unification of the VAT rate to 17,5% has 0,9% lower impact on the highest-income decile than on the mostly affected decile. Janský (2014) then continued the study of then proposed VAT reforms and estimated a QUAIDS model to simulate its impacts using the own- and cross-price and income elasticities. The incorporation of behavioral response brought significantly different resuls than micro-simulation which keeps the quantity of goods and services purchased fixed meaning lower estimated tax revenue using the fisrt method.

Chapter 4

Methodology

4.1 Estimation of QU/AIDS model

Deaton and Muellbauer suggested the estimation of QU/AIDS model by MLE and we will follow this suggestion. The first step of deriving the likelihhod function is to make a distrubutional assumption. As in the most applications, the multivariate normal distrubution of disturbances is assumed:

$$\boldsymbol{u} \sim N(\boldsymbol{u}, E) \tag{4.1}$$

From the probability density function

$$f_u(u_1, ..., u_K) = \frac{1}{\sqrt{|\boldsymbol{E}|(2\pi)^K}} \cdot exp\left\{-\frac{1}{2}(\boldsymbol{u}-\boldsymbol{\mu})'\boldsymbol{E^{-1}}(\boldsymbol{u}-\boldsymbol{\mu})\right\} \tag{4.2}$$

the log-likelihood function can be derived for N observations and K equations

$$L_N = -\frac{N}{2}ln(|\boldsymbol{E}| - \frac{NK}{2}ln(2\pi) - \frac{1}{2}(\boldsymbol{u}-\boldsymbol{\mu})'\boldsymbol{E^{-1}}(\boldsymbol{u}-\boldsymbol{\mu}) \tag{4.3}$$

Because of the adding-up condition ($\sum w_i = 1$) the covariance matrix $\boldsymbol{\Sigma}$ is singular. Thus one of the K demand equations is dropped and only $(K-1)$ equations are estimated. Barten (1969) showed that it does not make a difference which equation is dropped. If we follow Poi *et al.* (2002) and modify the last term in the equation 4.3 we can obtain the log/likelihood function to estimated $(K-1)$ equation:

$$L_N = -\frac{N}{2}ln(|S|) - \frac{N(K-1)}{2}ln(2\pi) - \frac{N(K-1)}{2} \quad (4.4)$$

where

$$S \equiv \frac{1}{N}\sum_{h=1}^{N} \hat{u}_h\hat{u}'_h, \hat{u}'_h \equiv [w_{1h} - \hat{w}_{1h}, ..., w_{K-1,h} - \hat{w}_{K-1,h}] \quad (4.5)$$

Now, the coefficients of (K-1) equations can be estimated based on the previous equation. The AIDS model can be written in a single equation including the price index P:

$$w_i = (\alpha_i - \beta_i ln\phi) + \sum_j \gamma_{ij} ln(p_j) + \beta_i[ln(\mu) - \sum_j \alpha_j lnp_j - \frac{1}{2}\sum_j\sum_k \gamma_{jk} lnp_j lnp_k] + \mu_i \quad (4.6)$$

The elasticities of the AIDS model are (Green and Alston, 1990, 1991):

- income elasticity $e^i_M = 1 + \frac{\beta_i}{w_i}$
- uncompensated price elasticity $e^i_{pj} = -\delta_i j + \frac{1}{w_i}(\gamma_{ij} - \beta_i\alpha_j - \beta_i \sum_k \gamma_{kj} ln(p_k))$

and for QUAIDS Banks *et al.* (1997):

- income elasticity: $e^i_M = 1 + \frac{1}{w^*_i}(\beta_i + 2\lambda_i(\Pi_i p_i^{\beta_i})^{-1} ln(\frac{\mu}{P})$
- uncompemsated price elasticity:

$$e^i_{pj} = -\delta_i j + \frac{1}{w_i}\Bigg\{ - \left(\beta_i + 2\lambda_i \left(\Pi_i p_i^{\beta_i}\right)^{-1} ln(\frac{\mu}{P}\right) \\ (\alpha_j + \textstyle\sum_k \gamma_{kj} ln(p_k)) - \lambda_i\beta_j(\Pi_i p_i^{\beta_i})^{-1}(ln(\frac{\mu}{P}))^2 + \gamma_{ij}\Bigg\}$$

4.2 Shonkwiler and Yen's estimator

There are three types of data used for the demand analysis: time series, budget survey and scanner data. Nowadays, the budget survey data is widely used, since it directly provides sociodemographics characeristics about the households. However, it is the only type of data where zeros can occur in the dataset. Zero means that the household does not consume a given food (beverage in our case) in a given period. The zero consumption has four main explanations. First is that the consumer is not interested in the product at all. Second is that the zero is the corner solution of his utility maximization problem. That means that at the given moment the price is too high or that the substitutes are evaluated as a better choice. The third is that the examined period is too short and the given item is bought only once over a longer period of time. In our case the households keep their food diary for two month in a year. Which is long enough period for purchasing beverages like juices or soft drinks, but spirits for example might be bought over a longer period of time. The last explanation is that the data is missreported.

As we are using a budget survey data, they naturally suffer from the selectivity problem. In the literature two approaches are used to construct censored systems. The first is a one-step solution incorporated in the maximum likelihood estimation, which is rather demanding and involves complicated calculations. Therefore, the second approach: two-step estimation procedure are more popular and simpler for application. The only disadvantage of the two-step estimators is the need to adjust the covariance matrix as devised by Murphy & Topel (1985). The mostly-used estimators are Heien & Wesseils (1990) and Shonkwiler & Yen (1999). We decided to use Shonkwiler & Yen (1999). They performed a Monte Carlo simulation to compare their estimation with Heien & Wesseils (1990) and proved the later one to perform poorly for high leves of censoring.

4.2.1 First stage: Probit model

The basic idea of this method is to run a probit regression in the first step to determine the pattern of censoring. A probit model is a binary response model, which general form is expressed as:

$$Prob(y = 1|\mathbf{x}) = G(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k) = G(\beta_0 + \mathbf{x}\beta), \qquad (4.7)$$

where $\mathbf{x}$ denotes a full set of independent variables, $\beta_0, ..., \beta_k$ are parameters to be estimated, and for all real numbers z, G stands for a function strictly between 0 and 1, that is $0 < G(z) < 1$. This condition implies that the estimated response probabilities can only range from 0 to 1 (Wooldridge 2015).

The two mostly used G functions are the logistic function

$$G(z) = \frac{exp(z)}{[exp(z) + 1]} = \Lambda(z), \qquad (4.8)$$

and the standard normal Cumulative Distribution Function (cdf)

$$G(z) = \Phi(z) = \int_{-\inf}^{z} \phi(\nu) d\nu, \tag{4.9}$$

where $\Phi(z)$ is the standard normal density:

$$\Phi(z) = \frac{1}{2\pi} exp(-z^2/2). \tag{4.10}$$

The shapes of both functions are similar. Both functions $G(z)$ are increasing in z, most quickly when $z = 0$. For $z \to -\inf$ we have $G \to 0$ and $G \to 1$ as $z \to \inf$. When the logistic function is used, the model is called logit and for standard cdf the model is called probit. There is no evidence for one of them to be better than the second one. Since in all relevant literature a probit model is used for Shonkwiler and Yen's estimator, we chose it as well.

Both of the models are derived from and underlying *latent varibale model*, where y^* is an unobserved variable, determined by

$$y^* = \beta_0 + \beta \mathbf{x} + e, y = 1[y^*]. \tag{4.11}$$

The function $1 = [\cdot]$ is an *indicator function*, which is equal to one, if the event in the brackets is true and zero if otherwise. In our case the event is the consumtion of selected beverage. This can be described as:

$$y = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{if } y^* \leq 0 \end{cases}$$

We assume that e is independent of $\mathbf{x}$ and that it has the stndard normal distribution. The response probability for y is then:

$$\begin{aligned} P(y = 1|\mathbf{x}) = P(y^* > 0|\mathbf{x}) =& P[e > -(\beta_0 + \beta \mathbf{x})|\mathbf{x}] \\ &= 1 - G[-(\beta_0 + \beta \mathbf{x})] = G(\beta_0 + \beta \mathbf{x}) \end{aligned} \tag{4.12}$$

4.2.2 Second stage: Incorporation of the estimated parametres into the model

In the second step the estimated parametres are used. Each share equation is broaden to take into account the censored nature of the data. The explanatory variables from the first step are denoted as $\boldsymbol{Z}$ and coeffcients $\boldsymbol{\eta}$. In the second stage, the dependent variable $y_{ih}, i = 1, ..., K, h = 1, ..., N$ is written as:

$$y_{ih} = \Phi(Z'_{ih}\hat{\eta}_i)f(X_{ih}\beta_i) + \delta_i\phi(Z'_{ih}\hat{\eta}_i) + \eta_{ih} \tag{4.13}$$

where X denotes the second stage explanatory variables with their coefficients β. δ is coefficient which needs to be estimated. The second stage specifically for AIDS model looks like (Ecker and Qaim, 2011):

$$w^*_{ih} = \Phi(Z'_{ih}\hat{\eta}_i)w_{ih} + \delta_i\phi(Z'_{ih}\hat{\eta}_i) + \eta_{ih} \tag{4.14}$$

where w_{ih} is known from the equation 4.6. What is different compared to the basic AIDS model is that w^*_i do not longer sum up to one. That causes the covariance-variance matrix to be non-singular. Because it was singular in the basic AIDS model estimation we estimated the model with (K-1) equations, but now the system should be estimated with K equations. The log-likelihood function for the model looks like (Yen et al., 2002):

$$L_N = \frac{NK}{2}ln(2\pi + 1) - \frac{N}{2}ln(|S|). \tag{4.15}$$

The elasticities of AIDS model under the Shonkwiller and Yen estimator look like:

- income elasticity $e^i_M = 1\vartheta + \frac{1}{w*_i}\Phi(Z'_{ih}\hat{\eta}_i)\beta_i$
- uncompensated price elasticity $e^i_{pj} = -\delta_i j + \frac{1}{w^*_i}\Phi(Z'_{ih}\hat{\eta}_i)(\gamma_{ij} - \beta_i\alpha_i - \beta_i\sum_k \gamma_{kj}ln(p_k)$

and for QUAIDS (Ecker and Qaim, 2011):

- income elasticity: $e^i_M = 1 + \frac{1}{w^*_i}\Phi(Z'_{ih}\hat{\eta}_i)(\beta_i + 2\lambda_i\left(\Pi_i p_i^{\beta_i}\right)^{-1} ln(\frac{\mu}{P}))$
- uncompemsated price elasticity:$e^i_{pj} = -\delta_i j + \frac{1}{w^*_i}\Phi(Z'_{ih}\hat{\eta}_i)$ $\left\{-\left(\beta_i + 2\lambda_i\left(\Pi_i p_i^{\beta_i}\right)^{-1} ln(\frac{\mu}{P}\right)(\alpha_j + \sum_k \gamma_{kj}ln(p_k)) - \lambda_i\beta_j(\Pi_i p_i^{\beta_i})^{-1}(ln(\frac{\mu}{P}))^2 + \gamma_{ij}\right\}.$

4.3 Standard errors

The application of Shonkwiler & Yen (1999) estimator solves the problem with censored dataset. However since it is a 2-stage estimation it causes heteroscedastic error term. We use bootstrapping to obtain robust standard errors for estimated parameters. Bootsrapping is a nonparametric approach which assumes that the current sample is representative of the population. Therefore the empirical distribution function $\hat{F}$ is a nonparametric estimate of the population distribution F. The desired statistics $\hat{\theta}$ can be calculated from the sample dataset as an empirical estimate of the true parameter θ. Critical moment of the analysis is the assumption that error terms are independentely identically distributed. In our dataset, households are assumed to be independet of each other. However if we use bootstraping, one household will be present multiple times in the re-sampled dataset and its own beverage expenditures and consumption shares will be correlated. Therefore we will use clustering on the household level. The same method is used in Janský (2014).

4.4 Incorporation of higher tax into the model

As we mentioned before, the VAT rates in the Czech Republic are 10%, 15% and 21%. The non-alcoholic beverages are in the group with 15% VAT. The data available to us are from the years 2001-2007. Between the years 1995-2004 the rates were 22% and 5% and between 2004-2007 19% and 5%. In both periods all food was taxed by the higher rate. The latest (unapproved) reform in 2013 proposed to unite the VAT rates to 17.5%.

Based on this we decided to simulate 4 different VAT rates for non-alcoholic beverages: 17.5%, 21%, 25% and 30%. To simulate the impacts of VAT changes on consumer spending patterns we used the estimated Marshallian (uncompensated) price elasticities. To estimate the 95% confidence interval we used bootstrapping for calculation of the own-price elasticities. To examine the impact of the possible taxation on different income groups, we also estimated the own-price elasticities for 4 different income groups determined as quartiles of the income distribution. On the basis of Dušek & Janský (2012a) and Janský (2014) we assume that changes in VAT are fully reflected in the prices. This assumption would rather be fulfilled in the long term. This fact should be considered while interpreting the results.

All the calculations in the Thesis were done in Stata 13 software. The commands were based on Poi *et al.* (2002) and Poi *et al.* (2008).

Chapter 5

Data description

The data for this thesis comes from the Czech Statistical Office (CSO). The data from CSO were analyzed within the project Integrace České ekonomiky do Evropské unie a její rozvoj ongoing under the auspices of Charles University in Prague. This thesis uses the budget survey data from years 2002-2007.

5.1 Family Budget Statistics

The aim of Family Budget Statistics (FBS) is to monitor the budgets of households. Therefore, a household is a statistical unit in this data. A single household involves people who live together and share their expenses on a regular household routine, thus they manage a common budget. If children who spend some days during the week in some other city are financially connected to the household, they are considered as members. A person who lives alone is also considered as a household.

Various type of data is collected about the households. The survey contains information about housing (type of a house, heating, water source etc.), house equipment (appliances, internet connection etc.), household members (gender, age, education, employment) and their relationship, and what is most important about their income and expenses (e.g. regular payments, fees, income from employment, spending on food and energy). For the expenses since 1999 an equivalent to internationally used COICOP - CZCOICOP has been developed. A brief overview can be seen in the table 5.1.

Table 5.1: Expense categories according to COICOP

Number	Cathegory
1	Food and alcoholic beverages
2	Alcoholic beverages, tobacco and narcotics
3	Clothing and footwear
4	Housing, water, electricity, fuels
5	Furnishings, household equipment; repairs
6	Health
7	Transport
8	Post and telecommunications
9	Recreation and culture
10	Education
11	Restaurants and hotels
12	Other goods and services

5.2 Data collection

The households involved in survey do so purely on the voluntary basis, therefore a specific treatment is required. There is an employer of CSO present in every region of the Czech Republic, who is responsible for the communication with the households. A stability of the worker is required to build and maintain trustworthiness of the households. In the process of choosing the households for the data collection, the employer should be able to apply psychological knowledge, since the households provide sensitive and very valuable data for CSO. The data are confidential and the CSO employees are bound to secrecy.

The selection of the households proceeds based on quota sampling, i.e. that a certain number of households is chosen according to specific characteristics. The main characteristics is the economic activity of the household leader. Those households with an economically active leader are later divided by the employment of the leader. Those without an active leader are later divided by economic activities of other members. By economically active individual we understand a person older than 15 years, who is either employed or unemployed but actively seeking job. For some households other characteristics like the size of the home town are used. Another important characteristic is the affiliation to income groups.

The data are collected from 3000 households, which are selected to be as close as possible to the household structure of the Czech Republic. However, this dataset involves less than a thousand of a total number of Czech households and is created by quota sampling as described above. Thus we must keep in mind that in some cases expanding the data on the entire population can be misleading. The collection of the data is based on a survey. The household completes in every month the Household intelligence diary (Deník zpravodajské domácnosti). A designated member of the household records cash and in-kind inflows and outflows of the whole household in the diary on the daily basis. To reduce the intensity of the workload the information about groceries are marked only for 2 month during the year in the Household intelligence diary with detailed information about groceries (Deník zpravodajské domácnosti s podrobným zápisem potravin). These 2 months are determined to be 6 months apart so when the dataset is completed, all months are distributed equally during the year. During other than these 2 months only total expenses on foodstuff and alcohol are recorded. A household is always involved in the survey for a year if its determining characteristics do not change. For the correctly and completely recorded diary the household receives a financial reward in CZK, which corresponds with the number of household members and the fact if detailed record of the groceries was kept in a given month.

5.3 Descriptive statistics

In every dataset from one year, various information about each household is provided, which classifies the data as cross-sectional. Between the years some households stay in the survey and some are replaced. Nevertheless, households' identification numbers change, which makes it impossible to connect them through the years. The data available to us are from the years 2002-2007. To make our simulation more relevant to the reality we decided to put the data together and create one dataset. To remove the effect of inflation from the data we multiplied them by base indices of consumer prices (an increase in CPI compared with the base year 2005), which are used to express the level of inflation on different time periods. CSO publishes the base indices. This adjustment changed the data type to repeated cross-sectional.

All food and beverages are included in the first two COICOP categories. Because we want to focus our analysis on beverages, we need to use the Household intelligence diary with detailed information about groceries, where the categories are further divided, see table 5.2. The descriptive statistics of the data can be found in the table 5.3.

As can bee seen from the table 5.3 the people mostly consume bottled water with mean consumption share of 26%. The least consumed beverages are syrups

Table 5.2: Beverages subcategories

Label	Cathegory	Examples
1	Syrups	Fruit and vegetable syrups intended for home preparation of drinks from water;lemon concentrates and other fruit concentrates intended to be consumed after dilution
2	Fruit and vegetable juices	Fruit and vegetable juices, i.e. natural untreated pulp pressed juice from fresh fruit or vegetables intended for direct consumption; ciders and nectars, ie. natural filtered and refining juice, either pure or supplemented with water (minimum proportion of pure fruit juice is 40%) for the direct consumption
3	Beer	Alcoholic and non-alcoholic beer
4	Wine	
5	Spirits	
6	Soft drinks	Non-alcoholic drinks made from fruit syrups and fruit juices (the proportion of pure juice is less than 40%), carbonated soft drinks (Coca- Cola, Fanta etc.), drinks from tea and coffee (iced tea, iced coffee with), energy drinks
7	Bottled water	Bottled mineral, carbonated and still water, with and without flavor

Table 5.3: Descriptive statistics of consumption shares and prices

	Consumption share w_i	Price p_i			Zero observations	
Category	Mean	Mean	Min	Max	Number	Percentage
1 Syrups	0.06	28.67	5.06	201.83	5950	0.29
2 Juices	0.06	19.60	3.48	91.71	5966	0.29
3 Beer	0.18	19.94	4.88	99.95	3014	0.15
4 Wine	0.15	75.34	2.93	537.98	2542	0.12
5 Spirits	0.14	204.47	11.22	920.00	2975	0.15
6 Soft drinks	0.16	10.49	1.00	94.88	2330	0.11
7 Bottled water	0.26	7.08	0.88	48.17	1253	0.06

and juices with mean consumption share of 6%. Soft drinks have the average consumption share of 16%. In every category, the maximum consumption share is 1, which means that for every beverage there exists a household which buys only it. The price was calculated directly from the budget survey data, as the amount bought in liters and total price paid for each beverage is known. The price range is wide, but no outliers were removed from the data. The data from the budget survey are censored; every beverage category has some zero observations. The most zero observations occur for syrups and juices: 29% in both cases. The least zeros occur for bottled water: only 6% of the respondents do not buy them at all. Soft drinks the average 11% of zero observations.

For two parts of the demand estimation, the socio-demographic variables are used; first is for the Shonkwiler and Yen's estimator and second for the final version of QU/AIDS model. In the literature for budget survey data the commonly used variables are demographic location, size of the household, presence of children and elderly in the family, sex, age, education, and employment of the person who is in charge of shopping, and income of the family. The choice of the socio-demographic variables was based partially on literature and partially on the potential they might have on the purchase. Their description and expected influence on the probability of beverage consumption follows.

Size is an integer representing the number of household's member. The size of a household influences budget of the household in both directions. Also, more members mean possible presence of different age groups with different preferences and requirements. Size of the household showed a strong correlation with the dummy varibale repsesenting if there are children present in the household. Therefore variable *childern* was not used.

Retired is a dummy variable equal to 1, if there is at least 1 retired person present in the household. Retired people have usually more tighter and different tastes than younger people. Therefore there is an expected negative effect for purchasing more expensive beverages like juices and wine.

Woman is a dummy variable equal to 1 if the leader of the household is a woman. Women have different tastes than men and if they have children they might make different shopping decisions for them than men would do. For alcoholic beverages the expected effect is negative, since women usually drinks less than men. On the contrary, for sweet drinks like syrups, juices, and soft drinks we expect a positive effect, since women shop for their children more often than men.

Age is an integer representing the age of a household's leader. During lifetime, the preferences and requirements for beverages vary. A higher age might relate to lower budget. Therefore, we expect a negative effect for purchasing of more expensive beverages like juices and wine. Younger people may have small children and buy for them sweet beverages, there we expect a possitive effect for syrups, juices, and soft drinks. The effect for alcoholic beverages may in general go in both direction, since higher age might mean a tighter budget, but also can relate to the absence of young children who decrease the consumption of alcohol by their parents.

Education 1 is a dummy variable equal to 1 if the leader of a household completed only primary education. The effect of this variable can go with both directions. Lower education is usually connected with lower budget, which would have a negative effect on purchasing of more expensive items. On the contrary less educated people make less responsible choices for their diet, which might have a positive effect on the consumption of alcoholic beverages and soft drinks.

Education 2 is a dummy variable equal to 1 if the leader of a household completed secondary education. People with higher education might make more responsible choices for their diet and dispose with higher income. Therefore, there is expected positive effect on the consumption of juices, bottled water, and wine. University education is omitted due to the dummy variable trap.

Village is a dummy variable equal to 1 if the residents of the household live in a village. Residents of a village have different shopping opportunities than residents of a city. Also, different consumption preferences and tighter budget restriction may be connected to the life in a village. We expect a positive effect on the consumption of beer and spirits, since those two articles are available in every shop and are cheaper than wine. The effect on non-alcoholic beverages can go in both directions, since residents of a village might have make less responsible diet choices, which would cause a positive effect for syrups and soft drinks. On the other hand, all beverages in our research are more expensive than tap water and if households from the village have lower budget per capita, they might buy less of everything.

Income is a decimal representing the income of the household per capita in thousands of CZK. The positive effect on every beverage category is expected since people with higher income have wider possibilities for shopping decisions.

Regional dummies are 13 different dummy variables representing the household's residency region. In different regions, different beverages might be preferred. Also the income inequality is present among the regions. For simplicity, the regional dummies will not be examined individually.

Chapter 6

Results

6.1 AIDS and QUAIDS model

In this section, the AIDS and the QUAIDS models were estimated. Estimates of the AIDS model are in the Table A.2 in the Appendix. To compare the two models, we conducted likelihood-ratio (LR) test. The LR statistic $LR = 2(logL_r - logL_u)$ has the χ^2_h distribution where $logL_r$ is the value of log-likelihood of restricted model and $logL_u$ of unrestricted model and h is the number of restrictions. The restricted, or nested, model in this case is the AIDS model, since it lacks the quadratic term from the QUAIDS model. The null hypothesis is that the restricted mode fits the data better. We expect the null hypothesis to be rejected, since the relationship between income and expenditure was proven non-linear on the Czech data before (Janda *et al.* 2010). The results of the LR test are in the Table 6.1.

Table 6.1: Likelihood-ratio of AIDS and QUAIDS model

H_0:	AIDS
H_1:	QUAIDS
LR:	127.37
P-value:	0.0000

From the estimation of the QUAIDS model, which is in the Table 6.2, can be seen that the coefficient λ of the quadratic term is significant in 4 out of 7 equations. λ is significant for beer, spirits, soft drinks, and bottled water and all the significances are at 1% level. That confirms our hypothesis about a non-linear relationship between income and expenditure. Due to the results of both tests we chose the QUAIDS model to be more suitable for the estimation of beverage demand of the Czech Households. The parameters of the QUAIDS model are difficult to be interpreted directly. In the non-treated version of the model like this one the γ_{ij} terms represent changes in relative prices. Each γ_{ij} represents 10^2 times the effect on the ith budget share of a 1% increase in the jth price with $(\frac{x}{P})$ held constant. β_i coefficients then represent the changes in real expenditure (Deaton & Muellbauer 1980). However, this interpretation is not valid later when the Shonkwiler and Yen's estimator is used, since the equation of the model is changed. Therefore, we will not interpret the coefficients from the QUAIDS models. We will only use them as quality indicator through their statistical significance.

Table 6.2: Estimates of QUAIDS model

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
α	-0.0373	-0.0014	0.8098**	0.2109**	0.0498	0.0259	-0.0575**
	(0.0211)	(0.0195)	(0.0463)	(0.0317)	(0.0267)	(0.0307)	(0.0316)
β	-0.0230	-0.0316**	0.2472**	-0.0016	0.0586**	-0.0669**	-0.1827**
	(0.0125)	(0.0115)	(0.0207)	(0.0190)	(0.0181)	(0.0192)	(0.0216)
γ_1	0.0196**	0.0087**	-0.0221**	-0.0045*	-0.0144**	0.0022	0.0105
	(0.0030)	(0.0021)	(0.0084)	(0.0022)	(0.0032)	(0.0031)	(0.0061)
γ_2	0.0087**	-0.0091**	-0.0130	0.0072**	-0.0186**	0.0231**	0.0018
	(0.0021)	(0.0030)	(0.0080)	(0.0023)	(0.0033)	(0.0030)	(0.0059)
γ_3	-0.0221**	-0.0130	0.1372**	0.0093	0.0257*	-0.0255	-0.1116**
	(0.0084)	(0.0080)	(0.0262)	(0.0123)	(0.0120)	(0.0139)	(0.0192)
γ_4	-0.0045*	0.0072**	0.0093	-0.0072*	-0.0147	0.0099*	0.0000
	(0.0022	(0.0023)	(0.0123)	(0.0034)	(0.0038)	(0.0041)	(0.0093)
γ_5	-0.0144**	-0.0186**	0.0257*	-0.0147	0.0802**	-0.0192**	-0.0390**
	(0.0032)	(0.0033)	(0.0120)	(0.0038)	(0.0069)	(0.0053)	(0.0107)
γ_6	0.0022	0.0231**	-0.0255	0.0099*	-0.0192**	-0.0481**	0.0577**
	(0.0031)	(0.0030)	(0.0139)	(0.0041)	(0.0053)	(0.0075)	(0.0094)
γ_7	0.0105	0.0018	-0.1116**	0.0000	-0.0390**	0.0577**	0.0805**
	(0.0061)	(0.0059)	(0.0192)	(0.0093)	(0.0107)	(0.0094)	(0.0218)
λ	0.0017	-0.0025	0.0228**	-0.0004	0.0102**	-0.0083**	-0.0235**
	(0.0018)	(0.0017)	(0.0029)	(0.0027)	(0.0029)	(0.0029)	(0.0037)
Log L	42965.405						
N	20500						

Standard errors under the estimates, calculated by 500 bootstrap replications
Significance of coefficients' estimates: $*p < 0.05, **p < 0.01$

The income, own price and cross price elasticities were calculated from the QUAIDS model and can be found in the Tables 6.3 and 6.4. As for the income elasticity, only syrups suggest negative, which means that they are inferior good. It can be explained by the fact that with higher income consumers might prefer either natural fruit and vegetable juices or soft drinks. Although, it has to be taken in account that the standard error in this case is quite large. Other goods are normal. From the normal goods, wine and beer are identified as luxuries with the income elasticity over one. The rest of them

Table 6.3: Income and own price Marshallian elasticities upon QUAIDS

	Income elasticity		Own price elasticity	
	Mean	Std.dev.	Mean	Std.dev.
Syrups	-2.5205	7.3294	-0.7133	0.0414
Juices	0.0472	2.0996	-1.1986	0.0414
Beer	3.0745	6.2467	-1.2948	0.0309
Wine	1.0113	0.0175	-1.0494	0.0231
Spirits	0.8628	0.2433	-0.4723	0.0307
Soft drinks	0.7943	0.6867	-1.3766	0.0222
Bottled water	0.7482	2.2685	-1.0148	0.0192

Table 6.4: Cross-price Marshallian elasticities upon QUAIDS

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
Syrups	-	0.1308	0.0884	0.0177	-0.1124	0.0508	0.1108
	-	(0.0286)	(0.0401)	(0.0314)	(0.0383)	(0.0308)	(0.0382)
Juices	0.1151	-	0.2177	0.1638	-0.2151	0.3430	-0.1841
	(0.0307)	-	(0.0405)	(0.0313)	(0.0390)	(0.0309)	(0.0380)
Beer	-0.0309	0.0264	-	-0.0173	-0.1216	0.0339	-0.0609
	(0.0138)	0.0130)	-	(0.0181)	(0.0195)	(0.0179)	(0.0216)
Wine	-0.0306	0.0470	0.0669	-	-0.0972	0.0631	-0.0062
	(0.0128)	(0.0119)	(0.0214)	-	(0.0179)	(0.0168)	(0.0202)
Spirits	-0.0811	-0.0962	-0.0472	-0.0866	-	-0.0497	-0.0572
	(0.0166	(0.0158)	(0.0245)	(0.0190)	-	(0.0188)	(0.0231)
Soft drinks	-0.0126	0.1136	0.1284	0.0683	-0.0527	-	0.1741
	(0.0120)	0.0112	(0.0204)	(0.0162)	(0.0170)	-	(0.0196)
Bottled water	-0.0029	-0.0493	0.0423	0.0054	-0.0365	0.1061	-
	(0.0089)	0.0083)	(0.0147)	(0.0115)	(0.0125)	(0.0116)	-

are necessities. All beverages have negative own price elasticity, which means that they are normal goods. Except for spirits and bottled water all beverages have own price elasticity lower than -1, which signifies an elastic demand. The relatively high level of own price elasticities can be explained by the fact that none of the examined beverages are necessary items. Everyone can drink tap water in case prices of drinks are high.

The cross price elasticities in our case are tricky for interpretation. We included all the beverages into the analysis, because we wanted as precise estimate of the demand as possible. However, the comparison of alcoholic and non-alcoholic beverages in the context of cross price elasticities is a complex issue, since they are very different categories bought for different purposes. Therefore, we decided to describe only the cross price elasticities within the categories of alcoholic and non-alcoholic beverages. In the category of non-alcoholic beverages, syrups and concentrates are substitutes to everything. Juices are as well, except for bottled water. Soft drinks are complements to juices and bottled water and substitutes to syrups. Soft drinks and syrups are the most similar products from the non-alcoholic section of beverages, so the substitution can be understandable. Beer is substitute to wine and spirits, so are the spirits to beer and wine. Wine is substitute to spirits, but complement to beer. Also, we are working with large standard errors, which has to be taken into account while interpreting the results.

6.2 Shonkwiler and Yen's estimator

The first step of Shonkwiler and Yen's estimator is to estimate a probit model for every beverage category. The dependent variable is the purchase of the given beverage category. It is equal to 0 if the household does not buy the item. The probit model was estimated according to the equation 6.1 and its results are in the Table 6.5.

$$\begin{aligned} purchase_i = \alpha + \beta_1 size + \beta_2 childen + \beta_4 retired + \beta_5 woman \\ + \beta_6 age + \beta_7 eduaction + \beta_8 village + \beta_9 income \beta_{10} region_1 \\ + \beta_{11} region_2 + \beta_{12} region_3 + \beta_{13} region_4 + \beta_{14} region_5 \\ + \beta_{15} region_6 + \beta_{16} region_7 + \beta_{17} region_9 + \beta_{18} region_{10} \\ + \beta_{19} region_{11} + \beta_{19} region_{12} + beta_{20} region_{13} + u \end{aligned} \tag{6.1}$$

The size and the income of a household are significant at 1% in all cases. Both variables have proven impact on household's consumption pattern in general and as we can see now even if we are considering beverages specifically. The impact of both variables is positive. The bigger the household is the more different tastes and requirements are represented. Also, bigger household means higher probability of children presence. Since children usually do not prefer to drink clean water, there is a possible positive impact on the consumption of all sweet non-alcoholic beverages. With higher income, the household has more possibilities how to divide their resources and they can afford to buy more goods. The presence of retired person in the household is significant only in case of syrups and concentrates, wine, spirits, and soft drinks. It has a a positive effect on the consumption of syrups and concentrates and soft drinks and negative one on wine and spirits. Retired people have usually more tighter than working population, so they might substitute juices by cheaper syrups and soft drinks. The negative effect on wine consumption can be also explained by the budget restrictions.

Table 6.5: Probit model for every beverage cathegory

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
size	0.3027**	0.1958**	0.0234	0.0585**	0.0639**	0.2819**	0.1146**
	(0.0108)	(0.0105)	(0.0122)	(0.0125)	(0.0119)	(0.0143)	(0.0156)
retired	0.1580**	-0.0159	0.0153	-0.0965**	-0.1082*	0.0750*	-0.0396
	(0.0421)	(0.0202)	(0.0424)	(0.0302)	(0.0452)	(0.0363)	(0.0330)
woman	0.0283	0.1263**	-0.6562**	-0.1153**	-0.2334**	-0.0004	0.0579
	(0.0317)	(0.0324)	(0.0578)	(0.0430)	(0.0668)	(0.0401)	(0.0559)
age	-0.0073**	-0.0110**	0.0111**	-0.0021	0.0072**	-0.0112**	0.0006
	(0.0018)	(0.0014)	(0.0015)	(0.0016)	(0.0018)	(0.0017)	(0.0013)
education_1	0.2703**	-0.2102**	-0.0615	-0.1722*	0.0057	0.1385*	-0.0784
	(0.0551)	(0.0432)	(0.0563)	(0.0474)	(0.0622)	(0.0418)	(0.0553)
education_2	0.1716*	-0.0857	0.0122	-0.0360	0.0868	0.1399**	0.0634
	(0.0548)	(0.0438)	(0.0411)	(0.0555)	(0.0699)	(0.0510)	(0.0618)
village	-0.0468	-0.1674**	0.0952*	-0.1679**	0.0087	-0.0850*	-0.0427
	(0.0338)	(0.0254)	(0.0468)	(0.0512)	(0.0308)	(0.0331)	(0.0355)
income	0.0567**	0.0752**	0.0161**	0.0118**	0.0272**	0.0725**	0.0348**
	(0.0039)	(0.0029)	(0.0031)	(0.0028)	(0.0025)	(0.0048)	(0.0027)
reg. dummies f-test	140000.00	1400000.00	28431.17	1300000.00	450000.00	30726.56	1000000.00
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Log pseudolikelihood	-11336.96	-11005.33	-7442.26	-7249.51	-7994.68	-6335.45	-4452.19
N	20500	20500	20500	20500	20500	20500	20500

Standard errors under the estimates, calculated by 500 bootstrap replications
Significance of coefficients' estimates: $*p < 0.05, **p < 0.01$

The position of a woman as household's leader is significant in case of juices, beer, wine, and spirits. It has a positive effect on the consumption of juices and a negative on all 3 alcoholic beverages categories. Women usually consider more the health-related impacts of consumed food and beverages and, they generally drink less alcohol. Age of the household's leader is significant for all beverages except for wine and bottled water. Age has a positive effect on the consumption of wine and spirits and a negative for syrups and concentrates, juices, and soft drinks. This might be explained by the fact that many young people have children and therefore buy more non-alcoholic beverages instead of alcoholic ones. For education, two dummy variables were used for education, from which the one for primary education is significant in more cases. If the leader of the household has only completed primary education, there is a higher chance that the household will consume syrups and concentrates and soft drinks and lower chance of consumption of juices and wine. The lower education is usually connected to lower income which can result in saving money by purchasing cheaper beverages like syrups instead of juices. The residence of the household in a village is negatively significant for juices, wine, and soft drinks and positively significant for beer.

The estimate of the QUAIDS model estimated by Shonkwiler and Yen's estimator can be found in the TableA.5 in Appendix. Compared to the first

Table 6.6: Income and own price Marshallian elasticities upon QUAIDS estimated by Shonkwiler and Yen's estimator

	Income elasticity		Own price elasticity	
	Mean	Std.dev.	Mean	Std.dev.
1 Syrups	-2.3135	6.8364	-0.7243	0.0410
2 Juices	0.0344	0.0428	-1.1756	0.0381
3 Beer	2.9583	4.9287	-1.3128	0.0922
4 Wine	1.2293	0.2175	-1.1035	0.0440
5 Spirits	1.0148	0.2433	-0.6534	0.0295
6 Soft drinks	0.8396	0.6647	-1.2566	0.0202
7 Bottled water	0.9152	1.3455	-1.0068	0.0182

version of the QUAIDS model, one more α is significant at 5% and one less β is significant. Four λs for the quadratic term are still significant, but now two of them only at 5%. However, all δs coefficients specific for this estimator are significant at 1% level.

The estimates of income and own price elasticities are in the Table 6.6. In comparison with the untreated QUAIDS model, syrups are still the only inferior good, others are normal. However, the normal goods seem to be more elastic under the Shonkwiler and Yen's estimator. Spirits are not a necessity anymore. The own-price elasticities are still all negative, which means that all goods are normal.

As for the cross price elasticities the goods tend to be more substitutional under the Shonkwiler and Yen's estimator. Juices are now substitutes to syrups and soft drinks. Bottled water is now a substitute to syrups. Nevertheless, we are still working with large standard errors compared to the estimates as in the previous case.

6.3 Final version of QUAIDS model

The final version of the QUAIDS model is estimated by Shonkwiler and Yen's estimator to deal with the selectivity problem in the dataset. The model is enlarged by 7 socio-demographic variables: the region where the household lives, size of the household, age and education of the leader of the household, dummy variable controlling if the household lives in a village, and income in thousand CZK per capita. The estimates of the model can be found in the Table 6.8.

Region is significant in 4 cases; the residence of a household impacts con-

Table 6.7: Cross-price elasticities upon QUAIDS estimated by Shonkwiler and Yen's estimator

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
Syrups	-	0.1125	0.0937	0.0160	0.0955	-0.0508	0.0942
	-	(0.0278)	(0.0381)	(0.0327)	(-0.0402)	(0.0329)	(0.0344)
Juices	-0.1036	-	0.2112	0.1621	-0.2409	-0.2984	-0.1657
	(0.0344)	-	(-0.0409)	(0.0332)	(-0.0449)	(0.0334)	(0.0422)
Beer	-0.0355	0.0248	-	-0.0178	-0.1289	0.0332	-0.0536
	(0.0135)	(0.0120)	-	(0.0179)	(0.0209)	(-0.0188)	(0.0216)
Wine	-0.0306	0.0451	0.0629	-	-0.0836	0.0631	-0.0068
	(0.0111)	(0.0105)	(0.0182)	-	(0.0184)	(0.0187)	(0.0222)
Spirits	-0.0908	-0.1078	-0.0491	0.0762	-	-0.0487	-0.0486
	(0.0141)	(0.0161)	(0.0240)	(0.0198)	-	(0.0176)	(0.0249)
Soft drinks	-0.0142	-0.1068	0.1143	0.0758	-0.0469	-	0.1602
	(0.0131)	(0.0120)	(0.0233)	(0.0175)	(0.0190)	-	(0.0178)
Bottled water	0.0026	-0.0508	0.0377	0.0046	-0.0347	0.1008	-
	(0.0100)	(0.0084)	(0.0167)	(0.0120)	(0.0126)	(0.0131)	-

sumption of juices, beer, wine, and spirits. There are differences among regions in preferred alcoholic beverages, which depend upon the production of given beverage in a specific region, price availability, and many others. Size of the household is significant in all cases except for beer with a positive impact on consumption share of all beverage categories. The positive impact can be explained by the fact that larger household has larger consumption of the beverages and usually greater accumulated budget. It enables them to purchase more diversified products which can be shared among members. The strongest impact is for soft drinks (0.0024) and for wine (0.0020).

Age of the household leader which serves as an approximation of the household's age group is significant in all cases except for syrups and concentrates and beer. The results are similar to the probit model, where the higher age had also negative impact on the purchase of juices and soft drinks, since they are often required by children and also behave as luxury good, which older people might not afford. Now soft drinks belong to the same group with the negative impact of age. The positive impact on consumption of spirits remained. What is also the same with the probit model is the prevailing influence of only primary education of the household leader. The largest negative impact is on wine (-0.0103) and juices (-0.0044) and the positive one on beer (0.0075) and syrups and concentrates (0.0028). Education is usually connected with the income level and primary education of the leader would probably cause the household income to be below average. The lower budget influences shopping decisions in the sense of replacing expensive products with cheaper ones, which is exactly the case of juices and syrups and wine and beer. The secondary

Table 6.8: Final censored model of QUAIDS

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
α	0.02038	0.0103	0.8475**	0.1833**	0.0438	-0.0030	-0.1021*
	(0.0171)	(0.0163)	(0.0435)	(0.0269)	(0.0232)	(0.0253)	(0.0306)
region	0.0001	0.0002**	0.0005**	-0.0003**	-0.0006**	0.0000	0.0001
	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
size	0.0017**	0.0005**	-0.0006	0.0020**	0.0015**	0.0024**	0.0008**
	(0.0003)	(0.0002)	(0.0005)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
age	0.0000	-0.0001**	-0.0001	0.0001**	-0.0001**	-0.0002**	-0.0002**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
education_1	0.0028**	-0.0044**	0.0075**	-0.0103**	-0.0016	-0.0035**	0.0025**
	(0.0008)	(0.0006)	(0.0018)	(0.0010)	(0.0008)	(0.0010)	(0.0011)
education_2	-0.0007	0.0025**	-0.0031	0.0047**	-0.0015	-0.0032**	0.0013
	(0.0008)	(0.0006)	(0.0018)	(0.0010)	(0.0008)	(0.0010)	(0.0011)
village	-0.0007	-0.0015**	0.0065**	-0.0061**	0.0008	0.0022**	-0.0035**
	(0.0005)	(0.0004)	(0.0012)	(0.0007)	(0.0006)	(0.0007)	(0.0007)
income	0.0003**	0.0002**	0.0004**	-0.0001	0.0004**	-0.0001	0.0003**
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
β	0.0300**	-0.0352**	0.2789**	-0.0495**	0.0531**	-0.0697**	-0.2076**
	(0.0098)	(0.0094)	(0.0168)	(0.0152)	(0.0144)	(0.0152)	(0.0182)
γ_1	0.0212**	0.0047*	0.0052	-0.0052*	-0.0092**	-0.0025	-0.0142*
	(0.0027)	(0.0019)	(0.0071)	(0.0022)	(0.0026)	(0.0027)	(0.0061)
γ_2	0.0047*	-0.0094**	-0.0127	0.0091**	-0.0161**	0.0198**	0.0044
	(0.0019)	(0.0026)	(0.0070)	(0.0021)	(0.0026)	(0.0025)	(0.0056)
γ_3	0.0052	-0.0127	0.1762**	-0.0110	0.0216*	-0.0355**	-0.1438**
	(0.0071)	(0.0070)	(0.0238)	(0.0108)	(0.0105)	(0.0118)	(0.0189)
γ_4	-0.0052*	0.0091*	-0.0110	-0.0077	-0.0168**	0.0137**	0.0179*
	(0.0022)	(0.0021)	(0.0108)	(0.0040)	(0.0033)	(0.0035)	(0.0083)
γ_5	-0.0092**	-0.0161**	0.0216*	-0.0168**	0.0749**	-0.0136**	-0.0407**
	(0.0026)	(0.0026)	(0.0105)	(0.0033)	(0.0053)	(0.0041)	(0.0095)
γ_6	-0.0025	0.0198	-0.0355**	0.0137**	-0.0136**	-0.0458**	0.0637**
	(0.0027)	(0.0025)	(0.0118)	(0.0035)	(0.0041)	(0.0062)	(0.0088)
γ_7	-0.0142*	0.0044*	-0.1438**	0.0179*	-0.0407**	0.0637**	0.1127**
	(0.0061)	(0.0056)	(0.0189)	(0.0083)	(0.0095)	(0.0088)	(0.0219)
λ	0.0095**	-0.0015	0.0261**	-0.0058**	0.0075**	-0.0076**	-0.0282**
	(0.0015)	(0.0014)	(0.0024)	(0.0021)	(0.0023)	(0.0023)	(0.0032)
δ	0.0481**	0.0143**	0.0038**	0.0688**	0.0187**	0.0659**	0.0118**
	(0.0068)	(0.0028)	(0.0018)	(0.0056)	(0.0059)	(0.0113)	(0.0018)

Standard errors under the estimates, calculated by 500 bootstrap replications
Significance of coefficients' estimates: $*p < 0.05, **p < 0.01$

education has less significant estimators than primary, but those which are significant go versus the primary education with a positive impact on juices and wine and a negative one on soft drinks. The residency of a household in a village is significant for all beverages except for syrups and concentrates and spirits. The strongest positive impact is on beer (0.0065) and soft drinks (0.0022). The negative impact is on wine (-0.0061), juices, and bottled water. Life in the village might relate to lower budget, so again cheaper beverages would be preferred over the more expensive ones. Income is not significant only for wine and soft drinks. In other relevant categories, it has always positive impact on share consumption of a given category. Higher income means more

Table 6.9: Income and own price Marshallian elasticities upon final censored model of QUAIDS

	Income elasticity		Own price elasticity	
	Mean	Std.dev.	Mean	Std.dev.
Syrup	-2.5656	6.5314	-0.6589	0.0395
Juices	0.0961	0.0927	-1.1856	0.0411
Beer	3.1174	5.4986	-1.2468	0.0299
Wine	0.9198	0.2537	-0.9804	0.0227
Spirits	1.2398	0.1929	-0.5275	0.0302
Soft drinks	0.6655	0.6427	-1.3580	0.0220
Bottled water	0.7266	1.7698	-1.1158	0.0192

possible money for beverage purchasing so the relationship is understandable. The interpretation of the other coefficient is difficult, as we stated before.

As for the other coefficients estimates, three αs are significant now, which is one less than for the Shonkwiler and Yen's estimator, but the same as for the uncensored version of the model. All βs are significant now. so are all δs specific for the Shonkwiler and Yen's estimator. 6 out of 7 λs responsible for the quadratic term are significant now, which confirms that the relationship between income and expenditure is not linear.

Comparing the income elasticities with the results from the 2 previous models does not bring any surprising results. Detail is in the Table 6.9. Again, they are all positive except for syrups, which are the only inferior good. However, some differences are present. Wine, which was luxury under the uncensored QUAIDS and estimation by Shonkwiler and Yen's estimator, is now considered to be a necessity. Spirits on the contrary were a necessity before and now behave as a luxury. As for the own price elasticities they are again all negative, which signifies normal goods. In comparison with the previous models, the demand for wine is inelastic for the first time. Bottled water has elastic demand, which it did not have upon uncensored QUAIDS.

The cross price elasticities stated in the Table 6.10 changed again from the Shonkwiler and Yen's estimator. Syrups and concentrates are now substitutes to juices and soft drinks and complements to bottled water. Juices are complements to syrups and soft drinks and substitutes to bottled water. Soft drinks are complements to syrups and bottled water and substitutes to juices. This is a different result from the first version of QUAIDS, where soft drinks were complements to juices and bottled water and substitutes to syrups. However soft drinks as a substitute to juices seem more reasonable, since these two products

Table 6.10: Cross price Marshallian elasticities upon final censored model of QUAIDS

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
Syrups	-	-0.1265	0.0788	0.0806	-0.1015	-0.1137	0.1373
	-	(0.0279)	(0.0384)	(0.0302)	(0.0369)	(0.0299)	(0.0369)
Juices	0.0993	-	0.1783	0.1702	-0.1986	0.3026	-0.1150
	(0.0300)	-	(0.0400)	(0.0311)	(0.0386)	(0.0309)	(0.0380)
Beer	-0.0435	0.0120	-	-0.0267	-0.1179	0.0077	-0.0632
	(0.0131)	(0.0127)	-	(0.0175)	(0.0191)	(0.0173)	(0.0213)
Wine	-0.0186	0.0449	0.0482	-	-0.0970	0.0474	-0.0108
	(0.0123)	(0.0118)	(0.0209)	-	(0.0177)	(0.0166)	(0.0200)
Spirits	-0.0898	-0.0932	-0.0473	-0.0841	-	-0.0345	-0.1010
	(0.0160)	(0.0156)	(0.0241)	(0.0187)	-	(0.0186)	(0.0229)
Soft drinks	0.0071	-0.1019	0.1038	0.0683	-0.0261	-	0.1863
	(0.0117)	(0.0113)	(0.0199)	(0.0159)	(0.0169)	-	(0.0196)
Bottled water	-0.0060	-0.0347	0.0459	0.0121	-0.0531	0.1077	-
	(0.0087)	(0.0083)	(0.0146)	(0.0115)	(0.0125)	(0.0116)	-

are close to each other. Bottled water is substitute to syrups and concentrates and juices and complement to soft drinks. As for the alcoholic beverages beer is a substitute for the other two as are spirits. Wine is a substitute to spirits, but a complement to beer.

Altogehther, we estimated four diffrent models. With every model the accuracy of the estimated results incerased. Overview and description of all models can be found in the Table 6.11.

Table 6.11: Overview and description of all models

Model	Description
AIDS	The basic version of the model, estimated by the equation 4.6
QUADIS	The quadratic term was added to the AIDS model.
QUAIDS under Shonkwiler and Yen's estimator	Shonkwiler and Yen's estimator was incorporated into the model to handle to censored data.
QUAIDS under Shonkwiler and Yen's estimator including socio-demographic variables	The final version of the QUAIDS model. Shonkwiler and Yen's estimator is used and socio-demographic variables are incorporated as well.

6.4 Simulated changes in quantity demanded

The aim of this thesis is to examine the changes in the demand for soft drinks under different taxation rates. To do so, we used the estimated own-price elasticity of demand. The results of the estimation are in the Table 6.12. For soft drinks the own-price elasticity is -1.3580, with standard deviation 0.0220, which signifies that soft drinks are normal good with price-elastic demand. To perceive the impacts of taxation in more detail, we also estimated the own-price elasticities for households in 4 income quartiles. The own price elasticity for the lowest income quartile denoted as M1 is -1.4741, which is higher than the own price elasticity of the whole dataset. The value for second lowest quartile is -1.5146, which means even more elastic demand than for the M1 quartile. The M2 group is a little wealthier, which means that it is able to react more flexibly that M1. Households in the M1 group might be stuck to their shopping habits, because the tight budget does not allow them to be creative in grocery shopping. The results for M3 and M4 are then as expected, with the elasticity of -1.3785 for M3 and -1.2975 for M4. Generally, we can say that taxation on soft drinks would have larger impact on households with lower income.

Table 6.12: Own-price elasticities for different income groups

	own-price elasticity	std.deviation
total	-1.3580	0.0220
M1	-1.4741	0.0478
M2	-1.5146	0.0508
M3	-1.3785	0.0547
M4	-1.2975	0.0542

Using the elasticities estimated by bootstrapping, we simulated the average percentage changes in quantity demanded after changes in VAT rates from 2016 baseline. The changes were simulated for all other beverage groups staying under current taxation of 15% and only soft drinks moving under different VAT rate. The results are in the table 6.13. With rising VAT the demand is naturally descending. Because the demand for soft drinks is price elastic, moving the soft drinks under different VAT rate would have a perceptible impact on the demand. For example, even moving the soft drinks under 21% VAT, which is currently used for non-food products, would mean decrease of the demand by 8.15%.

Table 6.13: Simulated average percentage changes in quantity demanded after changes in VAT rates from 2016 baseline (%)

VAT	Δ quantity demanded (%)	QUAIDS 95% confidence interval	
17.5%	-3.40	-3.35	-3.44
21%	-8.15	-8.10	-8.19
25%	-13.58	-13.54	-13.62
30%	-20.37	-20.33	-20.41

We also simulated the average percentage changes in quantity demanded after changes in VAT rates from 2016 baseline for different income quartiles. The results are in the table 6.14.

Table 6.14: Simulated average percentage changes in quantity demanded after changes in VAT rates from 2016 baseline applied to different income groups(%)

VAT/Income group	M1 (%)	M2 (%)	M3 (%)	M4 (%)
17.5%	-3.69	-3.79	-3.45	-3.24
QUAIDS 95%	-3.64	-3.74	-3.40	-3.20
confidence inteval	-3.73	-3.83	-3.49	-3.29
21%	-8.84	-9.09	-8.27	-7.79
QUAIDS 95%	-8.80	-9.04	-8.23	-7.74
confidence interval	-8.89	-9.13	-8.31	-7.83
25%	-14.74	-15.15	-13.79	-12.98
QUAIDS 95%	-14.70	-15.10	-13.74	-12.93
confidence interval	-14.78	-15.19	-13.83	-13.02
30%	-22.11	-22.72	-20.68	-19.46
QUAIDS 95%	-22.07	-22.68	-20.63	-19.42
confidence interval	-22.15	-22.76	-20.72	-19.51

As indicated by the estimates of the own-price elasticities, the effect would be the strongest for the second lowest quartile and the weakest for the highest income quartile. However, even for the highest income quartile the move of the soft drinks from the 15% VAT to 17.5% VAT would mean a decline in the quantity demanded by 3.34%, which is still considerable. Generally, the impact would be stronger for households with lower than median incomes as was stated before. This result can be perceived from two perspectives. The first is that the increased VAT would more negatively affect the lower-income households, since they would buy less soft drinks. According to our results soft drinks have an elastic demand, which only confirms this finding and suggests, that they would buy less, because they could not afford to buy the same quantity as before.

This fact could cause that rising of the VAT would be perceived as negative step against the low-income families, who prefer as lowest VAT on food as possible. The second perspective is that it may not be problem that the higher VAT would have larger impact on lower-income families. Many studies have proven that people suffering from obesity and overweight are often among those with lower incomes (see e.g. Roe & Eickwort (1976), Florêncio *et al.* (2001) or Pan *et al.* (2012)). No study examining this relation specifically in the Czech Republic in known to the author. However, since this relationship was proven in many countries including the European ones, we believe that there is a high probability of occurrence of this relationship in the Czech Republic as well. In that case moving soft drinks under higher VAT rate could be an effective tool in fighting overweight and obesity since it would have a larger impact on more risky population group.

Chapter 7

Discussion of the results

The thesis has three research questions: the value of the own-price elasticity of demand for soft drinks, simulated impacts on demand under different VAT rates and the influence of higher VAT rates on different income groups. The own price elasticity of demand for soft drinks of Czech household was estimated to be -1.3580 with the standard error 0.0220. The value over -1 means that soft drinks are normal goods with elastic demand. This elastic demand implies that imposing a higher VAT would have demonstrable effect of decreasing the consumption. After analyzing the own-price elasticity for income quartiles, we discovered that higher VAT would have a larger impact on the inhabitants in the lower quartiles. Since there is a proven positive relationship between lower income a suffering from obesity and overweight (see e.g.Roe & Eickwort (1976), Florêncio *et al.* (2001) or Pan *et al.* (2012)), our results suggest that a higher VAT on soft drinks might be beneficial even more through being levied more on the endangered group.

Demand estimation for soft drinks specifically was never conducted on the Czech data, therefore we have no relevant comparison in that matter. However, the own price elasticity of sugar-sweetened soft drinks was examined several times in various countries. Even though there are certain specifics to every country's demand for beverages, we believe that the results from other studies are comparable to our research.

The highest own price elasticity estimated was -4.445 (Fletcher *et al.* 2010) and the lowest -0.85 (Claro *et al.* 2012). However, the estimate from Fletcher *et al.* (2010) is quite far from the others, since the second highest estimation is -2.255 (Dharmasena & Capps 2012). The closest value to our estimation is -1.292 Lin *et al.* (2011). The average own-price elasticity is -1.654 and the

Table 7.1: Own-price elasticities of sugar-sweetened soft drinks in other studies

Author and year	Country	Own-price elasticity	Std. error
Barquera *et al.* (2008)	Mexico	-1.085	0.195
Bonnet & Requillart (2011)	France	-2.206	0.133
Claro *et al.* (2012)	Brazil	-0.85	0.434
Dharmasena & Capps (2012)	USA	-2.255	0.55
Finkelstein *et al.* (2010)	USA	-0.87	0.09
Finkelstein *et al.* (2013)	USA	-1.32	0.005
Fletcher *et al.* (2010)	USA	-4.445	1.806
Lin *et al.* (2011)	USA (Low-Income Population)	-0.949	0.082
Lin *et al.* (2011)	USA (High-Income Population)	-1.292	0.096
Smith *et al.* (2010)	USA	-1.264	0.089

median one -1.278. Our estimation is not far from that median value. The exact value is not the same compared to any study, which is rather expectable considering that the other studies were performed on data from different countries. We consider the estimate of own-price elasticity for soft drinks from the empirical part to be relevant and comparable with other foreign studies.

We estimated the impacts of possible sin tax on soft drinks through estimation of demand system for all beverages. This approach has several limitations. Firstly, many people drink tap water at home and therefore their consumption of beverages does not consist only of 7 categories used in this thesis. The consumption of tap water is a hardly measurable variable, since tap water at home is not used only for drinking. However qualified estimate might be possible and it leaves possibilities to future research. A similar problem is consumption of beverages in the restaurants and cafes. The budget survey did contain the data about this type of consumption, but due to the pricing problem it was inapplicable in this thesis. Although this type of data might be useful in the future research, since the consumption pattern of beverages would probably be different considering consumption at home and out. Another issue is that narrowing the demand only to beverages means omitting all other food categories as possible substitutes. Specifically, for soft drinks a substitution relationship between them and other sweets was proven (Finkelstein *et al.* 2013). The estimated of the demand for all food categories was done several times ((Janda & Rausser 1998), (Janda *et al.* 2000)). However, beverages were never divided into greater detail in those estimations. Therefore, an estimation of the demand for food with distinguished beverage categories might be good way how to examine for example the possible use of sweets are substitutes for soft drinks.

Chapter 8

Conclusion

The aim of the thesis was to estimate the own price elasticity of demand for soft drinks in the Czech Republic and to use it to simulate changes in the demand under higher Value Added Tax. To obtain the own price elasticity, the demand for all beverage categories was estimated through a demand system. For the estimation, the quadratic version of the AIDS model, QUAIDS was chosen, since the tests showed that it fitted the data better than the linear version. Since the data for all beverage categories were censored a special treatment was needed. Shonkwiler and Yen's estimator was chosen to handle this problem and to provide us with valid results. In the final version of QUAIDS the socio-demographic variables were included into the estimation.

The budget survey data used for this thesis were collected by Czech Statistical Office between the years 2002-2007 and contain the information about the consumption of given beverage categories: syrups and concentrates, fruit and vegetable juices, beer, wine, spirits, soft drinks, and mineral and other bottled water. Data from different years were connected into one dataset and created a repeated cross-sectional type of data.

The motivation for this thesis was the growing number of inhabitants suffering from overweight and obesity in the Czech Republic. It is a complex issue, which cannot be solved by single government intervention. It must be treated and prevented by a consequence of smaller interventions. One of the possible ways to treat overweight and obesity is tax high-calorie and less-nutritious foods like soft drinks. This approach was implemented in several countries around the world, but never in the Czech Republic.

The elasticity of demand for soft drinks is estimated to be elastic. The elasticity is stronger for lower income households. Therefore, we believe that introducing a higher Value Added Tax on soft drinks may have a beneficial impact. We encourage deeper reseach in the area of sin tax, since it may be a way how to fight negative externatilies such as overweight and obesity, that are caused by the development of the society.

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Appendix A

Additional tables

Table A.1: Correlation matrix for probit model

	size	retired	woman	age	education_1	education_2	village	income
size	1							
retired	-0.3115	1						
woman	-0.4626	-0.0639	1					
age	-0.4179	0.679	0.0355	1				
education_1	0.0707	0.0288	-0.1439	0.013	1			
education_2	-0.1054	-0.0292	0.202	-0.0328	-0.8057	1		
village	0.1079	-0.0052	-0.1513	-0.044	0.1659	-0.1034	1	
income	-0.1812	-0.0456	-0.0352	0.067	-0.104	0.0498	-0.078	1

Table A.2: Estimates of AIDS model

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
α	-0.0610**	0.0215*	0.5886**	0.2209**	-0.0553**	0.1080**	0.1773**
	(0.0095)	(0.0089)	(0.0164)	(0.0135)	(0.0155)	(0.0137)	(0.0174)
β	-0.0343**	-0.0145**	0.0901**	0.0018	-0.0115**	-0.0098**	-0.0218**
	(0.0014)	(0.0013)	(0.0028)	(0.0022)	(0.0020)	(0.0023)	(0.0027)
γ_1	0.0206**	0.0078**	-0.0134**	-0.0050**	-0.0102**	-0.0009	0.0011
	(0.0026)	(0.0018)	(0.0025)	(0.0019)	(0.0023)	(0.0019)	(0.0024)
γ_2	0.0078**	-0.0112**	0.0043	0.0071**	-0.0136**	0.0180**	-0.0124**
	(0.0018)	(0.0024)	(0.0023)	(0.0018)	(0.0022)	(0.0018)	(0.0021)
γ_3	-0.0134**	0.0043	-0.0014	0.0103**	-0.0129**	0.0142**	-0.0010
	(0.0025)	(0.0023)	(0.0058)	(0.0033)	(0.0035)	(0.0033)	(0.0039)
γ_4	-0.0050**	0.0071**	0.0103**	-0.0072*	-0.0150**	0.0098**	0.0000
	(0.0019)	(0.0018)	(0.0033)	(0.0034)	(0.0026)	(0.0025)	(0.0030)
γ_5	-0.0102**	-0.0136**	-0.0129**	-0.0150**	0.0709**	-0.0086**	-0.0106**
	(0.0023)	(0.0022)	(0.0035)	(0.0026)	(0.0042)	(0.0026)	(0.0032)
γ_6	-0.0009	0.0180**	0.0142**	0.0098**	-0.0086**	-0.0593**	0.0267**
	(0.0019)	(0.0018)	(0.0033)	(0.0025)	(0.0026)	(0.0035)	(0.0030)
γ_7	0.0011	-0.0124**	-0.0010	0.0000	-0.0106**	0.0267**	-0.0039
	(0.0024)	(0.0021)	(0.0039)	(0.0030)	(0.0032)	(0.0030)	(0.0050)
Log L	42914.647						
N	20500						

Standard errors under the estimates, calculated by 500 bootstrap replications
Significance of coefficients' estimates: $*p < 0.05, **p < 0.01$

Table A.3: Income and own price Marshallian elasticities upon AIDS

	Income elasticity		Own price elasticity	
	Mean	Std.dev.	Mean	Std.dev.
Syrups	-1.8663	6.6770	-0.7099	0.0413
Juices	0.2168	1.7006	-1.1973	0.0414
Beer	2.9947	5.4000	-1.2910	0.0309
Wine	1.0272	0.0469	-1.0499	0.0230
Spirits	0.8428	0.2226	-0.4785	0.0308
Soft drinks	0.8019	0.5484	-1.3726	0.0222
Bottled water	0.7871	0.8072	-1.0033	0.0190

Table A.4: Cross price price Marshallian elasticities upon AIDS

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
Syrups	-	0.1299	0.0931	0.0119	-0.1085	0.0491	0.0968
	-	(0.0286)	(0.0400)	(0.0312)	(0.0383)	(0.0307)	(0.0378)
Juices	0.1162	-	0.2190	0.1672	-0.2124	0.3451	-0.1822
	(0.0307)	-	(0.0404)	(0.0311)	(0.0391)	(0.0308)	(0.0377)
Beer	-0.0326	0.0232	-	-0.0275	-0.1263	0.0227	-0.0764
	(0.0137)	(0.0129)	-	(0.0179)	(0.0195)	(0.0178)	(0.0215)
Wine	-0.0326	0.0471	0.0619	-	-0.1012	0.0643	-0.0015
	(0.0127)	(0.0118)	(0.0214)	-	(0.0179)	(0.0168)	(0.0200)
Spirits	-0.0809	-0.0981	-0.0471	-0.0942	-	-0.0524	-0.0652
	(0.0166)	(0.0158)	(0.0245)	(0.0189)	-	(0.0187)	(0.0229)
Soft drinks	-0.0109	0.1152	0.1258	0.0734	-0.0482	-	0.1800
	(0.0120)	(0.0112)	(0.0204)	(0.0161)	(0.0170)	-	(0.0194)
Bottled water	-0.0027	-0.0472	0.0427	0.0141	-0.0319	0.1120	-
	(0.0089)	(0.0083)	(0.0147)	(0.0115)	(0.0125)	(0.0116)	-

Table A.5: QUAIDS estimated by Shonkwiler and Yen's estimator

	Syrups	Juices	Beer	Wine	Spirits	Soft drinks	Bottled water
α	-0.0362	0.0015	0.7693**	0.1940	0.0552**	0.0269*	-0.0627**
	(0.0418)	(0.0224)	(0.0505)	(0.0298)	(0.0257)	(0.0390)	(0.0309)
β	-0.0197**	-0.0303**	0.2373*	-0.0016	-0.0516**	-0.0756	-0.1571
	(0.0118)	(0.0321)	(0.0234)	(0.0192)	(0.0170)	(0.0180)	(0.0248)
γ_1	0.0198	0.0086**	-0.0193	0.0042	-0.0157	0.0023**	0.0093
	(0.0032)	(0.0023)	(0.0094)	(0.0092)	(0.0037)	(0.0032)	(0.0062)
γ_2	0.0076	-0.0089**	-0.0135	0.0070	-0.0196	-0.0219**	0.0017
	(0.0124)	(0.0031)	(0.0085)	(0.0421)	(0.0130)	(0.0030)	(0.0064)
γ_3	-0.0252	-0.0120*	0.1413**	-0.0083	0.0221*	-0.0217	-0.1149**
	(0.0190)	(0.0072)	(0.0256)	(0.0128)	(0.0132)	(0.0153)	(0.0204)
γ_4	-0.0046*	0.0076**	0.0079	0.0077	-0.0135**	0.0086*	0.0001
	(0.0021)	(0.0025)	(0.0117)	(0.0092)	(0.0035)	(0.0045)	(0.0089)
γ_5	-0.0151**	-0.0183	0.0265*	-0.0135***	0.0770	-0.0208**	0.0444
	(0.0029)	(0.0314)	(0.0130)	(0.0037)	(0.0571)	(0.0059)	(0.1112)
γ_6	0.0025	0.0207**	0.0273	0.0098*	-0.0169**	-0.0471*	0.0502**
	(0.0031)	(0.0026)	(0.0453)	(0.0045)	(0.0049)	(0.0286)	(0.0091)
γ_7	0.0103	0.0020	-0.1216**	0.0000	-0.0370**	-0.0658*	-0.0845
	(0.0063)	(0.0052)	(0.0205)	(0.0084)	(0.0116)	(0.0384)	(0.0918)
λ	0.0016	-0.0028	0.0244*	-0.0004**	-0.0110**	-0.0078*	-0.0265
	(0.0016)	(0.0025)	(0.0119)	(0.0025)	(0.0027)	(0.0027)	(0.0131)
δ	0.0437**	0.0130**	0.0035**	0.0717**	0.0170**	0.0599**	0.0098**
	(0.0053)	(0.0026)	(0.0012)	(0.0051)	(0.0054)	(0.0094)	(0.0016)
Log L	125667.615						
N	20500						

Standard errors under the estimates, calculated by 500 bootstrap replications

Significance of coefficients' estimates: $*p < 0.05, **\, p < 0.01$