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BACHELOR THESIS

Estimating the quadratic almost ideal demand system and the effects of population ageing in the Czech Republic

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

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Abstract

The aim of this thesis is to estimate the Quadratic Almost Ideal Demand System of non-durable goods on the Czech Republic Household Budget Survey data in two distinct models. Respective income, own and cross price elasticities are calculated and we interpret the resulting income, price and demographic characteristics of the household demand.

The first model is used to estimate the effects of the 2015 Value Added Tax reform in the Czech Republic, which introduced 10% reduced rate on medication and books. We estimate how much the reform changes the consumption behaviour of households, the biggest changes are in the commodities of clothing, books, medications and household goods. The households are estimated to spend $1,049$ billion CZK more on non-durable goods and the VAT revenue is estimated to decrease by 818 million CZK.

The second model is used to predict the effects of the population ageing on the household demand. We do this in four scenarios to separate effects of the household composition change and to analyse the composed effects of increasing wealth and redistribution among the working and retired households. The population ageing has the highest impact on the commodities of food, fuel and light, transport and leisure services. The shift in composition affects the consumption mostly in the same direction as the ageing and thus accelerates its effect. The simultaneous effects of an wealth increase and redistribution are not clear. In some cases they boost the effect from the population ageing, in some they mitigate the effect and the other they reverse the effect all together.

JEL Classification	D12, E12, H20, J11,
Keywords	Quadratic Almost Ideal Demand System, Czech Republic, price and income elasticities, consumer behaviour, tax impact, population ageing

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Abstrakt

Cílem této práce je odhadnout kvadratický téměř ideální poptávkový systém na datech ze Statistiky rodinných účtů v České Republice. Odhadneme celkem dva modely poptávky po spotřebním zboží a službách a vypočteme příslušné příjmové, vlastní a křížové cenové elasticity. Interpretujeme výsledky jako závislost nabídky na příjmech, cenách a demografických ukazatelých.

První model je použit na odhad efektu reformy daně z přidané hodnoty 2015 v České Republice, která přinesla 10% sníženou sazbu na léky a knihy. Náš odhad ukázal, že nejvíce se poptávka zvýší v oblečení, lécích a knihách a sníží v domácích potřebách. Dohromady odhadujeme, že domácnosti zvýší výdaje na spotřební zboží o 1 049 miliardy CZK a příjmy státu z DPH se sníží o 818 milionů.

Nakonec použijeme druhý model k odhadu efektu stárnutí populace na poptávku. Budeme zkoumat čtyři scénáře, abychom separovali efekt změny složení domácností a abychom zjistili, jak se tento efekt bude měnit při bohatnutí obyvatel a transferech mezi pracujícími domácnostmi a domácnostmi důchodců. Největší efekt má stárnutí populace na komodity jídla, paliv a energií, dopravy a volnočasových služeb. Změny složení domácností mají působení ve stejném směru jako stárnutí populace a budou tedy jeho efekt umocňovat. Souběžné efekty bohatnutí obyvatel a redistribuce nemají jasný vliv. V některých případech posilují efekt stárnutí populace, v některých ho oslabují a v jiných ho úplně změní.

Klasifikace JEL	D12, E12, H20, J11,
Klíčová slova	Quadratic Almost Ideal Demand System, Česká Republika cenové a příjmové elasticity, chování spotřebitele, dopady danění, stárnutí populace

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Chapter 1

Introduction

The household consumption is the biggest part (usually around 50%) of national Gross Domestic Product (GDP) in most developed nations, including the Czech Republic. Therefore a detailed knowledge of consumer behaviour is a relevant and important matter for both tax and social policy-making as well as for the long-term investment and production. The understanding of demand on the side of households is also a point of interest of economic theory especially for the welfare analysis.

In this thesis the Quadratic Almost Ideal Demand System (QUAIDS) is used, as it is one of the most recent models of static micro-approach to consumption. It is an extension of the former Almost Ideal Demand System (AIDS) which uses the log dependence of prices and income on demanded commodity shares of individuals or households. The main advantages of these models are the easy assessment of the neoclassical microeconomic theory and integrability. The macroeconomic estimations tend to be biased as they do not take properly into account the behavioural responses and consumer heterogeneity. The micro-approach avoids these issues.

The QUAIDS further extends the AIDS of quadratic term of log income and thus allows quadratic "hump-shaped" behaviour of Engel curves. This new higher flexibility in Engel curves was desired as the previous models had allowed only for linear behavioural and demographical responses in income-consumption relationship. This under-specification could cause a bias in the estimation of demand as was concern for previous research.

As already said the QUAIDS model takes prices, consumer income and various characteristics and predicts his/her demanded commodity share. In the theoretical part we explain the main features of the QUAIDS and its advantages and limitations.

In the empirical part we employ this model on the household consumption as we consider that the decisions are made at the level of household. For these purposes the Czech Statistical Office (CSO) conducts the annual Household Budget Survey (HBS) which we combine with the Consumer Price Index (CPI) also by CSO, to get complete information on consumption, prices and demographics.

We estimate the coefficients in two models. We bundle goods and services into 8 and 11 broader aggregated commodities excluding housing and non-durables goods. In both models we interpret the income coefficients to assess the shapes of Engel curves and the demographic coefficients to analyse effects of household characteristics such as employment, sex, education and so on. Furthermore, we compute and interpret the income and price elasticities.

In the first model the price elasticities are used to compute the effects of 2015 Value Added Tax (VAT) reform, which introduced 10% reduced rate for medication and books. The effects on consumption and the VAT revenue are analysed.

In the second model we focus on the ageing effects on consumption with implications of population ageing. Last part is dedicated to the analysis of effects of the population ageing on the demand. This is done in 4 scenarios. The first scenario projects the *ceteris paribus* effects of the population ageing on the aggregated demand. The second scenario separates the effects of household composition changes. The third and the fourth scenario analyse the mutual effects between income/redistribution change and the population ageing. The focus is on how the population ageing affects consumers behaviour.

Chapter 2

Theoretical part

2.1 Literature review

The demand and consumer behaviour has always been a subject of interest of economic studies. In this thesis we present the stationary microeconomic approach. It was first studied by Stone (1954), who estimated the demand system based on the Linear Expenditure System (LES) developed by Klein & Rubin (1947). The next most used model was the Almost Ideal Demand System (AIDS) developed by Deaton & Muellbauer (1980), that specifies the log-linear demand system.

The following research suggested there might be bias in estimated Engel curves as they have build-in shape within the LES and AIDS. Using parametric and non-parametric methods Banks *et al.* (1997) showed that an additional flexibility in Engel curves is desired. They introduced the Quadratic Almost Ideal Demand System (QUAIDS) adding the quadratic term of log income to the AIDS and showed that no additional degree of dependence on log income is needed.

Some researches on the AIDS and QUAIDS conducted especially in the Czech Republic are Crawford *et al.* (2003) and Janda *et al.* (2009), who employ the AIDS model to study food and alcoholic beverages. Brůha & Ščasný (2006) also used the AIDS on the Czech Republic data to examine the possible policy effects on energy and transportation. Janda *et al.* (2000) applied the AIDS model to study food import demand in the context of the early transition.

In relation to the tax policies Crawford *et al.* (2010) employs the QUAIDS to study the Value Added Tax (VAT) and excise in the UK. Abramovsky *et al.* (2012) uses the QUAIDS to estimate impacts of the Mexico 2010 VAT reforms.

This approach is then used by Janský (2014) on the proposed VAT reforms of 2013 in the Czech Republic. Our thesis then follows this research in the estimation of effects of the 2015 VAT reform.

Regarding the population ageing Lührmann (2008) uses the QUAIDS model to estimate the effects of population ageing and the age specific aggregated demand in the UK. This article was our guide for implementing the estimations of the population ageing model.

Lastly, the QUAIDS model on the Czech Republic data was estimated by Dybzcak *et al.* (2014) which we use for the comparison of elasticities and as a useful source of information regarding the demand system analysis.

2.2 Quadratic Almost Ideal Demand System

The QUAIDS is an extension to former AIDS developed by Deaton & Muellbauer (1980). It was first introduced by Banks *et al.* (1997) and it adds a quadratic term of income to the system. It was argued that AIDS exhibits a bias as the Engel curves tend to be non-linear. This turned out to be true as it was tested in Banks *et al.* (1997) against a model with quadratic term of income. They also showed that adding quadratic term of income to the demand system, and therefore making the Engel curves quadratic, is sufficient and no higher degree of dependence on income is needed. This need for quadratic order of income was also shown in the case of the Czech Republic by Dybzcak *et al.* (2014).

The QUAIDS is derived from the following indirect utility function

$$\ln u(x, \mathbf{p}, \mathbf{z}) = \left(\left(\frac{\ln x - \ln a(\mathbf{p}, \mathbf{z})}{b(\mathbf{p}, \mathbf{z})} \right)^{-1} + l(\mathbf{p}, \mathbf{z}) \right)^{-1} \tag{2.1}$$

or equivalently from the cost function

$$\ln c(u, \mathbf{p}, \mathbf{z}) = \ln a(\mathbf{p}, \mathbf{z}) + \frac{u \cdot b(\mathbf{p}, \mathbf{z})}{1 - u \cdot l(\mathbf{p}, \mathbf{z})}, \tag{2.2}$$

where x is income or in our case expenditure which is equal to c, $\mathbf{p}$ and $\mathbf{z}$ are vectors of prices and household characteristics (demographics). The $a(.)$, $b(.)$, $l(.)$ are the price aggregators and are defined as

$$\ln a(\mathbf{p}, \mathbf{z}) = \alpha_0 + \sum_i (\alpha_{i0} + \sum_k \alpha_{ik} z_k) \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{2.3}$$

$$b(\mathbf{p}, \mathbf{z}) = \prod_i p_i^{\beta_{i0}+\sum_k \beta_{ik} z_k} \tag{2.4}$$

$$\ln l(\mathbf{p}, \mathbf{z}) = \sum_i (\lambda_{i0} + \sum_k \lambda_{ik} z_k) \ln p_i.^1$$

To relax the notation we will always assume that the index k goes through 0 as well and we define $z_0 = 1$, now we can write simply $\sum_k \alpha_{ik} z_k$ instead of $\alpha_{i0} + \sum_k \alpha_{ik} z_k$ and so on.

The α_{ik}, β_{ik}, γ_{ik} and λ_{ik} are structural coefficients of interest which are to be estimated.

Applying Roy's identity on the indirect utility function (2.1), we get the budget shares w_i of commodity i given by

$$w_i = \frac{\partial \ln a(\mathbf{p}, \mathbf{z})}{\partial \ln p_i} + \frac{\partial \ln b(\mathbf{p}, \mathbf{z})}{\partial \ln p_i} \ln m + \frac{\partial l(\mathbf{p}, \mathbf{z})}{\partial \ln p_i} \frac{\ln^2 m}{b(\mathbf{p}, \mathbf{z})},$$

where $\ln m = \ln x - \ln a(\mathbf{p}, \mathbf{z})$.

Equivalently, we can use Shephard's lemma on the cost function (2.2) to obtain Hicks demand h_i for each good as

$$\frac{\partial c_i(u, \mathbf{p}, \mathbf{z})}{\partial p_i} = h_i(u, \mathbf{p}, \mathbf{z})$$

and the budget share as

$$\frac{\partial \ln c(u, \mathbf{p}, \mathbf{z})}{\partial \ln p_i} = \frac{p_i h_i}{c(u, \mathbf{p}, \mathbf{z})} = w_i.$$

In both cases we get

$$w_i = \sum_k \alpha_{ik} z_k + \sum_j \gamma_{ij} \ln p_j + \sum_k \beta_{ik} z_k \ln m + \frac{\sum_k \lambda_{ik} z_k}{b(\mathbf{p}, \mathbf{z})} \ln^2 m. \tag{2.5}$$

The coefficient cannot be arbitrary, the sum over all the commodities of the budget shares must be equal to 1 (for all prices, expenditure and household

[1] The summation variables i and j always go through the set of all commodities and k goes through household characteristics.

characteristics). This gives us the adding-up condition[2]

$$\sum_i \alpha_{ik} = \delta_{0k} \qquad \forall k \qquad\qquad \sum_i \gamma_{ij} = 0 \qquad \forall j,$$
$$\sum_i \beta_{ik} = 0 \qquad \forall k \qquad\qquad \sum_i \lambda_{ik} = 0 \qquad \forall k.$$

Further to comply with the theory of utility maximization the budget share function should be homogeneous of degree zero in $\mathbf{p}$ and x, which implies the homogeneity condition

$$\sum_j \gamma_{ij} = 0 \quad \forall i.$$

We can impose symmetry assumption which yields the symmetry condition

$$\gamma_{ij} = \gamma_{ji} \quad \forall i, j.$$

The negativity condition (from the concavity of expenditure function) cannot be imposed directly on the model coefficients but the resulting Slutsky matrix can be tested for negative semi-definiteness. However, if some of the externalities of the model turn out to be important or some goods turn out to be Giffen (probably from the externalities) then we do not expect the negativity criterion to be fulfilled.

The raw estimated parameters are very hard to interpret, therefore we want to report income and price elasticities. Furthermore, we can and will use them to estimate the effects of the tax reform in the Czech Republic in 2015.

2.2.1 Income Elasticities

To make the computations a little bit more manageable we denote $A_i := \sum_k \alpha_{ik} z_k$, similarly $B_i := \sum_k \beta_{ik} z_k$ and $L_i := \sum_k \lambda_{ik} z_k$. This makes the expression for w_i

$$w_i = A_i + \sum_i \gamma_{ij} \ln p_j + B_i \ln m + \frac{L_i}{b(\mathbf{p}, \mathbf{z})} \ln^2 m.$$

Now we denote μ_i the derivative of budget share w_i with respect to $\ln x$.

$$\mu_i := \frac{\partial w_i}{\partial \ln x} = B_i + 2\frac{L_i}{b(\mathbf{p}, \mathbf{z})} \ln m. \tag{2.6}$$

[2]From here δ_{ij} denotes Kronecker delta given by $\delta_{ij} = 0$ for all $i \neq j$ and $\delta_{ii} = 1$ for all i.

Further we use

$$\mu_i = \frac{\partial w_i}{\partial \ln p_i} = \frac{\partial w_i}{\partial x} x$$

and

$$\frac{\partial w_i}{\partial x} = \frac{\partial \frac{p_i q_i}{x}}{\partial x} = -\frac{p_i q_i}{x^2} + \frac{p_i}{x}\frac{\partial q_i}{\partial x} = -\frac{w_i}{x} + \frac{w_i}{q_i}\frac{\partial q_i}{\partial x},$$

to get

$$\mu_i = \frac{\partial w_i}{\partial x} x = -w_i + w_i \frac{x}{q_i}\frac{\partial q_i}{\partial x} = -w_i(1-\epsilon_i).^3$$

Finally, by expressing ϵ_i and substituting (2.6) we get

$$\epsilon_i = \frac{\mu_i}{w_i} + 1 = \frac{1}{w_i}\left(B_i + 2\frac{L_i}{b(\mathbf{p},\mathbf{z})}\ln m\right) + 1. \tag{2.7}$$

2.2.2 Own and cross price elasticities

Again we denote μ_{ij} the derivative of w_i with respect to $\ln p_j$

$$\mu_{ij} := \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i(A_j + \frac{1}{2}\sum_l(\gamma_{lj}+\gamma_{jl})\ln p_j) - \frac{B_j L_i}{b(\mathbf{p},\mathbf{z})}\ln^2 m.^4 \tag{2.8}$$

Furthermore, we use the same trick to obtain

$$\mu_{ij} = \frac{\partial w_i}{\partial \ln p_j} = \frac{\partial w_i}{p_j} p_j$$

and

$$\frac{\partial w_i}{\partial p_j} = \frac{\partial \frac{p_i q_i}{x}}{\partial p_j} = \frac{1}{x}(p_i \frac{\partial q_i}{\partial p_j} + \frac{\partial p_i}{\partial p_j} q_i) = \frac{p_i}{x}\frac{\partial q_i}{\partial p_j} + \delta_{ij}\frac{q_i}{x}.$$

Together we get

$$\mu_{ij} = \frac{\partial w_i}{\partial p_j} p_j = \frac{p_i q_i}{x}\left(\frac{\partial q_i}{\partial p_j}\frac{p_j}{q_i}\right) + \delta_{ij}\frac{q_i p_j}{x} = w_i(\epsilon^u_{ij} + \delta_{ij}).^{56}$$

Expressing ϵ^u_{ij} we get

$$\epsilon^u_{ij} = \frac{\mu_{ij}}{w_i} - \delta_{ij}$$

[3] Here ϵ_i denotes the income elasticity of demand for ith commodity.

[4] Index l also goes through the set of all commodities

[5] We denote ϵ^u_{ij} the uncompensated Marshall price elasticity of demand for ith good with respect to jth price.

[6] We used that $\delta_{ij}\frac{q_i p_j}{x} = \delta_{ij}\frac{q_i p_i}{x} = \delta_{ij} w_i$.

plugging (2.8)

$$\epsilon_{ij}^{u} = \frac{1}{w_i}\left(\gamma_{ij} - \mu_i(A_j + \frac{1}{2}\sum_l(\gamma_{lj} + \gamma_{jl})\ln p_j) - \frac{B_j L_i}{b(\mathbf{p},\mathbf{z})}\ln^2 m\right) - \delta_{ij}. \quad (2.9)$$

To obtain the compensated Hicks price elasticities ϵ_{ij}^{c} we use the Slutsky equation

$$\epsilon_{ij}^{c} = \epsilon_{ij}^{u} + \epsilon_i w_j. \quad (2.10)$$

Moreover, we can use the matrix with entries $\{\epsilon_{ij}^{c} w_i\}_{i,j}$ to check for the negativity condition. This matrix should be negative semi-definitive.

2.2.3 Model assumptions

There are several conditions which have to hold for the model to be consistent. We have already imposed several restrictions so that the resulting model agrees with the theory of utility maximization. This theory requires fixed prices for each individual consumer (in our case a household), therefore we assume prices to be fixed, e.i., not dependant on the total of demanded quantity. This implies that our model is limited from being used on prediction of supply-demand interactions on a market.

The QUAIDS is still useful in short term projections where we assume prices to be sticky on the supply side. Such shocks can be, for example, a change in the VAT rate or excise duties, change of price regulation in housing, medication or health care. Also, the QUAIDS model can be useful to analyse some *ceteris paribus* changes in household and income redistribution as it was done by Lührmann (2008) and as it is shown in this thesis.

Furthermore, we have to assume the weak separability between goods included and excluded from the model. Work and leisure are assumed to be separable by some. However, as Browning & Meghir (1991) showed on the UK surveys between 1979 and 1984 containing data on work/leisure distribution, this assumption is violated. This was concern for many previous researches on demand, i.e., Attanasio & Browning (1993) or Blundell *et al.* (1989). We do not have many indicators for work/leisure so this assumption limits the validity of our projections, however we include at least some variables to control for this non-separability as it is done in Lührmann (2008).

The second separability assumption concerns the time distribution of consumption. We assume the weak separability of preferences between goods in any two periods in similar fashion to most papers on micro analysis of demand. This assumption is supported by the two-stage decision making process and life-cycle theory where household first distributes consumption over time (savings) and then allocates the remaining income in given period between goods and services. For description and further information on separability and multi-stage budgeting see Janda *et al.* (2009) or Heath & Soll (1996)

The final separability assumption often accepted in papers on household demand, e.g., Lührmann (2008), Dybzcak *et al.* (2014), is the durable/non-durable goods separability. This assumption also follows from the two-stage decision making process and life-cycle theory. Durable goods are considered as savings or investment and therefore are not concerned in the second stage of decision making process.

We argue that the decision making process on the side of demand is not done by individuals but rather by the household as a whole. This can be a single person in case of single households but usually it is done by one of the parents or one of the couple, from now on we will call this person the head of the household. Moreover, we consider the household to be the best option of a unit for demand analysis.

2.3 Estimation

We consider the system of equations in the form of (2.5) plus the error term ϵ_i for each household, resulting in system of equations

$$w_i = \sum_k \alpha_{ik} z_k + \sum_j \gamma_{ij} \ln p_j + \sum_k \beta_{ik} z_k \ln m + \frac{\sum_k \lambda_{ik} z_k}{b(\mathbf{p},\mathbf{z})} \ln^2 m + \epsilon_i. \quad (2.11)$$

Furthermore, we use the Instrumental Variable (IV) method to limit the possible endogeneity of log income and its square term. We instrument all remaining variables for them and use the residuals, their square and cubic terms in the regression of (2.11). Because of the adding-up restriction we have to estimate only $n-1$ equations, where n is the number of commodities, and calculate the coefficients for remaining commodity from the adding-up condition.

We abuse the linearity of the model conditional on $a(\mathbf{p},\mathbf{z})$ and $b(\mathbf{p},\mathbf{z})$. First we replace $b(\mathbf{p},\mathbf{z})$ by 1 and $a(\mathbf{p},\mathbf{z})$ by Stone price index (Stone 1954)

$$a(\mathbf{p},\mathbf{z}) \approx \sum_i w_i \ln p_i,$$

then we use the Seemingly Unrelated Regression (SUR) developed by Zellner (1962) on equation (2.11) with $a(\mathbf{p}, \mathbf{z})$ and $b(\mathbf{p}, \mathbf{z})$ given. With estimated parameters we can update $a(\mathbf{p}, \mathbf{z})$ and $b(\mathbf{p}, \mathbf{z})$ by formula (2.3) and (2.4), respectively. We repeat the previous step until the parameters converge to 4 decimal places.

The income, Hicks and Marshall prices elasticities are then calculated from the parameters according to (2.7), (2.9) and (2.10), respectively. Their standard errors are calculated using the bootstrap method with 1300 iterations.

Chapter 3

Data

3.1 Household Budget Survey

For the purpose of our model we used the Household Budget Survey (HBS) conducted by the Czech Statistical Office (CSO). This survey contains expenditures of 3000 households each year. We used the data from 2000 to 2013 resulting in a sample of $42,459$ households. The original data had contained more than $43,000$ households because the data from before 2006 have more than 3000 households. On the other hand we excluded some data from each year that exhibited abnormalities, i.e., negative expenditures, negative income or missing data.

The data are gathered annually by the CSO from a sample of 3000 households, unfortunately the sample is updated each year which prevents us from using it as a panel data. We assume the sample to be pooled cross section instead, i.e., each year randomly chosen sample from the population. This assumption might be violated because some families are surveyed each year. However, the CSO selects the household sample such that the distribution of selected characteristics is the same as in the population, based on the micro-survey from the previous years. This is not true for the data before 2006 where some groups are excluded. Due to preliminary robustness checks by Dybzcak *et al.* (2014) and Janský (2014) which do not find significant difference between the periods before and after 2005, we conclude that there is no significant risk in using data from a longer period. (Janský 2014)

The selected characteristics for the choice of the sample are: economical (in)activity, employment, self-employment, retirement of the head of household and economical activity of other members of the household. Furthermore, the

CSO provides weights for the households so the predictions can be extended to the whole population.

The survey captures expenditure for goods as well as the households characteristics in a high level of detail, from the number of members to the ownership of durable goods such as TV, computer or camera. Therefore the HBS is an ideal dataset for such microeconomic demand analysis. The scale of survey allows us to control for a large spectrum of variables which is desirable to make various *ceteris paribus* predictions.

In the first model we want to capture the change in the household demand after the 2015 tax reform in the Czech Republic. Therefore we selected the following variables for the first model: number of children, number of members, age, sex, employment status, education of the head of the household, city size of the household residency, dummy variable for Prague and time trend. This choice corresponds with the research by Janský (2014).

In the second model we choose demographics to predict a change due to the population ageing, an expenditure growth and income redistribution. We selected: number of children in the age -5, 6-9, 10-14 and 15+, log of the household size, sex, education, age category of the head of the household, city size, region of the household residency, dummy for single households, time trend, car ownership and a type of housing. More detailed information about the demographics will be given in respective models. Frequency tables of used demographic variables can be found in Table B.1 and Table B.2.

For the purpose of our analysis the survey is too detailed, it contains around 340 expenditure items and around 30 income items. Therefore we aggregate individual goods and services into broader commodities. For the first model the commodities are food, eating consumed outside home, household goods, clothing, other services, transport and recreation, energy and other goods, this relates to grouping in Janský (2014). For the second model we bundled groups as follows: food, food out, alcohol and tobacco, fuel & light, household goods, household services, clothing & shoes, personal goods & services, transport, leisure goods, leisure services. This relates to grouping in Lührmann (2008).

In the first model more emphasis was given on the Value Added Tax (VAT) rate of individual goods (so that goods with the same VAT rate would be in the same commodity). In the second model more emphasis was given to the second-stage decision-making process. More on aggregation in respective models.

The aggregation brings several advantages: some aggregation is necessary to make the estimation manageable, the variation in expenditure levels can be large across households unlike the more stable relative prices. (Dybzcak *et al.* 2014) Finally, the households themselves do not plan the consumption to individual goods, we assume that the households budget they expenditure into broader commodities instead. This is also supported by the multi-stage budgeting theory. Of course, the aggregation also causes bias which we want to avoid by this micro-approach analysis.

To utilize the income data we use the total income as an Instrumental Variable (IV) to clean the expenditure for possible endogeneity.

3.2 Consumer Price Index

The price data are taken from the Consumer Price Index (CPI) by the CSO. The CPI contains prices of around 150 categories according to the Classification of Individual Consumption According to Purpose (COICOP). The prices are available for individual months but as those do not vary greatly and the HBS contains yearly data we use only the year average prices. We take advantage of the fact that the CPI contains prices for Prague separately and we apply them on the Prague households.

The HBS itself does not contain a price information but it can be obtained for some goods which contain the information on amount. However, this cannot be done for all the goods and therefore we opt to use the CPI as the sole source of price information. Using the household individual prices could cause bias in the sense that a household could simply substitute cheaper/expensive for lower/higher quality product. This however has no affect on the aggregate demand and therefore should not be accounted for in the demand analysis.

The prices are first computed for each commodity as weighted average of prices from the CPI with weights being the expenditures. The aggregated prices are then computed for each bundle with weights being expenditures of all the households. Finally, in the estimation the aggregate prices are used as they reflect the market effects on the demands rather than a shift in taste.

3.3 Ageing and Household Projections

Finally, for the projection of the population ageing we use the Population Projection of the Czech Republic 2013 conducted and available on the web pages of the CSO. This projection offers three scenarios of population ageing, in each it gives a number of people in a given age and a year until 2101. In our analysis we used the medium scenario only.[1]

Moreover, we used the Projection of the census households from 2001 also available from the CSO. As the population projection it offers a number of households based on their composition each year until 2030. However, the documentation on scenarios and methodology is not available from the CSO and the projection starts in the year 2001 and goes only until 2030.[2] This limits the assertions from this projection and we use it only for a comparison and an extension of our analysis.

A useful projection of households combined with age would be preferable to the projection of population ageing as the HBS units are households. With only the data on population ageing we have to map the population onto households which can cause bias and limit the assertions of our analysis.

[1]Projection can be found here - https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-do-roku-2100-n-fu4s64b8h4.

[2]Projection can be found here - https://www.czso.cz/csu/czso/projekce-poctu-cenzovych-domacnosti-v-ceske-republice-do-roku-2030-n-odmex25otb.

Chapter 4

Model for VAT reform analysis

In this section we are going to present the continuation of the VAT reform analysis done by Janský (2014). We use the STATA program available for this kind of analysis created by Janský (2013) and freely available on the web pages of Institute for Democracy and Economical Analysis (IDEA) at Center for Economic Research and Graduate Education - Economics Institute (CERGE-EI) - Tax models for the Ministry of Finance under the Quadratic Almost Ideal Demand System (QUAIDS) model. We extend this model by the data from 2000, 2012 and 2013 and apply it on the VAT reform of 2015 in the Czech Republic which introduced a new third tax rate of 10% on books, medication and baby nutrition. The VAT rates in the Czech Republic as of 2013 were the standard rate of 21% and the second reduced rate of 15%.

In this model we use the same grouping of commodities as created by Janský (2014) and we also exclude the housing expenditure. The grouping considers three criteria, the first is the natural grouping as people consider commodities during the expenditure allocation, the second is that the groups should be of similar size and the third is according to the VAT rates. The resulting grouping with their share and the VAT rates can be seen in Table 4.1.

We can see that *Food in* has the highest share of 23.3% and violates the similarity in the size criterion. This is due to the difficult sub-grouping in this category so we are forced to leave it with this high share. On the other hand *Clothing* has the lowest share of 7.7%. The other groups of commodities then have between 9% and 15% so the size criterion is met. The grouping by the HBS codes can be found in Appendix C.

For the demographics we use the same variables as Janský (2014), the descriptions can be found in Table 4.2. For the manageability of calculation

Table 4.1: Group shares in 2000-2013 and the VAT rate

Commodity (VAT rate)	Share (%)
1. Food in (Reduced)	23.3
2. Food out (Standard)	10.8
3. Household goods (Standard)	9.4
4. Clothing (Standard)	7.7
5. Other services (Reduced)	14.1
6. Transport (Standard)	14.9
7. Energy (Standard)	9.3
8. Other goods (Standard)	10.6

Source: CSO and authors' calculations.

Table 4.2: Variables used in the model

Variable	Description
Child	Number of children in the household
HH size	Number of members of the household
Age	Age of the head of the household
Sex	Sex of the head of the household
Empstat	Employment status of the head of the household
Educlow	Primary education or less
Educmid	Secondary education
City size	1 for regional capitals, 2 for cities and 3 for villages
Praha	Prague household
Time trend	2013 - year of survey

Source: Janský (2014).

we have to exclude some demographics surveyed in the HBS that might have an effect on demand. We include only those with the obvious effects on the household demand such as sex, age, children, members, employment status and education. Furthermore, we know the different prices, income and therefore the consumption behaviour of the Prague households, so we include a dummy variable for Prague. Lastly, we use the time trend to capture the possible shifts in taste during the examined period. Summary of demographics can be found in Appendix B.

4.1 Estimation

For the estimation of the model we use the equation of the form (2.11)

$$w_i = \sum_k \alpha_{ik} z_k + \sum_j \gamma_{ij} \ln p_j + \sum_k \beta_{ik} z_k \ln m + \frac{\sum_k \lambda_{ik} z_k}{b(\mathbf{p}, \mathbf{z})} \ln^2 m + \epsilon_i. \quad (4.1)$$

However, in this model we do not let variables interact with the log income and its square term, we set $\beta_{ik} = 0$ and $\lambda_{ik} = 0$ for $k \neq 0$. Moreover, we add non-demographic variables of the time trend, residuals from IV, its squared and cubic term to the right hand side of the equation. We impose both homogeneity and symmetry condition using the constraint option of the Seemingly Unrelated Regression (SUR) command in STATA.

Results

Resulting coefficients from the last iteration of the the SUR can be seen in Table A.1 in Appendix A. All equations are statistically significant, meaning that all the consumption shares are different from zero as expected. The Rs squared are very low for all the equations especially *Food out* where it is below 0.100. With the highest but still low value of 0.406 and 0.367 ended up *Food in* and *Transport*, respectively. This is probably due to the limitations in our data and the choice of variables as they do not explain commodity shares very well with a potentially big error. This is a similar issue as dealt with by Janda *et al.* (2009).

The coefficients of all the variables ended up being statistically significant for at least one equation. The price variables are less statistically significant then the demographical variables, which is probably due to their low variation during the examined period. It is surprising that own prices are statistically significant for only 3 commodities.

The non-squared term of the log income is significant for all the commodities as expected. The squared term is significant for 4 commodities and therefore it supports the use of the QUAIDS model against the Almost Ideal Demand System (AIDS) as the resulting Engle curves of *Food in, Household goods, Clothing* and *Transport* are non-linear. Only *Food in* exhibits the inverse hump-shaped Engle curve as the coefficient at the log income squared is negative, the other 3 exhibit hump-shaped Engle curve as their share increase more with more income. These results are more or less comparable to Janský (2014). At least the signs of the coefficients are all equal but for some commodities the coefficients themselves vary.

Almost all the demographic variables resulted statistically significant for all equations. We will discuss age effects in the next model but even in this model we can see that age plays an important role in the household demand. We can see that only *Food in* and *Energy* demanded shares grow with the size of the household, which is maybe expected for *Food* but it is surprising for *Energy* as we would expect some economy of scale inside the household for this commodity.

The demanded share of *Food* and *Energy* on the other hand decreases with the number of children, as could be expected. *Employment* is positively correlated with *Food out* and *Transport* and negatively with *Food in.* This seems reasonable as working people spend more on commuting and eating out for lunch or after work. Surprisingly, the Prague variable came out positive for *Food in* and non-significant for *Food out.* However, the *city-size* balances this with bigger cities having higher share in *Food out* and lower in *Food in.*

The education also has an impact on the household demand. The households with the head without higher education tend to spend more on *Food* and *Household goods* and much less on *Clothing* and *Other services.* The time trend has statistically significant effect only for *Household* - positive and *Energy* - negative.

The demographics coefficients also resulted similarly to Janský (2014), as we used the same method of estimation only with updated dataset.

4.2 Elasticities

We compute the income elasticity, Hicks and Marshall price elasticities according to (2.7), (2.9) and (2.10), respectively. The elasticities are computed individually for each household and then the weighted average is constructed with weights being the total expenditure. The resulting income elasticities can be seen in Table 4.3.

The income elasticities seem reasonable with *Food in* and *Energy* being the least elastic. Because they have the elasticity under 1 we consider them necessary goods. *Other services* and *Other goods* also fall into this category. None of the aggregated commodities turn out to be inferior (negative income elasticity). As expected we find *Transport* and *Household goods* with the highest elasticities and consider them as luxury goods. The other commodities *Food in* and *Clothing* have elasticity just above 1, so they are also considered as luxury goods.

Their significance is better then in Janský (2014), six out of the eight commodities have statistically significant income elasticities. Only statistically insignificant income elasticities are in the commodities with the lowest values, i.e., *Food in* and *Energy*. These commodities were also statistically insignificant in the previous research.

The income elasticities are comparable to previous research with an exception of *Energy* which resulted by 0.263 higher in Janský (2014). The results from Dybzcak *et al.* (2014) can be compared only for the categories which coincide with ours. We can still say that findings about necessity and luxury goods are the same. Our estimates come out lower in *Food* (which is compensated by our *Food out* category) and *Energy*. They result higher in *Clothing*, *Household goods* and *Transport*. Our categories of *Other goods* and *services* and corresponding *Other* categories result in similar elasticity.

The tables Table 4.4 and Table 4.5 show the uncompensated and compensated price elasticities. The own price elasticities are all negative as required by the theory for non-Giffen goods. However all commodities turn out to be inelastic except for *Food out* with price elasticity just below -1 and *Household goods* close to an unitary elasticity. The cross price elasticities are reasonable too as they tend to be lower then own elasticities, also *Food in* and *Food out* are substitutes as expected.

Considering the own-price elasticities four commodities result statistically

Table 4.3: Income elasticities

Commodity	Income Elasticity
1. Food in	0.358
2. Food out	1.117**
3. HH goods	1.864***
4. Clothing	1.343***
5. Other s.	0.757***
6. Transport	2.192**
7. Energy	0.182
8. Other g	0.957***

*,**,*** denote 10%, 5%, 1% significance level.

Source: CSO and authors' calculation.

significant in both uncompensated and compensated case, namely *Household goods*, *Clothing*, *Other services* and *Other goods*.

The significance of cross price elasticities result similarly in both uncompensated and compensated case. Most of the cross price elasticities are insignificant with only around 20 out of 56 resulting significant. It seems that the most significant results are in the categories *Clothing* and *Other goods*.

The own price elasticities come out different from Janský (2014) which is expected because of the low statistical significance. The major difference is in the *Household goods* which is now close to the unitary price elasticity, although it was elastic in the previous research. The other price elasticity remained their elastic and inelastic properties.

Compared to Dybzcak *et al.* (2014) the elasticities in *Food* and *Other* are comparable, the others come out different but similarly above −1. The major differences are in *Transport* and *Energy* which for them came out almost unitary. On the other hand our *Household goods* result almost unitarily elastic while inelastic for them.

Table 4.4: Marshall (uncompensated) price elasticities

Commodity	1.	2.	3.	4.	5.	6.	7.	8.
1. Food in	**-0.588**	0.118 **	-0.220	0.309	-0.056	0.161	0.338	-0.063
2. Food out	0.285 *	**-0.901**	0.137	0.017	0.333	0.052	0.007	0.071
3. HH goods	-0.570	0.178 **	**-0.811** ***	0.006	0.546	0.652 *	-0.157	0.156 *
4. Clothing	0.950	0.030	-0.003	**-0.685** **	-0.348	0.045 ***	0.240 ***	-0.230 ***
5. Other s.	-0.046	0.239	0.341	-0.184	**-0.508** **	-0.029	-0.062	0.249 ***
6. Transport	0.203	0.062	0.425 *	0.035 ***	-0.017	**-0.161**	-0.377	-0.169 ***
7. Energy	0.879	-0.013	-0.158	0.205 *	-0.145	-0.607	**-0.306**	0.145
8. Other g.	-0.117	0.070 *	0.129	-0.166 ***	0.341 ***	-0.250 ***	0.134 ***	**-0.140** ***

Price elasticity of demand for a commodity in row with respect to a change in price of a commodity in column. *,**,*** denote 10%, 5%, 1% significance level.

Source: CSO and authors' calculations.

Table 4.5: Hicks (compensated) price elasticities

Commodity	1.	2.	3.	4.	5.	6.	7.	8.
Food in	**-0.588**	0.118	-0.220	0.309	-0.056	0.161	0.338	-0.063
		**						
Food out	0.285	**-0.901**	0.137	0.017	0.333	0.052	0.007	0.071
	*							
HH goods	-0.570	0.178	**-0.811**	0.006	0.546	0.652	-0.157	0.156
		**	***			*		*
Clothing	0.950	0.030	-0.003	**-0.685**	-0.348	0.045	0.240	-0.230
				**		***	***	***
Other s.	-0.046	0.239	0.341	-0.184	**-0.508**	-0.029	-0.062	0.249
					**			***
Transport	0.203	0.062	0.425	0.035	-0.017	**-0.161**	-0.377	-0.169
			*	***				***
Energy	0.879	-0.013	-0.158	0.205	-0.145	-0.607	**-0.306**	0.145
				*				
Other g.	-0.117	0.070	0.129	-0.166	0.341	-0.250	0.134	**-0.140**
		*		***	***	***	***	***

Price elasticity of demand for a commodity in row with respect to a change in price of a commodity in column. *,**,*** denote 10%, 5%, 1% significance level.

Source: CSO and authors' calculations.

4.3 The VAT reform impacts

In this section we create two new groups: *medications/drugs* and *books and textbooks*. These goods were part of the fifth group - *Other services*. We assign them their new third VAT rate of 10% and use the price elasticities to compute the cross and own price effects on individual commodities for the year 2013. We sum the effects to get the total relative change in consumption as well as the total relative change in the VAT revenues. Furthermore, we extrapolated the 2013 expenditures onto the whole population to get at least some estimate of a nominal change (in CZK). The following Table 4.6 presents the final results.

Table 4.6: The 2015 VAT reform effect on the aggregate household demand and the VAT revenues

Commodity	Group share	Demand change		VAT revenues	
	(before)	%	mil. CZK	%	mil. CZK
Food in	25.6	0.09	169	0.00	25
Food out	10.6	-0.15	-137	0.00	-29
Household goods	6.8	-0.35	-168	0.00	-35
Clothing	6.1	0.79	275	0.01	58
Other services	13.3	0.48	410	0.01	61
Transport	11.6	0.06	227	0.00	48
Energy	12.7	0.10	99	0.00	21
Other goods	11.1	-0.14	-121	0.00	-25
Drugs	1.8	0.48	101	-0.06	-643
Books	0.4	0.48	23	-0.01	-178
Total	100	0.11	1,049	-0.06	-818

Source: Authors' calculations.

We can see to some extent that the households react to the changes in prices of just two commodities by changes in all the categories. This is the behaviour response often neglected in the aggregated analysis and biased in models not properly allowing for behavioural response. However, the QUAIDS results presented here should be interpreted with caution as some of the elasticities came out insignificant.

The responses in most commodities are modest. We can see the highest response in *Clothing* surprisingly. The second highest effect can be seen in the group *Other services* as well as *Drugs* and *Books* themselves, they will grow by 0.79% and 0.48% which corresponds to 275 and 410 million CZK, respectively. On the other hand *Household goods* has the highest decrease by 0.35% corresponding to 168 million CZK. In total the Czech households are estimated to spend more by 0.11%, which is 1, 049 million CZK. This can be caused by a shift from saving to expenditure or less spending on the other goods such as housing, that are excluded from this model.

The changes in the VAT revenues are relatively low compared to the total public budget revenue[1], however it is estimated to loose 818 million, 643 from *Drugs* and 178 from *Books*. The effects on the VAT revenues from other commodities cancel out each other, leaving the significant effect only from the affected goods. Our estimated effects are expected to be much lower than from the aggregated or other models analysis, as they do not take into account or bias the behavioural response. For example the Ministry of Finance estimated the loss to be around 3.3 billion CZK.[2]

[1]In 2013 The total revenue of the public budget was 1091, 86 billion CZK of that 230, 2 billion CZK was from the VAT.

[2]We were not able to retrieve the original report of Ministry of Finance. CTK - `http://ekonomika.idnes.cz/treti-sazba-dph-pripravi-stat-a-obce-o-3-3-miliardy-f6f-/ekonomika.aspx?c=A140911_135938_ekonomika_fih`.

Chapter 5

Model for population ageing and redistribution

The second model, which we present here, is designed to analyse the effects of population ageing on the consumption of households. We try to use the similar model as presented in Lührmann (2008) on the case of the UK data. However, we do not have the same information available and it is not an ambition of this text to carry out such a detailed analysis. Therefore we only calculate parameters of the QUAIDS model, corresponding elasticities, and then predict the household demand based on the population and the household projections by the CSO.

We try to use the same grouping as Lührmann (2008) and unlike in the first model we remove all durable commodities, besides housing we remove any car and furniture related commodities. These can be considered either an investment or saving and their irregular purchases could harm the validity of our projections.[1] In this model we do not consider the VAT rates of respective goods and services, we rather focus on their natural purpose as the consumers think about them during allocation of expenditure. The final grouping can be found in Table 5.1.

We can see again that *Food in* violates the rule about all groups having roughly the same size. On the other hand we assume that people think about this category as a whole and therefore we do not want to divide it any further. Unfortunately *Alcohol & Tobacco*, *Household goods* and *Leisure goods* have share below 5% and their results need to be interpreted with caution.

For the demographics we altered the STATA program to be more flexible

[1] For models concerning durable goods and their possible non-separability see Browning *et al.* (2014).

Table 5.1: Group shares in 2000-2013

Commodity	Share (%)
1. Food in	25.66
2. Food out	5.78
2. Alcohol & Tobacco	3.69
4. Fuel & Light	14.23
5. Household goods	4.86
6. Household services	12.83
7. Clothing	7.63
8. Personal goods & services	6.54
9. Transport	9.45
10. Leisure goods	2.35
11. Leisure services	6.97

Source: CSO and authors' calculations.

and manageable with choices of model variables. Thanks to this we could use more variables and also let some of them interact with the income terms. The final list of variables can be found in Table 5.2.

We replaced the sole number of children by the age categorization provided by the CSO. We expect the age of children to affect consumption, for example, smaller babies usually do not need as much food as later and the middle aged children use more *Personal goods* and *Clothing*. We replaced the size of household by its log term. Furthermore, we added dummy variable for the single households as we expect them to have different consumption pattern, i.e., spend more on *Food out* and *Leisure*. We extended the age variable for 5 year dummy to allow for the fluctuating changes of consumption during the lifetime. This is mainly for the purpose of our model to analyse and project the effects of the population ageing on the household demand.

We included the *car* ownership and *housing* for these surely affect *Fuel & Light* and *Transport* commodities. Although we do not expect the regions other then Prague to differ from each other, we decided to use the dummy for all the regions in the Czech Republic. Finally, we added the *Labour Force Participation Rate (LFP)* and *Economical Activity (EA)* to control for the non-separability between leisure and work as was mentioned in the theoretical part. The *education*, *employment status*, *city size* and *time trend* variables remained unchanged from the VAT reform model. For categories containing more than two options, the first category is always used as the control (comparison) one - the regional capitals for *city size*, Prague for *region*, tenant for *housing*, higher

Table 5.2: Variables used in the model

Variable	Description
d_5	Number of children under age of 5
d6_9	Number of children between age of 6 and 9
d10_14	Number of children between age of 10 and 14
d15_	Number of children above age of 15
Ln hh size	Log number of members of the household
Single	Dummy for a household with one member who is economically active
Age	5 year dummy variables -24, 25-29 ...75-79, 80+
Sex	Sex of the head of the household
Empstat	Employment status of the head of the household
Educlow	Primary education or less
Educmid	Secondary education
Housing	Dummy variable for a tenant, self-owned with/without mortgage housing
Car	Dummy for a presence of a car in the household
Region	Dummy for 14 administrative regions in the Czech Republic
City size	Dummy for the regional capitals, cities and villages
LFP	Labour force participation - the number of economically active divided by the household size
EA	Number of economically active members
Time trend	2013 - year of survey

Source: Authors.

education for *educ* and -24 for *age*.

5.1 Estimation

The model relies on the same equation (4.1) as the previous model. We add the time trend again as well as the IV residuals to the right hand side. This time we let *age* interact with the log income and its square term, we set $\beta_{ik} = 0$ and $\lambda_{ik} = 0$ for $k \neq 0$, *age*. This allows Engel curves to differ for different age groups. However, we do not let all the 5 year dummies interact, we allow only linear dependence of the log income coefficient on age. In this model we decided not to impose symmetry as it is often rejected in empirical analysis.[2]

[2] We estimated the model with symmetry restriction with similar results.

Results

The resulting coefficients for price, log income and demographics can be found in the following Table 5.3. The remaining coefficients for regions together with coefficients for the time trend, constant and IVs can be found in appendix in Table A.3.

Again the Rs squared of our model are very low, all below 0.5 as our variables do not explain the demand very well. This is probably due to the relatively stable price levels, heterogeneity of the sample and a big error as the households tend to act irrationally during the allocation process. The highest R squared is 0.4269 for *Food in* and the lowest only 0.0832 for *Household goods*. All equation came out statistically significant at less than 1% level.

The prices did not end up statistically significant for all the commodities and often not even for their own. However, all of them resulted statistically significant for at least one commodity, the least significant price was of *Food out* (for only two at 1% significance level and four at 10% level). The price coefficients cannot be naturally interpreted as the price also figures in the *lnm* and *lnm2* variables in the aggregators. We leave the price effects interpretation to the next section.

The income variables came out statistically significant at least for the linear term. The squared term turned out to be significant for 7 commodities at 5% level. It is harder to interpret the coefficients as the age interacting term affects the shape of Engel curves for the different ages. We can say that *Alcohol & Tobacco* has hump-shaped Engel curves for all ages as well as *Fuel & Light* and *Household services*. On the other hand *Clothing*, *Personal goods*, *Transport* and *Leisure goods and services* are inversely hump shaped. In this model it seems that all commodities exhibit non-linear behaviour at least for some ages. This again suggests the validity of the QUAIDS model against the AIDS.

We can compare these results with Lührmann (2008). The shape in terms of quadratic behaviour is the same for *Leisure services*, *Transport* and *Alcohol & Tobacco*. It is different for *Clothing* and *Personal goods*. Otherwise the coefficients in the income and price came out differently for Lührmann (2008) and us.

The demographic variables came out mostly statistically significant as expected. The children variables have the highest effect on food commodities and are not statistically significant for *Alcohol & Tobacco*, which is surprising. Households with more members spend more on *Food in* and *Fuel & Light* and less on *Alcohol & Tobacco*, *Clothing* and *Transport*. The variables control-

Table 5.3: Income and demographic variables

	Food in	Food out	Alc. & Tob.	Fuel & Light	Household goods	Household services	Clothing	Personal goods	Transport	Leisure goods	Leisure services
Log income and its square term											
lnm	-0.0737***	0.0160**	-0.2428***	-0.1149***	0.0414***	-0.0208**	0.1063***	0.0346***	0.0308***	0.0208***	0.2023
	(0.012)	(0.008)	(0.007)	(0.012)	(0.007)	(0.010)	(0.007)	(0.007)	(0.009)	(0.003)	
lnm2	0.0056**	-0.0005	-0.0508***	-0.0099***	0.0035**	-0.0010	0.0131***	0.0045***	0.0024	0.0016**	0.0315
	(0.003)	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	
lnm·age	-0.0007***	0.0007***	0.0004***	0.0000	-0.0003***	-0.0003**	0.0001	0.0001	0.0004***	-0.0001*	-0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
lnm2·age	-0.0000	0.0001***	0.0001***	0.0001***	-0.0001***	-0.0001***	-0.0000	-0.0000	0.0001***	-0.0000***	-0.0002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Household composition demographics											
d_5	-0.0243***	0.0086***	0.0001	-0.0055***	0.0014*	-0.0035***	0.0011	0.0104***	-0.0031***	0.0107***	0.0041
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
d6_9	-0.0259***	0.0190***	0.0008	-0.0050***	-0.0028***	-0.0068***	-0.0014**	-0.0017**	-0.0028***	0.0101***	0.0165
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
d10_14	-0.0162***	0.0151***	0.0012*	-0.0035***	-0.0022***	-0.0050***	-0.0008	-0.0040***	-0.0052***	0.0037***	0.0169
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
d15_	-0.0170***	0.0153***	0.0007	-0.0047***	-0.0061***	-0.0014	-0.0013**	0.0003	0.0051***	-0.0021***	0.0112
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
lnhhsize	0.1377***	-0.0576***	-0.0217***	0.0369***	-0.0062***	0.0009	-0.0142***	-0.0042**	-0.0143***	-0.0113***	-0.0460
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	
LPR	0.0109***	-0.0106***	-0.0191***	0.0096***	0.0051**	0.0023	-0.0043*	-0.0123***	0.0122***	-0.0024**	0.0086
	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.001)	
EA	-0.0164***	0.0154***	0.0144***	-0.0048***	-0.0046***	-0.0055***	0.0054***	0.0000	-0.0030***	0.0001	-0.0010
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

	Food in	Food out	Alc. & Tob.	Fuel & Light	Household goods	Household services	Clothing	Personal goods	Transport	Leisure goods	Leisure services
Head of the household characteristics											
single	0.0053***	-0.0019	0.0035***	-0.0065***	-0.0011	0.0001	0.0072***	0.0001	0.0020	-0.0018***	-0.0069
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
sex	-0.0032***	-0.0241***	-0.0228***	0.0090***	0.0030***	0.0089***	0.0158***	0.0154***	-0.0112***	0.0035***	0.0057
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
empstat	0.0074***	-0.0017*	-0.0091***	-0.0038**	-0.0013	0.0016	0.0009	0.0028***	-0.0004	0.0021***	0.0015
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
educlow	0.0152***	-0.0036***	0.0081***	-0.0029***	0.0030***	0.0014*	-0.0025***	-0.0046***	-0.0021***	-0.0009***	-0.0111
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
educmid	0.0068***	-0.0001	0.0031***	-0.0025***	0.0016***	0.0056***	-0.0019***	-0.0028***	-0.0045***	-0.0007**	-0.0046
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Housing, car ownership and municipality											
Mortgage	-0.0079***	-0.0060***	-0.0067***	0.0252***	0.0106***	0.0013	-0.0043***	-0.0031***	-0.0037***	-0.0014***	-0.0040
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Self-own	-0.0038***	-0.0042***	-0.0092***	0.0217***	0.0065***	-0.0054***	-0.0011*	-0.0020***	-0.0049***	-0.0004	0.0028
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Car	-0.0129***	-0.0077***	-0.0044***	-0.0038***	-0.0002	-0.0075***	-0.0092***	-0.0080***	0.0634***	-0.0036***	-0.0061
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	
City	0.0035***	0.0008	-0.0045***	0.0127***	0.0023***	-0.0027***	0.0002	-0.0029***	-0.0044***	0.0005*	-0.0055
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Village	0.0074***	-0.0035***	-0.0039***	0.0114***	0.0137***	-0.0126***	-0.0022***	-0.0067***	0.0106***	0.0003	-0.0145
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
R^2	0.3404	0.2014	0.1223	0.3170	0.0832	0.1420	0.2510	0.1167	0.4269	0.1442	
N	42458										

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Note: Leisure services' coefficients computed from adding-up restriction. Municipality compared to *Regional capital*, housing to *tenant* and education to *higher education*.

	Food in	Food out	Alc. & Tob.	Fuel & Light	Household goods	Household services	Clothing	Personal goods	Transport	Leisure goods	Leisure services
Age dummy variables											
25-29	-0.0009	-0.0058***	-0.0090***	0.0255***	0.0034*	0.0059**	-0.0134***	-0.0011	-0.0033	0.0012	-0.0025
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	
30-34	0.0025	-0.0037*	-0.0084***	0.0301***	0.0027	0.0077***	-0.0174***	-0.0017	-0.0092***	0.0019*	-0.0045
	(0.004)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	
35-39	0.0065	-0.0050**	-0.0044*	0.0350***	0.0004	0.0092***	-0.0207***	-0.0024	-0.0136***	0.0003	-0.0053
	(0.004)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.001)	
40-44	0.0056	-0.0061**	0.0003	0.0417***	-0.0011	0.0095**	-0.0242***	-0.0016	-0.0151***	-0.0007	-0.0083
	(0.005)	(0.003)	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.001)	
45-49	0.0038	-0.0022	0.0062*	0.0465***	-0.0050	0.0094**	-0.0278***	-0.0032	-0.0151***	-0.0021	-0.0105
	(0.006)	(0.003)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.003)	(0.004)	(0.002)	
50-54	0.0040	-0.0011	0.0109***	0.0527***	-0.0045	0.0101*	-0.0324***	-0.0029	-0.0197***	-0.0012	-0.0159
	(0.006)	(0.004)	(0.004)	(0.006)	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)	(0.002)	
55-59	0.0060	-0.0043	0.0108**	0.0541***	-0.0040	0.0096	-0.0329***	-0.0008	-0.0228***	0.0014	-0.0171
	(0.007)	(0.004)	(0.004)	(0.007)	(0.004)	(0.006)	(0.004)	(0.004)	(0.005)	(0.002)	
60-64	0.0041	-0.0021	0.0065	0.0518***	-0.0030	0.0088	-0.0314***	0.0008	-0.0253***	0.0016	-0.0118
	(0.008)	(0.005)	(0.005)	(0.008)	(0.004)	(0.007)	(0.005)	(0.005)	(0.006)	(0.002)	
65-69	0.0008	0.0005	0.0019	0.0449***	-0.0054	0.0098	-0.0298***	0.0079	-0.0243***	0.0018	-0.0081
	(0.009)	(0.005)	(0.005)	(0.009)	(0.005)	(0.007)	(0.005)	(0.005)	(0.006)	(0.003)	
70-74	0.0015	0.0079	0.0024	0.0391***	-0.0086	0.0098	-0.0306***	0.0136**	-0.0290***	0.0028	-0.0089
	(0.010)	(0.006)	(0.006)	(0.009)	(0.005)	(0.008)	(0.006)	(0.006)	(0.007)	(0.003)	
75-79	-0.0066	0.0184***	0.0012	0.0241**	-0.0093	0.0169*	-0.0303***	0.0222***	-0.0297***	0.0030	-0.0099
	(0.011)	(0.007)	(0.007)	(0.010)	(0.006)	(0.009)	(0.006)	(0.006)	(0.008)	(0.003)	
80+	-0.0391***	0.0374***	-0.0018	0.0350***	-0.0131**	0.0236**	-0.0324***	0.0365***	-0.0352***	0.0039	-0.0148
	(0.012)	(0.007)	(0.007)	(0.011)	(0.007)	(0.010)	(0.007)	(0.007)	(0.008)	(0.003)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Source: CSO and authors' calculations

ling for work/leisure separability came out significant indicating the possible non-separability.

Concerning the head of the household, the single households do not show a significant difference in consumption from other households. Sex however seems to determine the consumption a lot, women spend less on *Food* and *Alcohol & Tobacco* and more on *Clothing* and *Personal goods*, which seems reasonable. Employment status affects significantly only *Food in* and *Alcohol & Tobacco* in an expected way. Unsurprisingly, lower education implies higher expenditure on *Alcohol & Tobacco*.

Against tenants people in self-owned or mortgaged housing spend less on *Food* and *Alcohol & Tobacco*, but more on *Fuel & Light* and *Household goods*. *Car* ownership affects most significantly *Transport* in positive manner, which is in line with an intuition. It seems that people in villages spend more on *Fuel & Light* and *Transport* and less on *Household services*, again both in line with an intuition.

The demographic variables are hard to compare with other research as we chose a different set. However, most of our estimates came out in line with intuition and economic theory so we can say this supports validity of the model.

Concerning the ageing effects on consumption we can see that *Food out*, *Household goods* and *Leisure goods* remain relatively stable over the life time, there are some visible consumption trends in the other commodities. *Food in* share on consumption starts with drop after *-24* category and then has steady increase up to 4% in the *80+* category. *Alcohol & Tobacco* also seems to drop in the beginning, then increases, spikes around age of *50-59* and then decreases until the end. Similar situation can be seen in *Fuel & Light*, with a spike at the same age but without the initial drop.

Clothing and *Transport* seems to be slowly declining throughout the age up to 3.2% then there is 3% decline in *80+* respectively. *Personal goods* do not seem to change until later age *70+*, this is expected and reasonable as this commodity contains drugs and medication. *Leisure services* seem to decrease at first and spike again around the age *50-59*. These clear trends of age affecting the household demand support the validity of the QUAIDS model usage on an age related effects analysis.

The age effects can be compared to some of the results from Lührmann (2008). Namely the effects of ageing on *Food in* and *out* and *Household goods*. At least in the sense of the sign of the change in the categories of *Fuel & Light*, *Household services*, *Personal good*, *Tranposrt* and *Leisure goods*.

The regional coefficients came out significant, probably due to the selection of Prague as the control group. However, we can see that even the other regions differ from each other but maybe by not so much. We leave the interpretation of region results for a another research as it is not main focus of this thesis.

The time trend does not seem to have a big effect as it is significant only for *Food in* and *Alcohol & Tobacco* at 1% and for *Household goods*, *Fuel & Light* and *Transport* at 5% significance level. The IVs came out significant possibly implying the endogeneity of the income variables.

5.2 Elasticities

We computed the income elasticity, Hicks and Marshall price elasticities according to (2.7), (2.9) and (2.10) for each household individually and then we computed the weighted average with weights being the total expenditure of the households. This is the same as in the VAT reform model. The resulting income elasticities can be seen in the Table 5.4.

Table 5.4: Income elasticities

Commodity	Income Elasticity
1. Food in	0.656***
2. Food out	0.902***
3. Alcohol & Tobacco	-0.457***
4. Fuel & Light	0.302***
5. Household goods	1.793***
6. Household services	1.020***
7. Clothing	1.705***
8. Personal goods	1.342***
9. Transport	1.053***
10. Leisure goods	1.960***
11. Leisure services	2.461***

*,**,*** denote 10%, 5%, 1% significance level.

Source: CSO and authors' calculations.

The income elasticities seem reasonable except for the *Alcohol & Tobacco* which came out as inferior good. This is probably due to the endogeneity of income or the externalities of this commodity. Nevertheless all the income elasticities came out statistically significant even *Alcohol & Tobacco*.

Fuel & Light, *Food in* resulted as necessity goods, *Clothing* and *Household* *goods* came as luxury goods. We can say that the results are similar as in the VAT reform model (see Table 4.3). *Food out*, *Household services* and *Transport* in this case are close to the unitary income elasticity. *Household goods* are considered luxurious and *Leisure* commodities came out with the highest income elasticity thus also regarded luxurious which seems reasonable.

In Table 5.5 and Table 5.6 we present the uncompensated and compensated price elasticities. The own price elasticities are highlighted and, as we can see, negative as required by the economic theory. However some of the cross price elasticities are very high even higher than own price, this is doubtful and we should interpret these with caution.

We can see that again the price elasticities are not very statistical significant. In the uncompensated case 7 own price elasticities resulted statistically significant and some of them only at 10% level, in compensated case it is only 5. Around 50 cross price elasticities out of 110 ended up being significant in both uncompensated and compensated case. More or less all the commodities have at least some statistically significant elasticities with the exception of *Personal goods* and *Transport* which suggest their separability and low responsiveness to a price change.

Concerning the uncompensated elasticities the following commodities are the least elastic in the following order *Clothing*, *Alcohol & Tobacco*, *Food in*, *Personal goods* and *Transport*, these are considered inelastic, which at least in case of *Food in* and *Alcohol & Tobacco* seems reasonable. The remaining commodities are considered elastic in price in this order from least to most *Fuel & Light*, *Food out*, *Leisure goods*, *Household services*, *Leisure services* and *Household goods*.

The uncompensated elasticities resulted smaller with a single exception of *Alcohol & Tobacco* as its income elasticity is negative. The differences are marginal.

For the comparison with the VAT reform model see Table 4.4 and Table 4.5. The resulting own-price elasticities are different with the exception of *Tranport*. The *Food in* resulted less elastic than before and *Food out* more elastic. Also *Household goods*, *Energy* and *Clothing* resulted in different elasticities. The price elasticities are also different compared to Dybzcak *et al.* (2014).

Table 5.5: Marshall (uncompensated) price elasticities

Commodity	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Food in	**-0.338**	-1.765	0.267	0.513	-0.497	2.321	1.391	0.519	-0.151	-0.417	-2.477
	**		***	***	***						
2. Food out	0.683	**-1.470**	0.438	-0.022	1.288	1.422	-0.331	-0.194	-0.269	-0.769	-1.852
	***			***			*		*	*	
3. Alcohol & Tobacco	2.777	-0.246	**-0.232**	0.715	9.722	3.245	-5.410	-0.473	-0.636	-3.013	-4.881
	***			***	***		***	***		***	***
4. Fuel & Light	-1.429	3.632	-1.891	**-1.141**	-1.382	-4.135	0.373	-0.320	0.007	1.573	4.413
	***		*	***	***	***					
5. Household goods	-1.337	0.121	-1.192	-1.011	**-4.151**	-5.420	-0.910	-0.125	0.523	5.007	6.708
			***	*	***			***	*	***	
6. Household services	-0.371	-0.306	0.155	-0.545	1.026	**-1.992**	-2.136	-0.400	-0.016	1.325	2.204
	***		*	***	***	***				***	
7. Clothing	-0.253	-1.200	0.719	0.010	0.542	1.125	**-0.170**	0.301	-0.004	-1.575	-1.240
	***		***			***			**		**
8. Personal goods	-0.334	-0.313	0.570	-0.110	-3.706	-0.475	0.834	**-0.347**	0.337	0.064	2.129
	***					*					
9. Transport	0.224	1.120	0.039	-0.056	1.362	-0.499	-1.251	-0.307	**-0.411**	-0.668	-0.663
									*	*	
10. Leisure goods	0.665	-1.781	1.294	0.195	3.428	3.214	-0.527	-0.490	-0.550	**-1.632**	-5.780
	*		***	***	***	***	***			*	***
11. Leisure services	0.189	0.829	0.899	-0.094	-1.281	1.479	2.037	-0.332	-0.108	-2.550	**-3.266**
	***		**	***	***	**		*		***	*

Price elasticity of demand for a commodity in row with respect to a change in price of a commodity in column. *,**,*** denote 10%, 5%, 1% significance level.
Source: CSO and authors' calculations

Table 5.6: Hicks (compensated) price elasticities

Commodity	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Food in	**-0.163**	-1.729	0.292	0.611	-0.466	2.405	1.439	0.561	-0.091	-0.402	-2.435
		**	***	***	**					**	*
2. Food out	0.902	**-1.410**	0.469	0.092	1.332	1.533	-0.255	-0.134	-0.177	-0.746	-1.780
	***			***			*		**	*	
3. Alcohol & Tobacco	2.690	-0.283	**-0.239**	0.685	9.695	3.197	-5.461	-0.509	-0.695	-3.028	-4.942
	***			***	***		***	***		***	***
4. Fuel & Light	-1.344	3.646	-1.879	**-1.089**	-1.368	-4.094	0.392	-0.301	0.031	1.579	4.428
	***		*	***	***	***				*	
5. Household goods	-0.879	0.224	-1.126	-0.756	**-4.061**	-5.191	-0.773	-0.008	0.693	5.049	6.834
			***	*	***	*		***	*	***	
6. Household services	-0.107	-0.249	0.193	-0.394	1.075	**-1.856**	-2.060	-0.332	0.077	1.349	2.274
	***		*	***	***	***	*			***	
7. Clothing	0.174	-1.097	0.780	0.240	0.626	1.340	**-0.032**	0.414	0.161	-1.534	-1.112
	***		***			***			**		**
8. Personal goods	0.007	-0.235	0.618	0.078	-3.641	-0.302	0.938	**-0.256**	0.463	0.096	2.226
	***										
9. Transport	0.485	1.184	0.077	0.083	1.415	-0.368	-1.167	-0.239	**-0.297**	-0.643	-0.586
					**			*			
10. Leisure goods	1.165	-1.667	1.364	0.470	3.525	3.464	-0.376	-0.360	-0.366	**-1.584**	-5.641
			***	***	***	***	***			*	***
11. Leisure services	0.801	0.977	0.986	0.237	-1.160	1.792	2.234	-0.167	0.130	-2.490	**-3.075**
	***		**	***	***	**		*		***	*

Price elasticity of demand for a commodity in row with respect to a change in price of a commodity in column. *,**,*** denote 10%, 5%, 1% significance level.
Source: CSO and authors' calculations

5.3 Projection of the population ageing effects on the household demand

Finally, in this section we are going to use estimated commodity shares to project the effects of population ageing. We are going to do that in 4 scenarios similar to Lührmann (2008). Apart from just estimating the *ceteris paribus* effects of population ageing we also want to examine the effects of increasing income and redistribution on effects from population ageing.

We map the population to the households (in other words we assume that the number of households in a certain age category increases proportionally to the population). This assumption can be violated due to the demographical trends such as increasing proportion of single households and people leaving parents earlier. This could change the composition of households in such a way that some might have different shares than now. However, we do not find this assumption too restrictive as these demographical changes are slower than the population ageing. It would certainly be better to have estimates of a number of households per age category.

We use the projection of the household composition in the second scenario. It is here for comparison and analysis of the bias caused by our assumption. The mapping of population is then done in all the other scenarios.

We calculate the resulting share each year based on the following formula

$$w_{ik} = \sum_h \hat{w}_{ihk} \frac{x_{ih}}{X_k} \psi_h \frac{pop_{ak}}{pop_{a2013}}, \tag{5.1}$$

where k is year, h goes through all households, i is commodity, w_{ik} is total share of commodity in year k, $\hat{w}_{ihk}$ is estimated (fitted) share of commodity i of household h in year k, ψ_h is the sample weight of household h given by the CSO, x_{ih} is expenditure on commodity i of household h in 2013, X_k is total expenditure in year k and finally pop_{ak} is population or number of household with characteristic a in year k.

In the second scenario this characteristic will be the size of a household (1, 2, ... 6+) combined with a type of the household (single households, families with/out children, incomplete families with/out children) as provided by the CSO. In all the other scenarios characteristic a will be the *age* as we have the projection of the population ageing up to 2101.

First scenario *Age* is the projecting characteristic and all other variables are fixed (e.g., $\hat{w}_{ihk}$ does not change).

Second scenario *Household size* and *type* are the projecting characteristic, all other variables are fixed (e.g.,$\hat{w}_{ihk}$ does not change).

Third scenario *Age* is the projecting characteristic and we assume an increase in the income by 1% in non-retired households and further redistribution to all the households. We estimate that this corresponds to an 0.9% increase of income in all the households because around one in seven households is retired and the non-retired household have higher income. Therefore each year we increase the income by 0.9%, we update $\hat{w}_{ihk}$ and the new shares are calculated according to (5.1).

Fourth scenario In this scenario we first assume no redistribution at all, resulting in a 1% annual increase in the non-retired households only. Then we project a complete redistribution towards the retired households corresponding to a 1% annual increase in their income. The rest is computed as above.

For comparison we repeat the third and fourth scenarios without the effects of the population ageing, we will call this the **fifth scenario** and **sixth scenario**, respectively.

First and second scenario comparison

First, we present the fitted and real commodity shares in 2013, then we compare the first and second scenario projections in the year 2030. The results follow in Table 5.7.

We can see that fitted values match reasonably. Despite the small R squared in the estimation after aggregation the error disappears. The biggest difference of 0.44% is in *Leisure services* and *Transport* which is expected as *Leisure services* is the left out commodity computed only from the adding-up restriction.

The second scenario suggest the orientation of the bias caused by our assumption of the households ageing with the population. Luckily for us, the effect on most of the commodities is modest. It is not marginal only for *Food out*, *Fuel & Light*, *Household services* and *Transport*. In all these commodities it seems that the projection of shift due to the population ageing will be biased

Table 5.7: The real versus fitted commodity shares in 2013 and the first and the second scenario in 2030

	2000-13	2013		2030			
Commodity	Reality	Reality	Fitted	1 scen	Δ	2 scen	Δ
Food in	25.66	25.34	25.65	26.07	0.42	25.64	-0.01
Food out	5.78	5.62	5.30	5.13	-0.17	5.24	-0.06
Alc. & Tob.	3.69	3.56	3.67	3.70	0.03	3.67	0.00
Fuel & Light	14.23	15.42	16.04	16.51	0.47	16.32	0.28
HH goods	4.86	4.40	4.44	4.39	-0.05	4.42	-0.01
HH services	12.83	12.49	12.85	13.05	0.21	13.02	0.18
Clothing	7.63	6.61	6.29	6.01	-0.28	6.21	-0.08
Personal goods	6.54	6.74	6.87	6.87	0.01	6.86	0.00
Transport	9.45	10.33	9.89	9.54	-0.35	9.70	-0.20
Leisure goods	2.35	2.23	2.17	2.08	-0.09	2.15	-0.02
Leisure services	6.97	7.27	6.83	6.64	-0.19	6.76	-0.07

All numbers in %, Δ - the difference between fitted share in 2013

Source: CSO and authors' calculations.

towards zero as the effects due to the household composition change have the same orientation.

First scenario

The results of the first scenario are presented in Table 5.8. From the results it seems that around the year 2065 the ageing effects hit peak and turn their orientation. However, this is not true for all commodities.

The following commodities shares increase at least until 2065: *Food in*, *Fuel & Light*, *HH services* and *Personal goods*. This seems reasonable as those are the categories we expect retirees to spend more on. Most of them begin to decrease after 2065. The highest increase between 2013 and 2065 is in *Fuel & Light* by 0.86% and *Food in* by 0.78%.

Alcohol & Tobacco and *Household goods* seem to have stable consumption share over the period. On the other hand *Transport*, *Clothing* and *Leisure services* have the biggest decline −0.72%, −0.54% and −0.42% respectively, which is again in line with the expectations as the population ages.

Income rises by 1%

In the next Table 5.9 we compare the results of a 1% increase in income in

Table 5.8: The population ageing effects on consumption

	2013	2020	2035	2050	2065	Δ	2080	2101
Food in	25.65	25.86	26.13	26.47	26.43	0.78	26.36	26.35
Food out	5.30	5.21	5.07	4.92	5.02	-0.27	4.99	5.03
Alc. & Tob.	3.67	3.66	3.71	3.65	3.64	-0.03	3.65	3.64
Fuel & Light	16.04	16.18	16.64	16.83	16.90	0.86	16.79	16.83
HH goods	4.44	4.41	4.40	4.41	4.35	-0.08	4.40	4.37
HH services	12.85	12.91	13.12	13.23	13.28	0.43	13.22	13.24
Clothing	6.29	6.20	5.94	5.77	5.75	-0.54	5.81	5.80
Personal goods	6.87	6.87	6.87	6.95	6.98	0.11	6.95	6.96
Transport	9.89	9.77	9.44	9.24	9.18	-0.72	9.28	9.25
Leisure goods	2.17	2.13	2.07	2.08	2.05	-0.12	2.08	2.07
Leisure services	6.83	6.80	6.59	6.45	6.41	-0.42	6.48	6.46

Commodity shares in %, Δ - the difference between fitted share in 2013

Source: CSO and authors' calculations.

the non-retired households. The column *3 scen* represents the even redistribution among households, *4 scen* no redistribution, *5 scen* and *6 scen* represent the same without the population ageing.

We only present the results until 2050 because after this year the model predicts negative share in *Alcohol & Tobacco* which is obviously impossible and we cannot interpret these results. This is one of the disadvantages of the QUAIDS estimated by the SUR.

We can see that the income effects affect consumption more blatantly than just ageing. Comparing the third and fourth scenario we can see how a redistribution affects consumption, this difference is more subtle with the highest only 0.27% in 2030 in *Food in* but it gets bigger upto 0.76% in 2050. On the other hand the income and redistribution effects are affected by the population ageing, in the case of *Food in* it is around 0.4% and 0.8% in 2030 and 2050 respectively which is comparable to the first scenario.

In *Food out* we see a different trend, in 2050 the ageing causes its share to decrease by 0.35% in the redistribution case and by 0.48% without the redistribution, which is mildly different. We can say that in this case redistribution mitigates the decrease in this category. Also both of these effects are bigger than in the first scenario, meaning that the income and allocation effects magnify the ageing effect.

In 2050 this is much more visible in the next category *Alcohol & Tobacco*,

Table 5.9: The population ageing effects on consumption under changing income with different redistributions

	2013	2030				2050			
		3 scen	4 scen	5 scen	6 scen	3 scen	4 scen	5 scen	6 scen
Food in	25.65	22.82	23.09	22.47	22.62	20.89	21.65	20.25	20.47
Food out	5.30	6.19	6.17	6.35	6.35	6.61	6.52	6.96	7.00
Alc. & Tob.	3.67	1.90	1.84	1.73	1.67	1.05	0.93	0.67	0.48
Fuel & Light	16.04	13.67	13.86	13.24	13.34	12.09	12.63	11.41	11.53
HH goods	4.44	5.07	5.00	5.12	5.08	5.56	5.38	5.59	5.53
HH services	12.85	12.28	12.21	12.04	11.98	12.23	12.07	11.78	11.65
Clothing	6.29	7.98	7.94	8.29	8.28	8.88	8.74	9.47	9.52
Personal g.	6.87	7.69	7.58	7.68	7.61	8.31	8.02	8.20	8.08
Transport	9.89	10.39	10.47	10.77	10.84	10.51	10.68	11.23	11.39
Leisure g.	2.17	2.62	2.57	2.71	2.68	2.97	2.84	3.04	2.99
Leisure s.	6.83	9.39	9.27	9.61	9.55	10.90	10.54	11.39	11.36

Commodity shares in %

Source: CSO and authors' calculations.

where the differences are around 0.4%. *Fuel & Light* differ even by 1.1% in no redistribution case and 0.68% with redistribution, which is above and below the first scenario. These are interesting simultaneous effects. *HH goods* and *services*, *Transport* and *Leisure goods* behave more or less the same way as in the first scenario.

The ageing effect is amplified by the income increase without redistribution in the *Clothing* commodity. In *Personal goods* commodity something interesting happens. While in the redistribution case the ageing has the same effect as in the first scenario, without redistribution the effects is actually reversed and the ageing effect decreases its share by 0.6%. Finally, in *Leisure services* the redistribution increases the effect of ageing to −0.82% change.

Income rises by 1% for retirees

Lastly, we present the total redistribution scenario which allocates 1% income to retired households. We would like to note that this is hardly comparable to the previous case, we want to point out how this affects the ageing effects instead. The results can be found in Table 5.10. Here the *4 scen* column is the total redistribution with the population ageing and *6 scen* without ageing.

Again, the population ageing effect seems to peak around the year 2070,

Table 5.10: The population ageing effects on consuption with redistribution towards retirees

	2013	2040		2070		2101	
		4 scen	6 scen	4 scen	6 scen	4 scen	6 scen
Food in	25.65	23.65	23.53	21.75	22.15	19.03	20.14
Food out	5.30	5.80	6.00	6.34	6.32	7.14	6.89
Alc. & Tob.	3.67	2.37	2.23	1.77	1.72	0.35	0.60
Fuel & Light	16.04	14.49	14.13	13.03	13.05	10.85	11.45
HH goods	4.44	4.98	4.92	5.34	5.22	5.89	5.65
HH services	12.85	12.62	12.27	12.73	12.25	12.54	12.12
Clothing	6.29	7.35	7.65	8.09	8.25	9.44	9.27
Personal goods	6.87	7.65	7.51	8.35	7.93	9.16	8.53
Transport	9.89	9.88	10.41	9.79	10.50	10.15	10.75
Leisure goods	2.17	2.53	2.56	2.85	2.78	3.26	3.08
Leisure services	6.83	8.67	8.78	9.97	9.82	12.18	11.51

Commodity shares in %

Source: CSO and authors' calculations.

so we focus our description on this year. The other years can be found in the table.

In 2070 the effect of population ageing seems to be amplified by redistribution in the following categories: *Food in* and *Personal goods* as expected. We can see that the effects remains the same in *Household services* and *Transport* and the effects is mitigated in *Clothing.* On the other hand for it reverses the effect for the other commodities, e.g., the effect of the ageing on *Leisure services* was −0.42% in the first scenario and now it is +0.15%. Some commodities even change effects during the time, i.e., *Food out* is negatively affected by ageing in *2040* then on par in 2070 and then positively in 2101.

From all this we can see that the effects of the population ageing are connected to other variables which are not expected to be constant in the future. However, we can still say that the population ageing affects some commodities in all the scenarios in a similar way. Those are mainly *Food in*, *Personal goods*, *Transport* and maybe *Fuel & Light* and *Clothing.*

Our findings in the first scenario are similar to Lührmann (2008) at least in the most directions of the changes. They are expected as elderly households consume more in the commodities of *Food in*, *Energies* and *Household services.*

On the other hand we expect them to spend less on *Transport* due to mobility limitations, *Leisure services* and *Food out*. The expected increase in category of *Personal goods*, which contains drugs, medication and health expenses, was not so significant. The remaining scenarios are harder to compare as the level of income and the consumption patterns differ in the UK and Czech Republic.

Chapter 6

Conclusion

In this thesis we explained the main features of the Quadratic Almost Ideal Demand System (QUAIDS) as well as its advantages and limitations. We used and improved the program for Value Added Tax (VAT) analysis and updated the dataset for 3 more years 2000, 2012 and 2013. First, we estimated the original model for VAT reform analysis and we calculated elasticities and effects of the 2015 VAT reform in the Czech Republic.

Second, we configured the program for the purposes of the population ageing analysis and recalculated the coefficients and elasticities, then we interpreted the results with an interest in the effects of ageing. The last model was used to project the effects of the population ageing and redistribution accompanied by an increase in the income of the households.

In both models we found difficulties with the low explanatory power resulting in small Rs squared. After aggregation the results are in line with reality and the following results make economical and common sense. As the results seem reasonable we conclude the validity of the QUAIDS model. The significance of the squared log income terms suggests the QUAIDS is preferable to the simpler Almost Ideal Demand System (AIDS) specification.

The first model predicted reasonable changes in the demand after the implementation of the new 10% VAT rate on *Books* and *Medication*. The demand for these commodities is expected to rise by around 0.48%. The other affected commodities are *Clothing* and *Household goods*. The households are predicted to spend by 0.11% more in total which corresponds to 1,049 million CZK. The expected loss in the VAT revenues is 0.06% which corresponds to 818 million CZK. It is much lower than 3.3 billion predicted by the Ministry of Finance.

In the second model we found that the shape of Engel curves not only have non-linear shape but also that they change shape during the lifetime. Most significant effects of ageing is in commodities *Food in* and *Other services*.

Moreover, we predicted that *ceteris paribus* the population ageing will increase share of *Food in*, *Fuel & Light*, *Household services* and *Personal goods* and decrease share of *Clothing*, *Transport* and *Leisure services*. If we consider only the projected changes in the household composition, without the effects of ageing, the changes in demand are modest.

If the population ageing is accompanied by an increase in income, we estimated that this would boost the change in *Food out*, *Clothing* and *Leisure services*. There is no effect from the income increase on *Household goods* and *services*, *Transport* and *Leisure goods*. In *Personal goods*, containing drugs and health products, the income effect with redistribution does not affect the changes from population ageing. However without redistribution the effect is actually reversed.

In the last scenario we computed the effects of the population ageing with total redistribution towards the retired households. In 2070 this is predicted to affect mostly *Food in* and *Personal goods* in a positive manner. The *Household services* and *Transport* are not affected and the effect on *Clothing* is decreased. The redistribution reverses the effect in all the other commodities.

Unfortunately due to the limited extent of this thesis we could not provide more detailed analysis of population ageing as Lührmann (2008) and we leave this for further research.

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Appendix A

Table A.1: Price and income SUR coefficients of VAT reform model

	Food in	Food out	Household goods	Clothing	Other services	Transport	Energy	Other goods
Prices								
lnp1	0.0647*							
	(0.038)							
lnp2	0.0035	-0.0014						
	(0.024)	(0.024)						
lnp3	-0.0859***	0.0057	0.0148					
	(0.020)	(0.015)	(0.019)					
lnp4	0.0483**	-0.0060	-0.0044	0.0192				
	(0.020)	(0.018)	(0.012)	(0.020)				
lnp5	-0.0381	0.0196	0.0343*	-0.0387**	0.0517			
	(0.033)	(0.025)	(0.021)	(0.020)	(0.040)			
lnp6	-0.0208	-0.0075	0.0589***	-0.0019	-0.0287*	0.1172***		
	(0.018)	(0.013)	(0.013)	(0.010)	(0.017)	(0.020)		
lnp7	0.0613***	-0.0096	-0.0251**	0.0101	-0.0221	-0.0719***	0.0521***	
	(0.013)	(0.010)	(0.011)	(0.008)	(0.014)	(0.011)	(0.010)	
lnp8	-0.0330***	-0.0043	0.0018	-0.0266***	0.0219**	-0.0452***	0.0052	0.0803
	(0.010)	(0.008)	(0.008)	(0.006)	(0.010)	(0.009)	(0.006)	
Log income and its square term								
lnm	-0.2012***	0.0174***	0.0950***	0.0450***	-0.0332***	0.1630***	-0.0605***	-0.0255
	(0.007)	(0.006)	(0.007)	(0.004)	(0.007)	(0.009)	(0.007)	
lnm2	-0.0177***	0.0015	0.0052***	0.0057***	0.0010	0.0110***	-0.0009	-0.0058
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	
R^2	0.406	0.096	0.136	0.172	0.232	0.367	0.232	
N	42458							

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Table A.2: SUR coefficients of VAT reform model

	Food in	Food out	Household goods	Clothing	Other services	Transport	Energy	Other goods
Demographical variables								
age	0.0012***	-0.0008***	-0.0006***	-0.0006***	0.0006***	-0.0012***	0.0011***	0.0003
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
hh size	0.0511***	-0.0010	-0.0188***	-0.0081***	-0.0110***	-0.0185***	0.0147***	-0.0084
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
child	-0.0137***	-0.0170***	0.0059***	0.0067***	0.0239***	0.0023*	-0.0091***	0.0012
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
empstat	-0.0060***	0.0141***	-0.0134***	0.0090***	0.0027**	-0.0129***	0.0065***	0.0001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
educlow	0.0139***	0.0059***	0.0027***	-0.0048***	-0.0170***	-0.0020*	0.0004	0.0009
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
educmid	0.0066***	0.0055***	0.0021**	-0.0032***	-0.0091***	-0.0015	-0.0028***	0.0025
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
praha	0.0031***	0.0006	-0.0114***	-0.0041***	-0.0107***	0.0009	0.0091***	0.0125
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
city_size	0.0014***	-0.0060***	0.0002	-0.0019***	-0.0371***	0.0086***	0.0310***	0.0038
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	
Time trend and constant								
time trend	0.0007	0.0006	0.0026**	0.0016	-0.0008	-0.0042***	-0.0009	0.0004
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	
_cons	-0.2762***	0.1879***	0.3306***	0.1761***	0.1465***	0.5316***	-0.1725***	0.0760
	(0.014)	(0.012)	(0.013)	(0.010)	(0.015)	(0.014)	(0.010)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Note: Other goods coefficient computed from adding-up restriction without standard error, $\text{lnm} = \ln \frac{x}{a(\mathbf{p},\mathbf{z})}$ and $\text{lnm2} = \frac{1}{b(\mathbf{p},\mathbf{z})} \ln^2 \frac{x}{a(\mathbf{p},\mathbf{z})}$

Source: Authors' calculations.

Table A.3: Regional variables from the population ageing model

	Food in	Food out	Alc & Tob	Fuel & Light	Household goods	Household services	Clothing	Personal goods	Transport	Leisure goods	L services
Stredoc.	0.0044***	-0.0036***	0.0016*	0.0004	0.0034***	-0.0073***	0.0037***	0.0011	-0.0006	-0.0001	-0.0030
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Jihocessky	-0.0123***	0.0090***	-0.0030***	-0.0050***	0.0059***	-0.0092***	0.0134***	0.0017*	-0.0009	0.0013***	-0.0009
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Plzensky	0.0062***	0.0079***	-0.0032***	-0.0007	0.0032***	-0.0152***	0.0107***	0.0008	-0.0050***	0.0011**	-0.0058
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Karlovar.	-0.0061***	-0.0010	0.0044***	0.0095***	0.0014	0.0031*	-0.0006	-0.0007	0.0015	-0.0019***	-0.0096
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
Ustecky	-0.0054***	-0.0090***	0.0023**	0.0086***	0.0056***	0.0016	0.0044***	-0.0023**	0.0035***	0.0003	-0.0096
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Liberecky	0.0022	-0.0021*	-0.0075***	0.0162***	0.0033***	-0.0145***	0.0059***	-0.0009	0.0020	0.0009	-0.0055
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
Kralhrad.	-0.0020	0.0066***	-0.0050***	-0.0035**	0.0046***	-0.0125***	0.0083***	0.0020**	-0.0019	0.0024***	0.0010
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Pardub.	-0.0128***	0.0097***	-0.0063***	-0.0061***	0.0067***	-0.0059***	0.0133***	0.0017	-0.0037***	0.0038***	-0.0004
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
Vysocina	-0.0129***	0.0039***	-0.0055***	-0.0076***	0.0033***	-0.0075***	0.0152***	0.0036***	0.0009	0.0028***	0.0038
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Jihomor.	-0.0082***	-0.0029***	-0.0100***	0.0168***	0.0035***	-0.0073***	0.0113***	0.0009	-0.0033***	0.0015***	-0.0023
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Olomoucky	-0.0067***	0.0069***	-0.0083***	0.0076***	0.0036***	-0.0141***	0.0140***	0.0018*	-0.0092***	0.0001	0.0043
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	
Zlinsky	-0.0099***	0.0036***	-0.0065***	0.0076***	0.0025**	-0.0124***	0.0157***	0.0036***	-0.0039***	0.0009*	-0.0012
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	
Moravskosl.	0.0040***	0.0006	-0.0009	0.0079***	0.0033***	-0.0139***	0.0077***	-0.0005	-0.0030***	0.0009**	-0.0061
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Table A.4: Price SUR coefficients of the population ageing model

	Food in	**Food out**	**Alcohol & Tobacco**	**Fuel & Light**	**Household goods**	**Household services**	**Clothing**	**Personal goods**	**Transport**	**Leisure goods**	**Leisure services**
Prices											
lnp1	0.1661***	0.0388	0.1100***	-0.2047***	-0.0644***	-0.0456	-0.0214	-0.0221	0.0200	0.0163	0.0070
	(0.041)	(0.025)	(0.025)	(0.039)	(0.022)	(0.034)	(0.024)	(0.023)	(0.029)	(0.012)	
lnp2	-0.4678***	-0.0269	-0.0244	0.5002***	0.0123	-0.0388	-0.0817*	-0.0165	0.1074*	-0.0382	0.0744
	(0.086)	(0.052)	(0.052)	(0.081)	(0.046)	(0.070)	(0.049)	(0.048)	(0.060)	(0.024)	
lnp3	0.0854***	0.0221	0.0840***	-0.2418***	-0.0678***	0.0255	0.0294**	0.0291**	-0.0035	0.0256***	0.0120
	(0.024)	(0.015)	(0.015)	(0.023)	(0.013)	(0.020)	(0.014)	(0.014)	(0.017)	(0.007)	
lnp4	0.1344***	-0.0026	0.0473***	-0.0130	-0.0516***	-0.0669***	-0.0080	-0.0098	-0.0081	0.0036	-0.0253
	(0.021)	(0.013)	(0.013)	(0.020)	(0.012)	(0.018)	(0.012)	(0.012)	(0.015)	(0.006)	
lnp5	-0.1363	0.0756	0.3396***	-0.2074**	-0.1493***	0.1314	0.0493	-0.2399***	0.1307*	0.0829***	-0.0766
	(0.101)	(0.061)	(0.061)	(0.095)	(0.055)	(0.082)	(0.057)	(0.056)	(0.070)	(0.028)	
lnp6	0.5896***	0.0822	0.1162*	-0.5942***	-0.2614***	-0.1262	0.0883	-0.0300	-0.0469	0.0770***	0.1054
	(0.102)	(0.062)	(0.062)	(0.096)	(0.056)	(0.084)	(0.058)	(0.057)	(0.071)	(0.029)	
lnp7	0.3364***	-0.0172	-0.2353***	0.0271	-0.0345	-0.2756***	0.0825*	0.0614	-0.1136**	-0.0071	0.1759
	(0.078)	(0.047)	(0.047)	(0.073)	(0.042)	(0.063)	(0.044)	(0.043)	(0.054)	(0.022)	
lnp8	0.1220***	-0.0103	-0.0342	-0.0587*	-0.0011	-0.0513*	0.0319	0.0461**	-0.0271	-0.0087	-0.0086
	(0.035)	(0.021)	(0.021)	(0.033)	(0.019)	(0.028)	(0.020)	(0.019)	(0.024)	(0.010)	
lnp9	-0.0524*	-0.0147	-0.0414**	-0.0148	0.0314**	-0.0021	0.0100	0.0260	0.0578***	-0.0095	0.0097
	(0.029)	(0.018)	(0.018)	(0.027)	(0.016)	(0.024)	(0.017)	(0.016)	(0.020)	(0.008)	
lnp10	-0.1128	-0.0434	-0.1214***	0.2173***	0.2460***	0.1701***	-0.1156***	0.0059	-0.0618	-0.0135	-0.1708
	(0.071)	(0.043)	(0.043)	(0.067)	(0.039)	(0.058)	(0.041)	(0.040)	(0.050)	(0.020)	
lnp11	-0.6645***	-0.1036	-0.2403***	0.5899***	0.3404***	0.2794**	-0.0647	0.1499*	-0.0550	-0.1285***	-0.1030
	(0.143)	(0.086)	(0.086)	(0.134)	(0.077)	(0.116)	(0.082)	(0.080)	(0.100)	(0.040)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Table A.5: Time trend and IVs from the population ageing model

	Food in	**Food out**	**Alc & Tob**	**Fuel & Light**	**Household goods**	**Household services**	**Clothing**	**Personal goods**	**Transport**	**Leisure goods**	**L services**
time t.	-0.0081***	0.0007	0.0086***	-0.0062**	-0.0031**	0.0034	0.0001	0.0017	0.0043**	-0.0004	-0.0010
	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	
v1	0.1820***	-0.0363	-0.7340***	0.2193***	-0.0154	0.1157***	0.0954***	0.0283	0.1851***	-0.0465***	0.0064
	(0.047)	(0.029)	(0.029)	(0.045)	(0.026)	(0.039)	(0.027)	(0.026)	(0.033)	(0.013)	
v2	-0.0613**	0.0979***	-0.0333**	-0.2448***	0.0224	-0.0935***	0.0476***	0.0320**	0.1339***	0.0417***	0.0574
	(0.027)	(0.016)	(0.016)	(0.025)	(0.015)	(0.022)	(0.015)	(0.015)	(0.019)	(0.008)	
v3	-0.0448**	0.0074	0.1003***	0.0185	0.0071	-0.0010	-0.0166	-0.0455***	-0.0439***	0.0067	0.0118
	(0.020)	(0.012)	(0.012)	(0.019)	(0.011)	(0.016)	(0.011)	(0.011)	(0.014)	(0.006)	
v4	-0.0071***	0.0010	0.0397***	-0.0090***	0.0005	-0.0063***	-0.0066***	-0.0021	-0.0108***	0.0020***	-0.0013
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	
v5	0.0001	-0.0003***	0.0001***	0.0006***	-0.0000	0.0004***	-0.0002***	-0.0001**	-0.0004***	-0.0001***	-0.0001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
v6	0.0000	-0.0000	-0.0000***	-0.0000	-0.0000	0.0000**	0.0000*	0.0000***	0.0000**	-0.0000	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
cons	-0.0274	0.1773***	-0.2596***	-0.1096***	0.1324***	0.0725***	0.2818***	0.1344***	0.1217***	0.0690***	0.4075
	(0.022)	(0.013)	(0.013)	(0.021)	(0.012)	(0.018)	(0.013)	(0.012)	(0.015)	(0.006)	

Standard errors in parentheses. *,**,*** denote 10%, 5%, 1% significance level

Note: Leisure services' coefficients computed from adding-up restriction. Regions compared to *Prague*.

Source: CSO and authors' calculations

Appendix B

Demographic summary

Table B.1: Frequency of demographic variables

Common demographics								
hhsize	1	2	3	4	5	6	7	8
	9,898	14,763	7,214	8,904	1,465	177	32	6
Sex		female				male		
		11,381				31,078		
Empstat		unemployed				employed		
		10,110				32,349		
Educ		low		middle		high		
		12,190		17,931		12,338		
City_size		regional capital		city		village		
		12,425		17,258		12,776		
Children		0	1	2	3	4	5	6
		23,728	8,371	8,770	1,401	153	31	5

For description of variables see Table 4.2.

Source: CSO and authors' calculations.

Table B.2: Frequency of demographic variables - second model

Second model								
d_5		0		1		2		3
		36,401		4,927		1,108		23
d6_9		0		1		2		3
		37,397		4,585		468		9
d10_14		0		1		2		3
		36,106		5,376		945		32
d15_		0	1	2	3	4	5	
		34,122	6,036	2,157	136	7	1	
Age	-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59
	585	2,565	4,613	5,065	4,571	4,349	4,708	5,290
	60-64	65-69	70-74	75-79	80+			
	3,623	2,600	2,066	1,547	877			
Housing		Tenant		Mortgaged		Self-owned		
		23,519		4,111		14,829		
Region	PHA	STČ	JHČ	PLK	KVK	ULK	LBK	HKK
	5,824	4,711	2,794	2,299	1,481	3,380	1,660	2,334
	PAK	VYS	JHM	OLK	ZLK	MSK		
	2,008	2,270	4,116	2,541	2,186	4,855		
EA		0	1	2	3	4	5	
		8,694	16,455	16,089	1,020	200	1	
Car	27,146							
Single	5,631							
Obs.	42,459							

For description of variables see Table 5.2.

Source: CSO and authors' calculations.

Appendix C

Commodity bundles by the HBS codes

Table C.1: Aggregated commodities by the HBS codes - the first model

Commodity	Codes	Description
Food in	2010-2822, 2860, 2870, 2910	Food and beverages consumed at home
Food out	2830-2850, 2880, 2900-2902, 2920-2972, 3900-3903	Tobacco, alcoholic, non-alcoholic beverages and food consumed in restaurants and canteens
Household goods	3400-3570, 3700-3790, 3850, 4360, 4370, 4380	Furniture, kitchen and household equipment, electronics, toys and office supplies
Clothing	3010-3272, 3310, 4310, 4320	Clothing and shoes, cleaning
Other services	3300, 3360-3390, 3860-3890, 4040, 4050, 4110-4130, 4150-4170	Medication, drugs, medical equipment, books and periodicals, sewerage and public transport
Transport	3600-3650, 3810-3840, 4140, 4180, 4330, 4340, 4350, 4610, 4620, 4640	Cars, bicycles and repairs, taxi, vacation
Energy	3910-3930, 4020, 4030	Electricity and fuels
Other goods	3330-3332, 3350, 4060, 4210-4250, 4410, 4420, 4422, 4460, 5310-5340	Cleaning supplements, postal, internet and phone services

Source: CSO and authors.

Table C.2: Aggregated commodities by the HBS codes - the second model

Food in	2010-2822, 2860, 2870	Food and non-alcoholic beverages consumed at home
Food out	2880-2972	Non-alcoholic beverages and food consumed in restaurants and canteens
Alc. & Tob.	2830-2850, 3900-3903	Beer, wine, spirits and tobacco goods
Fuel & Light	3910-3930, 4020-4040	Fuel and electricity
Household g.	3310, 3330-3332, 3350, 3462-3490, 4360-4380	Cleaning and chemist goods, repairs
Household s.	3870, 4050-4070, 4210-4250, 4410-4422, 4440, 4460, 4751, 5060	Postal, internet and mobile services, financial services and fees
Clothing	3010-3260, 4310, 4320	Clothing and shoes, cleaning
Personal g. & s.	3272, 3300, 3340, 3360-3390, 3880, 4500-4560, 4710-4750, 4752-4790, 5210-5230, 5290	Medication, drugs, medical equipment, cosmetics, education, insurance
Transport	3640, 4110-4180, 4340, 4350, 5240	All public and private transport cost, including fees, insurance and gas
Leisure goods	3270, 3271, 3780, 3790, 3840-3860, 4330, 4450	Travel equipment, toys, books and flowers
Leisure services	4430, 4610-4654, 5350	Recreation, movies, theatres, concerts, museums, zoos and betting games

Source: CSO and authors.

Acronyms

QUAIDS Quadratic Almost Ideal Demand System

CSO Czech Statistical Office

HBS Household Budget Survey

VAT Value Added Tax

CPI Consumer Price Index

SUR Seemingly Unrelated Regression

COICOP Classification of Individual Consumption According to Purpose

CERGE-EI Center for Economic Research and Graduate Education - Economics Institute

IDEA Institute for Democracy and Economical Analysis

AIDS Almost Ideal Demand System

CZK Czech Koruna

LBR Labour Participation Rate

EA Economical Activity

IV Instrumental Variable

GDP Gross Domestic Product

LES Linear Expenditure System

Bachelor Thesis Proposal

Author	Bc. Michael Bílý
Supervisor	Petr Janský, Ph.D.
Proposed topic	Estimating the quadratic almost ideal demand system and the effects of population ageing in the Czech Republic

Topic characteristics The greatest share of gross domestic product of developed countries is private consumption. Thus understanding of private consumption is the goal of economists, policy makers and central banks. The main indicators of private consumption are aggregate demand and elasticity, which is the dynamics of demand with changing prices and income. If we want to observe, analyze and predict effects of external and internal changes (such as society aging, change in VAT) on private consumption, we have to derive aggregate demands and elasticities for various categories of people (age, income, household composition) using current economic models and statistical approaches. I would like to derive the demands and elasticities applying QUAIDS model of Banks at al. (1997) in my work. Then I will use the estimates to test hypothesis related to external and internal changes.

Methodology I will apply Quadratic Almost Ideal Demand System of Banks at al. (1997). I will use data from the Household Budget Survay provided by the Czech Statistical Office, the Consumer Price Index and other sources of information about prices. For computations and testing hypothesis I will use the statistical software STATA.

Outline

1. Introduction
2. Theoretical part

3. Literature review
4. QUIADS model
5. Data
6. Empirical part
7. Demand and elasticity estimation
8. Tested hypothesis
9. Results
10. Conclusion

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