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Abstract

Reforms of indirect taxes, such as the recent changes in rates of value added tax (VAT) in the Czech Republic, change prices of products and services to which households can respond by adjusting their expenditures. I estimate the behavioural response of consumers to price changes in the Czech Republic applying a consumer demand model of the quadratic almost ideal system (QUAIDS) form to the Czech Statistical Office data for the period from 2001 to 2011. I then derive the estimates of own- and cross-price and income elasticities and I use these to estimate the impact of changes in VAT rates, which were proposed or implemented between 2011 and 2013, on households and government revenues. I further find that this method, which allows for behavioural response, yields lower estimates of changes in VAT revenues than when I use the standard static simulation. These relatively small, but statistically significant differences might partly explain the past cases, and might lead to future cases, of the over-estimation of VAT revenues by the Ministry of Finance of the Czech Republic.

Keywords

consumer behaviour; demand system; QUAIDS; value added tax; Czech Republic

JEL classification

D12; H20; H31

1 Introduction

Value added tax (VAT) is one of the most important taxes in the Czech Republic and the rest of the developed world. The impact of VAT changes depends on microeconomic behaviour of the consumers and my objective here is to shed more light on this and, more generally, on household consumption and its taxation through VAT in the Czech Republic.

A rigorous analysis of impacts is desired especially in the Czech Republic since the reduced and standard value added tax (VAT) rates have gone through important changes recently. They were, respectively, 10% and 20% in 2011, 14% and 20% in 2012, and – after a last-minute change from the previously approved unification of rates at 17.5% - a one percentage point increase in both rates to 15% and 21% in 2013.

Existing impact evaluations of these VAT reforms have at best made use of first-order approximations (e.g. (Dušek & Janský 2012a) and (Dušek & Janský 2012b)). These studies used a standard method with no-behavioural-response static micro-simulation results and did not properly account for the potential for consumers to substitute between goods as relative prices change (Banks et al. 1996), which might cause over-estimation of the effects of tax changes.

For a more rigorous analysis it is good to have a detailed knowledge of individual preferences that are, of course, not readily available. So first, this paper derives second order approximations which do not display systematic biases as shown in (Banks et al. 1996) and require knowledge of the distribution of substitution elasticities, in contrast to first order approximations. Specifically, I estimate Quadratic Almost Ideal Demand System (QUAIDS), developed by (Banks et al. 1997) and applied for analysis of VAT reforms in Mexico by (Abramovsky et al. 2012). In this demand system, similarly to the only previously QUAIDS estimated for the Czech Republic by (Dybczak et al. 2010), demand depends not only on prices and incomes, but also other household characteristics such as size of the household or the employment status or age of the household head.

This almost ideal demand system allows me to take into account the consumers' substitution responses when relative prices change due to VAT reforms and is the first one in the Czech Republic built specifically for the analysis of tax policy. The model uses household expenditure and demographic data from the Household Budget Survey (HBS) and price data from the Consumer Price Index (CPI). To the best of my knowledge, this demand system is the first one in the Czech Republic built using only the consumer price information from CPI rather than HBS. The exclusive use of official figures on prices in CPI instead of unit values derived from expenditures and quantities recorded in HBS lowers the risk that observed price variation may instead reflect variations in quality.

I chose categories of expenditure so that they reflect not only functional groupings (e.g. food, clothes) but also reflect goods and services subject to different rates of VAT, i.e. in a similar way to (Abramovsky et al. 2012). Estimated price and income elasticities appear plausible in magnitude and sign. For instance, food is found to be a necessity while eating out is found to be a luxury. Strong luxuries include transport and recreation and household goods. This categorization, in combination with a simple VAT simulator, allows me to estimate how consumers respond to changes in VAT rates and the implications for consumers' spending patterns and government's tax revenues. I demonstrate this on the simulation of recent VAT reforms. I find that allowing for behavioural response makes difference to estimates of the tax revenues that are lower in comparison to the first order approximation holding behaviour fixed, specifically the standard static micro-simulation model allowing for no behavioural response and holding the quantity of purchases fixed (nominal expenditures rise or fall in line with the rise of fall in VAT rates).

The layout of the paper is as follows. Section 2 provides a brief literature review. In section 3, I discuss the theoretical consumer demand model and in the Appendix I show the derivation of the formulae for the estimation of elasticities. Section 4 describes the data. In section 5, I explain the estimation of the model. Section 6 discusses the results in the form of the estimated elasticities. Section 7 outlines the application of the model's results to the evaluation of changes in VAT rates. Section 8 concludes.

2 Literature review

The literature on consumer demand and VAT is quite voluminous and I will therefore focus only on three areas. First, I briefly introduce the most important contributions to demand system estimation. Second, I discuss the existing articles estimating demand systems for the Czech Republic. Third, I provide an overview of the literature on impacts of VAT in the Czech Republic.

First, (Stone 1954) was the first to estimate a demand system based on consumer preferences theory, specifically the linear expenditure systems developed by (Klein & Rubin 1947). A number of improvements have been developed and proposed over the decades; nowadays there are two main demand systems that are being estimated. The first is the Almost Ideal Demand System (AIDS) developed by (Deaton & Muellbauer 1980), the second is the Quadratic Almost Ideal Demand System (QUAIDS), developed by (Banks et al. 1997). QUAIDS is basically AIDS that allows Engel curves to be quadratic. Furthermore, (Poi 2002) and (Poi 2008) are useful introductions to estimating QUAIDS using the STATA software as I do. Recent applications of QUAIDS model similar to this paper are (Crawford et al. 2010), who discuss the implications of VAT for labour market participation on UK data, and (Abramovsky et al. 2012), who evaluate Mexican VAT reform.

Second, I discuss the existing demand systems for the Czech Republic. The demand systems have been estimated for the Czech Republic recently by two teams of researchers. Using the AIDS in modification by (Edgerton 1996), (Janda et al. 2010) estimate elasticities with focus on alcohol beverages and find, for example, a very low own-price elasticity of demand for beer. (Dybczak et al. 2010) are the first to estimate the QUAIDS for the Czech Republic and divide the expenditure into eight categories - food, clothing, energy, house, health, transport, education and other - that do not align with VAT rates as is the case in this paper. They estimate own- and cross-price and income elasticities and use them to analyse the impact of changes in regulated prices on consumer demand. In addition, a number of studies such as (Dubovicka et al. 1997) or (Janda et al. 2000) have focused on estimating Czech food demand elasticities using flexible function forms, to which also both AIDS and QUAIDS belong. Furthermore, (Crawford et al. 2004) develop a new method for estimation of price reactions and apply it on the Czech data.

Third, I provide a short overview of VAT in the Czech Republic and related literature. The Czech Republic introduced VAT in 1993 and it applies to most of household expenditures in the form of its two rates. From 2013, the increased both its reduced and standard rates by one percentage point to 15 % and 21 %, respectively. VAT and its changes in the Czech Republic have been studied by (Schneider 2004), who analysed tax burden of households and found VAT to be relatively regressive, and more recently by (Klazar et al. 2007), who focused on the impact of EU-accession related harmonisation of VAT rates. (Klazar & Slintáková 2010) studied the VAT in the Czech Republic and its impact on households and found VAT to be regressive when annual income is analysed while their lifetime income analysis indicated that VAT is progressive. (Dušek & Janský 2012a) and (Dušek & Janský 2012b) used a simple micro-simulator – without using a demand system and accounting for behavioural response to VAT changes as in this paper – to provide first independent estimates of the impact of the recently proposed VAT rates changes in the Czech Republic on the living standards of households and tax revenues. One objective of this paper is to compare the results of analysis of these VAT reforms according to whether behavioural change is taken into account or not.

3 Theory

I estimate the demand system of the Quadratic Almost Ideal Demand System (QUAIDS) form developed in (Banks et al. 1997) and I further use it for indirect tax policy analysis, as proposed by (Banks et al. 1996) and applied in, for example, (Crawford et al. 2010) or (Abramovsky et al. 2012). The QUAIDS model is a generalization of Almost Ideal Demand System (AIDS) model that allows for quadratic Engel curves. The QUAIDS can therefore allow a good to be a luxury at one level of income and a necessity at another, a property that (Banks et al. 1997) find to be of empirical relevance for the UK and (Dybczak et al. 2010) do the same for the Czech Republic.[1] (Banks et al. 1997) also showed that it is sufficient for the nonlinear term to be a quadratic in log income.

I introduce the QUAIDS model, basically as presented in (Banks et al. 1997), in the Appendix. The model does not allow for positive or negative externalities from expenditure on certain goods, for instance fuel, alcohol and tobacco. The assumption of no externalities can be easily neither altered nor tested and is a limitation on the usefulness of QUAIDS, for example, when looking at the welfare effects of excise duties on goods with negative externalities.

[1] Even earlier studies than (Banks et al. 1997) identified the importance of further terms in income for some, but not all, expenditure share equations, see for example (Atkinson et al. 1990) or (Blundell et al. 1993) and (Banks et al. 1997) for further discussion and references. This has been documented for the Czech Republic for the first time by (Dybczak et al. 2010).

4 Data

To estimate QUAIDS in the Czech Republic I employ the best available data: two datasets from the Czech Statistical Office (CSO). The Household Budget Survey (HBS) is a representative sample of around 3000 Czech households. For each of them, HBS contains information on how much they spend on various goods and services (around 250 expenditure items), who they are (around 60 demographic variables) and how they earn their income (around 30 income items).[2] The HBS data is basically a pooled repeated cross-section data set, and has been applied for estimation of the demand systems by both (Janda et al. 2010) and (Dybczak et al. 2010). I employ data for the period between 2001 and 2011 and therefore I have around 33000 households in total.

I use the CSO price data gathered for the purpose of the Consumer Price Index (CPI) that is classified into around 150 categories according to the classification of individual consumption by purpose (COICOP).[3] The price information is available for the Czech Republic as a whole and also separately for the capital city of Prague.

In the following part, I discuss two reasons why I opt to use the CPI as the only source of prices. This is in contrast to both (Janda et al. 2010) and (Dybczak et al. 2010), who divided the expenditures by the amount of purchased goods and services. This way, they obtained unit values, which they used as prices. Not only can this method be in some cases inaccurate, but also the HBS data for amounts of purchased goods and services is incomplete.

First, the HBS includes information on amounts of purchased goods and services only for a limited number of expenditure items. Unit values can be thus constructed only for those goods for which quantity information is available in the HBS. Therefore I would need to limit my analysis to a small subset of overall expenditures, which was basically done by (Janda et

[2] The CSO gathered the data in a way that only those for the period 2006-2011 can be considered fully representative, but as some preliminary robustness checks did not find significant differences between the two periods and since (Dybczak et al. 2010) showed the same, I conclude that there is no significant risk in using the data for the longer period. Furthermore I use the representativeness weights provided by the CSO so that the data reflect the overall Czech population. Still there are some further concerns for the real representativeness of this data, especially with its earlier editions. Although treatments of the potential problems of this nature are generally beyond the scope of this analysis, let me briefly review them. Earlier, the CSO was criticized for failing to provide the full dataset of HBS to European Union representatives (Eurostat 2009). Furthermore, as (Crawford & Z. Smith 2002) discuss, systematic over- or under-reporting of expenditures can occur due to forgetfulness (e.g., consumption outside the home), active concealment (e.g., receipt from a beauty studio), and guilt (e.g., cigarettes) . Another problem mentioned by (Crawford & Z. Smith 2002) that may occur in the Czech HBS is the following: as expenditures are recorded monthly, large and infrequent purchases may be underestimated. And this is also one of the reasons why I exclude housing from the expenditure data, both purchase and rent (the corresponding HBS codes in the 2011 data are 4010, 4080, 5440, 5550). Furthermore the relatively high and infrequent housing expenditures would distort the model. This is a common approach in the existing literature, for example (Banks et al. 1997).

[3] Some prices are regulated in the Czech Republic, either nationally (health care fees) locally (waste disposal service charge) and would therefore arguably require a special treatment, which I however do not provide here because of the complexity and because the share of regulated prices is very low.

al. 2010), or fill in the HBS unit values whenever these are not available by the CPI prices, which was done by (Dybczak et al. 2010). In contrast to (Janda et al. 2010), I prefer to analyse an as high share of overall household consumption as possible, which is made possible by applying the CPI data. In contrast to (Dybczak et al. 2010), I prefer the consistency of using only one complete source for the information on prices, the CPI. Second, the differences in unit values can be caused by product quality differences rather than price differences that I aim to study. With the unit values it is almost impossible to distinguish between the influence of changes in prices and quality since risk observed price variation may instead reflect variations in quality. By using the CPI data, I limit the extent of this problem.

In the expenditure share equations estimated in QUAIDS I further include a time trend and a number of demographic variables to control for preference variation that may be correlated with total expenditure or prices in a way that is consistent with the model. Table 1 provides the list of these variables.

I classify the HBS expenditure data according to the VAT rates, reduced and standard, presented in the appendices to the law on VAT as of January 2013. When HBS classification is not detailed enough to allow the accurate division according to the VAT rate or when some expenditures are exempted from VAT, I assign the VAT rate according to the one prevailing for that group. I merge the HBS and the CPI data using the HBS codes and COICOP codes and although these two classifications do not always match well, no significant compromises had to be made during the matching process.

In order to estimate QUAIDS, I divided the detailed expenditure items into eight groups. I have followed three principles while grouping the expenditure items and in this I differ from the previously estimated demand systems for the Czech Republic. First, the division should correspond to natural categories as people think about them, as is done for example by (Dybczak et al. 2010). Second, the expenditure groups should be of a similar size. Third and most important for my analysis, expenditure groups should be divided according to VAT rates as much as possible. A number of compromises had to be made when following these three principles and I have given most weight to the third one. I calculate the price indices of aggregated commodities as weighted arithmetic averages of the price indices of the individual goods and services making up the aggregated commodity. Table 2 provides the names and shares in total expenditures of the eight expenditure groups for the year of 2011. There is a more detailed description in Table A1 and basic summary statistics in Table A2 in the Appendix. I use this categorisation of expenditures into groups in the following analysis.

Table 1. Demographic and other variables used in the demand system.

Variable	Description
Child	= a number of children
Members	= a number of household members
Age	= age of the head of household
Sex	= 1 if the head of the household is female, 0 otherwise
Empstat	= 1 if the head of the household is employed, 0 otherwise
Educlow	= 1 if the head of the household has primary education or less, 0 otherwise
Educmid	= 1 if the head of the household has secondary education, 0 otherwise
City size	= 1 for regional capitals, = 2 for cities, 3 = for villages
Praha	= 1 if the household reside in the capital city, Praha 0 otherwise
Time trend	= year of the survey (computed as 2012 minus year of the survey)

Table 2. Expenditure groups and their average shares in 2011.

Group	Expenditure	Average share in the sum of these expenditures (%)
1	Food (mostly reduced VAT)	24.4
2	Eating out (mostly standard VAT)	10.7
3	Household goods (mostly standard VAT)	7.5
4	Clothing (mostly standard VAT)	6.2
5	Other services (mostly reduced VAT)	16
6	Transport and recreation (mostly standard VAT)	11.5
7	Energy (mostly standard VAT)	11.9
8	Other goods (mostly standard VAT)	11.9

Source: CSO and the author.

5 Estimation

The estimation of QUAIDS follows two stages and is similar as in, for example, (Abramovsky et al. 2012). At the first stage of the estimation, the values of $a(p)$ and $b(p)$ are unknown to me and therefore I approximate $b(p)$ as 1 and $\ln a(p)$, using the Stone price index named after (Stone 1954), as:

$\ln p^* \approx \sum_i w_i \ln p_i$.

QUAIDS is linear in parameters conditional upon the price indices and, therefore, I can and do employ a linear Seemingly Unrelated Regression (SUR) method to estimate the model. Adding up is imposed by excluding the equation for the nth good from the estimated system of equations; parameters for this equation are calculated using the parameters from the other (n-1) equations and the adding up restrictions (the results are not by construction sensitive to the choice of the nth good). Homogeneity (by expressing all prices relative to the price of the other remaining goods) and symmetry are imposed using linear restrictions on parameters.

The parameters estimated at the first stage are then used to calculate values for $a(p)$ and $b(p)$. The model is then re-estimated using the same specification as the first stage except that p^* is replaced with $a(p)$ and λ_i by $\frac{\lambda_i}{b(p)}$. The new parameter values are used to update $a(p)$ and $b(p)$, and the model is then re-estimated for a third time. This updating of price indices and re-estimation is iterated 8 times, by which time the parameter values have converged to 4 decimal places.

I instrument for expenditure using monetary income because it may be endogenous. I do so using a control function approach as is common in the literature and as applied in (Banks et al. 1997) or (Abramovsky et al. 2012).[4] I calculate standard errors using bootstrapping with 1300 iterations with clustering at the household level.

Table A3 in the Appendix presents the parameter estimates for the QUAIDS. It is difficult to interpret the parameters of QUAIDS directly and I will therefore discuss the elasticities as is also common in the existing literature.

[4] I regress the log of total expenditure (lnx) and the square of the log of total expenditure $(\ln x)^2$ on the prices and demographic variables included in the demand system and on the log of household monetary income and the square of the log of household monetary income and include linear, square and cubic terms of the residuals from these regressions in our demand system equations.

6 Elasticities

In this section I present the income and cross-price elasticities that I estimate using the derivation presented in the Appendix. I calculate the elasticities for each household individually and I subsequently construct a weighted average, with the weights being equal to the household's share of the total expenditure and total sample expenditure for the relevant good for the income and price elasticities, respectively.

Tables 3 and 4 show the Hicksian (compensated) and the Marshall (uncompensated) price elasticities, respectively. Statistical significance is depicted by colours. Own-price elasticities are on the diagonal and cross-price elasticities off the diagonal.[5] The elasticities are largely statistically insignificant and so the results should be interpreted with further caution. Still, most Marshall own-price elasticities are statistically significant at least at 10% level.

Both tables 3 and 4 show that all own-price elasticities are negative as required by economic theory. As far own-price elasticity of demands are concerned, eating out, food and energy are among the least elastic, whereas other services and goods and transport and recreation are among the most elastic. The patterns of cross-price elasticities and therefore substitution and complementarity seem reasonable. For example, food and eating out are substitutes. Not surprisingly, cross-price elasticities are mostly relatively small and smaller than own-price elasticities.

Table 5 presents the income elasticities, estimated using the total expenditure variable. Only half of the elasticities are statistically significant at least at 10% level and so the results should be interpreted with caution. The estimated income elastiticites seem reasonable. Other services, including public services, are necessity and the same holds for other goods, which have, however, an income elasticity of just below 1. Food and energy – similar to results in (Dybczak et al. 2010) – are both necessities, albeit not statistically significant. So both expenditure groups with reduced VAT rate – food and other services – are necessities. Eating out, clothing, household goods and transport and recreation have all income elasticity above 1 and are therefore considered luxuries.

[5] The tables show elasticities of a good in the column with respect to price changes of the good in the row. For example for Hicksian (compensated) cross-price elasticities, the number of the column corresponds to the i and the number of the row to the k in the following equation: $\epsilon_{ik}^{c} = \epsilon_{ik}^{u} + \epsilon_i w_j$.

Table 3. Hicksian (compensated) price elasticities.

Group	Food	Eating out	Household goods	Clothing	Other services	Transport, recreation	Energy	Other goods
Food (mostly reduced VAT)	-0.194	0.243	0.257	-0.092	0.214	-0.214	-0.206	0.170
Eating out (mostly standard VAT)	0.100	-1.081	0.304	-0.121	0.464	0.120	-0.139	0.038
Household goods (mostly standard VAT)	0.117	0.253	-1.366	0.088	0.115	0.331	0.113	-0.045
Clothing (mostly standard VAT)	-0.026	-0.082	0.078	-0.431	-0.098	0.211	0.416	-0.131
Other services (mostly reduced VAT)	0.111	0.603	0.187	-0.175	-0.851	0.029	-0.090	0.256
Transport and recreation (mostly standard VAT)	-0.101	0.135	0.492	0.397	0.013	-0.414	-0.079	0.013
Energy (mostly standard VAT)	-0.080	-0.112	0.091	0.526	-0.050	-0.081	-0.139	0.112
Other goods (mostly standard VAT)	0.073	0.040	-0.042	-0.192	0.195	0.018	0.123	-0.413

*Notes: Parameters in the numbered rows, SE denotes rows with bootstrapped standard errors. The cells with parameters are coloured in line with their significance. The darkest grey corresponds to the standard *** and means significance at the 1% level, the middle grey corresponds to ** and significance at the 5% level and the lightest grey to * and significance at the 10% level.*

Source: CSO and the author.

Table 4. Marshall (uncompensated) price elasticities.

Group	Food	Eating out	Household goods	Clothing	Other services	Transport, recreation	Energy	Other goods
Food (mostly reduced VAT)	-0.311	-0.010	-0.134	-0.385	0.036	-0.597	-0.306	-0.062
Eating out (mostly standard VAT)	0.053	-1.202	0.116	-0.260	0.382	-0.069	-0.179	-0.070
Household goods (mostly standard VAT)	0.079	0.147	-1.540	-0.039	0.046	0.148	0.080	-0.139
Clothing (mostly standard VAT)	-0.059	-0.168	-0.059	-0.533	-0.156	0.071	0.390	-0.206
Other services (mostly reduced VAT)	0.045	0.447	-0.053	-0.354	-0.966	-0.209	-0.144	0.115
Transport and recreation (mostly standard VAT)	-0.156	-0.023	0.221	0.190	-0.086	-0.738	-0.134	-0.128
Energy (mostly standard VAT)	-0.127	-0.211	-0.063	0.413	-0.117	-0.231	-0.186	0.017
Other goods (mostly standard VAT)	0.025	-0.078	-0.228	-0.329	0.114	-0.171	0.079	-0.522

*Notes: Parameters in the numbered rows, SE denotes rows with bootstrapped standard errors. The cells with parameters are coloured in line with their significance. The darkest grey corresponds to the standard *** and means significance at the 1% level, the middle grey corresponds to ** and significance at the 5% level and the lightest grey to * and significance at the 10% level.*

Source: CSO and the author.

Table 5. Income (total expenditure) elasticities.

Group	Expenditure	Income Elasticity
1	Food (mostly reduced VAT)	0.419
2	Eating out and other luxuries (mostly standard VAT)	1.100
3	Household goods (mostly standard VAT)	1.794
4	Clothing (mostly standard VAT)	1.295
5	Other services (mostly reduced VAT)	0.724
6	Transport and recreation (mostly standard VAT)	2.097
7	Energy (mostly standard VAT)	0.445
8	Other goods (mostly standard VAT)	0.991

*Notes: The cells with parameters are coloured in line with their significance. The darkest grey corresponds to the standard *** and means significance at the 1% level, the middle grey corresponds to ** and significance at the 5% level and the lightest grey to * and significance at the 10% level.*

Source: CSO and the author.

7 Simulation of VAT reforms

I use the results of the QUAIDS model to simulate the impacts of VAT reforms on consumer spending patterns and tax revenues and thus accounting for the changes in spending patterns. Estimates incorporating such behavioural response can then be compared to those based on the standard no-behavioural-response static micro-simulation results.

In the case of the Czech Republic, there are a number of recent changes in VAT rates suitable for simulation. The reduced and standard VAT rates were, respectively, 10% and 20% in 2011, 14% and 20% in 2012, and – after a last-minute change from the already approved unification of rates at 17.5% - a one percentage point increase in both rates to 15% and 21% in 2013.[6]

I compare the VAT rate changes using estimates incorporating behavioural response that account for changes in spending patterns with no-behavioural-response static micro-simulation results. When using the demand system for these purposes I model changes in VAT rates as changes in the prices of the eight aggregate expenditure groups used already in the QUAIDS demand system.

The last available year of the data is 2011, in which the VAT rates were 10% and 20%, and therefore I first simulate the VAT rates of 14% and 20% that were in place in 2012 and establish that as the status quo. I further compare this to the following two scenarios:

Table 6 shows spending patterns estimated using Marshall elasticities estimated by QUAIDS before the VAT changes, what they are estimated to be after the 2012 as well as 2013 VAT rates – including the earlier proposed – changes. Overall, neither the 2012 or 2013 approved VAT changes have a very substantial impact on spending patterns; the expenditure shares change only in terms of tenths of per cents. The larger change of introducing of a uniform 17.5% rate of VAT does have a larger effect. In particular, the share of food on which reduced VAT rate is currently levied increases significantly, by one percentage point (reflecting its low own-price elasticity of demand) whilst the share of other goods generally falls.[7]

[6] Here I provide a more detailed description of recent changes in VAT rates. Until 2011, the reduced VAT rate was 10% and the standard VAT rate was 20%. The 2011 law introduced two subsequent changes to VAT rates in 2012 and 2013. First, there was an increase in the reduced rate to 14% in 2012, keeping the standard rate at 20%. Second, a unification of both VAT rates at 17.5% was supposed to take place in 2013. But in November and December 2012 there was a new law finally approved, which changed the VAT rates for 2013 so that both VAT rates increase from the 2012 levels by one percentage point to 15% and 21% for reduced and standard VAT rate, respectively. One of the interpretations of these changes, for example according to Fiskální výhled ČR (Fiscal outlook ČR) from November 2011, is that the unification of VAT rates at 17.5% will eventually take place, but only from 2016. Furthermore, the VAT rates have become an important political issue since 2010 and further changes seem likely after the next general elections, which are to be held in the June 2014 at the latest.

[7] However, the increase in the share of food of around 2.4% (0.6 percentage points) from the 2012 levels is less than the 3.1% increase in the price of food following the imposition of VAT, implying the quantity of food purchased would be lower if VAT were imposed at the unified rate.

Table 7 shows spending patterns in the same way as table 6, but using a standard method: with no-behavioural-response static micro-simulation results and without the application of the QUAIDS results. Specifically, the table shows the estimated expenditure shares from the reforms using the static micro-simulation model allowing for no behavioural response and holding the quantity of purchases fixed (nominal expenditures rise or fall in line with the rise of fall in VAT rates).

Table 8 shows revenue estimates for the VAT changes on the basis of our sample of Czech households extrapolated for the whole population of the Czech Republic. Here I focus on the analysis of the 2013 VAT changes. Therefore I consider and first simulate the 2012 VAT rates of 14% and 20% as the baseline and compare it with both the approved reform of VAT rates of 15% and 21% and the proposed reform of the unified VAT rate of 17.5%.

The first two columns of table 8 shows the estimated revenues from the reforms using the standard static micro-simulation model allowing for no behavioural response and holding the quantity of purchases fixed (standard). The third and fourth columns use the QUAIDS model described above to allow spending patterns to change in response to the changes in prices. The magnitude of difference between the two estimation methods used is in line with the differences between results in tables 6 and 7: allowing for consumer spending patterns to change has a relatively small, but significant impact on additional VAT revenues.

With the standard method the estimated impact on VAT revenues is, rounding these figures, -1 billion CZK (Czech crowns) and 10 billion CZK for the 2013 proposal (unified VAT rate of 17.5%) and reality (15% and 21%), respectively. The corresponding estimates using QUAIDS are around zero and 7 billion CZK, i.e. lower in total by around 1 billion CZK and, as table 8 shows, also lower for individual expenditure groups than the standard estimates.

The estimated tax revenue after allowing for behaviour to adjust (in accordance with QUAIDS preferences) is, as expected, lower than the estimate using the standard static micro-simulation methodology that holds fixed the quantity of goods and services purchased. These relatively small, but significant differences might partly explain the past cases, and might lead to future cases of the over-estimation of VAT revenues by the Ministry of Finance of the Czech Republic.

In the government budget report for 2013 (Ministry of Finance of the Czech Republic 2012) (pages 12 and 13), the overall increase (mostly due to one percentage point increase in both VAT rates and an expected increase in consumption) in VAT revenues is estimated at 1.2% and at 9.8 billion CZK for central government and since around one third of VAT revenues goes to the regional governments, this corresponds to around 14 billion CZK. Although my estimates of around 10 and 8.5 billion CZK are limited in the sense that they cover only the VAT revenues raised from household consumption and are therefore not directly comparable with the Ministry's numbers, my expert estimate is that the Ministry's numbers are around the upper bounds of - my - realistic estimates and that – depending on the growth of household consumption in 2013 – their numbers might well be overestimated, partly by failing to account for behavioural response.

Table 6. Average expenditure shares after changes in VAT rates for 2013 (%) - QUAIDS.

Group	Expenditure	2011 (10% and 20%)	2012 (14% and 20%)	2013 proposal (17.5% and 17.5%)	2013 reality (15% and 21%)
1	Food (mostly reduced VAT)	24.4	24.9	25.5	25.1
2	Eating out (mostly standard VAT)	10.7	10.9	11.1	10.8
3	Household goods (mostly standard VAT)	7.5	7.4	7.5	7.4
4	Clothing (mostly standard VAT)	6.2	6.2	5.8	6.0
5	Other services (mostly reduced VAT)	16.0	16.1	16.0	16.1
6	Transport and recreation (mostly standard VAT)	11.5	10.9	10.8	11.0
7	Energy (mostly standard VAT)	11.9	11.7	11.4	11.7
8	Other goods (mostly standard VAT)	11.9	11.9	11.9	11.9
	Total	100	100	100	100

Source: CSO and the author.

Table 7. Average expenditure shares after changes in VAT rates for 2013 (%) - standard.

Group	Expenditure	2011 (10% and 20%)	2012 (14% and 20%)	2013 proposal (17.5% and 17.5%)	2013 reality (15% and 21%)
1	Food (mostly reduced VAT)	24.4	25.4	26.8	25.4
2	Eating out (mostly standard VAT)	10.7	10.4	10.0	10.4
3	Household goods (mostly standard VAT)	7.5	7.3	7.0	7.3
4	Clothing (mostly standard VAT)	6.2	6.0	5.8	6.0
5	Other services (mostly reduced VAT)	16.0	16.7	17.6	16.7
6	Transport and recreation (mostly standard VAT)	11.5	11.2	10.8	11.2
7	Energy (mostly standard VAT)	11.9	11.5	11.0	11.5
8	Other goods (mostly standard VAT)	11.9	11.6	11.1	11.6
	Total	100	100	100	100

Source: CSO and the author.

Table 8. Effect of consumer demand response on revenues from changes in VAT rates from the 2012 baseline (billions Czech crowns)

Group	Expenditure	2013 proposal (17.5% and 17.5%)	2013 reality (15% and 21%)	2013 proposal (17.5% and 17.5%)	2013 reality (15% and 21%)
	Method:	Standard	Standard	QUAIDS	QUAIDS
1	Food (mostly reduced VAT)	8.25	2.31	6.78	1.86
2	Eating out (mostly standard VAT)	-2.54	1.04	-1.53	0.73
3	Household goods (mostly standard VAT)	-2.06	0.84	-1.45	0.48
4	Clothing (mostly standard VAT)	-1.59	0.65	-0.59	0.53
5	Other services (mostly reduced VAT)	5.45	1.53	3.70	1.13
6	Transport and recreation (mostly standard VAT)	-3.64	1.49	-3.02	0.88
7	Energy (mostly standard VAT)	-2.37	0.97	-2.14	0.74
8	Other goods (mostly standard VAT)	-2.70	1.11	-1.97	0.78
	Total	-1.20	9.95	-0.23	7.13

Source: CSO and the author.

8 Conclusion

In this paper I have employed detailed data of Czech Statistical Office to estimate a consumer demand model of the quadratic almost ideal system (QUAIDS), derived the own- and cross-price and income elasticities and simulated the impacts of recent VAT reforms for the Czech Republic. Accounting for behavioural response yielded significantly different estimates of impacts of the reforms on the government revenues. The estimated tax revenue after allowing for behaviour to adjust (in accordance with QUAIDS preferences) is modestly, but significantly lower than the estimate using the standard static micro-simulation methodology that holds fixed the quantity of goods and services purchased. This contributes to the existing simulation of VAT reforms in the Czech Republic (Dušek & Janský 2012a) and (Dušek & Janský 2012b) and in other countries, including most Mexico (Abramovsky et al. 2012).

There are a number of interesting areas for further research. For example, when data for 2012 and 2013 are available, it should be interesting and enriching to look at the actual behaviour of consumers and, also, to compare it with the estimates of the models. Furthermore, there are a number of ways in which to estimate QUAIDS and similar models and it would be desirable to explore these for the Czech Republic. These options include the expenditures included and excluded in the demand system (such as exclusion of housing in most demand system including this estimation), the number of expenditure groups and division of goods among these groups, whether and how I deal with outlier data, whether and what taste shifters and demographic characteristics to include, time period and frequency, unit value prices or other, external prices, ways of computing elasticities (weighted average in this estimation or for a representative or an average household), a homogeneous or representative sample of the population.

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10 Appendix

10.1 QUAIDS model

This section introduces the QUAIDS model, basically as presented in (Banks et al. 1997). QUAIDS is based on the following indirect utility[8]:

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

Where x is total expenditure, p stands for prices, $a(p)$, $b(p)$, and $\lambda(p)$ are defined as:

$$\ln a(p) = \alpha_0 + \sum_i \alpha_i \ln(p_i) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i) \ln(p_j)$$

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

$$\ln \lambda(p) = \sum_{i=1}^{n} \lambda_i \ln(p_i)$$

where i=1,..., n denotes a good, $\ln a(p)$ is the translog price aggregator function, and $b(p)$ is defined as the simple Cobb-Douglas price aggregator.

Applying Roy's identity to the equation for $\ln a(p)$, I have the following equations for w_i, the share of expenditure on good i in total expenditure for each household:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{x}{a(p)}\right) + \frac{\lambda_i}{b(p)} \left(\ln \frac{x}{a(p)}\right)^2$$

These budget shares are quadratic in $\ln\left(\frac{x}{a(p)}\right)$ and, as (Banks et al. 1997) demonstrate, quadratic in $\ln(x)$ itself. For the resulting demands to be consistent with utility maximisation, the demand system must satisfy four key properties: adding-up; homogeneity; symmetry; and negativity (negative semi-definiteness). Only negativity cannot be imposed but the estimated Slutsky matrix can be tested to see if it satisfies this criterion. The first three properties can be imposed using linear restrictions on the parameters of the model:

$$\sum_{i=1}^{n} \alpha_i = 1; \sum_{i=1}^{n} \beta_i = 0; \sum_{i=1}^{n} \gamma_{ij} = 0 \; \forall j; \sum_{i=1}^{n} \lambda_i = 0;$$

(adding up)

[8] The same indirect utility function defines the AIDS model, but with the $\lambda(p)$term set to zero.

$$\sum_{i=1}^{n} \gamma_{ij} = 0 \ \forall j$$

(homogeneity)

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

(symmetry)

I make use of the QUAIDS characteristic to allow for household demographics and other variables such as time trend to affect demands in a fully theoretically consistent manner. Demographics, a time trend and other variables enter as taste-shifters in the share equations, z_k, and to maintain integrability are therefore part of α_i terms in $\ln a(p)$:

$$\ln a(p) = \alpha_0 + \sum_i \left\{ \alpha_i + \sum_{k=1}^{K} \alpha_{ik} z_k \right\} \ln(p_i) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i) \ln(p_j)$$

Which gives me the following new adding-up conditions that supersede $\sum_{i=1}^{n} \alpha_i = 1$:

$$\sum_{i=1}^{n} \alpha_i = 1; \sum_{i=1}^{n} \alpha_{ik} = 0;$$

Price and total expenditure elasticities are derived in (Banks et al. 1997) and I do so in the following sections.

10.2 Income elasticities

Price and total expenditure elasticities are derived and presented in (Banks et al. 1997) and I do so in this Appendix.

First, I derive the total expenditure, or income, elastitcity. I differentiate the share equation with respect to $\ln x$ to obtain

$$\mu_i = \frac{\partial w_i}{\partial \ln x} = \beta_i + 2 \frac{\lambda_i}{b(p)} \ln \left(\frac{x}{a(p)} \right)$$

I know that

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

And I also know that

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

And putting these together I arrive at

$$\frac{\partial w_i}{\partial \ln x} = \frac{\partial w_i}{\partial x} x = -\frac{p_i q_i}{x} + p_i \frac{\partial q_i}{\partial x} = -w_i + \frac{w_i x}{q_i} \frac{\partial q_i}{\partial x}$$

And after rearranging at

$$\frac{x}{q_i} \frac{\partial q_i}{\partial x} = \frac{\partial w_i}{\partial \ln x} \frac{1}{w_i} + 1$$

Which yields income elasticity as

$$\epsilon_i = \frac{x}{q_i} \frac{\partial q_i}{\partial x} = \left\{ \beta_i + 2 \frac{\lambda_i}{b(p)} \ln \left(\frac{x}{a(p)} \right) \right\} \frac{1}{w_i} + 1 = \frac{\mu_i}{w_i} + 1$$

10.3 Own price elasticities

Second, I derive the uncompensated (Marshall) own price elastitcities. I differentiate the share equation with respect to $\ln p_i$ to obtain

$$\mu_{ii} = \frac{\partial w_i}{\partial \ln p_i} = \gamma_{ij} - \left\{ \beta_i + 2 \frac{\lambda_i}{b(p)} \ln \left(\frac{x}{a(p)} \right) \right\} \left\{ \alpha_i + \sum_j \gamma_{ij} \ln(p_j) \right\} - \frac{\lambda_i \beta_i}{b(p)} \left\{ \ln \left(\frac{x}{a(p)} \right) \right\}^2$$

Where I use

$$\frac{\partial \left(\frac{1}{b(p)} \right)}{\partial p_i} = -\frac{1}{b(p)^2} \frac{\partial \ln b(p)}{\partial p_i} \frac{\partial b(p)}{\partial \ln b(p)} = -\frac{1}{b(p)^2} \beta_i b(p) == -\frac{\beta_i}{b(p)}$$

And

$$\frac{\partial \left(\frac{\lambda_i}{b(p)} \left\{ \ln \left(\frac{x}{a(p)} \right) \right\}^2 \right)}{\partial p_i} = \frac{\partial \left(\left\{ \ln \left(\frac{x}{a(p)} \right) \right\}^2 \right)}{\partial p_i} \frac{\lambda_i}{b(p)} + \frac{\partial \left(\frac{\lambda_i}{b(p)} \right)}{\partial p_i} \left\{ \ln \left(\frac{x}{a(p)} \right) \right\}^2$$

Therefore I derive the own price elasticities in the following way

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

and

$$\frac{\partial w_i}{\partial p_i} = \frac{\partial \left\{ \frac{p_i q_i}{x} \right\}}{\partial p_i} = \left(q_i + \frac{\partial q_i}{\partial p_i} p_i \right) \frac{1}{x} = \left(1 + \frac{\partial q_i}{\partial p_i} \frac{p_i}{q_i} \right) \frac{q_i}{x} = (1 + \epsilon_{ii}^u) \frac{q_i}{x}$$

And

$$\frac{\partial w_i}{\partial \ln p_i} = \frac{\partial w_i}{\partial p_i} p_i = (1 + \epsilon_{ii}^u) \frac{q_i}{x} p_i = (1 + \epsilon_{ii}^u) w_i$$

And therefore

$$\epsilon_{ii}^{u} = \left\{\frac{\partial w_i}{\partial \ln p_i}\right\}\frac{1}{w_i} - 1$$

I arrive at

$$\epsilon_{ii} = \left\{\gamma_{ij} - \left\{\beta_i + 2\frac{\lambda_i}{b(p)}\ln\left(\frac{x}{a(p)}\right)\right\}\left\{\alpha_i + \sum_j \gamma_{ij}\ln(p_j)\right\} - \frac{\lambda_i\beta_i}{b(p)}\left\{\ln\left(\frac{x}{a(p)}\right)\right\}^2\right\}\frac{1}{w_i} - 1$$
$$= \frac{\mu_{ii}}{w_i} - 1$$

which is the uncompensated own price elasticity.

I use the Slutsky equation, $\epsilon_{ii}^{c} = \epsilon_{ii}^{u} + \epsilon_i w_j$, to calculate the set of compensated (Hicksian) elasticities, ϵ_{ii}^{c}.

10.4 Cross price elasticities

Third, I derive the uncompensated (Marshall) cross price elastitcities. I differentiate the share equation with respect to $\ln p_j$ to obtain

$$\mu_{ik} = \frac{\partial w_i}{\partial \ln p_k} = \gamma_{ik} - \left\{\beta_i + 2\frac{\lambda_i}{b(p)}\ln\left(\frac{x}{a(p)}\right)\right\}\left\{\alpha_k + \sum_j \gamma_{ij}\ln(p_j)\right\} - \frac{\lambda_i\beta_i}{b(p)}\left\{\ln\left(\frac{x}{a(p)}\right)\right\}^2$$

Where I use

$$\frac{\partial w_i}{\partial \ln p_k} = \frac{\partial w_i}{\partial p_k}p_k$$

and

$$\frac{\partial w_i}{\partial p_k} = \frac{\partial\left\{\frac{p_i q_i}{x}\right\}}{\partial p_k} = \left(\frac{\partial q_i}{\partial p_k}p_i\right)\frac{1}{x} = \left(\frac{\partial q_i}{\partial p_k}\frac{p_i}{q_i}\right)\frac{q_i}{x} = \epsilon_{ik}^{u}\frac{q_i}{x} = \epsilon_{ik}^{u}\frac{w_i}{p_i}$$

And

$$\frac{\partial w_i}{\partial \ln p_k} = \frac{\partial w_i}{\partial p_k}p_k = \epsilon_{ik}\frac{w_i}{p_i}p_i = \epsilon_{ik}^{u}w_i$$

And therefore

$$\epsilon_{ik}^{u} = \frac{\partial w_i}{\partial \ln p_k}\frac{1}{w_i}$$

I arrive at

$$\epsilon_{ik}^{u} = \left\{ \gamma_{ik} - \left\{ \beta_i + 2\frac{\lambda_i}{b(p)} \ln\left(\frac{x}{a(p)}\right) \right\} \left\{ \alpha_k + \sum_j \gamma_{ij} \ln(p_j) \right\} - \frac{\lambda_i \beta_i}{b(p)} \left\{ \ln\left(\frac{x}{a(p)}\right) \right\}^2 \right\} \frac{1}{w_i} = \frac{\mu_{ik}}{w_i}$$

which is the uncompensated cross price elasticity.

The uncompensated price elasticity, both cross and own, could be written as

$$\epsilon_{ik}^{u} = \frac{\mu_{ik}}{w_i} - \delta_{ik}$$

where δ_{ik} is the Kronecker delta (a value of 1 if the variables are equal, and 0 otherwise).

I use the Slutsky equation, $\epsilon_{ik}^{c} = \epsilon_{ik}^{u} + \epsilon_i w_j$, to calculate the set of compensated (Hicksian) elasticities, ϵ_{ik}^{c}.

I also use to assess the symmetry and negativity conditions by examining the matrix with elements $\epsilon_{ik}^{c} w_i$, which should be symmetric and negative semidefinite in the usual way.

10.5 Definition of expenditure groups

Table A1. Definition of expenditure groups.

Group	Expenditure	HBS code	Expenditure items
1	**Food (mostly reduced VAT)**		
	Food	2010-2820, 2860, 2870, 2890, 2910	Meat, oils and fats, milk, cheese, eggs, bread and cereals, vegetables, fruit, sugar, chocolate, confectionery, coffee, tea and cocoa, mineral waters, soft drinks, school and kindergarten cafeteria
2	**Eating out and other luxuries (mostly standard VAT)**		
	Eating out	2880, 2900, 2920-2970	Cafeterias and eating out, drinks out
	Alcoholic beverages	2830-2850	Alcoholic beverages
	Tobacco	3900	Tobacco
	Cosmetics	3320, 3340, 4430	Cosmetics, hairdressing
3	**Household goods (mostly standard VAT)**		
	Household goods	3400-3490	Furniture and furnishings
	Household goods	3510-3570	Household appliances
	Household goods	3660	Children prams
	Household goods	3700	Mobile phones
	Household goods	3710-3760	Audio-visual, photographic, information technology equipment
	Household goods	3770-3790	Communication appliances, toys and other goods
	Household goods	3850	Stationery
	Household goods	4360, 4370	Maintenance or repair of household appliances
	Household goods	4380	Repair of audio-visual, photographic, information technology equipment
4	**Clothing (mostly standard VAT)**		
	Clothing	3010-3100	Clothing
	Clothing	3210-3270	Footwear
	Clothing	3310	Washing goods for clothes
	Clothing	4310	Repair or hire of clothing
	Clothing	4320	Repair or hire of footwear
5	**Public and other services (mostly reduced VAT)**		
	Healthcare	3300, 3370, 3380	Medicaments
	Healthcare	3360, 3390	Medical products and appliances
	Leisure	3860-3890	Newspapers and books
	Other services	4040	Heat energy and hot water supply
	Other services	4050	Cold water
	Other services	4070	Trash collection service
	Public transport	4110-4130,	Public passenger transport by railway, road

		4150, 4170	
	Public transport	4160	Public passenger transport by air
	Other services	4440	Financial services
	Leisure	4450	Flowers and plants
	Education	4500-4560	Pre-primary, primary and secondary education
	Leisure	4630	Accommodation
	Leisure	4650	Recreational or cultural services
	Healthcare	4710-4750	Outpatient services
	Healthcare	4760-4790	Outpatient services - regulatory fees
6	**Transport and recreation (mostly standard VAT)**		
	Transport	3600-3630	Purchase of vehicles
	Transport	3640	Fuels/lubricants for personal transport equipment
	Transport	3650	Spare parts and accessories for personal vehicles
	Recreation	3810-3840	Other recreational items and equipment
	Transport	4140, 4180	Road transport - taxi, other paid transport services
	Transport	4330-4350	Maintenance/repair of personal transport equipment
	Recreation	4610	Recreation home
	Recreation	4620	Recreation abroad
	Recreation	4640	Recreational and sport services
7	**Energy (mostly standard VAT)**		
	Energy	3910-3930	Solid fuels
	Energy	4020, 4030	Electricity, gas
8	**Other goods (mostly standard VAT)**		
	Other goods	3330, 3350	Goods for the maintenance of the dwelling
	Other services	4060, 4410, 4420	Other housing related services
	Other services	4210-4250	Postal, telephone or telefax services
	Other services	4460	Other administrative and consultancy services
	Other goods	5310-5340	Pets, animals and gardening

Notes: The budget survey codes are for the 2011 data and correspond to the codes from other years.

10.6 Summary statistics

Table A2. Summary statistics.

Variable	Mean	Standard deviation	Minimum	Maximum
Share of group 1	0.250528	0.083039	0.027277	0.772953
Share of group 2	0.10895	0.058785	0	0.634563
Share of group 3	0.086515	0.072745	0	0.766646
Share of group 4	0.074685	0.040686	0	0.396075
Share of group 5	0.151303	0.080748	0.000157	0.817917
Share of group 6	0.116551	0.111254	0	0.926354
Share of group 7	0.101474	0.074569	0	0.644764
Share of group 8	0.109995	0.058952	0	0.673282
Price of group 1	105.664	8.782365	95.76093	118.803
Price of group 2	104.7033	10.38965	91.95399	122.6353
Price of group 3	101.4283	12.96666	86.09968	127.8821
Price of group 4	99.46729	10.89089	85.29443	117.8754
Price of group 5	107.4887	16.35587	86.27722	131.4911
Price of group 6	99.30111	2.416328	96.05054	103.7259
Price of group 7	114.67	22.51243	88.72155	148.2528
Price of group 8	99.29503	7.617529	87.05231	107.4738
Log of price 1	4.656872	0.081977	4.561855	4.777466
Log of price 2	4.646311	0.09766	4.521288	4.809215
Log of price 3	4.611582	0.123143	4.455506	4.851109
Log of price 4	4.593952	0.107893	4.446109	4.769629
Log of price 5	4.665913	0.151136	4.457566	4.87894
Log of price 6	4.597861	0.024321	4.564875	4.641752
Log of price 7	4.723158	0.193399	4.485503	4.998919
Log of price 8	4.595061	0.078502	4.466509	4.677247
Expenditure	212086.9	117216.2	6033	1179924
Log of expenditure	12.11113	0.580605	8.705	13.98096
Monetary income	24389.6	13760.08	1496.33	349326.3
Age	49.27175	14.57138	19	90
Members	2.484382	1.183128	1	8.08
Children	0.727319	0.927318	0	6.08
Employment status	0.767074	0.422702	0	1
Education – low	0.313336	0.463857	0	1
Education – middle	0.379595	0.485293	0	1
Prague	0.137315	0.344185	0	1
City size	2.004437	0.771757	1	3
Year	6.127811	3.182767	1	11

Source: CSO and the author.

10.7 Demand system parameter estimates

Table A3. Demand system parameter estimates

Parameter	Food	Eating out	Household goods	Clothing	Other services	Transport, recreation	Energy	Other goods
α	0.046358	0.100136	0.155604	0.109328	0.142427	0.28602	0.023518	0.13661
α_{age}	0.001326	-0.00079	-0.00068	-0.00058	0.000643	-0.00135	0.001123	0.0003
$\alpha_{members}$	0.049348	-0.00044	-0.01812	-0.00725	-0.01095	-0.01738	0.013817	-0.00902
α_{child}	-0.01218	-0.01742	0.005527	0.005952	0.023893	0.000998	-0.00822	0.00145
$\alpha_{empstat}$	-0.00493	0.014755	-0.01449	0.008334	0.003534	-0.01571	0.008817	-0.00031
$\alpha_{educlow}$	0.013677	0.005296	0.002177	-0.00478	-0.01652	-0.00138	0.00053	0.001003
$\alpha_{educmid}$	0.005809	0.005661	0.001869	-0.00299	-0.00782	-0.00084	-0.00417	0.002492
α_{Praha}	0.003941	0.000254	-0.01202	-0.00413	-0.01034	-0.00029	0.010286	0.012303
$\alpha_{city\ size}$	0.002252	-0.00597	0.000119	-0.00203	-0.03711	0.00806	0.030975	0.003707
γ_1	0.13241	-0.01855	0.019764	-0.00474	-0.05231	-0.06482	-0.02672	0.014982
γ_2	-0.01855	0.089793	-0.0122	-0.069	0.031045	0.013768	-0.01365	-0.0212
γ_3	0.019764	-0.0122	-0.04021	0.017328	-0.0051	0.020847	0.003611	-0.00404
γ_4	-0.00474	-0.069	0.017328	0.053337	-0.00387	0.00328	0.017469	-0.01381
γ_5	-0.05231	0.031045	-0.0051	-0.00387	0.027087	0.010851	-0.00373	-0.00397
γ_6	-0.06482	0.013768	0.020847	0.00328	0.010851	0.076401	-0.02673	-0.03359
γ_7	-0.02672	-0.01365	0.003611	0.017469	-0.00373	-0.02673	0.054049	-0.00429
γ_8	0.014982	-0.0212	-0.00404	-0.01381	-0.00397	-0.03359	-0.00429	0.065917
β	-0.16127	0.012874	0.07334	0.027946	-0.02633	0.147396	-0.06294	-0.01101
λ	-0.0149	0.001073	0.001041	0.003087	0.003831	0.013533	-0.00283	-0.00484
Time trend	-0.00337	0.005435	0.004153	-0.00167	-0.00045	-0.00025	-0.003	-0.00085
V 1	0.185351	-0.035448	0.052109	0.062548	0.075640	0.185351	-0.035448	0.052109
V 2	-0.079931	0.182145	0.242086	0.110690	-0.038086	-0.079931	0.182145	0.242086
V 3	-0.065419	0.060658	0.088505	0.038049	-0.009383	-0.065419	0.060658	0.088505
V 4	-0.006339	0.000811	-0.002875	-0.003123	-0.003527	-0.006339	0.000811	-0.002875
V 5	0.000061	-0.000359	-0.000400	-0.000221	0.000002	0.000061	-0.000359	-0.000400
V 6	0.000004	-0.000005	-0.000007	-0.000004	0.000000	0.000004	-0.000005	-0.000007

Source: CSO and the author.

Notes: The parameters V1-6 relate to the linear, square and cubic terms of the residuals from two regressions as described in the footnote 7.