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2010

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CNB WORKING PAPER SERIES

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Kamil Dybczak, Peter Tóth and David Voňka *

Abstract

The purpose of this paper is to describe consumer behavior in the Czech Republic by estimating a demand system in which demand depends on income and prices, but also on other factors such as age, size of the household, and position on the labor market. We combine Household Budget Survey data with information on prices from alternative sources between 2000 and 2008. The main focus of our analysis is to provide estimates of both own- and cross-price and income elasticities, which can be used among other things when analyzing the impact of exogenous price changes on consumer demand. Based on our estimates, the commodity bundles of food, energy, and health and body care are necessary goods, as their budget elasticity is positive and below one at the same time. Clothing and shoes, transportation and communication, and education and leisure are luxury goods, with income elasticity above one. The own-price elasticities are negative for all commodity groups, as expected. The cross elasticities seem to be smaller than the own elasticities. We found expenditure on energy and transportation and communication to be the most affected by changes in their own prices. We use our estimates to analyze the impact of regulated price changes on consumer demand and discuss the further potential use of our results.

JEL Codes: D12, E21.
Keywords: Consumer behavior, demand systems, price and income elasticities, regulated prices.

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Acknowledgment: This work was supported by Czech National Bank Research Project No. D1/09. The authors would like to thank Kamil Galuščák, Tomáš Holub, Tibor Hlédik, Jan Brůha, Karel Janda, Stefan Sperlich, Alexandr Hobza, and participants at the interim and final seminars at the Czech National Bank for helpful discussion and comments. All errors and omissions are ours. The views expressed are those of the authors and do not necessarily reflect the views of the Czech National Bank or the European Commission.

Nontechnical Summary

Private consumption is the largest component of the gross domestic product of most developed economies, including the Czech Republic. Currently, private consumption expenditure in the Czech Republic forms about 50% of GDP. Understanding private consumption is of prime interest to economists and policy makers, including central bankers.

Our analysis is conducted at the household level using the Czech Household Budget Survey data and information on prices from alternative sources from 2000 to 2008. We split total consumer expenditure into eight commodity bundles: (1) food, (2) clothing and shoes, (3) energy, (4) furniture and home electronics, (5) health and body care, (6) transportation and communication, (7) education and leisure, and (8) other goods. We describe their consumption shares for different types of households, taking into account region of residence, family composition, age, and education of the head of the household.

We implement the QUAIDS model of Banks et al. (1997). QUAIDS combines the empirical flexibility of quadratic logarithmic Engel curves with integrability. The demand system was estimated by the non-linear SUR method. First, we estimate the stochastic version of the demand system for a representative household. Then we extend the model to include demographic variables such as age of the respondent, family size, and labor market position. In order to reflect structural changes in consumer preferences over time, we introduce a time trend into the model.

The main outcomes of our analysis are the estimated parameters – income and price elasticities, which can be easily used to quantify both the price and income effects of exogenous price adjustments such as changes in indirect tax rates or regulated prices. The vast majority of the parameters are statistically significant. There is some evidence of minor structural changes in demand over the years analyzed.

Based on our estimates, the commodity bundles of food, energy, and health and body care are necessary goods, as their budget elasticity is positive and below one at the same time. On the contrary, we identified clothing and shoes, transportation and communication, and education and leisure to be luxury goods, with income elasticity above one. In addition, transportation and communication is the most sensitive group to income changes, while energy is the least sensitive one.

The own-price elasticities are negative for all commodity groups, as expected. The cross elasticities seem to be smaller than the own elasticities, which is quite natural given the high level of aggregation. This indicates that the individual commodity groups do not have any strong substitutes or complements among the remaining ones. Based on the size of the own-price elasticities, we found expenditure on energy and transportation and communication to be the most affected by changes in their own prices. In addition, looking only at the substitution effect of a price change, transportation and communication is rated as a good with price elastic demand. The other commodity group with price elasticity close to 1 is energy. We interpret the estimated elasticities and demonstrate their potential use by analyzing the effect of regulated price changes on the consumption of specific commodity bundles.

Next, we present fitted Engel curves representing the relationship between demand for a good and household expenditure assuming that prices of all commodities stay unchanged. We

also present Engel curves for households with different characteristics.

As the QUAIDS model we use for estimation purposes assumes prices to be predetermined, the most suitable application for the model is to simulate the impact of exogenous price shocks which are not an outcome of demand and supply interaction, such as changes in world oil prices, indirect tax rates or regulated prices. Finally, we simulate the effects of a particular case of adjustments in regulated prices on consumer demand. The choice of regulated prices is supported by the following arguments. First, regulated prices were the main driver of inflation in 2008 and 2009. Second, regulated prices do not change regularly from one year to another. Third, if regulated prices are adjusted, the change is often very large. Consequently, understanding the impact of regulated prices on consumer demand is important both for forecasting and for policy decisions. Specifically, we simulate how a 30% increase in (1) regulated energy, (2) health fees, (3) transportation, (4) TV and radio fees, and (5) regulated rents affects consumption shares, expenditure, and quantity demanded for different commodity groups.

In our simulation outcomes, we show that as the price of energy increases, the quantity demanded falls almost to the same extent and the effects on other commodities are estimated to be very limited in terms of both quantity demanded and consumption expenditure. Increasing regulated health care fees by 30% reduces demand for health care by 15% but increases expenditure related to this bundle by 7%

Comparing the effects of adjustments in individual regulated prices on aggregate demand we find regulated rents and energy prices to play a crucial role. The role of health care, postal services, and TV and radio fees seems to be substantially lower.

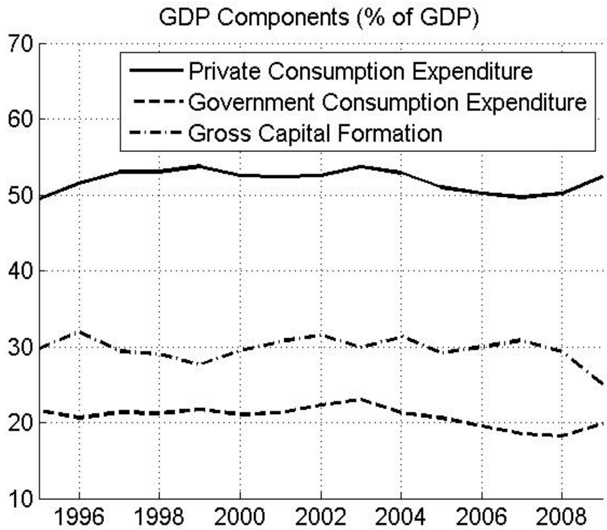
In addition, we present a simulation of a 10% increase in individuals' consumption expenditure. Not surprisingly, demand increases mainly in the case of luxury goods, i.e., clothing, furniture and home electronics, transportation and communication, and education and leisure. Demand for the remaining commodity groups, i.e., food, energy, and health and body care, increases less than proportionately with income. Indeed, the changes in the quantity demanded correspond to the changes in consumption expenditure, as prices do not change in this simulation.

1. Introduction

Private consumption is the largest component of the gross domestic product of most developed economies, including the Czech Republic. Currently, private consumption expenditure in the Czech Republic is about 50% of GDP, as depicted in Figure 1. Thus, understanding, analyzing, simulating, and forecasting private consumption is of prime interest to economists and policy makers, including central bankers. In addition, as pointed out by Blundell (1988), there are not many aspects of economic policy that do not require some knowledge of household or individual consumer behavior. A detailed analysis of consumer behavior has become an indispensable part of tax policy formulation. In particular, such information is often used to design and analyze the impact of changes in indirect taxes, income, and prices. Furthermore, detailed consumer behavior analysis is used to study the effects of credit constraints. Last but not least, the evolution of consumer preferences is crucial for the structure of industry over time.

To summarize, the main purpose of detailed demand analysis is to find out how demand for a specific commodity changes as income and prices change. Based on this information, several important observations and decisions can be made.[1]

Figure 1: Components of GDP 1995–2009



Source: CZSO.

Consumer behavior has for many years been of interest to both theoretical and empirical economists, who have increased our understanding of consumer preferences enormously.[2] Renewed interest has been registered recently in this research area mainly thanks to the increased availability of detailed datasets as well as increased computing capacities. In particular, empirical research has come up with more sophisticated models of consumer behavior.[3]

[1] Likewise, Banks et al. (1997) emphasize the necessity of demand models in evaluating policy reforms. Many additional arguments and examples supporting the importance of consumer demand analysis are provided in the surveys on consumer behavior by Brown and Deaton (1972), Blundell (1988), Barnett and Serletis (2008), and Deaton and Muellbauer (1980), the key monograph on microeconomic consumption modeling.

[2] See Brown and Deaton (1972) for an historical overview of the evolution of demand analysis since the nineteenth century.

[3] Barnett and Serletis (2008) provide an up-to-date survey of the state-of-the-art in static demand analysis.

Modern consumer demand analysis is practiced by formulating and estimating consumer demand systems, which can be defined as sets of equations describing how consumers or households with particular characteristics allocate their total expenditure to consumption of goods, given the prices of these goods and the incomes of the households. Thus, complete systems of consumer demand provide information on demand responses to changes in income (expenditure), prices of goods, and other variables of interest. In order to deliver meaningful and justified outcomes, such systems must satisfy the conditions required by neoclassical microeconomic theory and fit the data well.[4]

These demand systems are mostly estimated as static models, although there are many reasons to suspect that dynamic effects matter both theoretically and empirically. Thus, prices outside the specific period have no impact on the allocation of total expenditure among different commodity groups. Static analysis concerns the relative sizes and signs of substitution effects, while the temporal impact is largely ignored in this type of work. On the other hand, dynamic models emphasize life-cycle dynamic aspects of consumer behavior. However, these theoretically consistent dynamic models of private consumption are often rather simple and do not provide detailed outcomes since they use aggregated data. Consequently, analysis based on aggregated data suffers from aggregation bias arising from complex, possibly non-linear, interactions between individual characteristics and price and/or income effects.[5]

It has been recognized that the form/shape of Engel curves plays an important role in demand system modeling. To be more specific, demand systems allowing for more flexible Engel curves tend to provide more realistic results in both simulation and projection exercises. The most traditional and probably best known form of Engel curves is the linear one, represented for example by the Linear Expenditure System (LES) proposed by Stone (1954). Another often used form is the linear-logarithmic form as in the widely used Almost Ideal Demand System (AIDS) by Deaton and Muellbauer (1980). However, even this form is limiting for some types of commodities and more flexibility in Engel curves is desired. The subsequent development of demand systems has focused on improving the fit of the models to the observed data by introducing additional terms which are quadratic in expenditure, such as the Quadratic Almost Ideal Demand System (QUAIDS) by Banks et al. (1997).[6]

Using both the parametric and nonparametric methods within the static approach, Banks et al. (1997) demonstrate that Engel curves are in general non-linear, i.e., that the Working-Leser condition does not hold for all commodities.[7] Banks et al. (1997) argue that commonly used models of consumer behavior such as AIDS and LES display the mentioned low Engel curve flexibility, in the sense that expenditure shares are implicitly assumed to be monotonic functions of disposable income in these models.[8] In addition, they point out that due to a built-in assumption in AIDS and LES, the hump-shaped relationship observed for certain goods, including clothing and several food items, is ruled out. The authors offer an extension of the standard

[4] The restrictions imposed on demand systems by economic theory are discussed in section 5.
[5] See, for example, Powell et al. (2002), who discuss the trade-off between realism and parsimony in the choice of demand structure.
[6] Further extensions have been proposed recently. For example, Matsuda (2006) proposes a trigonometric flexible demand system. Alternatively, Blow (2003), using an unrestricted semi-parametric estimation approach, points out that for some commodities, even the quadratic form specifications seem to be restrictive and suggests expanding QUAIDS to include additional terms besides the quadratic term.
[7] For some commodities, such as food, the Working-Leser (linear) Engel curves provide a good fit. However, other commodities, such as alcohol and clothing, appear to have more complicated Engel curves.
[8] For a detailed analysis of AIDS and LES see Deaton and Muellbauer (1980).

AIDS model that is more flexible and can still fulfill the restrictions imposed by economic theory. The AIDS model extended to include a quadratic income term is called the Quadratic AIDS by Banks et al. (1997).[9] In an effort to provide as realistic an empirical analysis as possible, we estimate the QUAIDS demand system model using the Czech Household Expenditure Survey from 2005 to 2008.

As for consumption studies in the Czech Republic, the list of papers applying a detailed demand system based on individual data is relatively short. The most relevant references are the studies by Crawford et al. (2003) and Janda et al. (2009), who apply the AIDS model to the Household Budget Survey dataset to estimate a set of income, own-price, and cross-price demand elasticities for goods, paying special attention to the commodity bundle of food and alcoholic beverages. Next, applying the AIDS model, Brůha and Ščasný (2006) estimate the impact of possible policy interventions affecting energy and transportation expenses and paid taxes for different types of households. Janda et al. (2000) apply the AIDS model to study Czech food import demand in the context of early transition. In contrast to Janda et al. (2009) we do not concentrate on food in detail, but analyze the demand system formed by eight commodity bundles. Furthermore, we use a more flexible modeling technique, i.e., the QUAIDS model.

The structure of our study is as follows. First, we describe the consumption shares of different types of households by family composition, education, etc. Second, a primary analysis of the shape of the Engel curves using nonparametric and polynomial regression methods is provided. Third, we specify the QUAIDS system for selected bundles of goods. Fourth, we estimate the resulting system of equations using the non-linear SUR method, describe the estimated parameters, and quantify the elasticities of interest. Fifth, simulations of relevant changes in the prices of selected commodities and consumer expenditure are performed. In particular, we simulate the impact of a change in regulated prices on the demand for different commodity groups.

2. Data and Aggregation

There are several benefits in using detailed micro data for consumer demand analysis. In particular, analysis based on individual data may contribute to improved understanding of consumer behavior, greater precision of estimated parameters, and better forecasting and simulation outcomes. Furthermore, detailed data allow us to analyze responses of different consumer groups, depending on characteristics such as household income level, education, family size or region. Household budget data provide information concerning household consumption patterns, sources of income, and various demographic variables. We have excluded durable goods from our analysis and focus only on the allocation of expenditure on nondurable commodities.

For the purposes of this study we use data from the Household Budget Survey provided by the Czech Statistical Office. The structure of the sample concerning different expenditure and income groups is the same as in other countries following the structure of Household Budget Surveys. Our sample covers the years 2000 to 2008. The data set covers roughly 3,000 households each year.[10] Unfortunately, some groups of consumers are not represented in the

[9] The introduction of the quadratic income term was initially motivated by Gorman (1981), who suggested and proved that the Engel curves for certain commodities are non-linear functions of income, but are at most quadratic in income.

[10] Unfortunately, the sample of households is updated each year, so we cannot use panel regression techniques in our analysis.

sample until 2005.[11] Although we did not find a significant impact of including data before 2005 on our results, we decided to exclude these observations from our sample for estimation and simulation purposes.[12]

The sample provides detailed information on household income and its sources. Additionally, the disaggregation of consumption expenditure goes far beyond the intentions of our analysis. Subsequently, we aggregate the individual expenditure items into broader, but still quite homogeneous, groups with common properties.

It is common practice in empirical demand analysis to bundle individual goods into broader aggregates. Still, no rule exists on how to generate commodity groups, because the less detailed is the aggregation, the easier it is to estimate a demand system. There are several benefits to higher aggregation. In particular, the variation of expenditure levels (income) is often quite large across consumers in household expenditure datasets, but the level of relative price volatility is rather limited. Consequently, some degree of aggregation is unavoidable in the empirical work in order to make the estimation manageable. In addition, some degree of aggregation is supported even theoretically, since consumers probably use some form of grouping to simplify the decision-making process, for example so-called two or multi-stage budgeting.[13] Due to these arguments we split total consumer expenditure into eight commodity bundles as follows: (1) food, (2) clothing and shoes, (3) energy, (4) furniture and home electronics, (5) health and body care, (6) education and leisure, (7) transportation and communication, and (8) other goods.[14] The bundle of other goods reflects the rest of the consumer spending, so that total expenditure is reflected and the effect of remaining purchases is taken into account. The aggregation we follow reflects the main types of consumption expenditure and is in line with the Household Budget Survey methodology. Of course, alternative commodity groupings could be presented depending on the purpose of the analysis.

Before proceeding to the estimation and simulation exercises, we had to clean the original sample of outlier observations potentially leading to biased outcomes. As our analysis concerns almost all the items of the consumer basket, it is not possible to check the advisability of individual observations as is often the case in more focused studies.[15] Consequently, we follow a more conventional approach and exclude all observations within each commodity group with prices below and above the 1st and the 99th percentiles. As a result, our sample shrinks by 3,964 observations, falling from 26,602 to 22,638, i.e., by 14.9%. Using only data beyond 2005 our sample shrinks by 2,654 observations, falling from 12,757 to 10,103, i.e., by 20.8%. In addition, we excluded durable goods from our analysis and focused only on the allocation of expenditure on nondurable commodities.

In order to provide a detailed analysis of consumer demand, not only the quantity demanded, but also the prices of goods must be available. Thanks to the combination of quantities and prices, we can identify relationships among the demands for different commodity bundles. In particular, one can recognize if the commodities of interest are substitutes or complements or

[11] We would like to thank Jan Brůha for informing us about peculiarities related to data before 2005.
[12] We recalculated all the outcomes presented in this work for both the 2000–2008 and 2005–2008 intervals. The full-sample result is available upon request. To check roughly the stability of our results, Appendix C presents Engel curves estimated for the individual years from 2000 to 2008. In addition, Appendix B provides descriptive statistics of the sample from 2000 to 2008.
[13] Janda et al. (2009) provide an intuitive introduction to multi-stage budgeting.
[14] Detailed definitions of the eight commodity bundles are provided in Appendix A.
[15] See for example Janda et al. (2009) examining prices of three types of alcoholic beverages.

are not related to each other. Unfortunately, the Household Budget Survey does not provide the physical quantities consumed for all individual expenditure items. Consequently, one cannot quantify unit values for these relatively frequent cases. In order not to restrict our analysis due to data limitations we decided to impute unit prices from a different source, i.e., the data collected by the Czech Statistical Office. However, the aforementioned product-level unit prices underlying the construction of the CPI index are observed at a more disaggregated level than the consumption items contained in the Household Budget Survey. Hence, we matched a weighted average unit price from the CPI statistics to each consumption item with unobserved unit values in the budget survey. We used the weights of the CPI as provided by the Czech Statistical Office. Both the unit prices and the CPI weights were available at the Czech National Bank. Once the data on both the physical amounts consumed and the unit values were complete for all items, we proceeded with aggregation into the aforementioned eight commodity groups. Here, we simply summed total expenditure and the physical amounts consumed for each household and commodity group. Household-specific prices of a bundle were then computed as the ratio of total expenditure to physical amounts. The between-consumer variability of bundle prices then comes from the different composition of the bundles for different people.

3. Private Consumption Shares by Type of Household

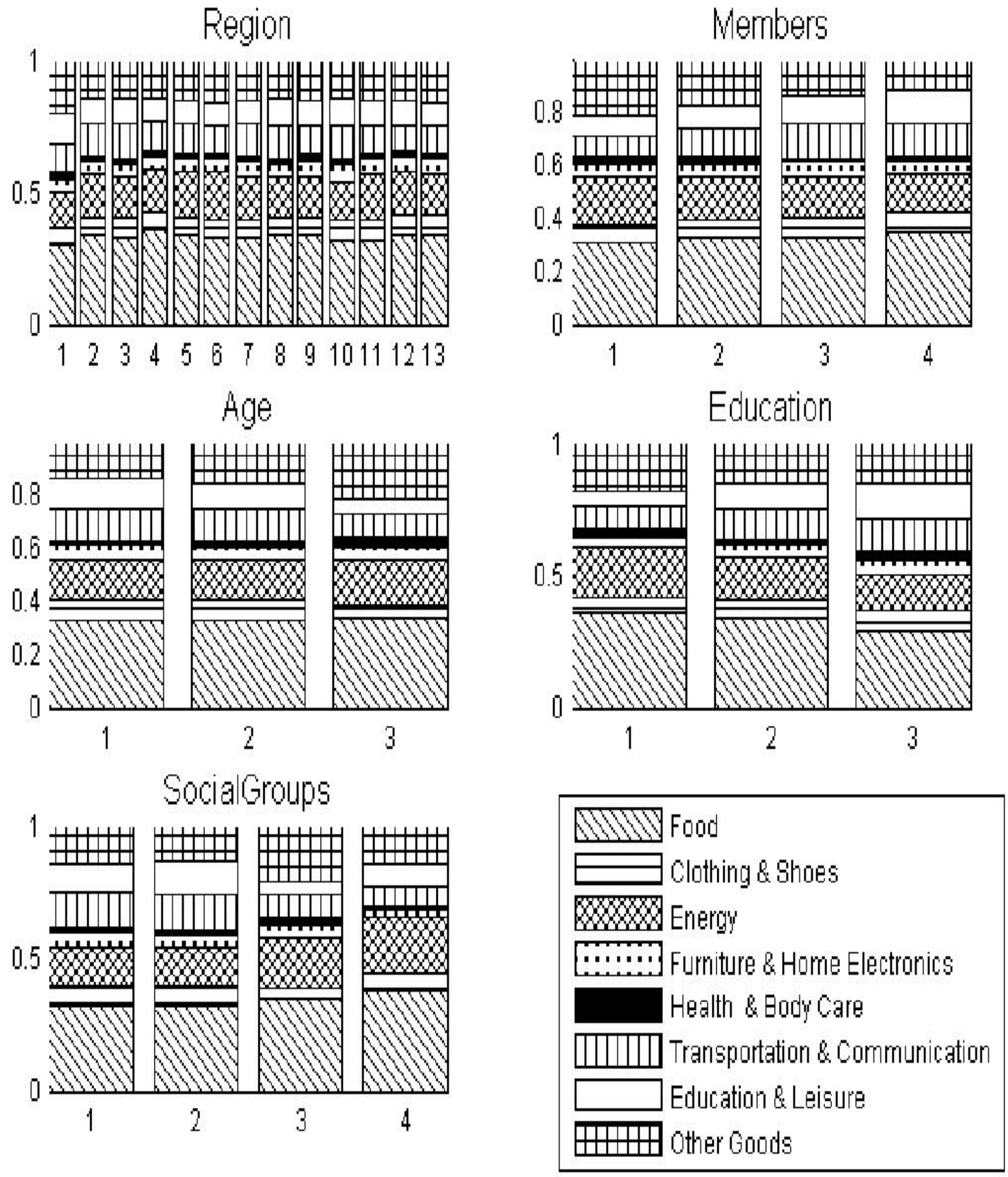
Demand analysis takes place not at the level of the individual consumer, but at the level of the household, composed typically of more than one individual. The effect of household composition on the allocation of consumption expenditure among different commodities has been discussed by many studies. For example, Blow (2003) and Moro and Sckokai (2000) point out different needs of different age groups, such as retirees and young individuals. Moreover, Luhrmann (2005) uses the life-cycle hypothesis to explain how household consumption of goods and services changes in the course of the life span.

There are, of course, additional factors affecting household demand. Obviously, the list can be very long. In empirical work, one may control for the impact of several characteristics by expanding the model to include, for example, labor status, education, region of residence, and possession of durable goods. In particular, it has been empirically tested and subsequently confirmed that these additional factors play a significant role in affecting private demand of households for commodities, because they proxy different preferences.[16] In general, these variables are called demographic factors and are broadly defined as any observable attribute of households (other than prices and income) that affects demand for goods and services. To conclude, specifying demographic effects correctly is crucial for parameter estimation, simulation, and projection purposes.

Concerning our analysis, the dataset consists of many demographic variables and other non-income variables representing individual household characteristics. Using Czech Household Budget Survey data from 2000 to 2008, we depict consumption shares in Figure 2, disaggregating households by place of residence, number of family members, age, education, and labor status of the household head.

[16] For example, Abdulai (2002) uses the size of the household, the age of the respondent, education, occupation status, and region.

Figure 2: Consumption Shares Depending on Demographic Characteristics 2000–2008



Note: Vertical axis of each subplot refers to budget shares of individual commodity groups.
Sub-figure Region: 1–13 refers to Prague, Central Bohemia, South Bohemia, Plzen, Karlovy Vary, Usti nad Labem, Liberec, Hradec Kralove, Pardubice, Vysocina, South Moravia, Olomouc, Zlin, and Moravia-Silesia.
Sub-figure Number: 1–4 refers to 1, 2, 3, and more than 3 household members.
Sub-figure Age: young (20–40), middle-aged (41–60), and old (over 61).
Sub-figure Education: 1 elementary, 2 secondary, and 3 higher education or university degree.
Sub-figure Social Groups: 1 employees, 2 self-employed, 3 retirees and economically non-active and 4 unemployed.
Source: CZSO, and authors' calculations.

As there are 13 regions in the Czech Republic, we can depict average consumption shares per region.[17] In the literature, differences among regions within a country are typically not found

[17] The 13 regions are Prague, Central Bohemia, South Bohemia, Plzen, Karlovy Vary, Usti nad Labem, Liberec, Hradec Kralove, Pardubice, Vysocina, South Moravia, Olomouc, Zlin, and Moravia-Silesia.

significant, although regional price developments may play a role. In the specific case of the Czech Republic, there do not seem to be significant differences among regions 2 to 13. As demonstrated by Figure 2, sub-figure Region, the single exception is Prague, whose average income and price levels are significantly different from the other regions. Finally, due to a high number of regions and relatively small variability of consumption shares among regions, we decided to omit this characteristic from our econometric exercise.

Family size is an additional factor significantly affecting the structure of private consumption expenditure. Evidently, the share of food increases with family size, as these commodities usually cannot be shared by family members. On the contrary, the shares of commodity groups like furniture and home electronics are expected to fall with increasing family size, since their consumption can be shared by the household members. Figure 2, sub-figure Members, refers to these observations. In this sub-figure we distinguish between single-person households and households with 2, 3, and more than 3 members.

As already discussed, the age of the household members plays a significant role in the consumption decision-making process. Luhrmann (2005) shows that it is not just the size, but mainly the structure of consumption which changes with age. In addition, she discovers that the expenditure shares of clothing, transportation, education, and leisure tend to decrease with age. On the other hand, health care spending is expected to rise with age. These observations are in line with our results presented in Figure 2, sub-figure Age. In this figure, the total sample is divided into three main groups called young, middle-aged, and old, defined in terms of age as 20 to 40, 41 to 60, and over 61 respectively.

Education is another relevant factor influencing consumer behavior. Within our sample, we distinguish between households whose head has (1) no or elementary education, (2) secondary education or (3) higher education. Not surprisingly, Figure 2, sub-figure Education, confirms that more highly educated people spend more on education and leisure and transportation and communication. On the other hand, it is very likely that education is significantly correlated with income. As income and prices are the key variables of any demand system, we exclude the education dummy variable from our econometric analysis in order to prevent an excessive level of multicollinearity among the explanatory variables.

Consumption behavior is affected by the labor market status of the household. We depict the consumption shares of four main groups in sub-figure Social Groups: (1) employees, (2) the self-employed, (3) economically non-active households and retirees, and (4) the unemployed. Based on the figure, one can see that economically non-active and unemployed households tend to spend a higher share of their budgets on food and energy and a smaller share on clothing and education and leisure compared to employed and self-employed households. As labor market status is usually included in the analysis of consumer demand systems, we keep this variable for further estimation purposes, even though it may be correlated with the household expenditure variable.

Unfortunately, as already indicated, not all potential demographic factors can be taken into account when estimating a detailed demand system like QUAIDS. This is mainly due to the high number of parameters to be estimated. On top of that, the number of parameters to be estimated increases significantly with each additional variable. Consequently, we decided to select the age of the respondent, the number of family members, and labor market status as the only demographic variables entering our QUAIDS. Our choice is based on the descriptive measures shown in Figure2 and is in line with the related consumer demand literature.

4. Assessment of the Engel Curves

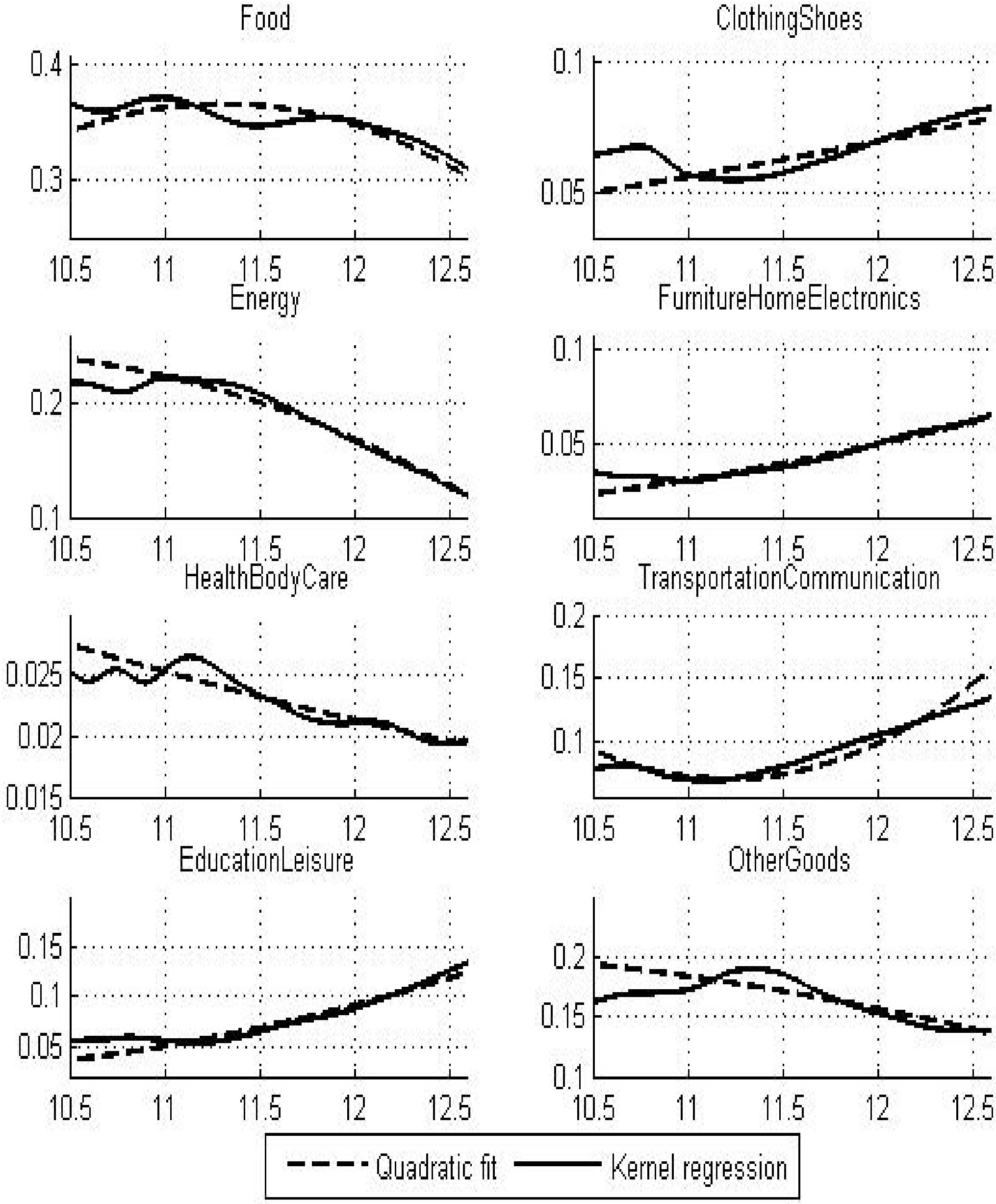
Before constructing the model of consumer behavior, Banks et al. (1997) analyze their data using polynomial and nonparametric regression techniques. Using these descriptive statistics, they strongly reject the Working-Leser (linear) specification of the Engel curves for some of the commodity groups analyzed. In other words, they identify commodity groups whose consumption shares are a linear function of income, but they also identify other commodity groups for which this assumption seems not to hold. They propose additional terms in income to be introduced into the demand system in order to specify a model with sufficient flexibility to describe the observed patterns while remaining consistent with microeconomic theory.

Based on the patterns found in their data, Banks et al. (1997) found that Engel curves require quadratic terms in the logarithm of expenditure.[18] Blundell et al. (1993) mention the properties and advantages of a quadratic extension of the AIDS model. They also show that the quadratic term must be price dependent and that the maximum possible rank of a demand system linear in functions of income is 3. By introducing the quadratic income term, the model gains more flexibility, which positively affects the quality of model outcomes such as projections and simulations. Importantly, such a model allows goods to be luxuries at some level of income and necessities at another. Thereafter, they estimate QUAIDS for a set of goods and demonstrate that the flexibility offered by their expanded system is needed, in the sense that the alternative demand systems linear in explanatory variables produce biased results. In addition, Banks et al. (1997) demonstrate that no more flexibility is needed, in the sense that nonparametric estimates do not significantly differ from the QUAIDS ones.

Before estimating QUAIDS on Czech Household Budget Survey data from 2000 to 2008, we run a set of nonparametric and polynomial regressions as proposed by Banks et al. (1997). Doing this we obtain a benchmark for assessing the relevance of QUAIDS outcomes, especially the shape of the Engel curves for different types of commodities. Depending on the commodity characteristics, we expect to find patterns in the Engel curves close to those obtained by Banks et al. (1997) or by Luhrmann (2005). Finally, finding hump-shaped Engel curves would confirm the need for the QUAIDS as opposed to the AIDS specification when working with Czech data.

[18] The abbreviation QUAIDS stands for the Quadratic Almost Ideal Demand System, where quadratic corresponds to the quadratic expenditure element of the demand system.

Figure 3: Kernel and Quadratic Regression 2005–2008



Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

Figure 3 shows the Engel curves for the eight main commodity groups using nonparametric and polynomial (quadratic) regression on Czech Budget Survey data between 2005 and 2008, i.e., the figures show consumption shares as function of the logarithm of consumption expenditure.

The main trends in the data can be summarized as follows. First, some degree of non-linearity between consumption shares and the logarithm of income seems to be present for all commodity groups.[19] Second, the consumption share of food decreases with income. Only for the lowest income groups does the share of food seem to be increasing. Energy and health and body care are also necessities. On the contrary, the share of clothing and shoes is rising with income, indicating that commodities bundled within this group are luxuries. The same applies to furniture and home electronics, transportation and communication, and education and leisure. Last but not least, these results are pure descriptive statistics; they reflect neither prices, nor the non-income variables discussed in the previous section. The impact of these additional variables on the consumption shares of different types of commodity groups will be estimated in section 6 and in Appendix D.

5. The Quadratic Almost Ideal Demand System

QUAIDS is a simple generalization of the original AIDS model which incorporates a quadratic income term. It is derived as a generalization of the PIGLOG preferences and maintains all the relevant properties of its linear counterpart (AIDS), thus allowing for exact aggregation over households. While alternative demand system specifications like Translog or AIDS have budget share equations that are linear in the logarithm of income, QUAIDS has more flexible Engel curves and retains integrability. By introducing the quadratic income term, the model gains more flexibility, which positively affects the quality of the model outcomes.[20]

Household preferences over n consumption bundles are represented by the following indirect utility function, where m is total household expenditure and vector $\mathbf{p}$ represents commodity prices:

$$\ln V = \left(\left[\frac{\ln m - \ln a\left(\mathbf{p}\right)}{b\left(\mathbf{p}\right)} \right]^{-1} + \lambda\left(\mathbf{p}\right) \right)^{-1} \tag{5.1}$$

where $\ln a\left(\mathbf{p}\right)$ is the translog price aggregator function

$$\ln a\left(\mathbf{p}\right) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j, \tag{5.2}$$

$b\left(\mathbf{p}\right)$ is the standard Cobb-Douglas aggregator

$$b\left(\mathbf{p}\right) = \prod_{i=1}^{n} p_i^{\beta_i} \tag{5.3}$$

and

$$\lambda\left(\mathbf{p}\right) = \sum_{i} \lambda_i \ln p_i \tag{5.4}$$

We must also impose the following restrictions derived from economic theory. In particular, we need to enforce additivity, homogeneity, and symmetry of the Slutsky matrix. Additivity

[19] Somewhat more non-linear than in Banks et al. (1997). The difference may be due to the much more heterogeneous Czech sample.

[20] Fisher et al. (2000) analyze the properties of alternative functional forms of demand systems. They conclude that globally flexible functional forms usually have more desirable properties and perform better. All the currently applied models fit the data well, but preference should be given to more parametrically parsimonious functions. Finally, they mention QUAIDS as performing best among all possible functional specifications.

(or adding-up) ensures that total expenditure is equal to the sum of individual expenditure on different commodities and goods. Homogeneity guarantees that the demand functions are homogeneous of degree zero in prices. Finally, negative semi-definiteness and symmetry of the Slutsky matrix are necessary for integrability of the demand system to well-defined preferences.

In order to guarantee the adding-up property of the demand system, we require:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{n} \beta_i = 0 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \lambda_i = 0 \tag{5.5}$$

An additional restriction guarantees that the indirect utility function is homogeneous of degree zero in m and **p**:

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \quad \forall i \tag{5.6}$$

Finally, by imposing symmetry of the Slutsky matrix we require:

$$\gamma_{ij} = \gamma_{ji} \tag{5.7}$$

Next, by applying Roy's identity to the indirect utility function one can derive the expenditure share equation:

$$w_i(\mathbf{p}) = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \left[\ln \frac{m}{a(\mathbf{p})} \right] + \frac{\lambda_i}{b(\mathbf{p})} \left[\ln \frac{m}{a(\mathbf{p})} \right]^2 \tag{5.8}$$

Finally, the parameters of the system of eight equations defined by 5.8 and restrictions 5.5, 5.6, and 5.6 will be estimated and analyzed.[21]

As mentioned in Lewbel (1991), it is usually difficult to interpret the raw demand system parameters directly. It is therefore useful to report price and income elasticities. As shown by Banks et al. (1997), by differentiating the expenditure share equation 5.8 with respect to the logarithm of total expenditure and the logarithm of prices, one derives expressions 5.9 and 5.10, which are used afterwards to quantify income elasticity and both uncompensated and compensated price elasticities, respectively.

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(\mathbf{p})} \ln \frac{m}{a(\mathbf{p})} \tag{5.9}$$

$$\mu_{ij} \equiv \frac{\partial w}{\partial p_j} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_k \gamma_{jk} \ln p_k \right) - \frac{\lambda_i \beta_j}{b(\mathbf{p})} \ln^2 \frac{m}{a(\mathbf{p})} \tag{5.10}$$

Consequently, the budget elasticities for the i commodities can be quantified as follows:

$$e_i = \frac{\mu_i}{w_i} + 1 \tag{5.11}$$

[21] Section 6 describes the estimation strategy and comments on the estimated parameters.

where e_i measures the responsiveness of demand for a specific good to changes in expenditure, i.e., it shows how the quantity purchased changes in response to a change in consumer expenditure, which is a proxy for total household income. The higher the income elasticity, the more sensitive consumer demand is to income changes. The value of e_i indicates the nature of a product and how it is perceived by consumers. It also tells us how much the level and pattern of demand for goods and services is affected by economic development. A good is called a normal good if its budget elasticity is positive. Specifically, so-called normal necessities have an income elasticity of between 0 and 1. Demand for such goods increases with income, but their budget share decreases. Luxury goods are goods with income elasticity of demand above 1. In this case, demand is highly sensitive to any change in income and the budget share increases with income. Finally, inferior goods have negative income elasticity. Thus, demand for this type of good falls as income rises.

A good whose price elasticity in absolute terms is greater than 1 is called price elastic. A good whose price elasticity is smaller than 1 is called price inelastic. Consequently, a given percentage increase in the price will reduce the quantity demanded by a higher percentage for an elastic good than for an inelastic good. Price elasticities can be derived either from the Marshallian demand equation or from the Hicksian demand equation. The Marshallian demand equation is obtained by maximizing utility subject to the budget constraint, while the Hicksian demand equation is derived by solving the dual problem of expenditure minimization at a certain utility level.

As for the Marshallian/uncompensated price elasticity, positive e^u_{ij} indicates gross substitutes and negative e^u_{ij} indicates gross complements. A zero value of e^u_{ij} suggests independent goods. The uncompensated price elasticity in the case of QUAIDS is defined as follows:

$$e^u_{ij} = \frac{\mu_{ij}}{w_i} + \delta_{ij} \tag{5.12}$$

where δ_{ij} represents the Kronecker delta.

Finally, the Slutsky equations allow us to derive Hicksian/compensated elasticities from Marshallian/uncompensated ones and vice versa:

$$e^c_{ij} = e^u_{ij} + e_i w_i \tag{5.13}$$

6. Results

The main outcomes of our analysis are the set of estimated parameters, the resulting elasticities, and a simulation study based on the parameters. We illustrate how the elasticities can be used in assessing the impact of exogenous price shocks on quantity demanded for individual commodity groups. The purpose of the simulation exercise is to describe the reactions of a representative household to specific shocks, such as an exogenous change in prices due to tax shifts, the exogenous development of prices of energy, or an adjustment to regulated prices by an executive authority. The simulation exercise pays special attention to the impact of an adjustment to regulated prices on consumption shares, quantity demanded, and expenditure on each specific consumption bundle. Furthermore, we report Engel curves disaggregated by demographic factors.

6.1 Estimation of the Demand System and Quantification of Budget and Price Elasticities

In order to estimate the parameters of the demand system, one can follow alternative estimation strategies. First, it seems that the majority of applied QUAIDS studies use the maximum likelihood approach.[22] Second, in order to deal with endogeneity and non-linearity of regressors, the original contribution on QUAIDS by Banks et al. (1997) proposes a two-stage GMM estimation procedure to estimate the system of non-linear equations. Third, another alternative estimation strategy is by Poi (2008), who implements a non-linear SUR method. Alternatively, one might use the approach developed by Browning and Meghir (1991). In our study, we estimate the demand system using the non-linear SUR as suggested by Poi (2008).

The QUAIDS model we are using for estimation and simulation purposes assumes prices to be predetermined. As discussed, for example, by Janda et al. (1998) this is equivalent to perfectly elastic supply and market-clearing demand. This assumption does not hold for all commodity prices. However, one can find examples where prices can be treated as exogenous. A particular case seems to be administratively regulated prices or prices of imported goods, which are not an outcome of domestic demand and supply interaction.[23]

First, we estimate the stochastic version of the demand system for a representative household defined by equation 5.8. Then, we re-estimate the model extended to include demographic variables reflecting the age of the head of the household, the number of family members, and the position on the labor market.[24] For all estimated variants, we account for structural changes in consumer preferences over time by introducing a time trend into the model.

Table 1 shows the estimated parameters of the QUAIDS model extended to include the time trend. Most of the parameters are statistically significant at the 5% level. In particular, the estimates of parameter λ are statistically significant for most of the eight commodity groups. This confirms the relevance of the quadratic extension of the linear AIDS. The quadratic term in the logarithm of expenditure is close to zero only in the case of furniture and home electronics, health and body care expenditure, and education and leisure. Thus, omitting the quadratic term of the remaining five commodity groups from our analysis could lead to significant biases mainly in the simulation exercise. Subsection 6.2 provides further evidence against AIDS and in favor of the QUAIDS specification based on the likelihood-ratio test.

We found the time trend to be statistically significant for most of the commodity bundles. In particular, the share of food, clothing, transportation, and communication is decreasing slightly over time, while the budget share of energy and furniture and home electronics is rising. The falling trend in the budget share of food, with income elasticity below one, is due to increasing income of households over time. The decreasing trend in the budget share of transportation and communication is probably due to the impact of technology on prices of these commodities. Therefore, lower prices might translate into a lower budget share of this

[22] See, for example Poi (2002), who explains the specifics of demand system estimation using the maximum likelihood estimation approach.

[23] When analyzing the impact of an adjustment to energy prices, Brůha and Ščasný (2006) estimate the model assuming separately these prices to be either endogenous or exogenous. They do not find the results to be significantly different in these two cases. They conclude that their finding probably reflects the fact that energy prices are exogenous for a small open economy such as the Czech Republic.

[24] Appendix D discusses in more detail the effect of alternative household characteristics on household demand for commodities. In addition, equations D.14 to D.18 demonstrate how demographic factors enter the demand system.

commodity group. At the same time, it might be the case that consumer preferences have changed over time and goods considered a luxury a few years ago might now be regarded as a necessity.

As already mentioned, the importance of demographic factors for analysis of household demand expenditure has been emphasized and discussed by both theoretical and empirical research.[25] In order to reflect the impact of demographic characteristics, we re-estimate the QUAIDS specification including demographic dummy variables. The size of estimated parameters α, β, and γ from the re-estimated models in Tables 17, 18, and 19 is roughly in line with the estimates referring to the representative household estimates presented in Table 1. Based on the results presented in Tables 17, 18, and 19 one may conclude that demographic variables, represented by parameters η_2, η_3, β_2, β_3 λ_2, and β_3, significantly affect household demand patterns, i.e., the majority of these demographic dummy variables were found to be statistically significant. Subsection 6.2 confirms the importance of demographic factors by rejecting the model specification without demographic characteristics using the likelihood-ratio test. Consequently, all types of elasticities and simulations presented in Tables 2 to 13 could be replicated for the household sub-groups defined by the demographic variables included.

As another step in our analysis, we compute the demand elasticities. The elasticities are calculated for each individual household and subsequently an average is constructed. Indeed, one might quantify the elasticities for the median (or other percentile) household, but for the sake of the simulation exercise and space reasons we present just the average over all households.[26] Table 2 provides budget elasticities for our eight commodity groups. Most of the elasticities are statistically significant at the 5% level. The only exception is furniture and home electronics. Based on our estimates, the commodity bundles of food, energy, and health and body care are necessary goods, as their budget elasticity is positive and below one at the same time. On the contrary we identified clothing and shoes, transportation and communication, and education and leisure to be luxury goods with income elasticity above one. In addition, transportation and communication is the most sensitive group to income changes, while energy is the least sensitive one.

Concerning price elasticities, Tables 3 and 4 provide estimates of uncompensated and compensated price elasticities, respectively. First, we find most of the elasticities to be statistically significant at the 5% level. Second, the own-price elasticities are negative for all commodity groups as expected. Third, the cross elasticities seem to be smaller than the own elasticities. This indicates that individual commodity groups do not have any strong substitutes or complements among the remaining ones.[27] Based on the size of the own-price elasticities, we found demand for energy and transportation and communication to be the most affected by changes in their own prices. In addition, looking only at the substitution effect of a price change, presented in Table 4, transportation and communication is rated as a good with price elastic demand. The other commodity group with price elasticity close to 1 is energy. Since the commodity bundle of transportation and communication includes fuels, one might conclude that households tend to follow prices of crude materials and energy relatively closely and adjust their consumption

[25] Therefore, we cannot ignore demographic factors. However, as it is not the main purpose of our study, we provide most of the outcomes devoted to this topic in Appendix D.

[26] For simplicity we present only the average, but we are able to provide elasticities for the median or other percentiles upon request.

[27] This observation could have been affected by the degree of commodity aggregation into commodity bundles. Using more detailed commodity bundles, one might find a higher degree of substitutability, for example between wine and beer.

behavior appropriately. On the contrary, we find food, clothing, and education and leisure consumption to be affected by changes in prices to a smaller extent. The stories told by compensated and uncompensated price elasticities seem to be comparable.

Next, we present the fitted Engel curves representing the relationship between demand for good i and household expenditure assuming that prices of all commodities stay unchanged. Indeed, as parameter λ is statistically significant for most of the commodity bundles analyzed, the resulting Engel curves are quadratic in the logarithm of expenditure. Based on the fitted Engel curves one can analyze how consumers with different levels of income perceive different goods. An upward-sloping Engel curve indicates a luxury good while a downward-sloping one corresponds to a necessity good. Looking at Figure 4 food seems to be a luxury for low-income households and a necessity for high-income households. On the contrary, transportation and communication follow the opposite pattern, i.e., low-income households perceive this commodity group as a necessity, while high-income households perceive these commodities as luxury ones. The convex Engel curve for the transportation and communication bundle is probably due to a different composition and different perception of this bundle for different income groups. For example, low-income households tend to use public transportation and travel less for leisure, while high-income households buy luxury cars etc.

Finally, we present Engel curves dependent on household characteristics. Figure 5 depicts Engel curves for three age groups. To be specific, the age of a household is defined as the age of the head of the household. In particular, we distinguish between young households (below the age of forty), middle-aged households (between forty and sixty), and old households (over sixty). Intuitively, old households tend to spend a higher part of their budget on food, energy, and health and body care than middle-aged and young households. The opposite conclusion seems to be true for clothing and education and leisure-related expenditure.

Figure 6 depicts Engel curves for four groups depending on the number of family members. In particular, we distinguish between households consisting of one, two, three, and more than three members. Looking at the fitted Engel curves, it seems that households with more members spend a higher proportion of their expenditure on food and energy. On the contrary, more numerous families spend less on commodities they can share like furniture and home electronics and transportation and communication.

Finally, Figure 7 depicts Engel curves for four groups characterized by different position on the labor market. To be specific, we present Engel curves separately for the groups of employees, the self-employed, the retired and non-active, and the unemployed. Looking at the fitted Engel curves for these groups, it is clear that unemployed and economically non-active households tend to spend a higher percentage of their budget on food and energy, and less on clothing, transportation and communication, and education and leisure goods. These conclusions are in line with the income patterns of low-income groups.

Table 1: Estimated Parameters of the QUAIDS Model

	Food	Clothing	Energy	House	Health	Transport	Education	Other
α	0.526	0.029	0.185	-0.083	0.039	0.250	-0.012	0.066
	(0.012)	(0.004)	(0.008)	(0.006)	(0.003)	(0.007)	(0.007)	(0.008)
β	0.082	0.029	0.025	0.005	-0.002	-0.200	0.047	0.013
	(0.006)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)
γ_1	0.076	-0.018	0.004	-0.013	-0.003	0.033	-0.031	-0.048
	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
γ_2	-0.018	0.034	0.000	-0.004	-0.001	0.012	-0.004	-0.019
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
γ_3	0.004	0.000	-0.013	0.003	0.000	0.012	-0.004	-0.002
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)	(0.001)
γ_4	-0.013	-0.004	0.003	0.030	-0.002	0.001	-0.007	-0.008
	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
γ_5	-0.003	-0.001	0.000	-0.002	0.011	-0.002	-0.002	-0.001
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
γ_6	0.033	0.012	0.012	0.001	-0.002	-0.075	0.016	0.002
	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)
γ_7	-0.031	-0.004	-0.004	-0.007	-0.002	0.016	0.053	-0.021
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)
γ_8	-0.048	-0.019	-0.002	-0.008	-0.001	0.002	-0.021	0.097
	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)
λ	-0.023	-0.005	-0.015	0.001	-0.000	0.051	-0.005	-0.005
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
trend	-0.003	-0.002	0.007	0.016	-0.002	-0.001	-0.010	-0.005
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)

Note: Standard errors provided in paretheses.
Source: Own calculations.

Table 2: Budget Elasticities

Food	Clothing	Energy	House	Health	Transport	Education	Other
0.894	1.028	0.589	1.058	0.841	1.499	1.233	0.869
(0.041)	(0.059)	(0.091)	(0.984)	(0.340)	(0.070)	(0.088)	(0.104)

Note: Standard errors provided in parentheses.
Source: Own calculations.

Table 3: Uncompensated Price Elasticities

	Food	Clothing	Energy	Furniture	Health	Transport	Education	Other
Food	-0.679	-0.045	0.064	-0.041	0.002	-0.001	-0.075	-0.120
	(0.006)	(0.003)	(0.006)	(0.003)	(0.002)	(0.008)	(0.005)	(0.015)
Clothing	-0.257	-0.487	0.008	-0.042	0.003	0.014	-0.014	-0.253
	(0.013)	(0.009)	(0.011)	(0.005)	(0.004)	(0.016)	(0.010)	(0.025)
Energy	0.265	0.043	-0.964	-0.012	0.014	0.002	0.007	0.058
	(0.010)	(0.004)	(0.006)	(0.004)	(0.002)	(0.012)	(0.007)	(0.021)
House	-0.191	-0.043	-0.041	-0.504	-0.028	-0.034	-0.070	-0.134
	(0.049)	(0.026)	(0.044)	(0.023)	(0.009)	(0.073)	(0.043)	(0.123)
Health	0.047	0.025	0.058	-0.076	-0.722	-0.051	-0.121	-0.001
	(0.021)	(0.012)	(0.016)	(0.008)	(0.009)	(0.026)	(0.016)	(0.044)
Transport	-0.183	-0.028	-0.102	-0.017	-0.022	-1.000	-0.045	-0.106
	(0.011)	(0.005)	(0.008)	(0.006)	(0.003)	(0.016)	(0.008)	(0.012)
Education	-0.411	-0.028	-0.096	-0.045	-0.039	-0.010	-0.338	-0.263
	(0.037)	(0.018)	(0.032)	(0.014)	(0.007)	(0.049)	(0.037)	(0.083)
Other	-0.297	-0.125	0.015	-0.056	-0.001	-0.021	-0.135	-0.252
	(0.019)	(0.010)	(0.016)	(0.008)	(0.004)	(0.030)	(0.016)	(0.038)

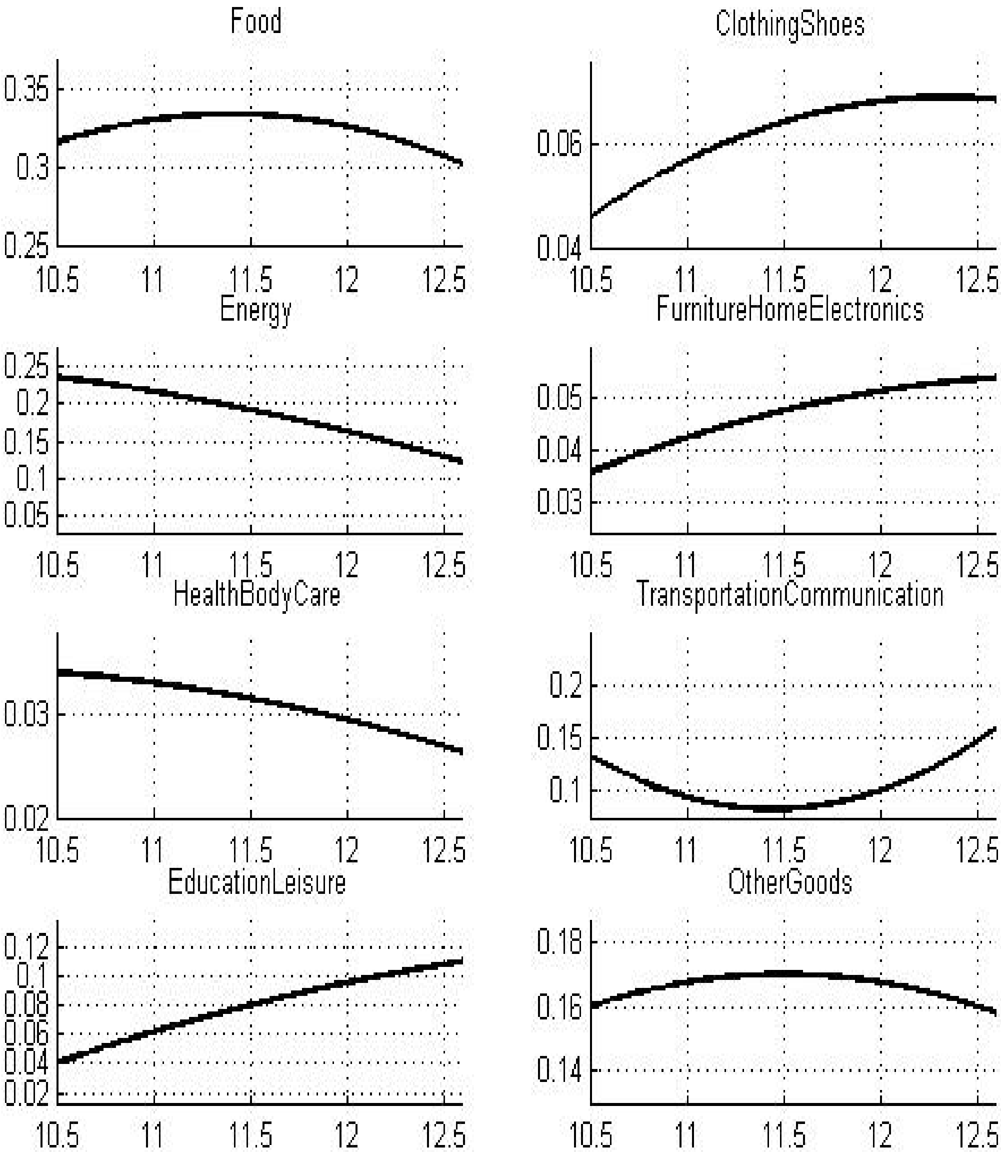
Note: An elasticity informs about a percentage change in quantity demanded for a good in row i as price of a good in column j increases by 1%. Standard errors provided in paretheses.
Source: Own calculations.

Table 4: Compensated Price Elasticities

	Food	Clothing	Energy	House	Health	Transport	Education	Other
Food	-0.373	0.026	0.193	-0.030	0.022	0.120	0.021	0.020
	(0.011)	(0.003)	(0.010)	(0.003)	(0.002)	(0.015)	(0.004)	(0.017)
Clothing	0.093	-0.407	0.156	-0.029	0.026	0.155	0.097	-0.090
	(0.025)	(0.007)	(0.017)	(0.005)	(0.004)	(0.028)	(0.009)	(0.028)
Energy	0.470	0.089	-0.875	-0.006	0.028	0.071	0.068	0.154
	(0.020)	(0.003)	(0.011)	(0.003)	(0.002)	(0.022)	(0.006)	(0.024)
House	0.124	0.033	0.105	-0.482	-0.003	0.129	0.054	0.041
	(0.113)	(0.015)	(0.076)	(0.021)	(0.013)	(0.135)	(0.037)	(0.140)
Health	0.332	0.092	0.176	-0.066	-0.703	0.066	-0.030	0.131
	(0.042)	(0.009)	(0.027)	(0.007)	(0.009)	(0.048)	(0.014)	(0.050)
Transport	0.322	0.092	0.109	0.003	0.011	-0.782	0.120	0.125
	(0.011)	(0.005)	(0.008)	(0.006)	(0.003)	(0.017)	(0.008)	(0.012)
Education	0.007	0.069	0.080	-0.029	-0.011	0.160	-0.209	-0.068
	(0.079)	(0.012)	(0.053)	(0.013)	(0.010)	(0.090)	(0.033)	(0.094)
Other	-0.002	-0.056	0.140	-0.045	0.019	0.098	-0.042	-0.112
	(0.039)	(0.007)	(0.026)	(0.007)	(0.005)	(0.051)	(0.014)	(0.044)

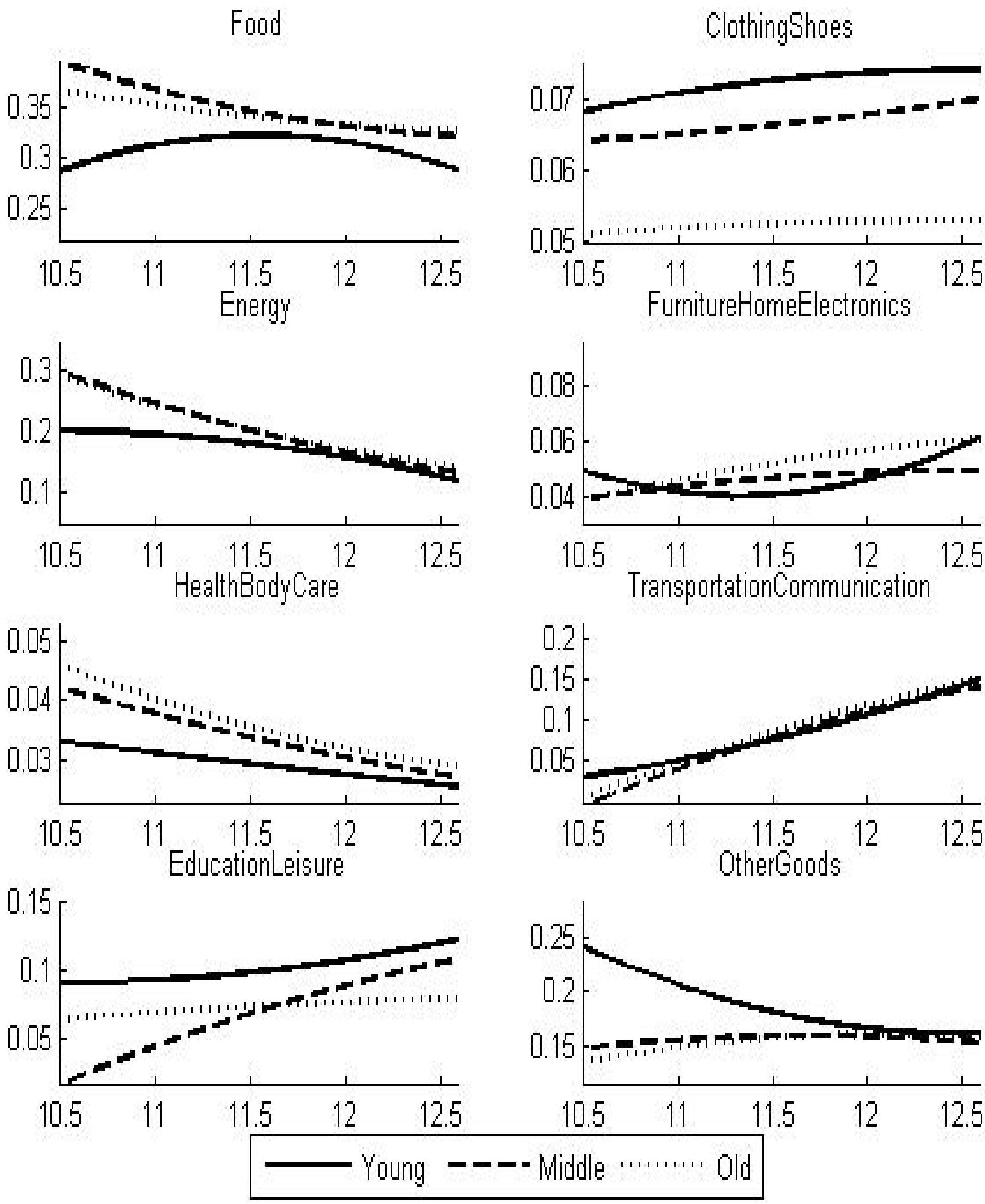
Note: An elasticity informs about a percentage change in quantity demanded for a good in row i as price of a good in column j increases by 1%. Standard errors provided in paretheses.
Source: Own calculations.

Figure 4: Fitted Engel Curves Using QUAIDS 2005–2008



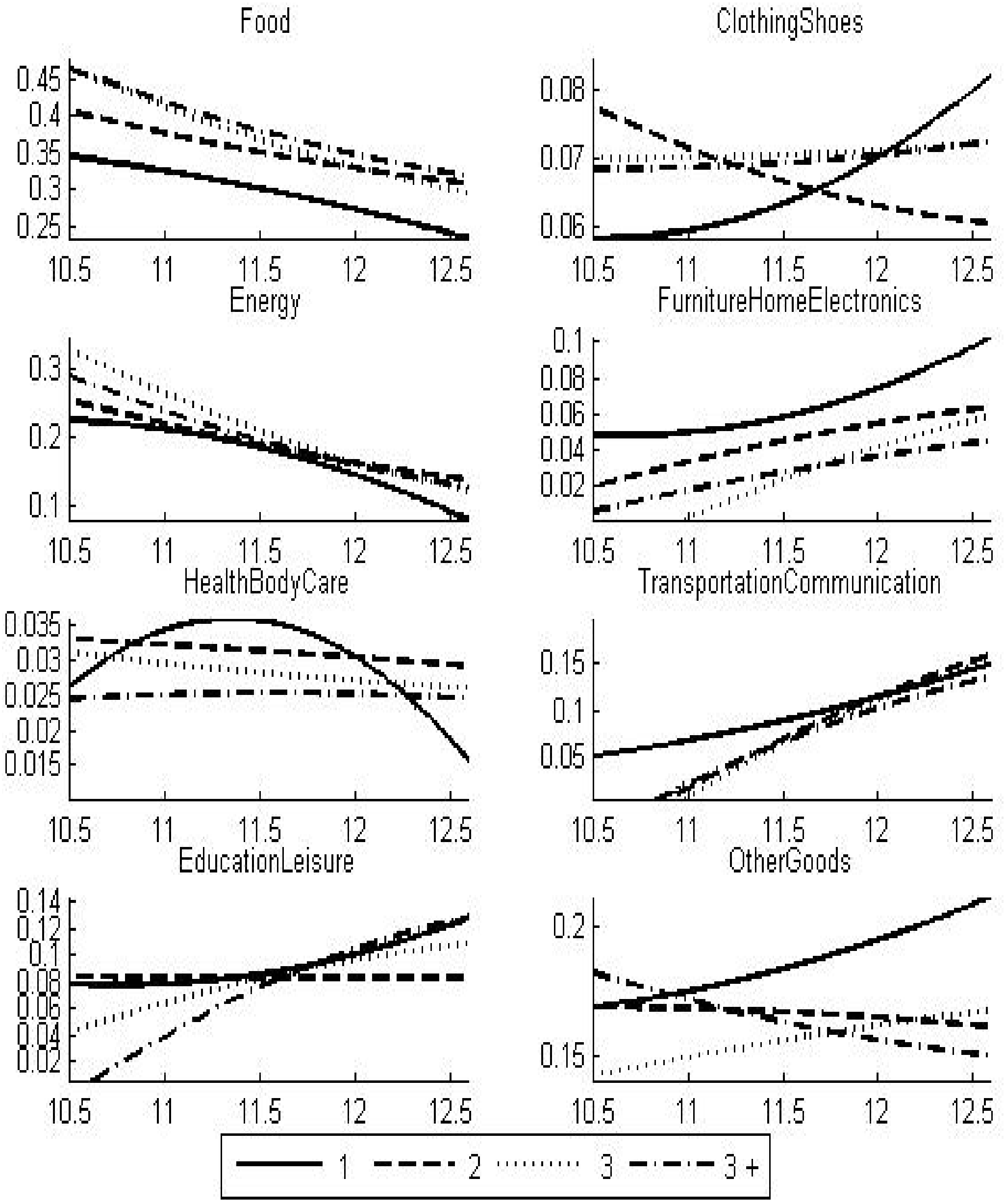
Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

Figure 5: Engel Curves for Different Age Groups 2005–2008



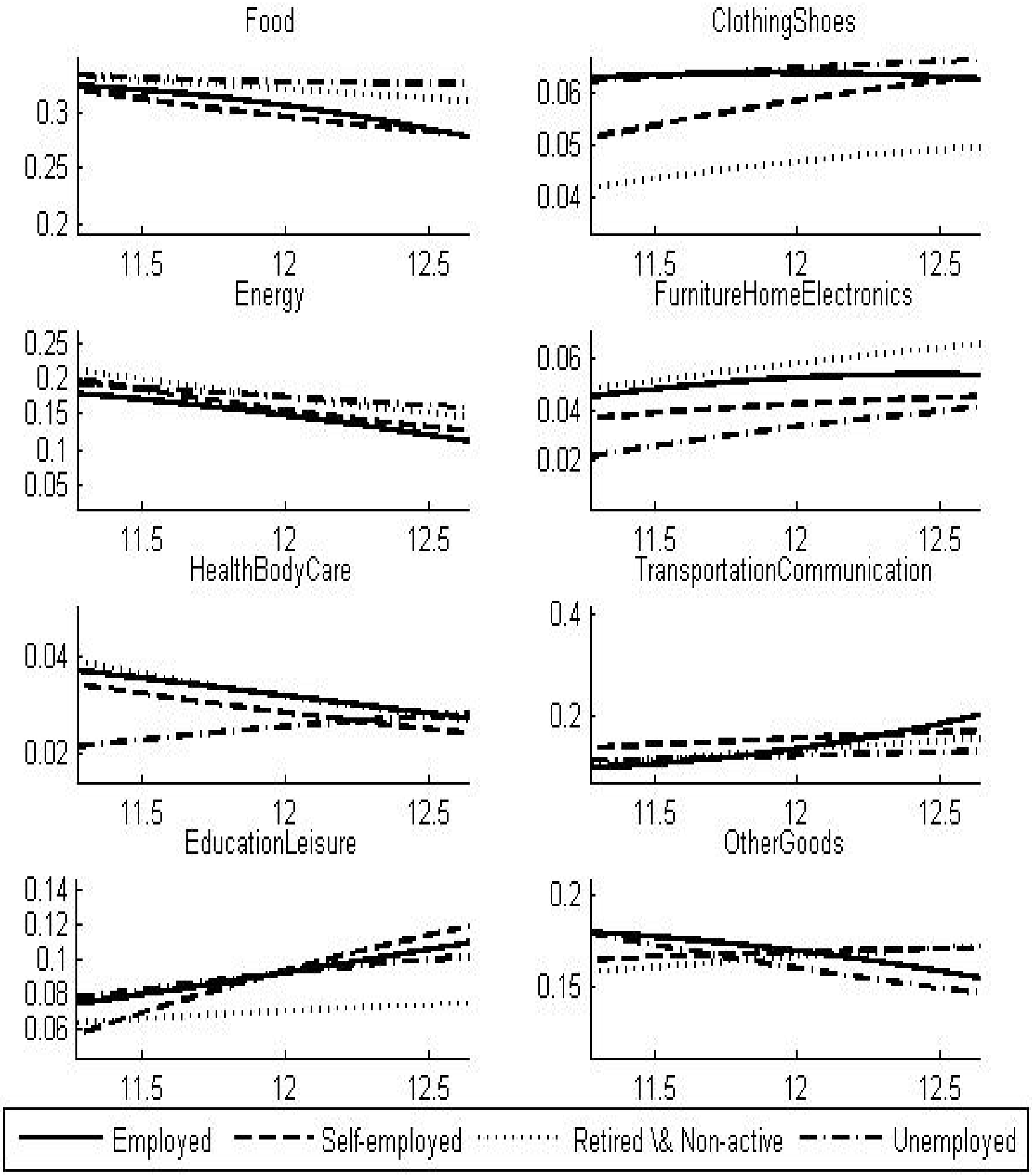
Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

Figure 6: Engel Curves by Number of Household Members 2005–2008



Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

Figure 7: Engel Curves by Position on the Labor Market 2005 - 2008



Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

6.2 Testing

In order to obtain parameter estimates in line with economic theory, it is necessary to make assumptions, which can often be numerous and restrictive. As described in section 5, the demand system applied for the purposes of our analysis also implies necessary restrictions on the parameters to be estimated. Consequently, to assess the validity and applicability of the model, we test the relevance of the restrictions imposed by economic theory, i.e., we compare the models with and without imposing these restrictions using the likelihood ratio (LR) test. First, we test the restricted model with linear Engel curves (AIDS) against the alternative of quadratic Engel curves (QUAIDS). The restricted model assumes λ_i to be zero in 5.8. Second, we test the relevance of the imposed homogeneity and symmetry restrictions given by 5.5, 5.6, and 5.7. When testing homogeneity, we impose only the adding-up restriction given by 5.5 in the case of the unrestricted model. In the case of symmetry, the unrestricted model is defined by the adding-up and homogeneity restrictions, i.e., by 5.5 and 5.6. Third, we test individually the significance of demographic factors, i.e., age of the respondent, number of family members, and labor market status. The outcomes of the specification tests are presented in Table 5. The first column indicates the restriction tested.

Table 5: Likelihood Ratio Tests of Restrictions

Restriction	$2(L_\Omega - L_\Psi)$	k	p-value
AIDS	1296	7	0.00
Homogeneity	613	7	0.00
Symmetry	1129	21	0.00
Non-age effect	503	42	0.00
Non-family size effect	1404	63	0.00
Non-labour market effect	1014	63	0.00

Note: L_Ω and L_Ψ represent the unrestricted and restricted maximum-likelihood. The test statistics has an asymptotic $\chi^2(k)$ distribution with k representing the number of required restrictions.
Source: Own calculations.

Based on the p-value from Table 5 we reject the linear AIDS model in favor of the extended QUAIDS model. Consequently, based on the test outcome, the linearity of Engel curves was rejected, supporting the use of more flexible quadratic Engel curves. Unfortunately, we rejected both the homogeneity and symmetry restrictions imposed on the model by the theory.[28] The last three rows of the table suggest that individual demographic effects cannot be rejected.[29]

[28] Rejection of the homogeneity and symmetry restrictions is relatively common in the empirical literature, see Deaton and Muellbauer (1980).

[29] It was originally indicated by Meisner (1979) that the standard test statistics for Slutsky symmetry and homogeneity are biased toward rejection of the null hypothesis, i.e., toward rejection of the hypothesis that the restricted model is nested within the unrestricted one. In particular, this conclusion holds for large demand systems. Unfortunately, there is no generally accepted way of size-correcting the LR test. However, Moschini et al. (1994) propose a size-correction of the LR in order to deal with over-rejection of the null hypothesis. Following the approach suggested by Moschini et al. (1994) we gained a reduction in the test statistic values, but the overall outcomes of the tests remained unchanged.

6.3 Results Comparison

As discussed by Brown and Deaton (1972), even though the empirical studies of demand systems are subject to one or more postulates of economic theory, several obstacles appear when comparing the estimated elasticities among different studies. First, alternative functional forms and restrictions are imposed on the model. Second, often the sample coverage differs substantially, i.e., many studies analyze samples of more or less homogeneous individuals. Third, different studies focus on specific commodity groups, i.e., commodity bundles are often defined differently depending on the purpose of the analysis.[30] There is an obvious trade-off between academic correctness and usability for policy. Academic studies can afford to focus on very specific types of already well-defined goods (types of meat for example) consumed by a relatively homogeneous group of people (such as middle-aged, single, childless people from a certain suburb of New York).

Being aware of the potential shortcomings, we compared our elasticities with Banks et al. (1997).[31] Nonetheless, we find the results of the two studies comparable. Concerning budget elasticities, Banks et al. (1997) estimated 0.57, 1.14, and 0.48 in the case of the food, clothing, and fuel bundles, respectively. Comparing to Table 2 we also find clothing to be a luxury commodity, with budget elasticity over 1, and food and energy to be normal goods, with budget elasticity below 1. In addition, the responsiveness of energy demand to income changes seems to be lower compared to reaction of food demand in both studies. Concerning both compensated and uncompensated price elasticities, Banks et al. (1997) found the compensated price elasticities of food, clothing, and fuel to be -0.78, -0.96, and -0.77, respectively. Our estimates, presented in Table 4, indicate comparable outcomes for fuel but somewhat lower outcomes in the case of food and clothing. The same conclusion holds for uncompensated elasticities in the two studies.

An overview study by Lewbel (1997) provides estimates of own-price elasticities for food and clothing coming from influential studies conducted between 1954 to 1997 and applying different types of models (LES, AIDS, Translog QES, and QUAIDS). In the case of food, the estimated own-price elasticities range from -0.40 to -0.96. In the case of clothing, the elasticities range between -0.48 and -1.38.[32] Our estimates of the own-price elasticities for food and clothing are within both intervals, but clothing elasticity seems to be at the upper bound of the interval. Another overview study by Blundell (1988) provides estimates for budget and price elasticities for different types of households. The average estimated budget elasticities are about 0.6, 0.3, 1.3, and 1.2 for food, fuel, clothing, and transportation, respectively, which is close to our estimates in Table 2. Concerning uncompensated price elasticities, Blundell (1988) estimated -0.45, -0.74,-0.84, and -0.7 on average for the same set of commodities. Again, our estimates tend to be in line with these results.

[30] Since the main goal of our study is to simulate the impact of various regulated price adjustments, we apply relatively broad bundles of commodities (see Appendix A for details). On the contrary, more focused studies usually define one specific commodity group, within which they scrutinize even more specific items. For example, Janda et al. (2009) focus on alcoholic beverages, treating the remaining demanded commodities as other goods.

[31] Even though the study by Banks et al. (1997) applies exactly the same model, it differs in two main dimensions. First, the study by Banks et al. (1997) covers a relatively homogeneous subsample of households for which there are two married adults with the husband employed and who live in London and the South East. On the contrary, our sample does not introduce any selection criteria on households, but introduces demographic variables into the model. Second, Banks et al. (1997) estimate elasticities just for food, fuel, clothing, alcohol, and other goods.

[32] Lewbel (1997) points out that the estimated elasticities seem to be higher in more recent studies thanks to more flexible functional forms but also due to different data sets, estimators, and treatment of demographic factors.

Turning to studies focused on the Czech Republic, Janda et al. (2009) provide estimates of elasticities for industrial and manufactured goods, services, food, and alcoholic beverages in particular. They found an income elasticity of food of 0.6. Next, Crawford et al. (2003) estimated a demand system of eight commodity groups, focusing in detail on the food category. At the same time, they provide estimates of -0.28 and 1.21 for clothing in the case of budget and uncompensated price elasticity, respectively. Both figures are in line with our estimates. Brůha and Ščasný (2006) and Ščasný and Brůha (2006) provide estimates of price and budget elasticities for different types of energy and means of transportation. As their results are too detailed, they are not strictly comparable with ours, but some overall similarity between their estimates and our estimates for energy and transportation is evident.

6.4 Simulation of the Effects of Adjustments in Regulated Prices

Having estimated the parameters of the quadratic demand system and the income and price elasticities, we can quantify the expected effects of changes in commodity prices and in the level of consumption expenditure on the budget shares of, expenditure on, and demand for specific commodity groups. The model estimates are applied to scrutinize the effect of adjustments in regulated prices on consumer demand for eight commodity groups. As regulated prices are set by the regulatory authority and these prices are not further adjusted by market forces, i.e., regulatory prices are exogenous, it is appropriate to use the QUAIDS model to simulate their impact on consumer demand.[33]

Furthermore, regulated prices are not only convenient for simulation using our model, but also an important issue in economic policy. The role of regulated prices in the Czech Republic is crucial.[34] In particular, regulated prices were the main driver of inflation in 2008 and have remained so during 2009. In addition, looking at Figure 8, two main observations appear. First, regulated prices tend to change abruptly from one year to another. Second, if regulated prices are adjusted, the change is often very large. For example, the price of energy jumped up by almost 40% in 2002 and TV and radio and health fees also by 40% in 2008. Thus, adjustments in regulated prices do not appear every year, but if they do appear they can be of significant size, with crucial implications for overall inflation. Thus, understanding the impact of regulated prices on consumer demand is important both for forecasting and for policy decisions.

Specifically, focusing on the evolution of regulated prices during 2008 and 2009, the biggest contributors to annual regulated price inflation were prices of energy for households. Next, about one-third of the rise in regulated prices in 2008 was due to the introduction of fees in health care. In addition, faster convergence of regulated rents to their market level contributed to inflation in 2008 and 2009. Administrative measures, such as an increase in the lower VAT rate from 5% to 9% and the introduction of environmental taxes on electricity, heat, and solid fuels, contributed roughly one-quarter to annual inflation.[35]

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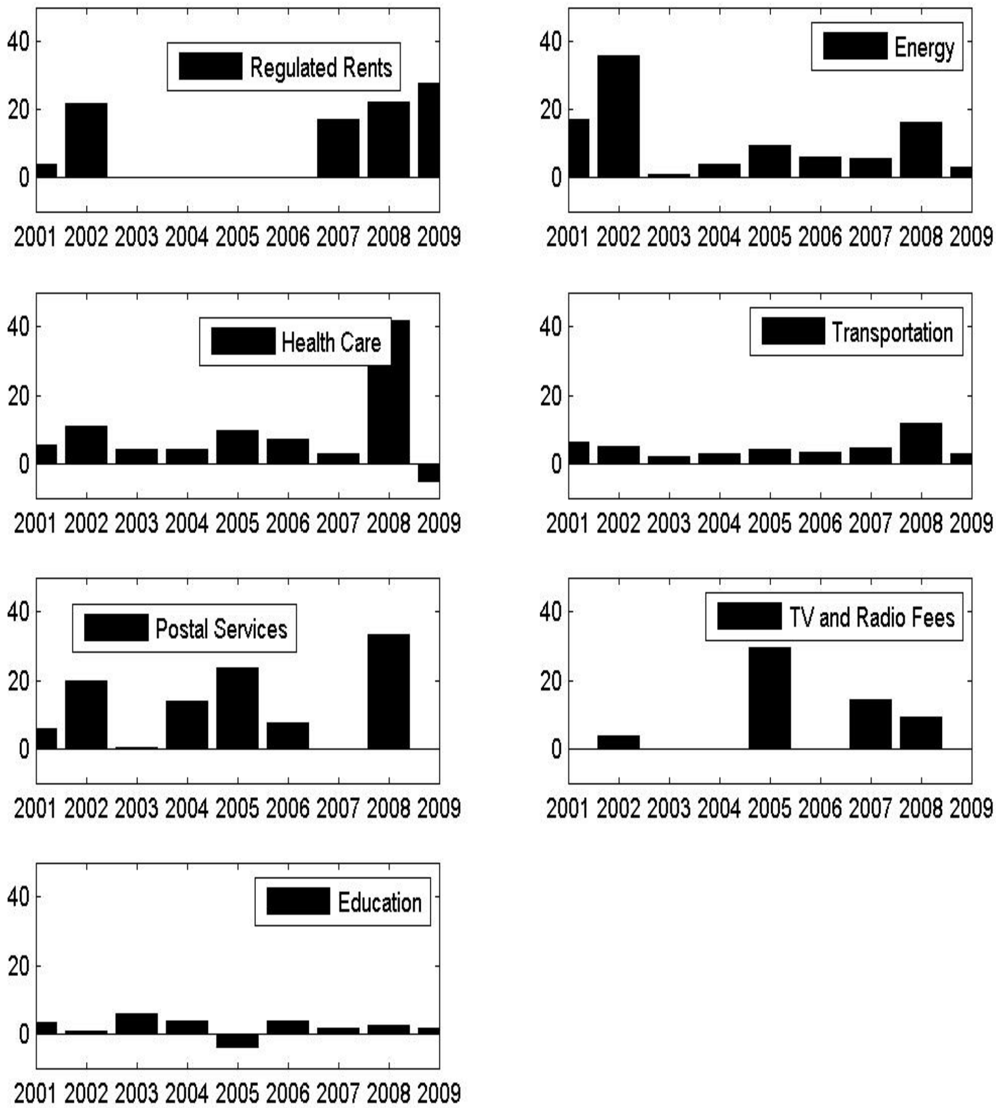
[33] Other possible situations to simulate using our model include, for example, a change in world energy prices or shift in indirect tax rates. Even though price adjustments are often treated as exogenous in these two cases, it is not evident to what extent producers or consumers would be able to affect the final price. This is not the case with regulated prices.

[34] Regulated prices are defined by Act No. 526/1990 Coll. Under this Act, price regulation means the setting or direct regulation of the level of prices by pricing authorities and local authorities. The main reason for regulating the prices of certain items of the consumer basket is the social aspect, together with the risk of monopolistic behavior by suppliers of goods/services.

[35] Details of recent and expected developments in regulated prices and administrative measures can be found at http://www.cnb.cz/en/monetary_policy/inflation_reports/2009/2009_IV/boxes_and_annexes/ir_IV_2009_box_II.html

Figure 8: Regulated Prices (Annual Growth Rates)



Source: CNB

Figure 8 depicts the development of the seven main representatives of regulated prices since 2001: (1) regulated rents, (2) health care, (4) transportation, (5) postal services, (6) TV and radio fees, and (7) education fees. As already mentioned, progress in regulated prices is quite erratic and one cannot find any systematic patterns in their development over time. However, in our simulation exercise we quantify the five most relevant regulated items. For the sake of our analysis, we selected five representative scenarios quantifying the effect of adjustments to regulated prices of regulated rents, energy, health care, transportation, and TV and radio fees.

To simulate realistic adjustments in regulated prices we need to proceed in the following steps. First, we quantify the shares of the five regulated prices in the specific commodity bundles. Table 6 distributes all the five regulated prices among the eight commodity bundles and specifies the shares. Second, we quantify how a 30% change in a specific regulated price translates into the price of a specific commodity bundle. Third, applying the estimated elasticities we quantify the impact on consumption shares, expenditure, and quantity purchased of specific commodity bundles before and after the change was introduced.

Table 6: Share of Regulated Prices Commodities in Commodity Bundles

Regulated price	Commodity bundle	2005	2006	2007	2008
Energy	Energy	0.96	0.95	0.96	0.96
Health Care	Health, body care	0.84	0.85	0.86	0.87
Postal Services	Transportation, communication	0.19	0.20	0.21	0.21
TV and radio fees	Education, leisure	0.15	0.16	0.18	0.20
Regulated rents	Other goods	0.29	0.29	0.29	0.30

Source: Own calculations.

Energy is an important commodity group that matters for policy makers. The estimated budget elasticity is the lowest among all eight budget elasticities, as demonstrated in Table 2. This indicates that households need roughly the same amount of energy, independent of their income level. At the same time, the compensated own-price elasticity is relatively high. The uncompensated price elasticity is very close to unity, indicating a price elastic commodity. Consequently, as the price of energy increases, the quantity of the energy bundle demanded falls almost to the same extent. The combination of low budget elasticity and high own-price elasticity suggests that households need energy whatever the level of their income, but reflect price developments significantly at the same time. As presented in Table 7, the effects of a change in regulated energy prices on other commodities are estimated to be very limited in terms of both quantity demanded and consumption expenditure.

Table 7: Simulation of a 30% Increase in Price of Regulated Energy

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.340	1.015	1.015
Clothing	0.073	0.073	1.001	1.001
Energy	0.157	0.158	1.006	0.781
House	0.052	0.051	0.979	0.979
Health	0.021	0.021	1.016	1.016
Transport	0.114	0.110	0.975	0.975
Education	0.098	0.096	0.970	0.970
Other	0.149	0.150	1.004	1.004

Source: Own calculations.

Obviously, health care does not have any strong substitutes or complements among the other commodity bundles analyzed in this study. Consequently, as demonstrated in Table 8, the impact of adjustments in health care fees seems to affect mainly the distribution of expenditure among different commodity bundles, leaving the quantity demanded to adjust to only a limited extent. The consumption shares remain unchanged. Specifically, increasing regulated health care fees by 30% reduces the quantity demanded by 15% but increases expenditure related to this bundle by 7%. The increase in health care expenditure is financed by a reduction in the quantity of luxury goods demanded and purchased, i.e., goods with the highest income elasticity, such as furniture and electronics, transportation and communication, and finally education and leisure.

Table 8: Simulation of a 30% Increase in Health Care Fees

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.336	1.000	1.000
Clothing	0.073	0.073	1.001	1.001
Energy	0.157	0.157	1.003	1.003
House	0.052	0.052	0.989	0.989
Health	0.021	0.022	1.071	0.849
Transport	0.114	0.113	0.994	0.994
Education	0.098	0.098	0.989	0.989
Other	0.149	0.149	1.000	1.000

Source: Own calculations.

Based on its budget and price elasticities, the transportation commodity bundle is a luxury commodity with very limited substitution possibilities. Consequently, a 30% increase in regulated transportation prices tends to affects household demand mainly via decrease in demand for transportation. In other words, as shown in Table 9, even relatively large increases in regulated prices of transportation tend not to affect the quantity demanded of all commodity groups except transportation. As an increase in transportation prices is almost fully offset by a reduction in the quantity demanded, the amount of money spent on each commodity group is not affected by this specific price change.

Table 9: Simulation of a 30% Increase in Postal Services Fees

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.336	1.000	1.000
Clothing	0.073	0.073	1.001	1.001
Energy	0.157	0.157	1.000	1.000
House	0.052	0.052	0.996	0.996
Health	0.021	0.021	0.997	0.997
Transport	0.114	0.114	0.999	0.940
Education	0.098	0.098	1.000	1.000
Other	0.149	0.149	0.999	0.999

Source: Own calculations.

The education and leisure commodity bundle is characterized by relatively high budget and relatively low own-price elasticity. Following Table 10, a 30% increase in TV and radio fees reduces the quantity of licenses demanded to only a limited extent, but adjusts the quantity of other commodities demanded downward as well. Due to relatively low own-price elasticity, an increase in TV and radio fees augments expenditure on this bundle. Accordingly, the consumption share of this bundle changes to the same extent.

Table 10: Simulation of a 30% Increase in TV and Radio fees

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.334	0.995	0.995
Clothing	0.073	0.073	0.999	0.999
Energy	0.157	0.157	1.000	1.000
House	0.052	0.052	0.993	0.993
Health	0.021	0.021	0.992	0.992
Transport	0.114	0.113	0.997	0.997
Education	0.098	0.102	1.047	0.988
Other	0.149	0.148	0.991	0.991

Source: Own calculations.

Regulated rents make up about 30% of the other goods bundle, i.e., roughly 5% of total expenditure.[36] Increasing regulated rents has relatively sizable effects on the quantity demanded of both other goods and the other commodities, especially those with relatively high budget elasticity. Table 11 suggests that after a 30% increase in regulated rents, the quantity of other goods demanded falls by 1.5%, while expenditure on this bundle adjusts upward by 7%. Consequently, expenditure on the remaining commodity groups remains unchanged or decreases.

Table 11: Simulation of a 30% Increase in Regulated Rents

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.332	0.989	0.989
Clothing	0.073	0.071	0.975	0.975
Energy	0.157	0.158	1.004	1.004
House	0.052	0.052	0.981	0.981
Health	0.021	0.021	1.000	1.000
Transport	0.114	0.113	0.990	0.990
Education	0.098	0.096	0.972	0.972
Other	0.149	0.158	1.072	0.984

Source: Own calculations.

Finally, we compare the effects of adjustments in individual regulated prices on aggregate demand. Table 12 provides estimates of the reduction in the overall quantity demanded assuming a unitary 30% shock to each regulated price. Not surprisingly, we find regulated rents and energy prices to play a crucial role. The estimated effects on aggregate demand are expected to be -2.7% and -1.5%, respectively. The role of health care, postal services, and TV and radio fees seems to be substantially lower, i.e., below 1% in absolute terms. The results are in line with

[36] Unfortunately, the estimated parameters and elasticities of the other goods bundle may have been affected by the fact that this bundle is treated as a residual group and many of its parameters are calculated so that the additivity restriction is satisfied.

the individual simulations presented above and the individual shares of the specific commodity bundles in individual demand.

Table 12: Impact of a 30% Increase in Regulated Price on Aggregate Demand

Regulated price	Δ aggregate Q
Energy	0.985
Health Care	0.992
Postal services	0.998
TV and Radio fees	0.996
Regulated Rents	0.973

Source: Own calculations.

Finally, to demonstrate another way of using our estimates, we present a simulation of a 10% increase in individuals' consumption expenditure. The results closely follow the estimated average budget elasticities as presented in Table 2. Of course, the changes in demand correspond to the changes in consumption expenditure, as prices do not change in this simulation. The consumption shares adjust slightly, depending on the size of the budget elasticity. Not surprisingly, demand increases mainly in the case of luxury goods, i.e., clothing, furniture and home electronics, transportation and communication, and education and leisure. The demand for the remaining commodity groups, i.e., food, energy, and health and body care, increases less than proportionately with income.

Table 13: Simulation of a 10% Increase in Consumption Expenditure

	Share old	Share new	Δ PQ	Δ Q
Food	0.335	0.332	1.089	1.089
Clothing	0.073	0.073	1.104	1.104
Energy	0.157	0.152	1.062	1.062
Furniture	0.052	0.053	1.122	1.122
Health	0.021	0.021	1.082	1.082
Transport	0.114	0.121	1.162	1.162
Education	0.098	0.100	1.130	1.130
Other	0.149	0.148	1.084	1.084

Source: Own calculations.

7. Conclusion

Our analysis is conducted on the household level using Czech Household Budget Survey data and information on prices from alternative sources from 2006 to 2008. We split total consumer expenditure into these eight commodity bundles: food, clothing and shoes, health and body care, furniture and home electronics, education and leisure, energy, transportation and communication, and other goods. We describe the consumption shares for different types of households taking into account region of residence, family composition, age, and education of the head of the household. Furthermore, we run nonparametric and polynomial regressions to check the commodity-specific shapes of Engel curves.

We implement the QUAIDS model of Banks et al. (1997), which allows for a detailed analysis of demand for individual commodities and can reflect characteristics of consumers. We estimate the stochastic version of the demand system for a representative household and the same model extended to include demographic variables reflecting the age of the head of the household, the number of family members, and the position on the labor market.

Most of the income elasticities are statistically significant at the 5% level. Based on our estimates, the commodity bundles of food, energy, and health and body care are necessary goods, as their budget elasticity is positive and below one at the same time. Clothing and shoes, transportation and communication, and education and leisure are luxury goods, with income elasticity above one. In addition, transportation and communication is the most sensitive group to income changes, while energy is the least sensitive one.

The own-price elasticities are negative for all commodity groups, as expected. The cross elasticities seem to be smaller in absolute value compared to the own elasticities. We found expenditure on energy and transportation and communication to be the most affected by changes in their own prices.

We present fitted Engel curves representing the relationship between the demand for goods and household expenditure, assuming that the prices of all commodities stay unchanged. Furthermore, we present the set of Engel curves depending on the aforementioned household characteristics.

Since the role of regulated prices is still crucial in the case of the Czech Republic, we decided to analyze their effects on consumer demand in the empirical part. First, regulated prices were the main driver of inflation in 2008 and have remained so during 2009. Second, regulated prices tend to change abruptly from one year to another. Third, if regulated prices are adjusted, the change is often very large. Thus, understanding the impact of regulated prices on consumer demand is important both for forecasting and for policy decisions. Specifically, we simulate how an increase in specific regulated prices affects consumption shares, expenditure, and quantity demanded in the case of five major regulated prices: (1) energy, (2) health fees, (3) transportation, (4) TV and radio fees, and (5) regulated rents. In each simulation, we augment a specific regulated price by 30%.

As the price of energy increases, the quantity of the energy bundle demanded falls almost to the same extent. The effects of a change in regulated energy prices on other commodities are estimated to be very limited in terms of both quantity demanded and consumption expenditure. Concerning health care, it seems this commodity bundle does not have any strong substitutes or complements among the other commodity bundles analyzed in this study. Specifically, increasing regulated health care fees by 30% reduces the quantity of this commodity bundle demanded by 15%, but increases expenditure related to this bundle by 7%. An upward adjustment of regulated transportation prices by 30% tends to be almost fully offset by a reduction in the respective quantity demanded; the amount of money spent on each commodity group is not affected by this specific price change. A 30% increase in TV and radio fees reduces the quantity of licenses demanded to only a limited extent, but adjusts the quantity of other commodities demanded downward as well. Due to relatively low own-price elasticity, an increase in TV and radio fees augments expenditure on this bundle. Finally, adjustments in regulated rents have relatively sizeable effects on the quantity of all commodity bundles demanded, especially those with relatively high budget elasticity. A 30% increase in regulated rents reduces the quantity of the other goods commodity bundle demanded by 1.5%, while expenditure on this bundle adjusts upward by 7%. Consequently, expenditure on the remaining commodity groups remains unchanged or decreases.

Comparing the effects of adjustments in individual regulated prices on aggregate demand, we find regulated rents and energy prices to play a crucial role. The role of health care, postal services, and TV and radio fees seems to be substantially lower.

Finally, we present a simulation of a 10% increase in individuals' consumption expenditure. Not surprisingly, demand increases mainly in the case of luxury goods, i.e., clothing, furniture and home electronics, transportation and communication, and education and leisure. Demand for the remaining commodity groups, i.e., food, energy, and health and body care increases less than proportionately with income. Indeed, the changes in the quantity demanded correspond to the changes in consumption expenditure, as prices do not change in this simulation. The consumption shares adjust slightly, depending on the size of the budget elasticity.

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Appendix A

Definitions of Commodity Bundles

Table 14: Definition of Commodity Bundles

Commodity Bundle	Budget Survey code	Commodity
Food	201 ... 291	Meat, oils and fats, milk, cheese, eggs, bread and cereals
		vegetables, fruit, sugar, chocolate, confectionery
		coffee, tea and cocoa, mineral waters, soft drinks
		alcoholic beverages, cafeteria, restaurant
	390	Tobacco
Clothing	301 ... 310	Clothing
&	321 ... 327	Foot ware
Shoes	431, 432	Repair/hire of clothing/footwear
Health	336 ... 339	Medical products/appliances
&	471 ... 475	Outpatient services
Body Care	443	Hairdressing
Furniture	340 ... 349	Furniture and furnishings
&	351 ... 357	Household appliances
Home Electronics	436, 437	Maintenance/repair of the dwelling and appliances
Education	371 ... 376	Audio-visual, photographic, IT eq.
&	381 ... 384	Other recreational items and equipment
Leisure	385 ... 389	Newspapers, books and stationery
	461 ... 465	Recreational/cultural services
	450 ... 456	Pre-primary, primary and secondary education
	433, 438	Repair of audio-visual, photographic, IT eq.
Energy	391 ... 393	Solid fuels
	402 ... 405	Electricity, gas, heat energy, water supply
Transportation	411 ... 418	Passenger transport by railway, road, air
&	364	Fuels/lubricants for personal transport equipment
Communication	360 ... 363	Purchase of vehicles
	434, 435	Maintenance/repair of personal transport equipment
	421 ... 425	Postal, Telephone/telefax services
	370, 377	Telephone and telefax equipment
Other Goods	331 ... 335	Materials for the maintenance/repair of the dwelling
	401, 408	Actual rentals for housing
	441 ... 446	Other services

Source: Household Budget Survey.

Appendix B

Descriptive Statistics

Table 15: Descriptive Statistics of the Sample

	2001	2002	2003	2004	2005	2006	2007	2008
w Food	0.344	0.338	0.344	0.336	0.331	0.324	0.328	0.329
	(0.088)	(0.085)	(0.086)	(0.087)	(0.088)	(0.087)	(0.088)	(0.089)
w Clothing	0.077	0.075	0.077	0.072	0.069	0.070	0.071	0.068
	(0.042)	(0.041)	(0.041)	(0.039)	(0.039)	(0.037)	(0.037)	(0.038)
w Energy	0.147	0.159	0.163	0.156	0.160	0.162	0.155	0.160
	(0.062)	(0.066)	(0.071)	(0.069)	(0.072)	(0.073)	(0.068)	(0.073)
w House	0.051	0.049	0.053	0.051	0.052	0.053	0.056	0.055
	(0.057)	(0.054)	(0.057)	(0.054)	(0.058)	(0.058)	(0.061)	(0.059)
w Health	0.019	0.019	0.019	0.021	0.022	0.023	0.026	0.019
	(0.020)	(0.020)	(0.019)	(0.020)	(0.022)	(0.021)	(0.025)	(0.020)
w Transport	0.126	0.120	0.110	0.115	0.112	0.116	0.107	0.107
	(0.095)	(0.082)	(0.087)	(0.091)	(0.091)	(0.099)	(0.097)	(0.096)
w Education	0.097	0.096	0.085	0.104	0.099	0.100	0.103	0.103
	(0.069)	(0.068)	(0.062)	(0.072)	(0.071)	(0.071)	(0.073)	(0.070)
w Other	0.139	0.143	0.149	0.146	0.154	0.152	0.156	0.158
	(0.077)	(0.076)	(0.080)	(0.080)	(0.087)	(0.086)	(0.089)	(0.091)
lnp Food	3.210	3.202	3.186	3.206	3.204	3.227	3.166	3.229
	(0.157)	(0.160)	(0.162)	(0.165)	(0.172)	(0.185)	(0.187)	(0.188)
lnp Clothing	5.222	5.224	5.209	5.211	5.210	5.252	5.196	5.196
	(0.490)	(0.500)	(0.488)	(0.493)	(0.501)	(0.487)	(0.470)	(0.471)
lnp Energy	4.552	4.645	4.650	4.676	4.738	4.146	4.107	4.131
	(0.418)	(0.408)	(0.402)	(0.394)	(0.391)	(0.902)	(0.871)	(0.850)
lnp House	5.560	5.540	5.585	5.544	5.561	5.491	4.161	4.151
	(0.802)	(0.795)	(0.786)	(0.774)	(0.787)	(0.815)	(1.016)	(1.005)
lnp Health	4.183	4.191	4.941	5.014	5.009	5.035	4.718	5.026
	(0.669)	(0.671)	(0.379)	(0.453)	(0.459)	(0.460)	(0.554)	(0.607)
lnp Transport	0.449	3.939	3.935	3.847	3.888	2.090	2.578	2.918
	(0.990)	(0.464)	(0.572)	(0.654)	(0.668)	(1.867)	(1.855)	(1.811)
lnp Education	5.521	5.562	5.776	5.650	5.612	5.550	5.747	5.806
	(0.583)	(0.574)	(0.629)	(0.573)	(0.591)	(0.592)	(0.611)	(0.587)
lnp Other	5.396	5.455	5.456	5.478	5.526	5.565	5.542	5.571
	(0.471)	(0.457)	(0.461)	(0.473)	(0.494)	(0.480)	(0.489)	(0.506)

Note: w represents the share of expenditures on a commodity to overall expenditures, lnp stands for logarithm of commodity price.
Source: Own calculations.

Table 16: Number of Observations

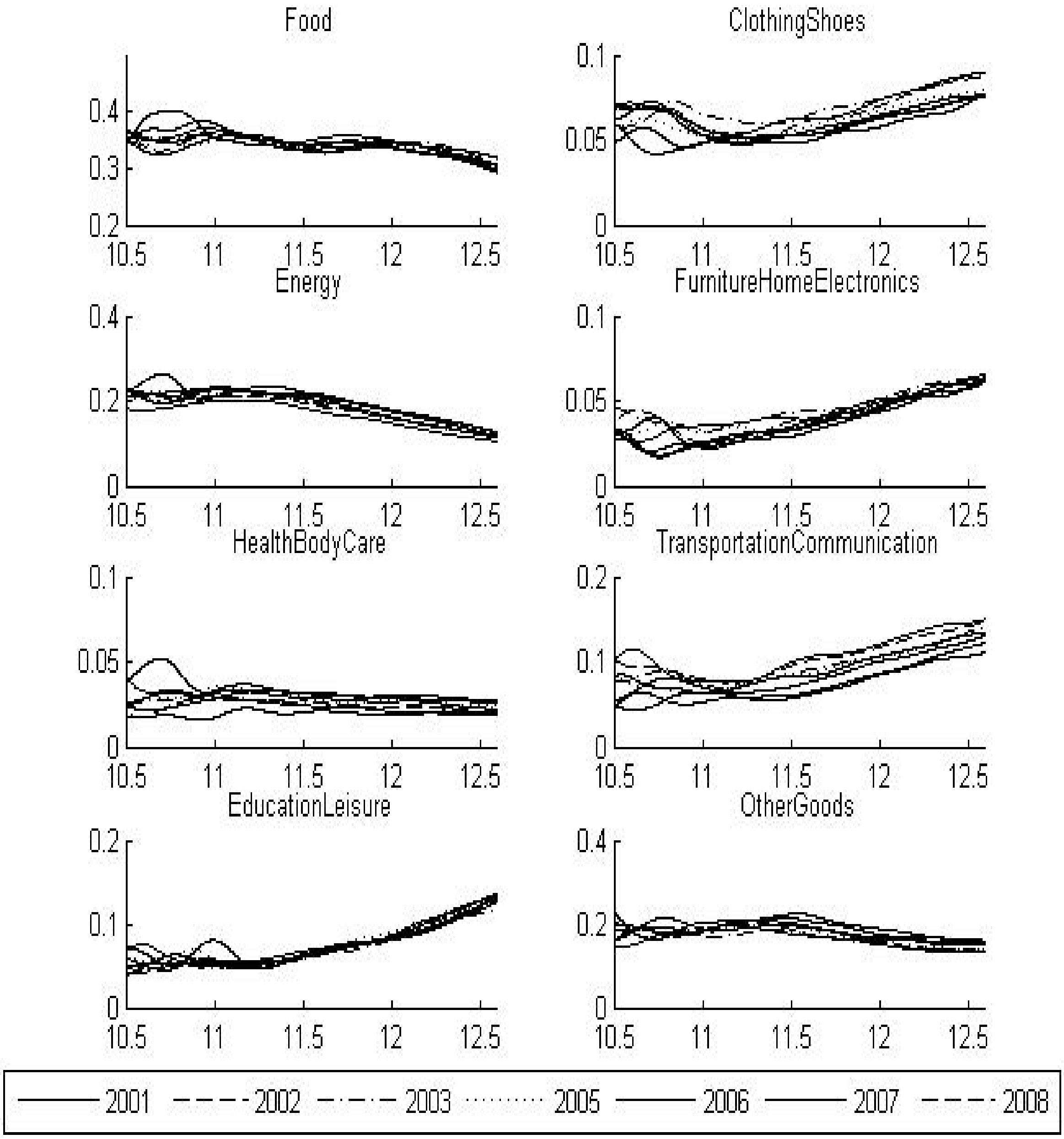
	2001	2002	2003	2004	2005	2006	2007	2008
# obs.	3174	3190	3114	3057	2989	2569	2372	2173
socgr $_1$	1868	1894	1914	1879	1852	1408	1301	1233
socgr $_2$	392	372	419	401	393	371	333	309
socgr $_3$	570	585	428	431	429	500	499	422
socgr $_4$	344	339	353	346	315	290	239	209
member $_1$	519	548	485	515	566	424	382	370
member $_2$	998	1008	939	923	986	906	874	752
member $_3$	618	631	667	614	569	508	450	407
member $_4$	1039	1003	1023	1005	868	731	666	644
age $_1$	1195	1193	1173	1086	1044	899	764	681
age $_2$	1365	1365	1404	1413	1359	1174	1091	1032
age $_3$	614	632	537	558	586	496	517	460

Note: $\text{socgr}_1 \ldots \text{socgr}_4$ represent households with head of household being employed, self-employed, retired & economically non-active and unemployed respectively.
$\text{member}_1 \ldots \text{member}_4$ represent number of observations with 1, 2, 3 and over 3 members respectively.
$\text{age}_1 \ldots \text{age}_3$ represent number of observations with head of household of age between 20-40, 41-60 and above 60 respectively.
Source: Own calculations.

Appendix C

Kernel Fitted Engel Curves in 2000–2008.

Figure 9: Kernel Regressions 2000–2008



Note: Vertical axis of each subplot refers to budget shares of individual commodity groups. Horizontal axis represents logarithm of expenditure.
Source: CZSO, authors' calculations.

Appendix D

The Quadratic Almost Ideal Demand System with Demographic Effects

It is desirable to include demographic variables in the demand analysis, as there are systematic differences in consumption behavior between households with different characteristics. Household characteristics may enter the demand system in a variety of ways. The intercept and slope parameters are dependent on household characteristics in each budget share equation of the demand system. Thus, parameters α, β, and γ are allowed to vary depending on the household characteristics. The impact of prices is the same over households. Several studies have analyzed the role of demographic determinants in demand analysis. For example, Moro and Sckokai (2000), Luhrmann (2005), and Blow (2003) stress the role of demographic determinants in demand analysis. They suggest that leaving out demographic factors from aggregate demand analysis may produce misleading results. We consider heterogeneity in age, number of household members, and employment status. Demographic variables enter the model by means of dummy variables for age, number of family members, and labor market status.

$$\ln V^h = \left(\left[\frac{\ln m^h - \ln a\left(\mathbf{p}, z^h\right)}{b\left(\mathbf{p}, z^h\right)} \right]^{-1} + \lambda\left(\mathbf{p}, z^h\right) \right)^{-1} \tag{D.14}$$

where $\ln a\left(\mathbf{p}, z^h\right)$ is the translog price aggregator function

$$\ln a\left(\mathbf{p}, z^h\right) = \alpha_{i0} + \sum_{i=1}^{n} \left(\alpha_i + \sum_{k=1}^{K} \eta_{ik}^h z_k^h \right) \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j, \tag{D.15}$$

$b\left(\mathbf{p}, z^h\right)$ is the standard Cobb-Douglas aggregator

$$b\left(\mathbf{p}, z^h\right) = \prod_{i=1}^{n} p_i^{\beta_{i0} + \sum_{k=1}^{K} \beta_{ik}^h z_k^h} \tag{D.16}$$

and $\lambda\left(\mathbf{p}, z^h\right)$ is defined as follows:

$$\lambda\left(\mathbf{p}, z^h\right) = \sum_{i=1}^{n} \left(\lambda_{i0} + \sum_{k=1}^{K} \lambda_{ik} z_k^h \right) \ln p_i \tag{D.17}$$

Indeed, the same set of restrictions defined by 5.5 and 5.6 in the case of the benchmark QUAIDS model in section 5 applies here as well. Likewise, Roy's identity is used to derive the expenditure share equation

$$w_i^h\left(m^h, \mathbf{p}, z^h\right) = \alpha_i + \sum_{k=1}^{K} \eta_{ik}^h z_k^h + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \left(\beta_{i0} + \sum_{k=1}^{K} \beta_{ik} z_k^h \right) \left[\ln \frac{m^h}{a\left(\mathbf{p}, z^h\right)} \right] + \frac{\left(\lambda_{i0} + \sum_{k=1}^{K} \lambda_{ik} z_k^h \right)}{b\left(\mathbf{p}, z^h\right)} \left[\ln \frac{m^h}{a\left(\mathbf{p}, z^h\right)} \right]^2 \tag{D.18}$$

Table 17: Estimated Parameters of the QUAIDS Model for Different Age Groups

	Food	Clothing	Energy	House	Health	Transport	Education	Other
α	0.449	0.024	0.272	-0.007	0.051	0.120	-0.136	0.226
	(0.010)	(0.004)	(0.007)	(0.005)	(0.004)	(0.006)	(0.008)	(0.010)
η_2	0.088	0.028	-0.160	0.005	-0.011	0.101	0.075	0.874
	(0.009)	(0.004)	(0.007)	(0.005)	(0.003)	(0.006)	(0.006)	(0.008)
η_3	0.085	0.006	-0.135	0.023	-0.002	0.094	0.030	0.899
	(0.009)	(0.004)	(0.008)	(0.006)	(0.003)	(0.007)	(0.007)	(0.009)
γ_1	0.102	0.022	-0.026	-0.018	-0.006	-0.040	0.019	-0.052
	(0.006)	(0.003)	(0.005)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)
γ_2	-0.097	-0.017	0.027	0.019	0.005	0.049	-0.014	0.028
	(0.006)	(0.003)	(0.005)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)
γ_3	-0.098	-0.021	0.027	0.023	0.006	0.052	-0.020	0.031
	(0.006)	(0.003)	(0.005)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)
γ_4	0.080	-0.022	0.014	-0.013	0.002	0.001	-0.030	-0.032
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
γ_5	-0.022	0.036	0.001	-0.003	0.002	0.001	-0.001	-0.013
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
γ_6	0.014	0.001	-0.005	-0.002	-0.000	-0.003	-0.003	-0.001
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
γ_7	-0.013	-0.003	-0.002	0.033	-0.002	-0.002	-0.004	-0.007
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
γ_8	0.002	0.002	-0.000	-0.002	0.005	-0.001	-0.003	-0.004
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β	0.001	0.001	-0.003	-0.002	-0.001	0.009	-0.001	-0.004
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_2	-0.030	-0.001	-0.003	-0.004	-0.003	-0.001	0.057	-0.015
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
β_3	-0.032	-0.013	-0.001	-0.007	-0.004	-0.004	-0.015	0.075
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
λ	-0.022	-0.004	-0.004	0.006	0.001	0.017	0.000	0.006
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
λ_2	0.951	-0.023	2.770	-0.286	0.041	-1.746	-1.005	-0.701
	(0.116)	(0.048)	(0.090)	(0.066)	(0.030)	(0.118)	(0.075)	(0.098)
λ_3	0.824	-0.128	2.080	-0.331	0.309	-1.634	-0.402	-0.718
	(0.136)	(0.056)	(0.107)	(0.079)	(0.035)	(0.142)	(0.091)	(0.113)
trend	-0.002	-0.002	0.002	0.007	-0.000	-0.005	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: η_2, η_3, β_2, β_3 λ_2, λ_3 reflect age of a head of a household, i.e. $20-40$, $41-60$ and above 60 respectively. The reference groups are young households with age between $20-40$. Standard errors in parentheses.
Source: Own calculations.

Table 18: Estimated Parameters of the QUAIDS Model for Different Size of a Household

	Food	Clothing	Energy	House	Health	Transport	Education	Other
α	0.452	0.002	0.279	-0.044	0.055	0.046	-0.131	0.339
	(0.011)	(0.005)	(0.007)	(0.005)	(0.005)	(0.006)	(0.008)	(0.010)
η_2	0.038	0.030	-0.156	0.070	-0.009	0.166	0.032	0.830
	(0.010)	(0.005)	(0.007)	(0.005)	(0.003)	(0.006)	(0.007)	(0.008)
η_3	0.041	0.048	-0.183	0.059	-0.015	0.171	0.070	0.811
	(0.010)	(0.005)	(0.007)	(0.005)	(0.003)	(0.006)	(0.007)	(0.008)
η_4	0.052	0.052	-0.169	0.048	-0.018	0.148	0.089	0.797
	(0.010)	(0.005)	(0.007)	(0.005)	(0.003)	(0.006)	(0.007)	(0.008)
γ_1	0.133	0.022	-0.040	0.009	-0.002	0.003	0.028	-0.153
	(0.009)	(0.005)	(0.006)	(0.004)	(0.003)	(0.003)	(0.006)	(0.007)
γ_2	-0.138	-0.016	0.043	-0.002	0.000	0.013	-0.029	0.129
	(0.009)	(0.004)	(0.006)	(0.004)	(0.003)	(0.003)	(0.006)	(0.006)
γ_3	-0.133	-0.017	0.035	-0.004	0.001	0.018	-0.028	0.128
	(0.009)	(0.004)	(0.006)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)
γ_4	-0.133	-0.016	0.043	-0.002	0.000	0.009	-0.035	0.134
	(0.009)	(0.004)	(0.006)	(0.004)	(0.003)	(0.004)	(0.006)	(0.006)
γ_5	0.087	-0.023	0.012	-0.015	0.002	-0.005	-0.028	-0.030
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.002)
γ_6	-0.023	0.037	0.000	-0.004	0.001	0.000	-0.001	-0.011
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
γ_7	0.012	0.000	-0.003	-0.002	0.000	-0.003	-0.005	0.001
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
γ_8	-0.015	-0.004	-0.002	0.033	-0.002	-0.000	-0.004	-0.006
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β	0.002	0.001	0.000	-0.002	0.005	-0.001	-0.003	-0.004
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_2	-0.005	0.000	-0.003	-0.000	-0.001	0.011	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_3	-0.028	-0.001	-0.005	-0.004	-0.003	-0.001	0.060	-0.017
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
β_4	-0.030	-0.011	0.001	-0.006	-0.004	-0.000	-0.017	0.067
	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)
λ	-0.035	-0.003	0.000	0.003	-0.001	0.008	-0.004	0.032
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
λ_2	1.424	0.617	2.158	-0.523	-0.138	-1.875	-0.017	-1.646
	(0.111)	(0.050)	(0.088)	(0.064)	(0.030)	(0.116)	(0.074)	(0.097)
λ_3	1.865	0.204	2.249	-0.519	-0.092	-1.429	-0.720	-1.557
	(0.137)	(0.061)	(0.113)	(0.083)	(0.038)	(0.152)	(0.094)	(0.118)
λ_4	2.339	0.205	2.303	-0.193	-0.108	-1.640	-1.756	-1.151
	(0.144)	(0.064)	(0.117)	(0.085)	(0.040)	(0.156)	(0.096)	(0.127)
trend	-0.002	-0.002	0.002	0.007	-0.000	-0.004	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: η_2, η_3, η_4, β_2, β_3, β_4, λ_2, λ_3,λ_4 reflect a number of household members, i.e. 2, 3 and over 3 respectively. The reference groups are households with one member. Standard errors in parentheses.
Source: Own calculations.

Table 19: Estimated Parameters of the QUAIDS Model for Reflecting Position on the Labor Market

	Food	Clothing	Energy	House	Health	Transport	Education	Other
α	0.504	0.034	0.255	-0.031	0.043	0.170	-0.119	0.143
	(0.008)	(0.003)	(0.006)	(0.004)	(0.003)	(0.006)	(0.007)	(0.007)
η_2	0.018	0.025	-0.131	0.034	-0.009	0.032	0.089	0.942
	(0.009)	(0.004)	(0.007)	(0.005)	(0.002)	(0.007)	(0.006)	(0.007)
η_3	0.056	0.000	-0.100	0.052	0.001	0.017	0.025	0.950
	(0.009)	(0.004)	(0.007)	(0.006)	(0.003)	(0.008)	(0.007)	(0.008)
η_4	0.105	0.017	-0.095	0.012	-0.013	0.012	0.061	0.901
	(0.009)	(0.004)	(0.007)	(0.005)	(0.002)	(0.008)	(0.007)	(0.008)
γ_1	0.056	0.014	-0.013	0.008	-0.002	-0.076	0.014	-0.003
	(0.004)	(0.002)	(0.003)	(0.002)	(0.001)	(0.003)	(0.003)	(0.004)
γ_2	-0.054	-0.013	0.019	-0.007	0.001	0.081	-0.014	-0.015
	(0.005)	(0.002)	(0.004)	(0.003)	(0.001)	(0.004)	(0.003)	(0.004)
γ_3	-0.054	-0.016	0.012	-0.002	0.003	0.088	-0.019	-0.011
	(0.004)	(0.002)	(0.004)	(0.003)	(0.001)	(0.003)	(0.003)	(0.004)
γ_4	-0.041	-0.014	-0.004	-0.007	0.002	0.096	-0.015	-0.017
	(0.005)	(0.002)	(0.004)	(0.003)	(0.001)	(0.003)	(0.003)	(0.004)
γ_5	0.081	-0.019	0.013	-0.014	0.001	0.004	-0.027	-0.038
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
γ_6	-0.019	0.036	0.001	-0.004	0.002	0.001	-0.001	-0.017
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
γ_7	0.013	0.001	-0.007	-0.001	-0.000	-0.001	-0.002	-0.003
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
γ_8	-0.014	-0.004	-0.001	0.033	-0.002	-0.001	-0.005	-0.007
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β	0.001	0.002	-0.000	-0.002	0.006	-0.001	-0.003	-0.003
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
β_2	0.004	0.001	-0.001	-0.001	-0.001	0.002	-0.001	-0.002
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
β_3	-0.027	-0.001	-0.002	-0.005	-0.003	-0.001	0.057	-0.018
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
β_4	-0.038	-0.017	-0.003	-0.007	-0.003	-0.002	-0.018	0.087
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
λ	-0.014	-0.003	-0.006	0.000	-0.000	0.025	0.001	-0.003
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
λ_2	1.012	-0.162	2.371	-0.412	-0.008	-0.999	-1.332	-0.470
	(0.209)	(0.088)	(0.166)	(0.126)	(0.055)	(0.226)	(0.144)	(0.174)
λ_3	0.213	-0.156	1.690	-0.410	0.275	-0.942	-0.476	-0.195
	(0.134)	(0.056)	(0.105)	(0.079)	(0.035)	(0.142)	(0.092)	(0.110)
λ_4	0.289	0.142	0.605	-0.086	0.096	-0.348	-0.621	-0.077
	(0.148)	(0.062)	(0.115)	(0.088)	(0.038)	(0.157)	(0.101)	(0.122)
trend	-0.002	-0.002	0.002	0.007	-0.000	-0.004	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: η_2, η_3, η_4, β_2, β_3, β_4, λ_2, λ_3,λ_4 represent groups of self-employed, retired & economically non-active and unemployed respectively. The reference groups are employed heads of households. Standard errors in parentheses.
Source: Own calculations.

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ISSN 1803-7070