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Effects of Price Shocks on Consumer Demand: Estimating the QUAIDS Demand System on Czech Household Budget Survey Data*

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Abstract
The purpose of this paper is to provide estimates of price and income elasticities of Czech consumer demand, which can be used when analyzing the impact of exogenous price changes on consumer behavior. We estimate a demand system in which demand depends on income, prices and other socio-economic household characteristics. We combine the Household Budget Survey data with information on prices from alternative sources between 2000 and 2008. 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. Clothing, transportation, education and leisure are luxury goods, with income elasticity above one. We found expenditure on energy and transportation and communication to be the most elastic 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.

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. Thus, understanding, analyzing, simulating and forecasting private consumption is of prime interest to economists and policymakers, 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]

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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]

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 those 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 lifecycle 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

[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 a 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.

[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.

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 aforementioned 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 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. Finally, a recent study by Janský (2014) uses Czech household budget survey data from 2001 to 2011 to estimate a QUAIDS demand system. The author applies the estimates to simulate the impact of past and planned VAT reforms on tax revenues in the Czech Republic. As the main difference from Janský (2014), we simulate the impact of changes in regulated prices on consumer demand based on the QUAIDS estimates.

[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).

[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.

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, we specify the QUAIDS system for selected bundles of goods. Third, we estimate the resulting system of equations using the non-linear SUR method, describe the estimated parameters and quantify the elasticities of interest. Finally, we simulate the impact of a change in regulated prices on aggregate consumer demand and the demand for different commodity groups.

2. Data and Aggregation

There are several benefits in using detailed microdata 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 and region. Household budget data provide information concerning household consumption patterns, sources of income and various demographic variables.

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[10] and income groups is the same as in other countries following the structure of Household Budget Surveys. Our sample covers the years 2001 to 2008. The data set covers roughly 3,000 households each year.[11] Unfortunately, some groups of consumers are not well represented in the sample until 2004.[12] 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.[13]

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 the aggregation, the easier it is to estimate a demand system. There are several benefits to higher aggregation. In particular, the variation

[10] We have excluded investment-like expenditures, such as the purchase of real estate or financial securities. Our eight consumption groups contain mainly non-durable and semi-durable goods and services. However, expenditures on durable goods, such as transport equipment or home electronics, are also included.

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

[12] We would like to thank Jan Brůha for informing us about peculiarities related to data before 2005.

[13] We recalculated all the outcomes presented in this work for both the 2001–2008 and 2005–2008 intervals. The full-sample result is available upon request. To roughly check the stability of our results, Appendix C of our working paper Dybczak *et al.* (2010) presents Engel curves estimated for individual years from 2001 to 2008. In addition, Appendix B provides descriptive statistics of the sample for each year from 2001 to 2008.

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 multistage budgeting.[14] 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.[15] 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 cleanse 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.[16] 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.[17] 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%.[18]

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 levels of demand for different commodity bundles. In particular, one can recognize if the commodities of interest are substitutes or complements, or 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 consumer price index (CPI) are observed at a more disaggregated level than the consumption items contained in the Household Budget Survey. Therefore, we matched a weighted average unit price from the CPI statistics to each consumption item with unobserved

[14] Janda *et al.* (2009) provide an intuitive introduction to multistage budgeting.

[15] Detailed definitions of the eight commodity bundles are provided in Appendix A.

[16] See, for example, Janda *et al.* (2009), who examine prices of three types of alcoholic beverages.

[17] Note that unit prices are not surveyed directly in the budget survey. We compute them as the ratio of reported expenditures and physical amounts consumed or fill them in from more aggregated price statistics if physical amounts are missing. Based on our impression from checking parts of the price data in detail, we believe that, by excluding the top and bottom percentiles of unit prices, we got rid of erroneous data in the majority of cases.

[18] Descriptive statistics and numbers of observations for each year can be found in Appendix B.

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 in 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 lifecycle hypothesis to explain how household consumption of goods and services changes in the course of a household's lifecycle.

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, employment status, education, region of residence and wealth. 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.[19] 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.

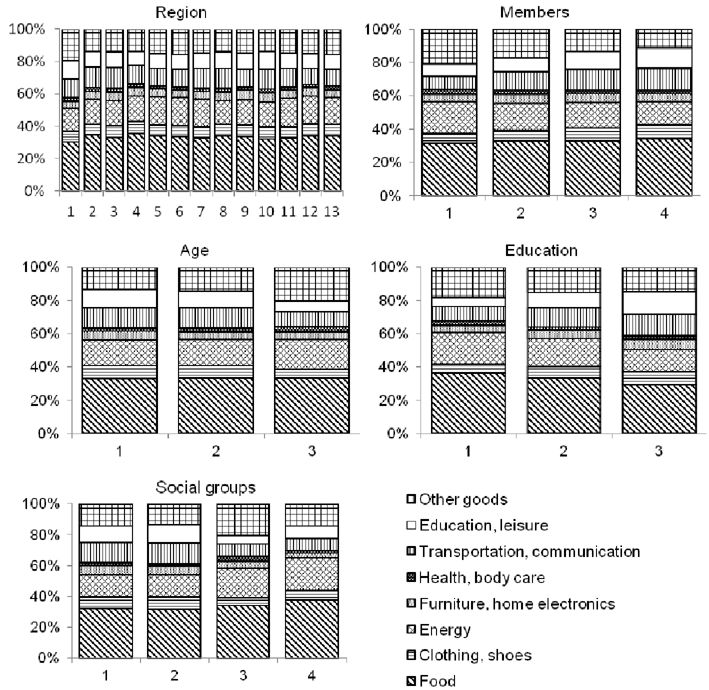
Concerning our analysis, the dataset consists of many demographic variables and other non-income variables representing individual household characteristics. Using Czech Household Budget Survey data from 2001 to 2008, we depict consumption shares in *Figure 1*, disaggregating households by place of residence, number of family members, age, education and employment status of the household head.

As there are 13 regions in the Czech Republic, we can depict average consumption shares per region.[20] In the literature, differences among regions within a country are typically not found 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 1*, subfigure 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

[19] For example, Abdulai (2002) uses the size of the household, the respondent's age, education and employment status, and region.

[20] The 13 regions are Prague, Central Bohemia, South Bohemia, Plzeň, Karlovy Vary, Ústí nad Labem, Liberec, Hradec Králové, Pardubice, Vysočina, South Moravia, Olomouc, Zlín and Moravia-Silesia.

Figure 1 Consumption Shares Depending on Demographic Characteristics, 2000–2008



Notes: The 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, Plzeň, Karlovy Vary, Ústí nad Labem, Liberec, Hradec Králové, Pardubice, Vysočina, South Moravia, Olomouc, Zlín, and Moravia-Silesia. Sub-figure Number: 1–4 refers to one, two, three and more than three 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.

Sources: CZSO and the authors' calculations.

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. Conversely, 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 1*, sub-figure Members, refers to these observations. In this sub-figure we distinguish between single-person households and households with two, three and more than three 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 that 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, healthcare spending is expected to rise with age. These observations are in line with our results presented in *Figure 1*, 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 1*, 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 *Figure 1* and is in line with the related consumer demand literature.

4. 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.[21]

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:

$$\ln V = \left(\left[\frac{\ln m - \ln a(\mathbf{p})}{b(\mathbf{p})} \right]^{-1} + \lambda(\mathbf{p}) \right)^{-1} \tag{4.1}$$

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

$$\ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln(p_i) + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln(p_i) \ln(p_j) \tag{4.2}$$

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

$$b(\mathbf{p}) = \prod_{i=1}^{n} p_i^{\beta_i} \tag{4.3}$$

and

$$\lambda(\mathbf{p}) = \sum_{i=1}^{n} \lambda_i \ln p_i \tag{4.4}$$

We must also impose the following restrictions derived from economic theory. In particular, we need to enforce the additivity, homogeneity and symmetry of the Slutsky matrix. Additivity (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, the negative semi-definiteness[22] 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:

$$\sum_{i=1}^{n} \alpha_i = 1 \quad \sum_{i=1}^{n} \beta_i = 0 \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \quad \sum_{i=1}^{n} \lambda_i = 0 \tag{4.5}$$

An additional restriction guarantees that the indirect utility function is homogeneous of degree zero in m and $\mathbf{p}$:

$$\sum_{i=1}^{n} \gamma_{ij} = 0 \quad \forall j \tag{4.6}$$

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

$$\gamma_{ij} = \gamma_{ji} \tag{4.7}$$

[21] Fisher *et al.* (2000) analyze the properties of alternative functional forms of demand systems. They conclude that 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.

[22] Unfortunately there is no simple way of imposing the negative semi-definiteness restriction on our estimator. We are left with checking whether this property is fulfilled by our estimates ex-post. See subsection 5.2 for related results.

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

$$w_i(\mathbf{p}) = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \left[\ln \frac{m}{a(\mathbf{p})} \right] + \frac{\lambda_i}{b(\mathbf{p})} \left[\ln \frac{m}{a(\mathbf{p})} \right]^2 \tag{4.8}$$

Finally, the parameters of the system of eight equations defined by 4.8 and restrictions 4.5, 4.6 and 4.7 will be estimated and analyzed.[23]

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 4.8 with respect to the logarithm of total expenditure and the logarithm of prices, one derives expressions 4.9 and 4.10, which are used afterwards to quantify income elasticity and both uncompensated and compensated price elasticities, respectively.

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(\mathbf{p})} \ln \frac{m}{a(\mathbf{p})} \tag{4.9}$$

$$\mu_{ij} \equiv \frac{\partial w}{\partial p_j} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_k \gamma_{jk} \ln p_k \right) - \frac{\lambda_i \beta_i}{b(\mathbf{p})} \ln^2 \frac{m}{a(\mathbf{p})} \tag{4.10}$$

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

$$e_i = \frac{\mu_i}{w_i} + 1 \tag{4.11}$$

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

[23] Section 5 describes the estimation strategy and comments on the estimated parameters.

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, a positive e_{ij} indicates gross substitutes and negative e_{ij} indicates gross complements. A zero value of e_{ij} suggests independent goods. The uncompensated price elasticity in the case of QUAIDS is defined as follows:

$$e_{ij}^{u} = \frac{\mu_{ij}}{w_i} + \delta_{ij} \tag{4.12}$$

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:

$$e_{ij}^{c} = e_{ij}^{u} + e_i w_i \tag{4.13}$$

5. 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.

5.1 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.[24] 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 suggested 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),

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

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.[25]

First, we estimate the stochastic version of the demand system for a representative household defined by Equation 4.8. 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.[26] For all estimated variants, we account for structural changes in consumer preferences over time by introducing a time trend[27] 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 5.2 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 decreases slightly over time, while the budget share of energy and furniture and home electronics rises. 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 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.[28] In order to reflect the impact of demographic

[25] 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.

[26] Appendix D of our working paper Dybczak *et al.* (2010) discusses in more detail the effect of alternative household characteristics on household demand for commodities.

[27] The descriptive statistics of sample mean expenditure shares by years (*Appendix B*) suggest the presence of a mild time trend with some minor fluctuations around it. Those fluctuations may arise due to changes in the relative prices of the commodity bundles, so we did not want to remove them with time dummies.

[28] 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 of our working paper Dybczak *et al.* (2010).

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 parentheses.
Source: The authors' own calculations.

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 is roughly in line with the estimates referring to the representative household estimates presented in *Table* 1.[29] Based on the results, 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

[29] The estimates of the extended model can be found in Tables D16, D17, and D18 of our working paper Dybczak *et al.* (2010).

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: The authors' own calculations.

dummy variables were found to be statistically significant. Subsection 5.2 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 *7* 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 using the fitted values of expenditure shares w_i 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 due to space constraints we present only the average over all households.[30] *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. Conversely, 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 group most sensitive 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.[31] 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.[32] 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 communica-

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

[31] Similarly to the budget elasticities above, the fitted expenditure shares are used to compute the price elasticities for each household individually. The price elasticities reported in *Tables 3* and *4* are sample averages.

[32] 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.

Table 3 Uncompensated Price Elasticities

	Food	Clothing	Energy	House	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)

Notes: An elasticity gives information about a percentage change in the quantity demanded for a good in row *i* as the price of a good in column *j* increases by 1%. Standard errors provided in parentheses.

Source: The authors' own calculations.

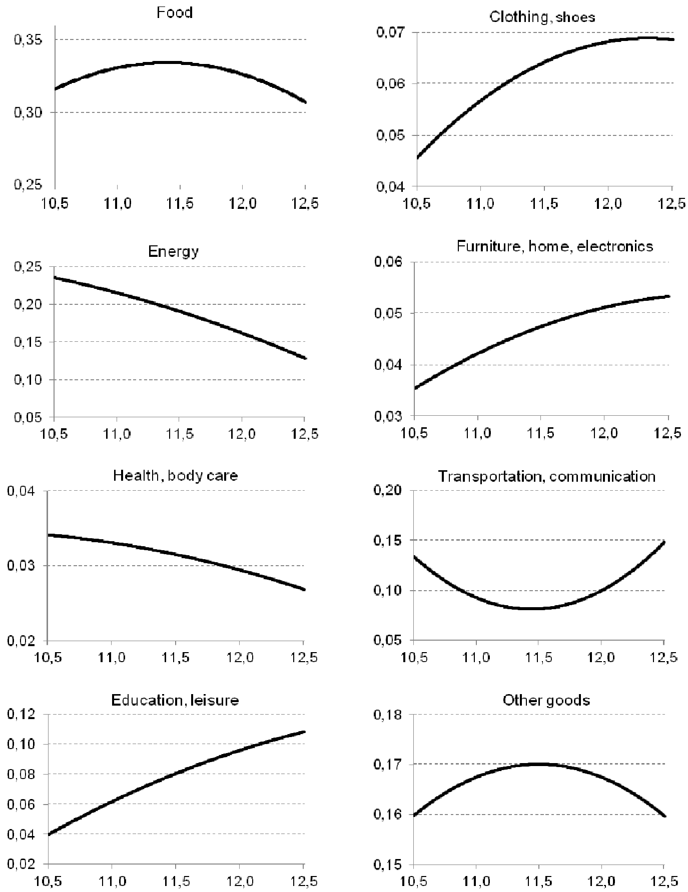
Table 4 Compensated Price Elasticities

	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)

Notes: An elasticity gives information about a percentage change in the quantity demanded for a good in row *i* as the price of a good in column *j* increases by 1%. Standard errors provided in parentheses.

Source: The authors' own calculations.

Figure 2 Fitted Engel Curves Using QUAIDS, 2005-2008



tion includes fuels, one might conclude that households tend to follow prices of crude materials and energy relatively closely and adjust their consumption behavior appropriately. Conversely, 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 2*, food seems to be a luxury for low-income households and a necessity for high-income households. Conversely, transportation and communication follow the opposite pattern, i.e. low-income

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-labor market effect	1014	63	0.00

Notes: L_Ω and L_Ψ represent the unrestricted and restricted maximum likelihood. The test statistics have an asymptotic $\chi^2(k)$ distribution with k representing the number of required restrictions.

Source: The authors' own calculations.

households perceive this commodity group as a necessity, while high-income households perceive these commodities as luxuries. 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.[33]

5.2 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 4, 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 imposition of 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 4.8. Second, we test the relevance of the imposed homogeneity and symmetry restrictions given by 4.5, 4.6 and 4.7. When testing homogeneity, we impose only the adding-up restriction given by 4.5 in the case of the unrestricted model. In the case of symmetry, the unrestricted model is defined by the adding-up and homogeneity restrictions,[34] i.e. by 4.5 and 4.6. 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.

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 line-

[33] Engel curves according to different household characteristics can be found in our working paper Dybczak *et al.* (2010).

[34] We did not mention the negative semi-definiteness (NSD) property of the Slutsky matrix, which is also required by the QUAIDS model. However, this restriction cannot be imposed when estimating the SUR system. Therefore, we could only check whether our estimated Slutsky matrix is NSD. Based on our point estimates, we have verified that the aforementioned property is satisfied, though we did not test it statistically and left the issue of testing for future research.

arity 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.[35] The last three rows of the table suggest that individual demographic effects cannot be rejected.[36]

5.3 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.[37]

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.[38] In particular, regulated prices were the main driver of inflation in 2008 and remained so during 2009. Furthermore, regulated prices tend to change abruptly from one year to the next. Also, if regulated prices are adjusted, the change is often very large. For example, the price of energy jumped by almost 40% in 2002 and TV and radio and healthcare fees also rose 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 healthcare. In addition, faster convergence of regulated rents to their market level contributed to inflation in 2008 and 2009.

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

[36] 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.

[37] Other possible situations to simulate using our model include, for example, a change in world energy prices or a 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.

[38] 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.

Table 6 Share of Commodities with Regulated Prices in Each Commodity Bundle

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: The authors' own calculations.

Table 7 Impact of a 30% Increase in Regulated Prices 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: The authors' own calculations.

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.[39]

To simulate realistic adjustments in regulated prices, we need to take the following steps: first, we quantify the shares of the five regulated prices in the specific commodity bundles. *Table 6* distributes all 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.

To save space, we present here only the total effects of adjustments in individual regulated prices on aggregate consumer demand, but not on the demand for each commodity bundle separately.[40] *Table 7* provides estimates of the reduction in the overall quantity demanded assuming a unitary 30% shock to each regulated price. Not surprisingly, we find that regulated rents and energy prices play a crucial role. The estimated effects on aggregate demand are expected to be -2.7% and -1.5%, respectively. The role of healthcare, postal services, and TV and radio fees seems to be substantially lower, i.e. below 1% in absolute terms.

6. Conclusion

Our analysis is conducted on the household level using Czech Household Budget Survey data and information on prices from alternative sources from 2005 to

[39] Further details of the aforementioned developments of regulated prices can be found in Box 2 on pages 30–31 of the Czech National Bank's Inflation Report IV/2009 at http://goo.gl/WjJzn6.

[40] The more detailed results can be found in our working paper Dybczak *et al.* (2010).

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.

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 group most sensitive 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 remained so during 2009. Second, regulated prices tend to change abruptly from one year to the next. 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) healthcare fees, (3) transportation, (4) TV and radio fees, and (5) regulated rents. In each simulation, we augment a specific regulated price by 30%. Comparing the effects of adjustments in individual regulated prices on aggregate demand, we find that regulated rents and energy prices play a crucial role. The role of healthcare, postal services, and TV and radio fees seems to be substantially lower.

Appendix A Definitions of Commodity Bundles

Table A8 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 & Shoes	301 . . . 310	Clothing
	321 . . . 327	Foot ware
	431, 432	Repair/hire of clothing/footwear
Health & Body Care	336 . . . 339	Medical products/appliances
	471 . . . 475	Outpatient services
	443	Hairdressing
Furniture & Home Electronics	340 . . . 349	Furniture and furnishings
	351 . . . 357	Household appliances
	436, 437	Maintenance/repair of the dwelling and appliances
Education & Leisure	371 . . . 376	Audio-visual, photographic, IT eq.
	381 . . . 384	Other recreational items and equipment
	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 & Communication	411 . . . 418	Passenger transport by railway, road, air
	364	Fuels/lubricants for personal transport equipment
	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.

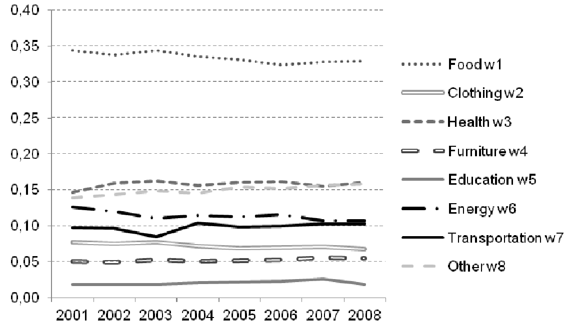
Appendix B Descriptive Statistics

Table B9 Descriptive Statistics

	2001	2002	2003	2004	2005	2006	2007	2008
w_1	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_2	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_3	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_4	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_5	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_6	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_7	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_8	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_1	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_2	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_3	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_4	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_5	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_6	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_7	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_8	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: Sample means; standard errors in brackets.
Source: The authors' own calculations.

Figure B3 Sample Average Consumption Shares by Years



Source: The authors' own calculations.

Table B10 Numbers 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

Notes: $socgr_1$ . . . $socgr_4$ represent households with head of household being employed, self-employed, retired & economically non-active and unemployed respectively.

$member_1$ . . . $member_4$ represent number of observations with 1, 2, 3 and over 3 members respectively.

age_1 . . . age_3 represent number of observations with head of household of age between 20–40, 41–60 and above 60 respectively.

Source: The authors' own calculations.

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