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Abstract

Computable general equilibrium (CGE) models require external parameters for proper estimations and can be relatively sensitive to the elasticity estimates used in them. We estimate LES demand elasticities and Frisch parameters for all Finnish household income deciles. These estimates will be used also in VATTAGE CGE model. We use three different methodologies for the estimation of demand elasticities: price index based approach, pseudo-panel dataset based regressions with exogenous Frisch parameters, and finally cross-section data based estimations with the Frisch parameters. Only the last methodology provides adequate results despite the use of detailed and extensive data. We conclude that the estimation of LES demand elasticities for narrow commodity groups is cumbersome with standard household consumption survey data. Typically these surveys account consumption only from a time period of a few weeks. The chance of consuming various durable consumption items during such a short time period is low. Use of longer survey periods could decrease the share of zero consumption observations and help on the identification of elasticities.

Key words: demand elasticity, linear expenditure function, household consumption data, computable general equilibrium

JEL classification numbers: D12, C68

Tiivistelmä

Yleisen tasapainon (YTP) mallinnuksessa luotettavien tulosten saaminen edellyttää valideja arvoja eksogeenisille joustomuuttujille. Mallinnustulokset voivat olla herkkiä käytetyille joustoille. Tässä työssä estimoitiin useita LES-kysyntäjoustoja sekä Frisch parametrit eri tulodesiileille suomalaista VATTAGE YTP-mallia varten. Joustojen estimoimiseksi kokeiltiin kolmea eri metodia: joustojen laskemista suoraan hintaindeksien avulla, pseudo-paneeli tietokannan käyttöä yhdessä eksogeenisten Frisch parametrien kanssa ja poikkileikkausaineistoja Frisch parametrien kanssa. Vain viimeinen näistä metodeista tuotti järkeviä tuloksia, vaikka käytössämme oli runsaasti hyvin hienojakoista tulonjakoaineistoa. Tämä viittaa siihen, että LES-kysyntäjoustojen estimoiminen pienille tuoteryhmille on hankalaa tavallisten kulutustutkimusaineistojen avulla. Tyypillisesti tulonjakoaineistot mittaavat kulutustietoja vain lyhyiltä aikajaksoilta. Todennäköisyys kestokulutushyödykkeiden ostamiseen näillä ajanjaksoilla on pieni. Pidempien aikajaksojen käyttäminen kulutustutkimuksissa voisi vähentää nollahavaintoja ja helpottaa joustojen identifioimista.

Asiasanat: kysyntäjousto, LES kysyntäfunktio, kulutustutkimusaineisto, yleisen tasapainon mallit

JEL-luokittelu: D12, C68

Summary

Computable general equilibrium (CGE) models require external parameters for proper estimations and can be relatively sensitive e.g. to the utility forms and elasticity estimates used in them. We derive household income decile specific Frisch parameters and income and own price elasticities for a Finnish VATTAGE CGE model based on the linear expenditure system (LES). We use data from Finnish household consumption surveys from three years, with around 4000-5000 observations in each of the annual databases.

Our main conclusion is that it is very difficult to obtain good estimates on household's income and price demand elasticities based on the LES function, even with detailed and extensive data. We use three different methodologies for the estimation of demand elasticities.

First, we try the estimation of the elasticities with the help of consumer price index information and the use of full pseudo-panel data. Because the price indexes do not vary enough between product groups, these estimations fail due to multicollinearity. The second approach for the estimations is the use of exogenous Frisch indexes together with the full pseudo-panel database. With this approach, the estimation method proposed by Creedy (2001) fails again, mostly because the panel has only three time periods included. Further, the data has a lot of zero consumption observations for various products. Typically household consumption surveys account consumption only from a time period of few weeks. The chance of consuming various durable consumption items during such a short time period is low.

The last, and slightly more successful, estimation approach is the use of Frisch indexes with cross-section data. This provides us relatively credible results for some 40 commodity groups. We could also obtain results on the elasticities between different household income deciles. According to the results, product groups that have relative large elasticities in general display most differences in the elasticity estimates across household income deciles. The sector specific elasticity estimates match fairly well previous results. However, we have some doubt on the obtained results since they are based only on data from one year and we recommend other estimation methods to be considered in the future. The binary choice of households for the consumption of some product at all might be specifically important to control for with a separate probit model. Similarly, the use of longer survey periods of household consumption surveys could help on the identification of elasticities.

1. Introduction

There is growing interest in the field of applied economic research to study the effects of changes in policies and economic structures. Computable general equilibrium (CGE, called also applied general equilibrium) models have become increasingly popular in studying these effects. They can quickly calculate the impacts of various shocks or policy changes on different sectors and economic indicators, while also taking into account the dynamics of the impacts and any possible secondary effects. However, these models require external parameters for proper estimations and can be relatively sensitive e.g. to the utility forms and elasticity estimates used in them (Willenbockel, 2004).

CGE models usually present household demand as a maximization problem where the economic agents maximize their utility by consuming as much as possible subject to their income (it should be noted that saving is considered as one consumption item). With the help of the utility functions we can derive the demand functions of the households. Estimating the levels of different elasticities is crucial for the determination of the utility and demand functions and for gaining reliable modelling results.

It is possible to depict household demand in general equilibrium models with several functional forms which are based on the maximization of the utility function subject to the budget constraint. The main focus in this paper is on the linear expenditure system. It is one of the easiest to use both theoretically and econometrically and it is also consistent with demand theory. With the help of this model we try to derive household income decile specific income and own price elasticities for the Finnish VATTAGE CGE model. The calculation of income decile specific elasticities would allow us to determine specific demand functions for the 10 representative households with different income levels. However, in practice, during this study and our estimation efforts we mostly learned how difficult it is to estimate these elasticities at detailed commodity levels even with relatively large household level pseudo-panel data. We tried three different main methods for the estimation: price index based approach to estimate demand price elasticities, pseudo-panel dataset based regressions and the use of an exogenous Frisch parameter, and finally cross-section data based estimations with the Frisch parameter. Only the third method tried provided us results and even those results should be still compared with results from other, more sophisticated estimation methods.

The paper is organized as follows. Section 2 deals with the basics of general equilibrium model whereas section 3 presents the derivation of linear expenditure system and demand elasticities. The different practical possibilities for the estimation of these elasticities are also presented in section 3. Finally, we present our results in section 4 and conclude in section 5.

2. Computable general equilibrium models

Computable general equilibrium (CGE) models have become popular in recent decades for the analysis of policies or external shock's effects on the economy. The models have been used to estimate how an economy might react, for example, to changes in environmental policies or changes in taxes. Increasingly, dynamic CGE models are used also for forecasting and scenario analysis. However, the aim of CGE model estimations is to give an indication of the direction and size of the effects rather than to forecast the exact outcome of a change in policy. (Honkatukia, 2009)

The first systematic study on CGE models was made by Johansen in 1960. In his paper Johansen studied a multisectoral growth of 1960 for Norway. Later on, Scarf (1967) provided an algorithm that helped to compute the static equilibrium for the competitive economies. His work raised interest in CGE modelling towards the 1970s. Starting from the early 1970's Shoven & Whalley (1972, 1973, 1974) have been among of the major contributors to the field. Today CGE modelling is one of the main tools in applied economics for ex-ante impact assessments. Several textbooks and leading journals have published on the topic and several universities have included the field to their curricula. (Dixon & Parmenter, 1996)

CGE models are characterized, as suggested by its name, by computability and generality. Computability means that the models produce numerical results and thus, use numerical data in order to get the coefficients and parameter values for the equations. The data is often a set of input-output accounts but also data e.g. on income flows and income distribution are needed. (Dixon & Parmenter, 1996; Honkatukia, 2009)

Generality suggests that the model explicitly includes the optimizing behaviour of economic agents. Households are represented as utility maximizers and firms maximize profits or minimize costs. Product and factor prices play an important role in determining the decisions made by households and firms on consumption and production. The models employ also market equilibrium assumptions. This means that according to the economic theory, demand and supply are assumed to balance. In other words, the model explains how the supply and demand decisions made by the economic agents affect the determination of prices and how the prices change in order to bring the economy to equilibrium. (Dixon & Parmenter, 1996; Honkatukia, 2009)

CGE models are based on a database that describes the initial state of the economy. The database most commonly used is the social accounting matrix (SAM) that represents all the flows of economic transactions during the base year. SAM is expressed in a matrix form, which means that each transaction is represented both as expenditure (column) and as receipt (row). Finally, all the columns and rows are added up in order to ensure the equilibrium and accounting consistency. The column sums must equal the corresponding row sums. The flows in SAM are based on the standard national accounts (SNA), which enable international comparisons. SAM can also be extended to include other flows of the economy simply by adding more columns and rows. (Mitra-Kahn, 2008)

Instead of being estimated, many parameters of CGE models are calibrated. Calibration refers to the estimation of numerical parameter values for the model based on SAM information on prices and quantities. However, the information contained in SAM is sometimes inadequate. This means that it is impossible to calibrate all the parameters needed and that calibration might lead to poor estimates of the true parameters. Therefore estimation of some parameters is also required.

The ongoing debate in applying CGE models is the validity of key behavioural parameters used in the calibration process. In a lot of the cases instead of estimating the parameters they are borrowed from estimates available in literature. The CGE results have been shown to be very sensitive to the parameter values. Hence, key parameters estimation is very crucial.

Elasticities are among the most important parameters that need to be estimated from external data sources for CGE models. In this study we will limit ourselves to the estimation of the crucial income and price demand elasticities for the VATTAGE CGE model of VATT. In the VATTAGE model the linear expenditure system is used to illustrate the consumption behaviour of the consumers. Hence, the next section introduces the linear expenditure system and how these consumption elasticities can be estimates based on it. Appendix 1 also shortly introduces three other functional forms of demand theory.

3. Linear expenditure system

The linear expenditure system (LES) is a functional form often-used to model the behaviour of the household sector. Consumers make decisions on how to spend their budget on goods and services based on their preferences. The linear expenditure system models this consumption decision made by the households.

Linear expenditure system was first introduced by Stone (1954) and ever since it has been one of the most used functional forms to model household behaviour in CGE models. LES is very easy to deal with both theoretically and econometrically, which accounts for its popularity in empirical studies. There are also several requirements that have to be met when choosing a functional form in CGE models and LES meets these requirements. It is continuous, homogenous of degree zero and it satisfies Walras's law (i.e. household expenditure equals household incomes with any set of prices). Hence, it is consistent with demand theory. (Stone, 1954; Deaton, 1993) Further on, it accounts for the fact that, for many commodities, people have some mandatory amount that they need for subsistence, while only the rest of the consumption is voluntary. The income elasticities of the mandatory consumption parts are assumed to be practically zero (i.e. completely inelastic), while the elasticities for the so-called luxury parts of the consumption vary by product. However, a drawback of the model is that the Engel curves are straight lines, which follows from the assumption of constant marginal budget shares. Engel curves describe the relationship between expenditure on product *i* and total expenditure on all products.

3.1 Derivation of LES demand function and demand elasticities

The linear expenditure system can be derived from maximizing the Stone-Geary direct utility function subject to household budget constraint. The derivation of LES function follows Blonigen, Flynn and Reinert (1997) and Loughrey and O'Donoghue (2011). The Stone-Geary (also known as Klein-Rubin utility function) is defined as:

$$U = (x_1 - \gamma_1)^{\beta_1}(x_2 - \gamma_2)^{\beta_2} \cdots (x_n - \gamma_n)^{\beta_n}, \tag{1}$$

and we can write the household maximizing problem as:

$$\text{max:}\, U = \prod_i (x_i - \gamma_i)^{\beta_i} \;\; s.t. \;\; \sum_i p_i x_i = y \tag{2}$$

or expressed in the log-form:

$$\text{max:}\, U = \sum_i \beta_i \log(x_i - \gamma_i) \;\; s.t. \;\; \sum_i p_i x_i = y. \tag{3}$$

Here x_i is the consumption quantity for product i, p_i is its price and y is the total expenditure or income of the households. The LES parameters $\beta_i > 0$ and $\gamma \geq 0_i$

are respectively the marginal budget share of product i and the subsistence (or minimal) consumption of the same. We also have the following characteristics for the equations: $0 < \beta_i < 1$, $(x_i - \gamma_i) > 0$ and $\sum_i \beta_i = 1$.

With the help of Lagrangian we can derive the Marshallian demand functions of households for product *i*:

$$x_i = \gamma_i + \left(\frac{\beta_i}{p_i}\right)\left(y - \sum_j p_j \gamma_j\right). \tag{4}$$

When expenditure is a linear function of income and prices, it is useful to multiply the equation (2.3) by prices p_i. This gives us a linear function:

$$p_i x_i = p_i \gamma_i + \beta_i \left(y - \sum_j p_j \gamma_j\right), \tag{5}$$

which is known as the linear expenditure system. Here $\sum_j p_j \gamma_j$ is the committed level of expenditures and $y - \sum_j p_j \gamma_j$ is the uncommitted income. The interpretation of the model is that consumers spend a committed amount on each product and after that divide the remaining uncommitted income among all products in fixed amounts β_i. From the above equation we can see that the Engel curve is a straight line, which results from the earlier assumption of constant marginal budget shares.

The linear expenditure system can further be used to derive the demand elasticities. This is done by differentiating the equation with regard to (w.r.t.) p_i and p_j for own- and cross-price elasticities and w.r.t. *y* for the income elasticity and after this multiplying by p_i/x_i, p_j/x_i and y/x_i respectively. Elasticities measure the percentage variation in one variable to a variation in another variable. The own-price elasticity measures the change in the demand of a commodity i when the price of that commodity changes. The cross-price elasticity measures the change in the demand of commodity i when the price of commodity *j* changes.

The own-price elasticities are derived as:

$$e_{ii} = \frac{\gamma_i(1-\beta_i)}{x_i} - 1 < 0. \tag{6}$$

Because of the decreasing slope of the household demand curve, the own-price elasticity is usually negative. This means that a rise in the price of a commodity leads to a decrease in the demand of that commodity.

Cross-price elasticities are:

$$e_{ij} = -\frac{\beta_i \gamma_j p_j}{p_i x_i}. \tag{7}$$

If the elasticity is positive, the commodities are said to be substitutes. Thus an increase in the price of the commodity j increases the demand of commodity i. With a negative elasticity value, the commodities are said to be complementary. Then an increase in the price of commodity j decreases the demand of commodity i.

Income elasticity assesses the change in demand for a commodity i when the income of the representative household changes. The income elasticity is defined as:

$$e_i = \frac{\beta_i y}{p_i x_i} = \frac{\beta_i}{w_i} > 0 \quad \Rightarrow \quad \beta_i = \frac{p_i x_i e_i}{y} = w_i e_i \qquad (8)$$

In the case of income elasticity we can distinguish three groups of commodities: luxury goods, normal goods and inferior goods but inferior goods are excluded when using the linear expenditure system.

3.2 Estimation of LES parameters and elasticities in practice

Annabi et al. (2006) acknowledge the problem of several free parameters in the calibration process when using a LES function. The calibration of LES function can be done either 1) by estimating income and price elasticities directly or 2) by estimating first only income elasticities and then using exogenous Frisch parameters to obtain price elasticities. So, in essence, the two possible approaches differ on how price elasticities are estimated. We will first present the way to estimate the income elasticities. After that we present the different possibilities for price elasticities estimation.

In practise, we tried all mentioned methodological possibilities for the estimation of the elasticities. We started with the use of price data, but had to leave this methodology due to estimation difficulties. After that we turned to the use of the Frisch parameter for the estimation of the price elasticities with a pseudo panel database. However, also this method failed us due to data limitations. At the end, only regressions with cross-section data, with separate estimations for all three survey years, provided us with significant results. The data issues related to the different methodological possibilities are presented in section 4.

Estimation of income elasticities

We estimate the income elasticities with a method used by Creedy (2004). All parameters in LES are estimated for the different household income groups. The calibration procedure follows that of Creedy (2001, 2004), Loughrey and O'Donoghue (2011) and Annabi et al. (2006).

We begin by introducing the budget share that is derived from the budget constraint:

$$w_i = \frac{p_i x_i}{y}. \quad (9)$$

According to Engel rule we have $\sum_i w_i e_i = 1$. With the help of budget shares we are able to derive income elasticities e_i. However, there can be a problem with some negative income elasticities because of the variability in budget shares. To overcome this problem we need to smooth the data for which Creedy (2001) introduces the following form:

$$w_{ki} = a_i + b_i \ln y_k + c_i \left(\frac{1}{y_k}\right). \quad (10)$$

Here $y_k$is the arithmetic mean value of total consumption in each household group k. The equation can be estimated either by using (pseudo)panel data or cross-section data with ordinary least square regressions. According to Creedy (2001) the form fit most of the groups reasonably well and it also ensures that the weights add to unity.

After solving the budget shares we are able to calculate the income elasticities using budget data. Following Creedy (2004) we can express income elasticity in the following form:

$$e_i = 1 + \frac{(y_k/c_i)b_i - 1}{(y_k/c_i)(a_i + b_i \ln y_k) + 1}. \quad (11)$$

Estimation of price elasticities with price information

In case price information per commodity is available, price elasticities can be estimated, for example in line with Barnes & Gillingham, 1984. However, this method requires direct price information per product or relatively detailed price index information, since the prices have to vary enough between the different observations. In case the price information does not vary significantly, multicollinearity problems often prevent the use of this approach. This happened also for us, as will be later explained in the section on data.

Estimation of price elasticities with the use of an exogenous Frisch parameter

With the help of an exogenous, separately estimated Frisch parameter, it is also possible to get estimates for the consumption function even if price data at hand is not sufficient. The Frisch parameter is the negative ratio between total expenditure and discretionary expenditure. It measures the sensitivity of the marginal utility of income to total expenditures and establishes a relationship between income and own-price elasticities. Own-price and cross-price elasticities can be derived by using the Frisch parameter in conjunction with income elasticity. (Annabi et al., 2006)

The Frisch parameter is defined as:

$$FRISCH = -\frac{y}{y-\sum_j p_j\gamma_j}, \tag{12}$$

where the supernumerary expenditure $y - \sum_j p_j\gamma_j$ represents the income available after the minimal consumption is satisfied.

With the help of the Frisch parameter we can determine the subsistence consumption level:

$$\gamma_i = x_i + \frac{\beta_i}{p_i}\left(\frac{y}{Frisch}\right) \tag{13}$$

From this we derive the own-price and cross-price elasticities. This way, the elasticities can be calculated using only household budget data. We need then information on the income elasticity, budget share and the Frisch parameter for the calculation of the price elasticities. Additivity is assumed as the utility is expressed as $\sum_i u_i(x_i)$. (Creedy, 1996)

The own-price elasticity is calculated with the help of the Frisch parameter as $(i = j)$:

$$e_{ii} = \frac{e_i}{Frisch} - e_i w_{ki}\left(1 + \frac{e_i}{Frisch}\right) \tag{14}$$

and cross-price elasticities for $i \neq j$ as:

$$e_{ij} = -e_i w_{kj}\left(1 + \frac{e_j}{Frisch}\right). \tag{15}$$

We can get values for the committed expenditure $p_i\gamma_i$ after determining values for the marginal budget share $\beta_i = w_i e_i$ that tells us the proportion of supernumerary income devoted to the supernumerary expenditure on each good. The equation for the committed expenditure is the following:

$$p_i\gamma_i = \frac{y_k w_{ki}(1+e_{ii})}{1-\beta_i} \tag{16}$$

and after, with the help of the other equations we get:

$$p_i\gamma_i = \frac{y(w_{ki}+\beta_i)}{Frisch}. \tag{17}$$

Estimation of the Frisch parameter

As seen in the previous section, after determining values for the expenditure weights and total income elasticities, we are able to calculate values for own- and cross-price elasticities with the help of the Frisch parameter. The problem with the Frisch parameter is that we cannot get direct estimates for the parameter using household budget data (Creedy, 2004). Hence, many research papers use external information in specifying the Frisch parameter(s).

There has been constant debate about the Frisch parameter and whether or not it varies with income and if it does vary, what is the form of such variation. Frisch (1959) suggested that the absolute Frisch value would be lower for the high-income households and higher for the low-income households. However, Frisch did not justify his proposition in any way nor did he explain how he estimated the values for the parameters. Fortunately, Lluch, Powell and Williams (1977) found empirical support for his work and they also provided the following specification where the variation in the Frisch parameter with income is given by:

$$\log(-Frisch) = \phi - \alpha \log(y + \theta). \tag{18}$$

The values for ϕ, α and θ can be obtained by a process of trial and error. For example Creedy (2001) used values of 9.2, 1.05 and 177 respectively in order to produce variations in the Frisch parameter that are consistent with Frisch's work.

Below are some example values from earlier studies for the Frisch parameter and the coefficients in the "Frisch equation". In this study, we use an estimation of VATT (Kinnunen) on the level of the Frisch parameter for household income deciles. These estimates are based on an optimization problem that imitates econometric system estimation of the LES expenditure system. Although the optimization algorithms are powerful, the weakness of this approach is that no statistical inference tools for the significance of the results are readily available in the program package used. The data are from the Statistics Finland's household budget survey of 2006. Appendix 2a presents the formulation of the optimization problem in GAMS. Appendix 2b presents the results.

Table 1. Frisch estimates

Article	Frisch parameter	
Frisch (1959)	-10	very poor
	-4	poor
	-2	middle income
	-0,7	better off
	-0,1	rich
Tulpule & Powell (1978)	-1,82	average income for Australia
Creedy & Sleeman (2005)	-1,9	based on Dixon et al. (1982)
Honkatukia, Kinnunen & Marttila (2009)	-5,63	farmers
	-5,39	students
	-3,77	entrepreneurs
	-3,73	unemployed
	-2,88	retired
	-2,68	lower white-collar
	-2,36	blue-collar
	-2,19	upper white-collar
	-2,40	all households
He et al. (2011)	-3	median value of the parameter values -4 and -2
Kinnunen (see appendix 2)	-3,14	1st lowest decile
	-3,99	2nd decile
	-3,74	3rd decile
	-3,80	4th decile
	-2,20	5th decile
	-1,87	6th decile
	-1,75	7th decile
	-1,86	8th decile
	-2,30	9th decile
	-1,72	10th Highest decile
Cornwell & Creedy (1996)	$\log(-Frisch) = 18.57 - 1.72 \log y$	
Creedy (1998)	$\log(-Frisch) = 5 - 0.5 \log y$	
Creedy & Dixon (1998)	$\phi = 18.566$ $\alpha = 1.719$ $\theta = 10\ 575$	
Creedy (1999)	$\phi = 9.2$ $\alpha = 1.05$ $\theta = 177$	
Creedy (2001)	$\phi = 15.2$ $\alpha = 1.227$ $\theta = 8595$	

4. Data

In order to produce elasticity estimates based on the linear expenditure system, micro data on household expenditure is needed. The data used in this study is from the Statistics Finland's household budget survey (HBS). It contains data on how households' use their income on 900 different expenditure items. The survey is conducted through interviews and via diaries collected from the households in addition to purchase receipts and administrative registers. (Tilastokeskus, 2011)

The data used covers the three most recent survey years (1998, 2001 and 2006). There were around 4500 responses to the survey at 1998, around 5500 responses at 2001 and around 4000 responses at 2006. The consumption commodities in HBS are classified according to COICO-HBS classification with a total of 900 headings. These 900 items are divided into twelve main consumption groups, which include e.g. food and beverages, clothing, energy, transportation, health and education. However, for our purposes the consumption items were reclassified according to VATTAGE product grouping. After reclassification of the consumption bundles there are total of 59 commodity groups.

Considering the different methodological possibilities for the estimation of elasticities, we also collected price information. The prices were depicted from consumer price indexes of Statistics Finland and the base year was chosen to be 1998. Since there is a strong correlation among the price variables obtained, it is impossible to run any regression on the system as most of the price variables are dropped due to multicollinearity. Therefore, the price information methodology for the estimation of consumer's price demand elasticities does not work with the data available for us.

As the price data methodology failed us, we made a second attempt on the estimation of the elasticities by forming a pseudo-panel dataset from the HBSs. This method requires the use of the estimated Frisch parameters for the different income deciles. Estimations with (pseudo) panel data can be considered to provide most reliable estimation result since any cohort specific unobserved heterogeneity can be captured with fixed effects. We formed cohorts of the households to form the pseudo panel database from the three separate surveys. We obtained a total of 160 representative households, which were further grouped according to their stage in life and income decile group. The households were divided into income deciles according to their equivalent income. The first decile includes the least earning 10 per cent of the households and the tenth decile includes the most earning households. Furthermore, a few adjustments on the data were needed since some expenditure and reclassification values were missing. We did not have expenditure information for all three years for certain commodities. As we had data only from 3 subsequent years in our pseudo panel database and for many of the 58 commodities zero expenditures were reported by many household cohorts, our estimations of function (10) were unfortunately mostly insignificant (or only either a or b parameters got a value significantly different from zero). The numbers of zero observations by commodity group are reported in Appendix 5. Hence, we had to drop also this methodology.

The pseudo panel estimation would have been our preferred option, but at the end we had to opt for the use of yearly cross-section data with all possible observations included in order to obtain significant results. In contrary to the panel data estimations, which are considered to provide medium term elasticity estimates, cross-section data provided us long-term elasticity estimates. (Koetse et al, 2008) We used all three annual databases with the total of 4000 to 5500 observations per database for the regressions and obtained (finally) significant results with this methodology. The results presented in the next section are therefore based on the cross-section data and our estimated Frisch parameters.

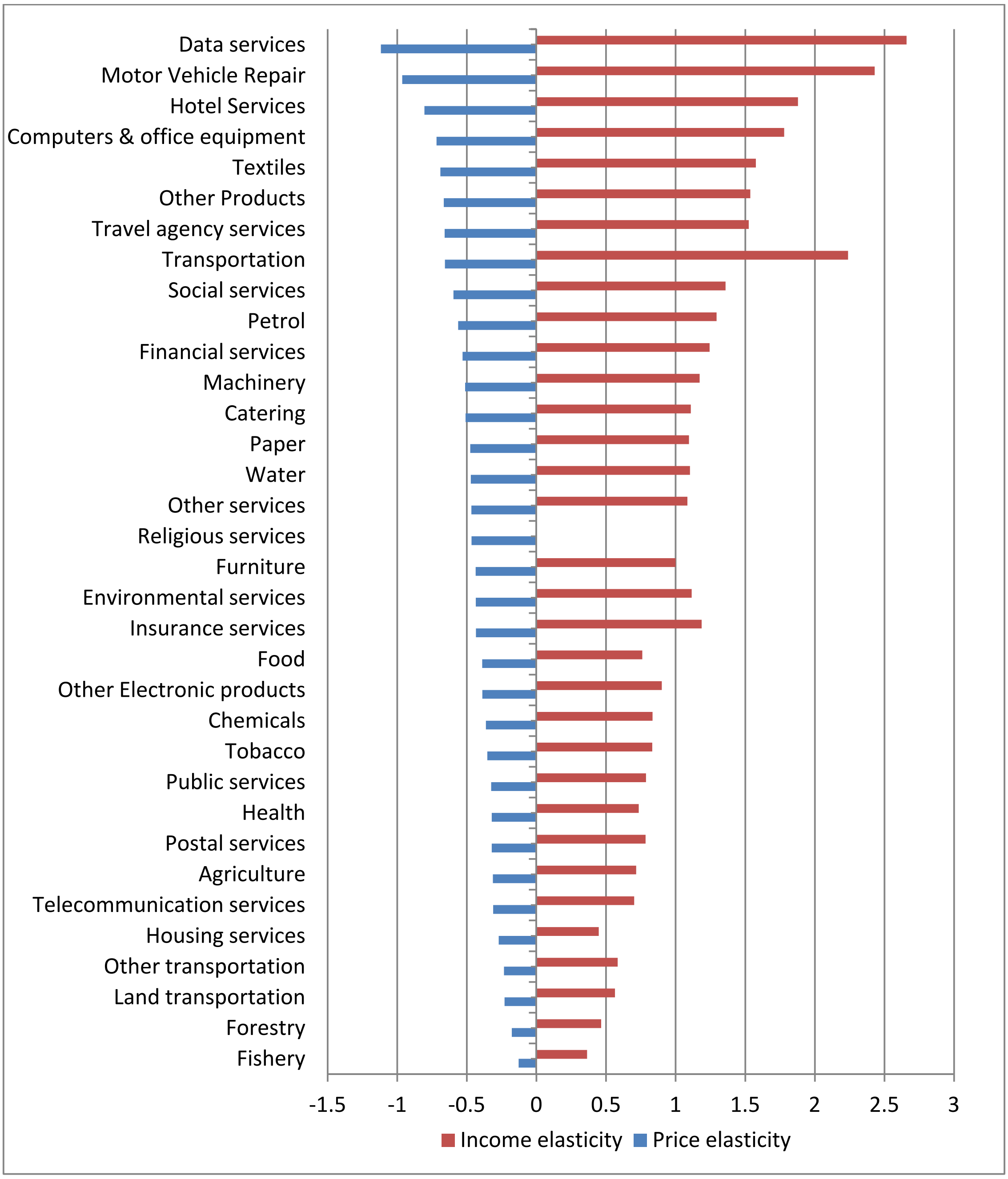
5. Results

5.1 Results for all income deciles in average

As mentioned earlier, after we had tried the estimation of the elasticities with price data in addition to pseudo panel data without success, we ran the regressions separately for each commodity and each year. For some commodities we got estimates from 3 years, but for various commodities significant results were obtained only for 1 or 2 years or for no year at all. Out of the 58 different commodity groups, we got estimates on the level of the income elasticities and price elasticities in the different household income deciles for 40 commodity groups. One of the main reasons for the estimation difficulties for some commodity groups was the low level of actual observations in the data. As presented in Appendix 5, large share of the households report zero expenditure for various product categories at each year. Based on the estimation results and Heien & Wessells (1990), it seems that it might be important to control first for the binary decision of households for buying certain items at all with a separate probit model. Further, other estimation methods (like maximum likelihood) are also recommended for future work.

Despite some doubts on the estimation results, Figure 1 presents the overall levels of price and income elasticities estimated for a selection of different product types. This provides some view on the obtained estimation results. The figure includes only the most reliable estimates for some common consumer demand products. The estimates represent the average elasticities of all households, in comparison to the household income decile specific elasticities that will be presented later on. As the figure shows, the income and own price elasticity estimates are interconnected and based on the same estimation results. If the income elasticity is high (i.e. elastic), the price elasticity is also likely to be rather elastic. The most price elastic products in general include data services, motor vehicle repair services and hotel services. On the other end, housing and transportation services are among the least price sensitive product groups for all consumer types in average. All sector specific results on income and own-price elasticities are presented in appendix 3 and 4, respectively.

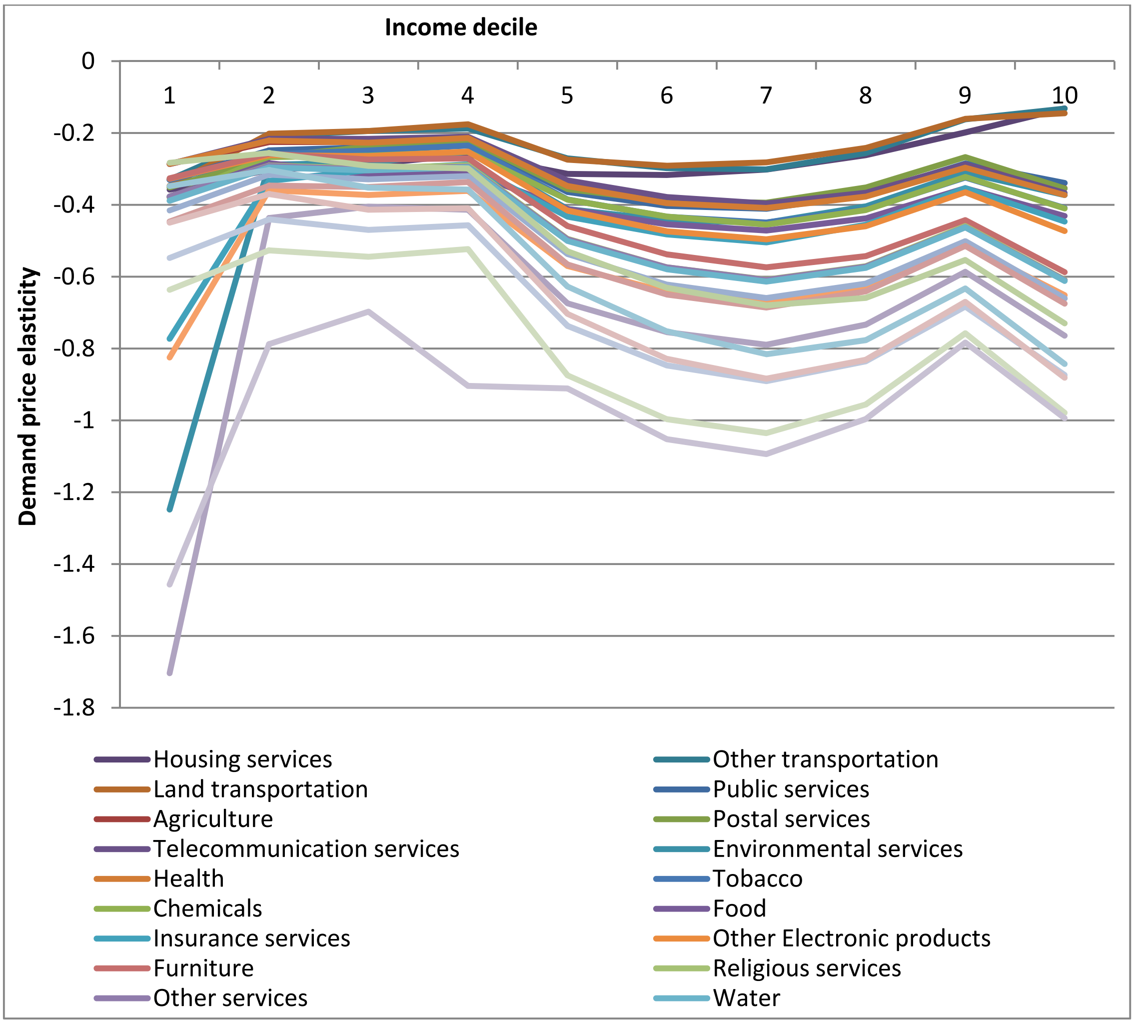
Figure 1. Own price and income elasticities per product, all households in average



5.2 Income decile specific results

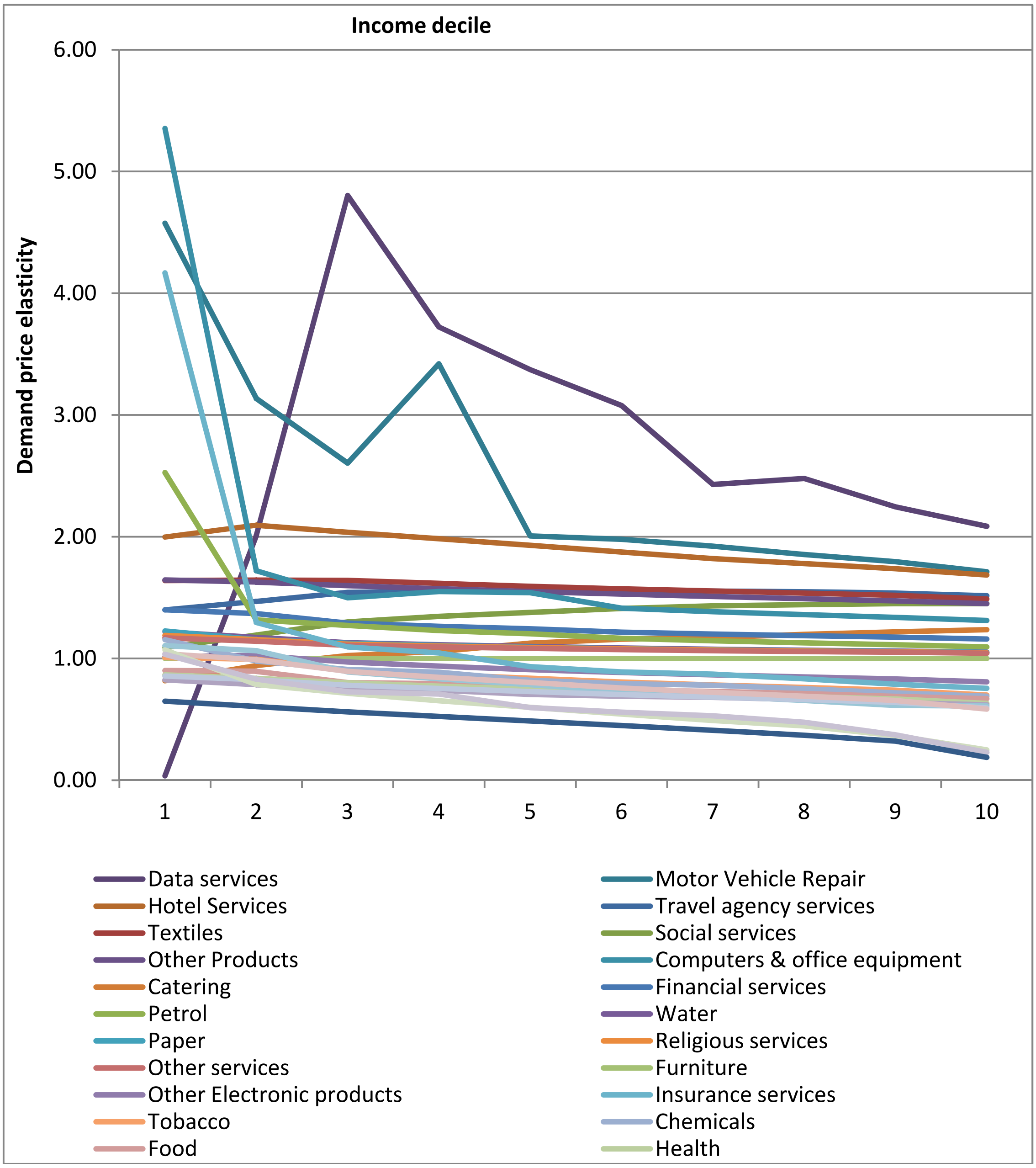
As figure 2 illustrates, the price elasticities of products that are relatively inelastic (in the top part of the figure) do not vary much across the different income deciles. For example, price elasticities of land transportation and housing services are between around -0.15 and -0.35 in all income deciles. The price elasticities that are relatively elastic (lowest part of the figure), on the contrary, tend to vary significantly between income deciles. The price elasticity of computers and other office equipment is around --1.7 in the poorest (1st) income decile, while the same elasticity is around -0.4 in the 4th income decile and -0.7 in the richest, 10th, decile. Similarly, motor vehicles repair services price elasticity varies between -1.4 in the lowest income decile and around -0,8 in the 9th decile. The lowest income decile often exhibits elasticity estimates that are significantly different compared to other income deciles. Otherwise the elasticities seem to increase in the 6th and 7th income decile and in the highest income decile in comparison to the others.

Figure 2. Own price elasticities per income decile



For comparison, Figure 3 shows income elasticity estimates by product category and income decile. Similar to the price elasticities, the income elasticities which are in general relatively high, vary most across the different income deciles. The highest income elasticity is found for data services. The lowest decile appears to use these services hardly at all (which explains the relatively low estimate for them), while for the 3rd decile the elasticity is the highest and decreases afterwards in the higher income deciles. The income elasticities that are relatively low vary also little across the different income deciles. In various product categories a decreasing trend is found from the elasticity of the 2nd income decile towards the estimates of higher income decile. At the highest income decile, forestry and fishery products seem to be inferior products as their income elasticities are estimated to be on the negative side.

Figure 3. Income elasticities per decile



6. Conclusions

Our main conclusion is that it is very difficult to obtain good estimates on household's income and price demand elasticities based on the LES function, even with detailed and extensive data. With data from household consumption surveys from three years, with around 4000-5000 observations in each of the annual databases, we had to try three different estimation approaches before obtaining any results.

First, we tried the estimation of the elasticities with the help of consumer price index information and the use of our full pseudo-panel data. Because the price indexes do not vary enough between product groups, these estimations failed due to multicollinearity.

Our second approach for the estimations was the use of exogenous Frisch indexes together with the full pseudo-panel database. With this approach, the estimation method proposed by Creedy (2001) failed again, especially since the panel has only three time periods included.

Our last, and slightly more successful, estimation approach was the use of Frisch indexes with cross-section data. This provided us relatively credible results for some 40 commodity groups. We could also obtain results on the elasticities between different household income deciles. According to the results, product groups that have relative large elasticities in general display most differences in the elasticity estimates across household income deciles. The sector specific elasticity estimates match relatively well previous results. However, we have some doubt on the obtained results and recommend other estimation methods to be considered in the future. The binary choice of households for the consumption of some product at all might be specifically important to control for with a separate probit model. Similarly, the use of longer survey periods of household consumption surveys could help on the identification of elasticities.

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Appendix 1. Other functional forms in CGE models

Cobb-Douglas

Cobb-Douglas functional form is one of the most commonly used functions in economic analysis. It is especially applied on the production side of the economy but can also be a representation of consumer demand.

The utility maximizing problem using Cobb-Douglas utility function is:

$$\text{max: } U(x) = \prod_{i=1}^{n} x_i^{\alpha_i} \; s.t. \; \sum_{i=1}^{n} p_i x_i = y,$$

where x_i is the quantity demanded for product i. The elasticities can be derived from this utility function.

The problem with Cobb-Douglas function is that the budget shares are constant which leads to unitary income elasticities. This means that when the incomes of the households change, the amount spent on particular goods does not change. This means that the Cobb-Douglas function is limited in its ability to explain the actual consumption behavior. (Annabi et al. 2006; Blonigen et al. 1997.)

Constant elasticity of substitution

Constant elasticity of substitution can also be applied both on the production and demand side of the economy.

The maximization problem is:

$$\text{max: } U(x) = \left[\sum_{i=1}^{n} \alpha_i^{\frac{1}{\varepsilon}} x_i^{\frac{(\varepsilon-1)}{\varepsilon}}\right]^{\frac{\varepsilon}{(\varepsilon-1)}} \; s.t. \; \sum_{i=1}^{n} p_i x_i = y$$

where α_i is the share parameter, x_i is the consumption of product i, ε is the elasticity of substitution

The drawback with CES function is the same as with Cobb-Douglas. Because of the unit income elasticity the budget shares of the products do not change when the income level of the households changes. (Annabi et al. 2006; Blonigen et al. 1997.)

Almost ideal demand system (AIDS)

Almost ideal demand system was introduced by Deaton and Muellbauer (1980) and has been very popular ever since to represent household demand in general equilibrium models. The advantage of the model is that budget shares are not constant as they are in the Cobb-Douglas and CES forms. So, the income elasticities change with income changes.

The system is defined as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln \ p_j + \beta_i \ln \left(\frac{y}{P}\right),$$

where w_i is the budget share of product i, α_i, γ_{ij} and β_i are the model parameters, p_j is the price of product j, y is the total expenditure and P is a price index defined as:

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j.$$

P is usually approximated by the Stone geometric price index P^*, where $\ln P^* = \sum_{i=1}^{n} w_i \ln p_i$. With the help of these equations and some restrictions it is possible to derive the parameter estimates and thus income and price elasticities.

The problem with AIDS is that the application of the model requires certain conditions on the data and these requirements cannot always be met. The parameters tend to be also nonlinear and thereby hard to estimate. (Annabi et al. 2006.)

Appendix 2. Estimation of Frisch parameters

A2.a Extract of the Program code for the estimation of LES system with GAMS-program

```
$STITLE Estimation of LES parameters from Statistics Finland HBS 2006


sets

h    observations in total 4007

com    a preliminary group of aggregate consumption goods imported before edition

sg  Studied groups

/

0    1st decile

1    2nd decile

2    3rd decile

3    4th decile

4    5th decile

5    6th decile

6    7th decile

7    8th decile

8    9th decile

9    10th decile

/ ;

PARAMETERS

eh(h)          Total consumption of household

cons(com,h)     Actual consumption of good c by h

weight(h)       Weight coefficient

weightchk       Checking the weigh parameter

ehbar           Average total consumption

EHBARSG(sg)     Average total consumption per socioeconomic group
```

```
consbar(com)     Average consumption of c
consbarsg(com,sg) Average consumption of c for socioeconomic group sg
betabar(com)     Average consumption share
sgdummy(sg,h) Dummy for study groups
hTOsg(h,sg)  Mapping between h and sg
weightcount(sg) nr of weighted observations by sg
wsum          sum of weights
CONSSUMSG(com,sg) Groups' consumption of good c
CONSSUMUPSG(com,sg) Groups' consumption of good c weighted by koraika
CONSHRSG(com,sg) Groups' share of consumption of good c
EHSUMSG(SG)     Groups' sum of total cons
EHSHRSG(SG)    Groups' share of total cons;
eh(h)  =      DATA06(h,'A01_12') ;
cons(c,h)  = DATA06(h,c) ;
weight(h)  = DATA06(h,'koraika')/(SUM(hp, DATA06(hp,'koraika')) /card(hp)) ;
weightchk  =  SUM(h, weight(h)) / card(h) ;
display weightchk  ;
ehbar      =    SUM(h, eh(h)*weight(h))/sum(hp, weight(hp)) ;
consbar(c)  = sum(h, cons(c,h)*weight(h))/sum(hp, weight(hp))  ;
betabar(c) = consbar(c) / ehbar ;
sgdummy(sg,h) = 0;
sgdummy(sg,h)$(DATA06(h,'desmodJK') eq sg.val) = 1 ;
display sgdummy ;
weightcount(sg) = sum(h$sgdummy(sg,h), weight(h));
wsum = sum(sg, weightcount(sg));


EHBARSG(sg) = sum(h$sgdummy(sg,h), eh(h)*weight(h)) /
            sum(hp$sgdummy(sg,hp), weight(hp));
consbarsg(c,sg) =  SUM(h$sgdummy(sg,h), cons(c,h)*weight(h)) /
```

```
            sum(hp$sgdummy(sg,hp), weight(hp))  ;
CONSSUMSG(c,sg) = sum(h$sgdummy(sg,h), cons(c,h)*weight(h));
EHSUMSG(sg)  =  sum(h$sgdummy(sg,h), eh(h)*weight(h)) ;
CONSSUMUPSG(c,sg)  = sum(h$sgdummy(sg,h), cons(c,h)*DATA06(h,'koraika'));
CONSHRSG(c,sg)   = CONSSUMSG(c,sg)/sum(sgp,CONSSUMSG(c,sgp));
EHSHRSG(SG)     =  EHSUMSG(SG) / SUM(SGP,EHSUMSG(SGP));
```

VARIABLES

```
CSG(SG,COM)   Constants of the study groups and products
ERRLIN(com,h)    Estimation error for the linear variant
BSG(SG,COM)  Beta to the study groups
FRISCH(sg)     Frisch for each sg
ETA(COM,SG)    Expenditure elasticity for each c of sg
OBJVALIN      Objective value
GAMMASG(SG,COM)   GAMMA for study groups
SUBSISTSG(SG)  SUBSISTENCE cons for SG;
POSITIVE VARIABLES BSG, GAMMASG, SUBSISTSG ;
```

EQUATIONS

```
ESTLINEQ(com,h)     Central funtion for linear estimation
OBJVALINEQ         Objective value equation
CONSTRBSGEQ(SG)   Adding-up constraint for sg study groups
ERRSUMEQ(com)       Sum of erros should equal zero
ERRSUMLINEQ(com)    Sum of erros should equal zero
CONSTSUMEQ         Adding-up constraint for CONST
CONSTSUMSGEQ(SG)       Adding-up constraint for each CSG
CONSTSGEQ(SG,com)    Definition of GAMMASG
SUBSSGEQ(SG)        Relation btw GAMMASG and SUBSISTSG
FRISCHEQ(SG)     Definition of Frisch for each sg
```

```
ETAEQ(COM,SG)    Definition of ETA for each sg
ETA_FRISCH_EQ(COM,SG) Restriction for ETA
FRISRESTR(SG)    Additional restriction for FRISCH;


ESTLINEQ(c,h).. cons(c,h)*weight(h) =E=
       SUM(SG,sgdummy(sg,h)*CSG(SG,C)$consbarsg(c,SG)
       + (BSG(SG,C)*sgdummy(sg,h)$consbarsg(c,SG))*eh(h)*weight(h))
       + ERRLIN(c,h)*weight(h) ;
OBJVALINEQ..     OBJVALIN =E=  SUM((c,h), ABS(ERRLIN(c,h)*weight(h))**2)
               /1000000;
ERRSUMLINEQ(c)..     SUM(h, ERRLIN(c,h)*weight(h)) =E= 0;
CONSTRBSGEQ(SG)..  SUM(C, BSG(SG,C)) =E= 1 ;
CONSTSUMSGEQ(SG)..  SUM(c, CSG(SG,C)) =E= 0;
CONSTSGEQ(SG,c)..  CSG(SG,C) =E= GAMMASG(SG,C) -BSG(SG,C)*SUBSISTSG(SG);


SUBSSGEQ(SG)..      SUM(C,GAMMASG(SG,C)) =E= SUBSISTSG(SG) ;
FRISCHEQ(SG)..     FRISCH(sg)    =E=  - (ehbarsg(sg))
             /(ehbarsg(sg) - sum(c, GAMMASG(sg,c))) ;
ETAEQ(c,sg)$(consbarsg(c,sg)).. ETA(C,SG)   =E=
           BSG(SG,C) * (ehbarsg(sg)) /consbarsg(c,sg) ;
ETA_FRISCH_EQ(C,SG)$(consbarsg(c,sg))..  ETA(C,SG) =L= ABS(FRISCH(SG)) ;
FRISRESTR(SG)..   FRISCH(SG) =G= -5.5 ;


SOLVE LESSG  USING DNLP  MINIMIZING OBJVALIN ;
*  Result parametes
PARAMETERS
BETALINR(com,sg)  Result for BETALIM
CONSTLINR(com,sg) Resulting constant
FRISCHX(sg)         FRISCH parameter needed in LES function
```

```
ETAX(com,sg)        Expenditure elasticity of C

GAMMASGX(com,sg)      Gathering of gamma resuls

SUBSISTSGX(SG)       Total subsistence consumption;

BETALINR(c,SG)  =   BSG.L(SG,C) ;

CONSTLINR(c,SG) =   CSG.L(SG,C) ;

GAMMASGX(c,SG)  =   GAMMASG.L(SG,C);

SUBSISTSGX(SG)  = sum(c,GAMMASG.L(SG,C));

FRISCHX(sg)     =  -(ehbarsg(sg)) /(ehbarsg(sg) - sum(c, GAMMASGX(c,sg))) ;

ETAX(c,sg)$(consbarsg(c,sg))= BETALINR(c,sg)*(ehbarsg(sg)) /consbarsg(c,sg) ;
```

A2.b Obtained Frisch parameters

Frisch parameters from GAMS optimization problem

Value of Frisch	Income decile
-3,14	1^{st} lowest income decile
-3,99	2^{nd} decile
-3,74	3^{rd} decile
-3,80	4^{th} decile
-2,20	5^{th} decile
-1,87	6^{th} decile
-1,75	7^{th} decile
-1,86	8^{th} decile
-2,30	9^{th} decile
-1,72	10^{th} Highest decile
-2,45	Aggregate household

Note: The Frisch values presented here for the deciles were scaled downwards in order to produce an equal aggregate Frisch value than what was obtained for one representative aggregate household with an identical optimization problem. The value of scaling parameter was 0.726. Consumption shares of deciles were used as weights in calculation of the aggregate value from decile results.

Appendix 3. Income elasticities

	Product	Income decile 1	2	3	4	5	6	7	8	9	10	all	Obs Year
C_01	Agriculture	0.85	0.82	0.78	0.75	0.73	0.70	0.68	0.66	0.64	0.59	0.72	2001
C_02	Forestry	0.98	0.79	0.70	0.61	0.54	0.46	0.38	0.32	0.25	-0.06	0.46	2006
C_05	Fishery	0.93	0.70	0.58	0.51	0.43	0.36	0.26	0.17	0.06	-0.16	0.36	2001
C_13_4	Mining	1.01	0.88	0.82	0.81	0.75	0.72	0.71	0.68	0.64	0.61	0.75	1998
C_15	Food	0.90	0.89	0.80	0.79	0.76	0.74	0.73	0.71	0.69	0.67	0.76	1998
C_159	Beverages	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_16	Tobacco	1.01	0.99	0.90	0.87	0.84	0.81	0.78	0.76	0.74	0.70	0.83	2001
C_17_9	Textiles	1.64	1.64	1.64	1.62	1.59	1.57	1.55	1.54	1.52	1.49	1.58	2001
C_20	Wood and cork products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_212	Paper	1.23	1.15	1.12	1.11	1.09	1.08	1.07	1.06	1.06	1.05	1.10	2006
C_22	Publishing	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_232011	Petrol	2.53	1.32	1.27	1.23	1.20	1.17	1.14	1.13	1.11	1.09	1.29	2001
C_23209	Other oil products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_24	Chemicals	1.15	0.98	0.91	0.89	0.82	0.79	0.78	0.75	0.72	0.69	0.83	1998
C_25	Rubber and Plastic	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_26	Non-metallic minerals	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_28	Metal Products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_29	Machinery	1.29	1.23	1.20	1.18	1.17	1.16	1.15	1.14	1.14	1.13	1.17	2006
C_30_1	Computers & office equipment	5.35	1.72	1.50	1.55	1.54	1.41	1.38	1.36	1.34	1.31	1.78	2001
C_32	TV & Radio	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_33	Other Electronic products	1.01	1.02	0.97	0.94	0.91	0.88	0.87	0.85	0.83	0.81	0.90	2006
C_34_5	Transportation	2.96	-0.86	4.13	2.98	1.61	2.37	2.52	2.21	2.23	2.03	2.24	2001
C_361	Furniture	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2001
C_362_6	Other Products	1.64	1.63	1.60	1.57	1.55	1.53	1.51	1.49	1.47	1.45	1.54	2006
C_4011	Electricity	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_4032	Heat	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_41	Water	1.22	1.17	1.13	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.10	2001
C_502	Motor Vehicle Repair	4.58	3.14	2.60	3.42	2.01	1.98	1.92	1.85	1.79	1.71	2.43	2001

		Income decile											
	Product	1	2	3	4	5	6	7	8	9	10	all	Obs Year
C_527	Household equipment repair	0.67	0.19	0.23	0.12	0.44	-0.69	-1.12	-6.17	-1.05	-1.89	-1.09	2006
C_551	Hotel Services	2.00	2.09	2.04	1.98	1.93	1.87	1.82	1.78	1.74	1.69	1.88	2006
C_553	Catering	0.82	0.94	1.02	1.06	1.13	1.16	1.17	1.20	1.22	1.24	1.11	1998
C_601	Rail Transportation	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_602_3	Land transportation	1.07	0.79	0.71	0.65	0.60	0.54	0.49	0.45	0.36	0.25	0.56	2006
C_61	Water transportation	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_6309	Other transportation	1.03	0.83	0.73	0.71	0.60	0.56	0.53	0.48	0.37	0.23	0.58	1998
C_633	Travel agency services	1.40	1.47	1.54	1.55	1.55	1.56	1.55	1.55	1.54	1.51	1.53	2001
C_641	Postal services	1.10	1.06	0.89	0.83	0.78	0.73	0.69	0.65	0.61	0.61	0.78	2001
C_642	Telecommunication services	0.82	0.78	0.74	0.74	0.70	0.69	0.68	0.66	0.64	0.62	0.70	1998
C_65	Financial services	1.40	1.37	1.29	1.26	1.24	1.22	1.20	1.19	1.17	1.16	1.24	2001
C_66	Insurance services	4.17	1.30	1.09	1.05	0.93	0.89	0.87	0.83	0.79	0.75	1.19	1998
C_701_2	Housing services	0.65	0.60	0.56	0.52	0.49	0.45	0.41	0.37	0.32	0.19	0.45	2001
C_7031	Real estate services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_71	Transport rental services	1.75	-3.06	-7.26	0.64	2.45	3.32	2.63	2.95	-109.05	2.48	-11.11	2001
C_72	Data services	0.04	2.01	4.80	3.72	3.37	3.08	2.43	2.48	2.25	2.08	2.66	2001
C_741	Legal & financial services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_743	Technical testing	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_747	Cleaning services	0.72	0.43	0.11	0.27	0.59	-0.46	-0.79	1.90	-2.04	0.16	0.06	1998
C_748	Other services for business	1.25	1.22	1.19	1.18	1.17	1.16	1.15	1.14	1.14	1.13	1.17	2001
C_751_2	Public services	1.04	0.99	0.89	0.84	0.80	0.76	0.72	0.69	0.65	0.58	0.79	2001
C_80	Education	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_851	Health	0.86	0.84	0.80	0.77	0.75	0.73	0.71	0.69	0.67	0.63	0.74	2006
C_852	Veterinary services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_853	Social services	1.09	1.19	1.30	1.35	1.38	1.41	1.43	1.44	1.45	1.45	1.36	2001
C_90	Environmental services	3.93	1.15	1.06	0.95	0.91	0.83	0.79	0.75	0.71	0.64	1.12	2001
C_911	Labor unions	1.90	1.28	0.72	0.68	0.42	0.26	-0.20	0.07	2.69	-4.49	0.30	2001
C_913	Religious services	1.19	1.15	1.12	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.09	2001
C_921_4	Entertainment & news services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_93_5	Other services	1.17	1.14	1.11	1.09	1.08	1.07	1.06	1.06	1.05	1.04	1.08	2001

Appendix 4. Own-price elasticities

		Income decile											
	Product	1	2	3	4	5	6	7	8	9	10	all	Obs Year
C_01	Agriculture	-0.29	-0.23	-0.23	-0.22	-0.34	-0.39	-0.40	-0.37	-0.29	-0.35	-0.31	2001
C_02	Forestry	-0.31	-0.20	-0.19	-0.16	-0.25	-0.25	-0.22	-0.18	-0.11	0.04	-0.18	2006
C_05	Fishery	-0.30	-0.18	-0.16	-0.14	-0.20	-0.19	-0.15	-0.09	-0.03	0.09	-0.13	2001
C_13_4	Mining	-0.32	-0.22	-0.22	-0.21	-0.34	-0.38	-0.40	-0.36	-0.28	-0.36	-0.31	1998
C_15	Food	-0.38	-0.28	-0.32	-0.31	-0.41	-0.45	-0.47	-0.44	-0.35	-0.43	-0.39	1998
C_159	Beverages	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_16	Tobacco	-0.33	-0.26	-0.25	-0.23	-0.39	-0.43	-0.45	-0.41	-0.32	-0.41	-0.35	2001
C_17_9	Textiles	-0.55	-0.44	-0.47	-0.46	-0.74	-0.85	-0.89	-0.84	-0.68	-0.87	-0.69	2001
C_20	Wood and cork products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_212	Paper	-0.39	-0.30	-0.31	-0.29	-0.50	-0.58	-0.61	-0.57	-0.46	-0.61	-0.48	2006
C_22	Publishing	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_232011	Petrol	-0.82	-0.36	-0.37	-0.36	-0.57	-0.64	-0.67	-0.63	-0.51	-0.65	-0.56	2001
C_23209	Other oil products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_24	Chemicals	-0.38	-0.27	-0.26	-0.25	-0.39	-0.43	-0.45	-0.41	-0.32	-0.41	-0.36	1998
C_25	Rubber and Plastic	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_26	Non-metallic minerals	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_28	Metal Products	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_29	Machinery	-0.42	-0.32	-0.33	-0.32	-0.54	-0.62	-0.66	-0.62	-0.50	-0.66	-0.51	2006
C_30_1	Computers & office equipment	-1.70	-0.44	-0.41	-0.41	-0.67	-0.75	-0.79	-0.73	-0.59	-0.76	-0.72	2001
C_32	TV & Radio	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_33	Other Electronic products	-0.33	-0.26	-0.26	-0.25	-0.42	-0.47	-0.50	-0.46	-0.36	-0.47	-0.39	2006
C_34_5	Transportation	1.91	0.69	-1.11	-0.82	-0.56	-1.20	-1.41	-1.17	-0.99	-1.17	-0.66	2001
C_361	Furniture	-0.33	-0.26	-0.27	-0.27	-0.46	-0.54	-0.57	-0.54	-0.44	-0.59	-0.44	2001
C_362_6	Other Products	-0.53	-0.41	-0.43	-0.42	-0.71	-0.81	-0.86	-0.80	-0.64	-0.84	-0.67	2006
C_4011	Electricity	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_4032	Heat	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_41	Water	-0.39	-0.30	-0.30	-0.30	-0.50	-0.58	-0.61	-0.58	-0.46	-0.61	-0.47	2001
C_502	Motor Vehicle Repair	-1.46	-0.79	-0.70	-0.90	-0.91	-1.05	-1.09	-1.00	-0.78	-0.99	-0.96	2001

	Product	Income decile											Obs
		1	2	3	4	5	6	7	8	9	10	all	Year
C_527	Household equipment repair	-0.21	-0.05	-0.06	-0.03	-0.20	0.36	0.64	3.45	0.46	1.10	0.63	2006
C_551	Hotel Services	-0.64	-0.53	-0.54	-0.52	-0.87	-1.00	-1.04	-0.96	-0.76	-0.98	-0.80	2006
C_553	Catering	-0.28	-0.26	-0.29	-0.30	-0.53	-0.63	-0.68	-0.66	-0.55	-0.73	-0.51	1998
C_601	Rail Transportation	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_602_3	Land transportation	-0.35	-0.20	-0.19	-0.18	-0.27	-0.29	-0.28	-0.24	-0.16	-0.14	-0.23	2006
C_61	Water transportation	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_6309	Other transportation	-0.33	-0.21	-0.19	-0.19	-0.27	-0.30	-0.30	-0.26	-0.16	-0.13	-0.23	1998
C_633	Travel agency services	-0.45	-0.37	-0.41	-0.41	-0.70	-0.83	-0.88	-0.83	-0.67	-0.88	-0.66	2001
C_641	Postal services	-0.35	-0.27	-0.24	-0.22	-0.36	-0.39	-0.39	-0.35	-0.27	-0.35	-0.32	2001
C_642	Telecommunication services	-0.29	-0.22	-0.22	-0.21	-0.33	-0.38	-0.40	-0.37	-0.29	-0.37	-0.31	1998
C_65	Financial services	-0.45	-0.35	-0.35	-0.34	-0.57	-0.65	-0.69	-0.64	-0.51	-0.68	-0.53	2001
C_66	Insurance services	-0.77	-0.33	-0.30	-0.29	-0.43	-0.48	-0.50	-0.46	-0.35	-0.45	-0.43	1998
C_701_2	Housing services	-0.36	-0.30	-0.29	-0.26	-0.31	-0.32	-0.30	-0.26	-0.20	-0.13	-0.27	2001
C_7031	Real estate services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_71	Transport rental services	-0.54	0.78	1.95	0.30	5.34	-0.58	-1.38	-1.47	47.60	0.12	5.61	2001
C_72	Data services	0.00	-0.50	-1.28	-0.98	-1.53	-1.64	-1.38	-1.33	-0.98	-1.21	-1.12	2001
C_741	Legal & financial services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_743	Technical testing	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_747	Cleaning services	-0.23	-0.11	-0.03	-0.07	-0.27	0.27	0.45	-0.96	1.06	-0.03	0.02	1998
C_748	Other services for business	-0.40	-0.31	-0.32	-0.31	-0.53	-0.62	-0.65	-0.61	-0.49	-0.66	-0.50	2001
C_751_2	Public services	-0.33	-0.25	-0.24	-0.22	-0.36	-0.40	-0.41	-0.37	-0.28	-0.34	-0.32	2001
C_80	Education	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_851	Health	-0.29	-0.22	-0.23	-0.21	-0.35	-0.40	-0.41	-0.38	-0.30	-0.37	-0.32	2006
C_852	Veterinary services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_853	Social services	-0.35	-0.30	-0.35	-0.36	-0.63	-0.75	-0.82	-0.78	-0.63	-0.84	-0.60	2001
C_90	Environmental services	-1.25	-0.29	-0.28	-0.25	-0.41	-0.44	-0.45	-0.40	-0.31	-0.37	-0.44	2001
C_911	Labor unions	-0.60	-0.32	-0.19	-0.18	-0.18	0.19	0.13	0.51	-1.02	6.34	0.49	2001
C_913	Religious services	-0.38	-0.29	-0.30	-0.29	-0.49	-0.57	-0.61	-0.57	-0.46	-0.61	-0.47	2001
C_921_4	Entertainment & news services	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	
C_93_5	Other services	-0.38	-0.29	-0.30	-0.29	-0.50	-0.57	-0.61	-0.57	-0.46	-0.61	-0.47	2001

Appendix 5. Zero expenditures

There are a total of around 4000 observations for each year, but not all households report consumption of all commodities. Below are presented 1) the percentages of zero expenditures within all the observations in average over the three yearly datasets and 2) zero observations at year 2006 per income decile.

Table A4.1 Share of zero expenditure by product group, all yearly datasets, average, percentage

Product		Year		
		1998	2001	2006
C_01	Agriculture	0.03	0.02	0.02
C_02	Forestry	0.70	0.59	0.59
C_05	Fishery	0.58	0.56	0.65
C_13_4	Mining	0.90	0.89	0.90
C_15	Food	0.00	0.01	0.00
C_159	Beverages	0.23	0.19	0.19
C_16	Tobacco	0.71	0.70	0.73
C_17_9	Textiles	0.30	0.24	0.26
C_20	Wood and cork products	0.95	0.94	0.91
C_212	Paper	0.28	0.25	0.25
C_22	Publishing	0.04	0.04	0.05
C_232011	Petrol	0.35	0.32	0.35
C_23209	Other oil products	0.97	0.97	0.97
C_24	Chemicals	0.17	0.14	0.13
C_25	Rubber and Plastic	0.31	0.22	0.17
C_26	Non-metallic minerals	0.82	0.80	0.77
C_28	Metal Products	0.71	0.69	0.64
C_29	Machinery	0.35	0.30	0.33
C_30_1	Computers & office equipment	0.57	0.51	0.46
C_32	TV & Radio	0.43	0.40	0.35
C_33	Other Electronic products	0.57	0.56	0.49
C_34_5	Transportation	0.51	0.49	0.48
C_361	Furniture	0.53	0.50	0.48
C_362_6	Other Products	0.46	0.39	0.36
C_4011	Electricity	0.06	0.05	0.05
C_4032	Heat	0.80	0.70	0.71
C_41	Water	0.52	0.56	0.54
C_502	Motor Vehicle Repair	0.91	0.89	0.89
C_527	Household equipment repair	0.97	0.97	0.97
C_551	Hotel Services	0.72	0.86	0.79
C_553	Catering	0.30	0.26	0.27
C_601	Rail Transportation	0.93	0.84	0.84
C_602_3	Land transportation	0.73	0.67	0.69

Product		1998	2001	2006
		Year		
C_61	Water transportation	0.99	0.97	0.97
C_6309	Other transportation	0.56	0.58	0.58
C_633	Travel agency services	0.86	0.81	0.85
C_641	Postal services	0.85	0.86	0.85
C_642	Telecommunication services	0.03	0.01	0.01
C_65	Financial services	0.66	0.67	0.65
C_66	Insurance services	0.10	0.09	0.08
C_701_2	Housing services	0.01	0.01	0.00
C_7031	Real estate services	0.97	0.98	0.98
C_71	Transport rental services	0.89	0.87	0.88
C_72	Data services	0.97	0.97	0.96
C_741	Legal & financial services	0.99	0.99	0.99
C_743	Technical testing	0.93	0.90	0.90
C_747	Cleaning services	0.59	0.59	0.56
C_748	Other services for business	0.86	0.89	0.91
C_751_2	Public services	0.39	0.38	0.38
C_80	Education	0.70	0.67	0.63
C_851	Health	0.25	0.27	0.27
C_852	Veterinary services	0.99	1.00	1.00
C_853	Social services	0.86	0.86	0.88
C_90	Environmental services	0.58	0.51	0.49
C_911	Labor unions	0.37	0.38	0.39
C_913	Religious services	0.92	0.95	0.92
C_921_4	Entertainment & news services	0.02	0.02	0.01
C_93_5	Other services	0.67	0.63	0.74

Table A4.2 Zero expenditure by income decile and product group, year 2006

		Income decile									
Product		0	1	2	3	4	5	6	7	8	9
C_01	Agriculture	0.08	0.04	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.00
C_02	Forestry	0.89	0.70	0.64	0.59	0.63	0.49	0.54	0.52	0.54	0.51
C_05	Fishery	0.79	0.67	0.68	0.66	0.60	0.66	0.64	0.57	0.63	0.62
C_13_4	Mining	0.90	0.91	0.88	0.88	0.91	0.89	0.89	0.91	0.90	0.90
C_15	Food	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00
C_159	Beverages	0.31	0.33	0.26	0.21	0.17	0.18	0.17	0.15	0.13	0.11
C_16	Tobacco	0.67	0.67	0.73	0.71	0.73	0.73	0.74	0.72	0.76	0.81
C_17_9	Textiles	0.37	0.41	0.33	0.33	0.22	0.23	0.21	0.15	0.20	0.20
C_20	Wood and cork products	0.93	0.93	0.93	0.91	0.93	0.91	0.91	0.89	0.90	0.92
C_212	Paper	0.39	0.31	0.25	0.29	0.21	0.21	0.21	0.25	0.21	0.24
C_22	Publishing	0.22	0.10	0.05	0.07	0.02	0.02	0.03	0.02	0.02	0.01
C_232011	Petrol	0.66	0.56	0.47	0.35	0.32	0.30	0.26	0.25	0.24	0.26
C_23209	Other oil products	0.99	0.98	0.97	0.98	0.98	0.97	0.97	0.97	0.97	0.97
C_24	Chemicals	0.31	0.19	0.13	0.13	0.15	0.10	0.09	0.10	0.09	0.11
C_25	Rubber and Plastic	0.24	0.25	0.20	0.23	0.19	0.15	0.14	0.13	0.13	0.14
C_26	Non-metallic minerals	0.85	0.81	0.77	0.77	0.77	0.78	0.74	0.76	0.71	0.73
C_28	Metal Products	0.73	0.77	0.71	0.67	0.62	0.63	0.62	0.58	0.55	0.63
C_29	Machinery	0.46	0.46	0.40	0.37	0.34	0.31	0.26	0.26	0.27	0.27
C_30_1	Computers & office equipment	0.54	0.61	0.50	0.52	0.48	0.44	0.43	0.42	0.37	0.38
C_32	TV & Radio	0.45	0.50	0.43	0.40	0.34	0.28	0.30	0.29	0.27	0.32
C_33	Other Electronic products	0.67	0.62	0.58	0.53	0.50	0.49	0.45	0.42	0.42	0.36
C_34_5	Transportation	0.66	0.59	0.59	0.54	0.45	0.44	0.42	0.39	0.41	0.46
C_361	Furniture	0.56	0.57	0.54	0.55	0.50	0.46	0.46	0.41	0.40	0.43
C_362_6	Other Products	0.49	0.54	0.43	0.38	0.35	0.35	0.32	0.27	0.29	0.28
C_4011	Electricity	0.21	0.06	0.07	0.04	0.06	0.03	0.02	0.02	0.02	0.01
C_4032	Heat	0.69	0.71	0.78	0.72	0.65	0.74	0.70	0.69	0.76	0.70
C_41	Water	0.88	0.73	0.61	0.56	0.55	0.48	0.46	0.45	0.45	0.43
C_502	Motor Vehicle Repair	0.96	0.93	0.92	0.91	0.87	0.91	0.88	0.87	0.86	0.85
C_527	Household equipment repair	0.99	0.98	0.98	0.98	0.99	0.97	0.97	0.96	0.94	0.96
C_551	Hotel Services	0.89	0.89	0.91	0.87	0.83	0.79	0.80	0.72	0.69	0.63
C_553	Catering	0.37	0.45	0.43	0.32	0.32	0.26	0.19	0.17	0.16	0.14
C_601	Rail Transportation	0.77	0.85	0.87	0.87	0.84	0.84	0.85	0.83	0.83	0.84
C_602_3	Land transportation	0.67	0.73	0.75	0.72	0.70	0.71	0.68	0.64	0.67	0.65
C_61	Water transportation	0.99	0.99	0.98	0.98	0.99	0.97	0.96	0.95	0.95	0.93
C_6309	Other transportation	0.76	0.65	0.62	0.59	0.60	0.58	0.59	0.50	0.50	0.46
C_633	Travel agency services	0.90	0.93	0.94	0.93	0.88	0.85	0.84	0.81	0.79	0.72
C_641	Postal services	0.86	0.86	0.87	0.87	0.82	0.86	0.87	0.82	0.81	0.86
C_642	Telecommunication services	0.06	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01
C_65	Financial services	0.68	0.69	0.73	0.62	0.64	0.64	0.61	0.64	0.59	0.66
C_66	Insurance services	0.41	0.21	0.12	0.07	0.06	0.04	0.02	0.02	0.01	0.00

Product		Income decile 0	1	2	3	4	5	6	7	8	9
C_701_2	Housing services	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_7031	Real estate services	0.99	0.99	0.98	0.98	0.97	0.97	0.99	0.98	0.97	0.95
C_71	Transport rental services	0.91	0.94	0.93	0.91	0.91	0.91	0.89	0.85	0.82	0.79
C_72	Data services	0.97	0.95	0.98	0.98	0.96	0.95	0.96	0.95	0.94	0.94
C_741	Legal & financial services	0.99	0.99	0.99	0.98	0.99	0.98	0.99	0.98	0.99	0.98
C_743	Technical testing	0.95	0.94	0.91	0.89	0.91	0.87	0.88	0.88	0.85	0.92
C_747	Cleaning services	0.90	0.73	0.63	0.58	0.59	0.50	0.49	0.49	0.47	0.42
C_748	Other services for business	0.94	0.93	0.92	0.92	0.91	0.93	0.91	0.88	0.90	0.89
C_751_2	Public services	0.72	0.49	0.42	0.38	0.37	0.29	0.30	0.33	0.30	0.37
C_80	Education	0.62	0.71	0.69	0.68	0.63	0.63	0.60	0.57	0.62	0.57
C_851	Health	0.40	0.27	0.28	0.29	0.27	0.23	0.23	0.22	0.27	0.28
C_852	Veterinary services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
C_853	Social services	0.97	0.90	0.91	0.86	0.84	0.87	0.84	0.85	0.89	0.88
C_90	Environmental services	0.89	0.67	0.58	0.55	0.51	0.42	0.42	0.40	0.37	0.33
C_911	Labor unions	0.84	0.69	0.58	0.47	0.41	0.30	0.29	0.22	0.17	0.22
C_913	Religious services	0.98	0.94	0.94	0.93	0.92	0.92	0.92	0.88	0.91	0.85
C_921_4	Entertainment & news services	0.04	0.04	0.02	0.02	0.01	0.01	0.00	0.01	0.01	0.00
C_93_5	Other services	0.93	0.82	0.82	0.79	0.72	0.75	0.72	0.69	0.68	0.62

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