Using a Generalized Differenced Demand Model to Estimate Price and Expenditure Elasticities for Milk and Meat in Austria

Schätzung von Preis- und Einkommenselastizitäten für Milch und Fleisch in Österreich mithilfe eines Allgemeinen Differenzierten Nachfragemodells

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Abstract

Applying a generalized demand system approach, we estimate both current price and expenditure elasticities in the Austrian food retail market based on a dataset covering a time period of approximately ten years. Within the framework of a three-stage-budgeting approach, more disaggregated demand reactions for milk products and types of meat are estimated. Conformable with demand theory, price reactions are found to be less elastic the more aggregated the product groups are. Generally, demand for pork and beef turns out fairly price-elastic. Similarly, price reactions for cheese and milk are stronger than average estimates for European markets. Substitution patterns are more distinct than those found in a comparable study for Germany. In addition, our study indicates the importance of modeling a comprehensive budgeting process rather than isolated levels of product aggregation when deriving both price and expenditure elasticities of demand.

Key Words

food demand; Austria; elasticity; meat; milk

Zusammenfassung

Das Kernstück dieser Arbeit liegt in der Berechnung aktueller Preis- und Ausgabenelastizitäten für den österreichischen Lebensmitteleinzelhandel. Anhand von Daten für einen Zeitabschnitt von etwa zehn Jahren erfolgt die Errechnung dieser Elastizitäten auf Basis eines verallgemeinerten Ansatzes zur Nachfragemodellierung und unter Zugrundelegung eines dreistufigen Budgetierungsprozesses. Disaggregierte Nachfragereaktionen werden hierbei für die Kategorien Milch und Fleisch analysiert. Im Einklang mit der ökonomischen Theorie nimmt die Stärke der Elastizität mit dem Grad der Aggregation ab. Überdies finden sich für die Teilgruppen Schwein und Rind relativ elastische Preisreaktionen, dies gilt auch für die Teilgruppen Trinkmilch und Käse im Vergleich mit den in anderen Studien für europäische Märkte gefundenen Durchschnittswerten. Substitutionsbeziehungen zwischen den einzelnen Teilgruppen von Fleisch fallen höher aus als in einer vergleichbaren Studie für das benachbarte Deutschland. Zudem deuten unsere Ergebnisse darauf hin, dass ein Modellierungsansatz, welcher alle Stufen eines Budgetierungsprozesses abbildet, einem Ansatz auf Basis isolierter Stufen vorzuziehen ist.

Schlüsselwörter

Nachfrage nach Nahrungsmitteln; Österreich; Elastizitäten; Fleisch; Milch

1 Introduction

Exact knowledge of demand responses associated with price and expenditure changes for food products can be considered important for several reasons. Most obviously, there is the self-interest of food retail companies considering the impacts of alternative price formations (e.g., BOLTON et al., 2006; FOX et al., 2005). However, consumer reactions are also important in other contexts. For instance, an assessment of the effects of supply shifts from technological progress on farmers' welfare (WOHLGENANT, 1993; CHUNG and KAISER, 1999), or forecasts of price developments in global agricultural markets must take into account demand aspects, just as an evaluation of the effects of taxes on unhealthy food consumption relies heavily on estimated demand and expenditure elasticities (e.g., SACKS et al., 2010; CHOUINARD et al., 2007; CASH et al., 2005). While there are a number of studies on European food markets, most estimation approaches are based on a rather arbitrary choice of demand models. In contrast to this, we use a more flexible model that nests four demand specifications whose adequacy can be statistically tested. The focus of this study is put on the Austrian food retail market, which is characterized by a relatively high concentration ratio. While this has caused concerns regarding the market power of the food retail sector in Austria (BWB, 2007), comparably little is known about demand reactions in this market. Although these demand reactions have not remained completely unobserved, to date, research has either been constrained to a limited number of products (SALHOFER et al., 2012) or is rather out-dated (SCHNEIDER and WÜGER, 1988). Therefore, it is our aim to provide precise up-to-date estimates on price and expenditure elasticities of demand for the Austrian food retail market and to compare these with respect to neighboring markets. While many demand studies are constrained to products on one level of aggregation, we adopt the concept of multistage budgeting. As previously recognized for example by SEALE et al. (2003) and YOU et al. (1996), introducing and combining multiple stages of budgeting allows for a derivation of more accurate price and expenditure elasticities. Based on this, we will also examine the impact of multistage budgeting on elasticity estimates.

The rest of the paper is organized as follows: in the next section the modeling approach nesting four common demand models is explained, and its utilization in terms of multistage budgeting is characterized. In section 3, the dataset is described, while the results and a comparison with similar investigations abroad are presented in section 4. The final section 5 draws some conclusions.

2 Modeling Approach

A variety of approaches exist to model consumer demand, whereas most of these are targeted to limit the a priori restrictions on demand elasticities, i.e. to have a flexible form. DEATON and MUELLBAUER's (1980) Almost Ideal Demand System (AIDS) meets this requirement and has been utilized in a multitude of studies (e.g., KASTERIDIS et al., 2011; TIFFIN and ARNOULT, 2010, ZHEN et al., 2011) on food demand, while being recognized for its relative ease of implementation and its sound theoretical foundation (ALSTON and CHALFANT, 1993). Another prominent example of a flexible-form demand model is the Rotterdam model (e.g., BROWN and LEE, 2010; KHALED et al., 2004) by BARTEN (1964) and THEIL (1965). Aside from these, several other models have been developed, such as the Quadratic AIDS model (BANKS et al., 1997), models that allow imposing curvature restrictions (RYAN and WALES, 1998) or dynamic models (ANDERSON and BLUNDELL, 1983). Comparisons have been made in order to filter out superior models (e.g., MEYER et al., 2011; KATCHOVA and CHERN, 2004; BARNETT and SECK, 2008; WANG et al., 1996), while the suitability and performance of a model seem to depend rather on data than on universal criteria (BARTEN, 1993; MATSUDA, 2005). Here we opt for a nesting model based on BARTEN (1993), which has the benefit that the nested models' adequacy can be tested against each other and against the superordinate model itself. The nested models included are the AIDS, the Rotterdam and two intermediary forms, namely the Central Bureau of Statistics (CBS) model and the National Bureau of Research (NBR) model. All of these four models are nested in their differenced form, whereas GAO and SHONKWILER (1993) note that difference models are preferable since spuriously desisting from differencing induces more severe distortions than the use of differencing in cases in which it would not have been necessary.

We start with the four basic models in their differenced forms (OKRENT and ALSTON, 2011):

Rotterdam:

$$w_i d\ln q_i = \lambda_i d\ln Q + \sum_{j=1}^{N} \pi_{ij} d\ln p_j \quad (1a)$$

FDLAIDS[1]:

$$dw_i = \psi_i d\ln Q + \sum_{j=1}^{N} \gamma_{ij} d\ln p_j \quad (1b)$$

CBS:

$$w_i(d\ln q_i - d\ln Q) = \psi_i d\ln Q + \sum_{j=1}^{N} \pi_{ij} d\ln p_j \quad (1c)$$

NBR:

$$(dw_i + w_i d\ln Q) = \lambda_i d\ln Q + \sum_{j=1}^{N} \gamma_{ij} d\ln p_j \quad (1d)$$

where *d* indicates that a variable is used in first-differenced form; *ln* represents the natural logarithm; w_i is the budget share for good $i = 1,\ldots,N$; q_i is the consumed quantity of good *i*; p_j is the price of good *j*; all Greek letters are parameters to be estimated; $d\ln Q$ is the Divisia Volume Index, which is defined as follows:[2]

[1] FDLAIDS denotes the first-difference form of the Linear Almost Ideal Demand System.

[2] Note that the Divisa Volume Index is equivalent to the real expenditure variable $\ln Q = \ln m - \ln P$, in LA/AIDS models, with m denoting total expenditure and $\ln P = \sum_i^n w_i \ln p_i$. In first-differenced form this real expenditure term becomes $d\ln Q = d\ln m - \sum_i^n w_i d\ln p_i$. The logarithmic differential of the total expenditure m, with $m = \sum_i^n p_i q_i$, can be written as $d\ln m = \sum_i^n w_i d\ln p_i + \sum_i^n w_i d\ln q_i$ (BARTEN, 1993). Hence, $d\ln Q = \sum_i^n w_i d\ln p_i + \sum_i^n w_i d\ln q_i - \sum_i^n w_i d\ln p_i = \sum_i^n w_i d\ln q_i$.

$d\ln Q = \sum_{i}^{N}(w_i \, d\ln q_i)$ (1e)

According to BARTEN (1993) and EALES et al. (1997), the four basic models in equations (1a) to (1d) are nested in

$$dw_i = (\beta_i + \varphi_1 w_i) d\ln Q + \sum_{j=1}^{N}\left[\theta_{ij} - \varphi_2 w_i (\delta_{ij} - w_j)\right] d\ln p_j \quad (1f)$$

with δ_{ij} representing the Kronecker Delta (δ_{ij} = 1 for $i = j$, 0 otherwise). The parameters to be estimated are the constant price coefficient θ_{ij}, the expenditure coefficient β_i, and the model's nesting parameters φ_1 and φ_2. OKRENT and ALSTON (2011) refer to equation (1f) as the Generalized Ordinary Differential Demand System (GODDS). The GODDS nests the four individual sub-models such that the price coefficient θ_{ij} is composed of $\theta_{ij} = \varphi_2 \gamma_{ij} + (1 - \varphi_2)\pi_{ij}$, and the expenditure coefficient β_i is given as $\beta_i = \varphi_1 \psi_i + (1 - \varphi_1)\lambda_i$ (OKRENT and ALSTON, 2011). We transform equation (1f) into a stochastic regression model by adding an error term, ε_i, and an intercept α_i, defined as

$$\alpha_i = \alpha_{i0} + \alpha_{il} \sum_{l=2}^{k} DM_l + \alpha_{BSE} D_{BSE} \quad (1g)$$

with k seasonal dummy variables (*DM*). In addition, dummy variable D_{BSE} is included to account for the potential impact of the BSE crisis on meat demand (ISHIDA et al., 2010).

As a key feature of the GODDS, different values for the nesting parameters can be hypothesized to test which of the nested models is most suitable for the data at hand. Generally, the nesting parameters correspond to each of the sub-models according to the restrictions outlined in Table 1. For example, if the hypothesis that φ_1 = -1 and φ_2 = 0 is not rejected, the NBR can be applied instead of the more general GODDS model. In case none of the nesting parameter restrictions is affirmed, the GODDS itself should be applied (XIE et al., 2009; MATSUDA, 2005).[3] However, estimation of the GODDS decreases the degrees of freedom as compared to any of the sub-models.

[3] DEATON et al. (1980) mention the similarity between the AIDS and the Rotterdam model. Differences in the two models, as well as their intermediary forms CBS and NBR, are due to assumptions on a rather technical level, i.e. regarding the relationship of the budget shares and the Slutsky term or the marginal expenditure shares (TAYNARD et al., 2006). However, it is not possible to discriminate between the models on economic grounds, i.e. based on the plausibility of the respective restrictions.

Table 1. Sub-models of the GODDS and corresponding parameter restrictions

	φ_1	φ_2
FDLAIDS	0	0
Rotterdam	-1	1
CBS	0	1
NBR	-1	0

Note: φ_1 and φ_2 are the nesting parameters of the GODDS
Source: EALES et al. (1997)

Following YUAN et al. (2009) we impose restrictions of homogeneity and symmetry on the parameters in the following form:

$\sum_{j=1}^{N} \theta_{ij} = 0 \; \forall \; i$ (homogeneity) (2a)

$\theta_{ij} = \theta_{ji} \; \forall \; i \neq j$ (symmetry) (2b)

$\sum_{i=1}^{N} \beta_i = -\varphi_1$ (adding − up) (2c)

$\sum_{i=1}^{N} \theta_{ij} = 0 \; \forall \; j$ (2d)

Given the restrictions in equations (2a) to (2d), we have to exclude one of the equations in the system, to avoid singularity in the variance-covariance matrix when estimating the GODDS or any of its sub-models. It follows that the parameters of the omitted equation can be recovered from the estimated results and these restrictions. Since estimates may otherwise vary depending on the units used with absolute prices, we follow MOSCHINI (1995) and normalize prices by dividing them by their respective means.

In the sequel, we will estimate demand parameters for food products at different aggregation levels and obtain demand elasticities from these parameter estimates. The highest aggregation level considered includes food and non-food, whereas at the lowest aggregation level, we will look at three types of meat and three types of milk products. For each aggregation level, the estimation procedure contains four consecutive steps. First, we test the hypothesis that prices and expenditure can be treated as exogenous in the GODDS, utilizing the stochastic form of equation (1f) and a HAUSMAN (1978) test.[4] As in KINNUCAN et al. (1997) or XIE et al. (2009), this exogeneity test is applied to guide the choice of the estimation method. In choosing our instruments, we follow XIE et al. (2009) and use a consumer price index, an energy price index, an index for agricultural raw material

[4] Throughout the article, we employ a critical level of 5% for significance tests.

prices, prime interest rates in the Euro zone, the exchange rate between the Euro and the Swiss Franc and lags in both prices of all goods at each respective stage and expenditure. If the hypothesis of price and expenditure exogeneity is rejected in the Hausman test, an instrumental variable approach, such as the method of Iterative Three Stage Least Squares (IT3SLS), is advisable, whereas in case of exogeneity of prices and expenditure, a least squares-based method like Iterative Seemingly Unrelated Regression (ITSUR) is more efficient (HILL et al., 2008: 287).[5] Second, to see if a sub-model of the GODDS is most suitable for the data, the respective hypotheses for the nesting parameters in Table 1 are tested. Third, we again test for an adequate estimation technique in the case of an accepted sub-model via a Hausman test. Finally, parameter values are estimated. Based on the estimated parameter values, price and expenditure elasticities are derived.[6] Depending on which model is chosen, the following formulae in Table 2 are applied.

Table 2. Price and expenditure elasticities for all potential models

Model	Expenditure elasticity (η_i)	Marshallian, uncompensated price elasticity (η_{ij})
FDLAIDS	$1 + \frac{\psi_i}{w_i}$	$\frac{\gamma_{ij} - \psi_i w_j}{w_i} - \delta_{ij}$
Rotterdam	$\frac{\lambda_i}{w_i}$	$\frac{\pi_{ij} - \lambda_i w_j}{w_i}$
CBS	$1 + \frac{\psi_i}{w_i}$	$\frac{\pi_{ij} - (\psi_i + w_i) w_j}{w_i}$
NBR	$\frac{\lambda_i}{w_i}$	$\frac{\gamma_{ij} - \lambda_i w_j}{w_i} + w_j - \delta_{ij}$
GODDS	$1 + \varphi_1 + \frac{\beta_i}{w_i}$	$\frac{\theta_{ij} - \beta_i w_j}{w_i} + (\varphi_2 - 1)\delta_{ij} - (\varphi_2 + \varphi_1) w_i$

Source: EALES et al. (1997), authors' own calculations

Similar to EDGERTON (1997), CARPENTIER and GUYOMARD (2001), or more recently BOUAMRA-MECHEMACHE et al. (2008) and OKRENT and ALSTON (2011), we apply the concept of multistage budgeting. In our case, we define three stages of budgeting. In particular, it is assumed that consumers first decide how much to spend on food in general versus non-food, and then continue to allocate their spending at each level of further disaggregation. At a second allocation step they choose how much of their food budget to spend on broad product groups such as meat, milk products, vegetables, etc. At the third decision level, the budget for these broad product groups is allocated to sub-groups, in such a way that e.g. the meat budget is allocated between beef, pork and poultry.

We first estimate a demand system at each stage and then calculate uncompensated price elasticities and expenditure elasticities for all three stages following the formulae in Table 2. However, these price elasticities only give conditional elasticities, i.e. they ignore that price changes of sub-categories (e.g. beef) to some extent change the price level and budget allocation at more aggregated categories (e.g. meat and food) (EDGERTON, 1997). For example, a decrease in the price of beef could reallocate more of the meat budget to beef, because it becomes cheaper relative to pork and poultry. However, consumers may also reallocate more of their food budget to meat in general, because it becomes cheaper compared to other groups such as vegetables or milk products, hereby further increasing beef consumption. The same logic carries over to the category food as compared to non-food. If we estimate demand reactions for e.g. different meat products in isolation (as in Table 2), ignoring all other products, we will only be able to provide conditional elasticities of demand. The same reasoning does apply to expenditure elasticities. Hence, we apply formulae which connect the three individual budgeting stages, analogous to DEATON (1975: 157), EDGERTON (1997) and BOUAMRA-MECHEMACHE et al. (2008), to derive unconditional-uncompensated price elasticities and unconditional expenditure elasticities. The formulae are described in Appendix A.[7]

5 Following XIE et al. (2009), theoretical constraints of (2a) - (2d) are not imposed in the course of the Hausman test.

6 To get from expenditure elasticities to income elasticities, upstream decision levels up to the choice of how much to spend on food and non-food, have to be incorporated (THIELE, 2008). To avoid unnecessary confusion, we stick to the term expenditure elasticities, bearing in mind that whenever all of our budgeting stages are combined, one might use the term income elasticity instead.

7 Compensated price elasticities η_{ij}^* can be obtained by applying the Slutsky equation: $\eta_{ij}^* = \eta_{ij}{}^U + w_j \eta_i{}^U$, with $\eta_{ij}{}^U$, $\eta_i{}^U$ referring to unconditional-uncompensated price and expenditure elasticities. However, since the differences between compensated and uncompensated elasticity values turned out to be very small, compensated elasticity values are not presented. They are available upon request.

In what follows, the term "conditional" is used for a price elasticity (or expenditure elasticity) computed at a given stage (starting from the second stage) in the vertical structure of a multistage budgeting process. Instead, the term "unconditional" refers to the first stage estimates of the price elasticities (or expenditure elasticities) and to the values calculated using the method suggested in Appendix A. All price elasticities and expenditure elasticities in tables are unconditional ones, but some conditional elasticities are discussed in the text.

Table 3. Descriptive statistics of variables at all stages of budgeting

Categories	Price		Units	Expenditure share	
	Mean	Standard deviation		Mean	Standard deviation
Stage 1[a]					
Non-food	0.77	0.20	2005 = 1	0.88	0.01
Food	0.83	0.17	2005 = 1	0.12	0.01
Stage 2[b]					
Milk products	1.99	0.16	€/kg	0.46	0.02
Oils and fats	4.05	0.25	€/kg	0.06	0.01
Fruits	1.36	0.18	€/kg	0.16	0.01
Meat	5.72	0.60	€/kg	0.16	0.28
Vegetables	1.41	0.21	€/kg	0.16	0.02
Stage 3[c]					
Meat products					
Beef	7.57	1.00	€/kg	0.24	0.17
Pork	5.30	0.58	€/kg	0.39	0.32
Poultry	4.83	0.49	€/kg	0.38	0.25
Milk products					
Drinking milk	0.76	0.08	€/kg	0.26	0.02
Cheese	2.36	0.13	€/kg	0.25	0.02
Other milk	2.07	0.18	€/kg	0.49	0.02

[a]annual data 1976-2010, n = 35. Prices of food and non-food at this first stage refer to price indices for Austria, with values of the year 2005 set as numeraire prices.
[b]monthly data, January 2000 - June 2009; n = 114
[c]monthly data, January 1997 - June 2009, n = 150

Source: author's own calculations based on data from OECD and RollAMA Austria

3 Data

Our dataset mainly consists of data from the Austrian household panel RollAMA, which contains information on total expenditures in Euro and overall quantities purchased, in kilogram, during the time period 1997 to 2009. While participating in the RollAMA panel, households complete consumption forms on all household members' purchases at any food retailer. For best possible representativeness, the panel is constructed on the basis of stratified sampling, i.e. a quota system is used, in compliance with the Austrian population census, to capture 115 types of households. Consumption form data are aggregated over time and households on a monthly level.

Food products in the dataset include several milk products, oils and fats (including vegetable oil, margarine and butter), fruits, vegetables, pork, poultry, and beef. As with many comparable household datasets, we only have expenditures and purchased quantities of the goods available, leading to the use of unit values instead of actual retail prices. Annual data from 1976 to 2010 on overall household expenditures and purchased quantities of food and non-food products in Austria, which were obtained from the OECD, complement the basis for our analysis. Descriptive statistics are presented in Table 3. Data used to construct instrumental variables are derived from both the International Monetary Fund and the OECD.

In terms of our assumption on the three stages of budget allocation, the first stage is constituted by the choice between food and non-food products. At the second stage, consumers decide between five relatively broad groups of food products, namely milk products, oils and fats, fruits, meat and vegetables. Beyond these five groups, which are included in our dataset, other food product groups exist. According to a consumer survey of STATISTIK AUSTRIA in 2009/10, our five product groups cover about 60 percent of monthly consumer expenses on food. Most notably, bread and cereal products are not included, which account for about 20 percent of the expenses on food in Austria.[8] Hence, as is often the case in demand studies (e.g. EALES and HENDERSON, 2001), we have to assume that our five food product groups are separable from all other omitted food product groups. The third and last stage includes milk products and meat products on a more disaggregated level. Milk products are clustered into three main groups: 1) drinking milk including fresh milk, ESL (extended shelf life) milk and UHT (ultra high treatment) milk; 2) cheese in all forms; and 3) a residual category of other milk

[8] The effect of such an omission on our estimated price and expenditure elasticities can hardly be assessed. Reactions following a price change for any product might be overstated when e.g. prices of omitted substitutes in a given period change in the same direction.

Table 4. Price and expenditure elasticities in the FDLAIDS model at the 2nd stage[1)]

Unconditional-uncompensated price elasticities					
% reaction in quantity following a % change in price	% change in price				
	Milk prod.	Oils and fats	Fruits	Meat	Vegetables
Milk products	**-0.64*****	0.13***	0.04	0.05	0.02**
Oils and fats	0.90***	**-1.24*****	0.14	0.00	-0.17***
Fruits	0.13*	0.05	**-0.66*****	-0.02	0.03
Meat	0.16	0.00	-0.01*	**-0.91*****	0.18
Vegetables	0.09*	-0.06***	0.04	0.21*	**-0.63*****
Unconditional expenditure elasticities					
% reaction in quantity following a % change in expenditure	Milk prod.	Oils and fats	Fruit	Meat	Vegetables
	0.38***	0.30***	0.38***	0.49***	0.35***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
[1)] All elasticity estimates are evaluated at the mean of the data. Since elasticities of demand consist of combinations of parameter estimates, corresponding standard errors were obtained based on the delta method (SPANOS, 1999).
Source: author's own calculations using ITSUR with homogeneity and symmetry constraints. Parameter values for the group of vegetables were recovered from the homogeneity and symmetry restrictions.

products including yoghurt, whipped cream, curd and sour cream. Meat is simply disaggregated into pork, poultry and beef.

4 Results

At the first stage, exogeneity of prices and expenditure is not rejected based on the Hausman test (Table B1 in Appendix B). Therefore, we use ITSUR when testing for the adequate sub-model. In the second step, both, the NBR model and the FDLAIDS are not rejected. We continue with the NBR in the third step, where the Hausman test suggests the use of ITSUR for parameter estimation. In the fourth and last step, the parameters are thus estimated by the NBR model using ITSUR and price and expenditure elasticities are derived from the estimated parameters.[9] A detailed presentation of all the parameter estimates and the rest of the test results can be found in Appendix B (Tables B1 to B3 for the first stage). The R^2 for the food equation is 0.63[10]. The main insight at this stage is that demand reactions, as expected, turn out to be less elastic for food than for non-food both in prices and expenditures. Notably, the expenditure elasticity of food is clearly less than one, indicating that conditional and unconditional estimates of price and expenditure elasticities at the second and the third stage will not be the same.

For the second stage, ITSUR is applied to the FDLAIDS model, as indicated by the respective Hausman and sub-model tests (Table B4). Values for R^2 range from 74% for milk products to 83% for fruits (Table B5). [11] In terms of price elasticities, all own-price reactions are negative and highly significant (Table 4), with price elasticities ranging from -0.63 to -1.24.

The relatively high price elasticity for oils and fats seems reasonable, given their storability. Our estimate of the own-price elasticity for milk products is -0.64. With all other factors unchanged, our result implies that e.g. a price decrease for milk products of 5 percent, as observed between 2008 and 2010 in Austria (according to Eurostat statistics), causes an increase in demanded quantity of milk products by about 3 percent.

In the most recent comparable study for Germany, THIELE (2008) considers a selection of goods which is similar to the one used here. In her study, a two-stage budgeting process is assumed, applying an AIDS model to cross-section data from the 2003 German

9 Note that estimation of the first stage is based on annual data. Instead of the monthly dummies mentioned in equation (1f), we use a time trend at this first stage. Beyond, in the first-stage test for exogeneity, lagged prices and expenditure variables are used as the only instruments, since energy prices, exchange rates, interest rates and the agricultural raw material price index were not available for the whole time period 1976 to 2010.

10 Depending on the underlying data and the method used, values for R^2 differ considerable across demand studies. We find our values of R^2 to be in a satisfactory range compared to related studies (e.g., BOUAMRA-MECHEMACHE et al., 2008, and MICHALEK and KEYZER, 1992).

11 The results in iterated SUR are invariant to the choice of which equation is omitted.

expenditure and consumption survey. At first, when comparing her results with the ones we found, a considerable difference can be observed for milk products. Opposed to our estimate of -0.64, THIELE's findings suggest an own-price elasticity of -1.00. This difference is narrowed down once we exclude the first stage of budgeting, as did THIELE (2008), leading to a value of about -0.89 for the conditional own-price elasticity of milk products in our case. As shown by this example, the conditional and unconditional elasticity values may differ substantially, which is a finding also stated by CAPPS and LOVE (2002). However, for the remainder of product groups, differences are smaller between conditional and unconditional own-price elasticities (-1.27 vs. -1.24 for oils and fats, -0.75 vs. -0.66 for fruits, -1.00 vs. -0.91 for meat and -0.72 vs. -0.63 for vegetables) and values are relatively similar to THIELE's findings for Germany, where the results are -0.80 for fruits, -1.02 for meat and -0.55 for vegetables. In terms of cross-price reactions, we find mostly substitution responses among the product groups, i.e., the demand for a product group increases when the price of another product group goes up.

All expenditure elasticities are highly significant and relatively inelastic ranging from 0.30 (oils and fats) to 0.49 (meat). Thus, a ceteris paribus increase in real income of e.g. 20 percent, i.e. an increase in the order of magnitude as experienced by the average Austrian over the last 15 years (according to OECD statistics) but with all prices and other factors remaining constant, would increase the consumption of meat by about 10 percent. Our expenditure elasticities are considerably smaller than those derived by THIELE (2008) for Germany, who obtained 1.19 for meat, 0.99 for fruits, 0.97 for vegetables and 0.89 for milk products. However, these differences almost completely disappear, if we calculate conditional expenditure elasticities, not considering the first stage, as did THIELE (2008). When neglecting the first stage of budgeting, our expenditure elasticity is 1.34 for meat, 1.05 for fruits, 0.96 for vegetables and 0.90 for milk products.

Estimations at the third stage for the different types of meat are conducted using ITSUR in the FDLAIDS model, as suggested by the Hausman and the sub-model tests (Table B6). Own-price parameters are significant, while R^2 is 0.38 for pork and 0.45 for beef (Table B7). Once more, own-price elasticities are negative and highly significant for all three types of meat (Table 5).

Noticeably, for beef and pork, own-price elasticities are in an elastic range, at -1.46 and -1.24, respectively, while it is at -0.97 for poultry. As predicted by theory, the price elasticity of a specific type of meat is higher than the one for the meat group as a whole. Once more, referring to the case of Germany, conditional price elasticities in THIELE (2008) are considerably lower at first glance (-0.53 for beef, -0.83 for pork and -0.69 for poultry). However, to make our estimates comparable, we again have to neglect the first stage, to get back from unconditional to conditional elasticities. In this case, the change induced by a negligence of the first stage is rather small (-1.42 vs. -1.46 for beef, -1.27 vs. -1.24 for pork and -1.04 vs. -0.97 for poultry) and price reactions remain more elastic than in the German case. Cross-price reactions are significant for beef demand regarding poultry prices and vice versa. Among the different meat types, pork is most expenditure-elastic. Our estimate of the elasticity of beef demand with respect to changes in the expenditure allocated to meat as a whole (conditional expenditure elasticity) is very similar to THIELE's findings for beef. Results are still fairly similar for pork, but our estimate is substantially lower for poultry (1.46 vs. 1.45 for beef, 1.50 vs. 1.61 for pork, 1.23 vs. 0.88 for poultry, the latter numbers referring to our study).

Table 5. Price and expenditure elasticities in the FDLAIDS model at the 3rd stage, meat

Unconditional-uncompensated price elasticities			
% reaction in quantity following a % change in price	% change in price		
	Beef	Pork	Poultry
Beef	**-1.46*****	0.25	0.36***
Pork	0.18	**-1.24*****	0.20
Poultry	0.26*	0.15	**-0.97*****
Unconditional-expenditure elasticities			
% reaction in quantity following a % change in expenditure	Beef	Pork	Poultry
	0.53***	0.59***	0.32***

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints. Parameter values for the group of poultry were recovered from the homogeneity and symmetry restrictions.

Table 6. Price and expenditure elasticities in the CBS model at the 3rd stage, milk

Unconditional-uncompensated elasticities			
% reaction in quantity following a % change in price	% change in price		
	Drinking milk	Cheese	Other milk
Drinking milk	**-1.03****	0.06	0.17
Cheese	0.07	**-1.35*****	0.34
Other milk	0.10	0.16	**-1.13*****
Unconditional-expenditure elasticities			
% reaction in quantity following a % change in expenditure	Drinking milk	Cheese	Other milk
	0.45***	0.59***	0.48***

Source: author's calculations using IT3SLS with homogeneity and symmetry constraints. Parameter values for the group of other milk products were recovered from the homogeneity and symmetry restrictions.

For milk products, the respective Hausman and specification test results encourage the application of the IT3SLS method to the CBS model (Table B8).[12] For the drinking milk equation, R^2 is 0.65, while it is 0.76 for the cheese equation (Table B9).[13] Own-price parameters are again found to be significant, and own-price elasticities yield the expected negative signs. Table 6 shows the price and expenditure elasticities for the three types of milk products.

The price elasticity for drinking milk is -1.03, while the one for cheese is even higher, at -1.35. Price reactions for the residual category are estimated at -1.13. Again, in line with theory, the price elasticities for the three subcategories are more elastic than at the more aggregated level in stage 2. Expenditure elasticity is 0.45 for drinking milk, 0.59 for cheese and 0.48 for residual milk products. BOUAMRA-MECHEMACHE et al. (2008), reviewing 16 studies, recapitulated demand elasticities for dairy products in the EU. Values of price elasticities from these 16 studies are in the following range: for drinking milk between -1.07 and 0.15 with an average of -0.53 and for cheese between -1.33 and -0.15 with an average of -0.60. Reported expenditure elasticities for drinking milk are between -0.04 and 1.30 with an average of 0.56 and for cheese between 0.02 and 3.22 with an average of 0.78.[14] Thus, our results are quite in line with these findings for drinking milk and cheese, indicating that price reactions for milk and cheese in Austria are relatively high as compared to those found in other European studies. Overall, demand for drinking milk and cheese in Austria seems to be rather sensitive to changes in price, but rather insensitive to changes in expenditures.[15] As opposed to the different meat types, the three sorts of milk products do not show any significant cross-price relationships.

5 Conclusions

We estimated elasticities of demand for several product groups in Austria, using a generalized model that nests four popular demand specifications. A three-stage-budgeting framework was assumed, with overall food demand at the first stage, aggregate product groups (milk products, oils and fats, fruits, meat, vegetables) at the second and more disaggregate milk products (drinking milk, cheese, other milk products) and meat products (beef, pork, poultry) at the third stage. Price elasticities at the most disaggregated level

12 Unlike ITSUR, IT3SLS is not invariant to the choice of which equation is omitted from estimation. We follow the typical procedure in demand studies (e.g. in GOULD et al. (1990), YEN and HUANG (2002)) and omit the residual product group (other milk products). Results do not vary considerably when the cheese equation is omitted instead. However, when excluding drinking milk, the own-price elasticity of drinking milk turns insignificant.

13 In line with other studies we report R^2 for this instrumental variable regression. However, as WOOLDRIDGE (2009: 516) states: "Although it does not really hurt to report the *R*-squared for IV estimation, it is not very useful, either."

14 The residual category is defined differently in our case, as butter is already included in the category oils and fats at the second stage of the budgeting process, while BOUAMRA-MECHEMACHE et al. (2008) look at butter at the third stage. Beyond, they exclude fresh dairy products from the residual category, while this is not the case in our analysis. Thus, a comparison of elasticities for the residual category is not very meaningful.

15 Notably, price elasticities are throughout higher than in the study of SCHNEIDER and WÜGER (1988) about twenty years earlier. However, their overall approach differs from ours, thus direct comparisons would be quite disputable.

were in the range of -1.03 (drinking milk) to -1.46 (beef) and from -0.63 (vegetables) to -1.24 (oils and fats) at the more aggregated second stage. We compared our findings to a recent paper by THIELE (2008) for the neighboring market of Germany as a reference point. In her study, micro-level data were available, with the advantage that a censoring mechanism could be incorporated and socio-demographic variables were encased. Beyond, THIELE (2008) had a complete range of food product groups available, while some product groups were missing in our case. Furthermore, the data in our study cover a broader time horizon. Hence, it is these differences in data availability that somewhat hampers a direct comparison of the estimates. Apart from this, we opted for a three-stage budgeting approach, while THIELE (2008) assumes two stages of budgeting, which does not include a budget decision between food and other products (our first stage). However, by excluding our first-stage in estimating elasticities, we can make our results comparable to THIELE (2008) in a consistent way. Once we do that, our price and expenditure elasticities estimates are remarkably close to those of THIELE (2008), indicating that Austrian and German consumers respond similarly to price and expenditure changes with regard to food products. According to statistics from STATISTIK AUSTRIA (2009/2010) and STATISTISCHES BUNDESAMT (2013), budget shares of general product groups such as meat or milk are extremely similar for Austria and Germany, which may suggest that findings for demand reactions in Germany could also apply for Austria, at least on a rather aggregated level such as our second stage. Mentionable differences in the outcomes with regard to THIELE's (2008) findings for Germany occur only for the three types of meat at the third stage, where price reactions for Austria are by tendency higher. Beyond, we found that price changes in one type of meat alter demand for other types of meat in Austria, while this is not detected by THIELE (2008) for Germany. Observed differences between estimates including all three stages of budgeting and those that exclude the first stage indicate the necessity to consider equal budgeting structures when comparing estimates of different studies.

In summation, our findings suggest that for broader categories, demand reactions in the Austrian retail market do not differ substantially from those in Germany. However, on a more disaggregate level, price sensitivities in Austria tend to be stronger for meat. For the case of milk products, drinking milk also exhibits a rather strong own-price reaction compared to average values for Europe. Building on our findings of similar demand reactions for Germany and Austria, the role of product heterogeneity within our product groups could be further investigated. This aspect is particularly important as long as unit values instead of actual retail prices are used. As an example, increases in unit values could also be attributable to improved product quality. If consumers are willing to pay for this increase in quality, they might mistakenly be assumed to be less price-responsive. However, the same set of consumers might be very responsive to price increases which are not accompanied by an increase in product quality. Beyond, another interesting starting point for future analyses on the Austrian retail market would be to investigate the role of socio-demographic aspects on demand.

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Appendix A: Calculation of Unconditional Elasticities of Demand

Starting from two groups a and b at the first stage, denote two exemplary sub-groups r and s at the second stage and two exemplary commodity groups i and j at the third stage. Regarding the second and the third stage of our estimations, we follow BOUAMRA-MECHEMACHE et al. (2008) and apply the following formula to get from conditional-uncompensated to unconditional-uncompensated price elasticities:

$$e_{ij} = \delta_{rs}\, e_{(a)(r)ij} + w_{(b)(s)j}\left[\frac{\delta_{rs}}{E_{(b)(s)j}} + e_{(r)(s)}\right] E_{(a)(r)i}\, E_{(b)(s)j} + w_{(b)(s)j}\, w_{(b)s}\, E_{(a)r}\, E_{(a)(r)i}\,(E_{(b)(s)j} - 1) + w_{(b)(s)j}\, w_{(b)s}\left[\frac{\delta_{ab}}{E_{(b)(s)j}\, E_{(b)s}} + e_{(a)(b)}\right] E_{(a)(r)i}\, E_{(a)r}\, E_{(b)(s)j}\, E_{(b)s} + w_{(b)(s)j}\, w_{(b)s}\, w_b\, E_{(a)(r)i}\, E_{(a)r}\, E_{(a)}(E_{(b)(s)j}\, E_{(b)s} - 1)$$

with the following definitions:

δ_{rs}	dummy equal to 1 if $r = s$ and 0 otherwise
$e_{(a)(r)ij}$	conditional price elasticity of good i with respect to good j
$w_{(b)(s)j}$	budget share of good j in commodity sub-group s
$E_{(b)(s)j}$	conditional expenditure elasticity of good j (conditional w.r.t. expenditures of sub-group s)
$e_{(r)(s)}$	conditional price elasticity of sub-group r with respect to sub-group s,
$E_{(a)(r)i}$	conditional expenditure elasticity of good i (conditional w.r.t. expenditures of sub-group r)
$w_{(b)s}$	budget share of sub-group s in group b
$E_{(a)r}$	conditional expenditure elasticity of sub-group r (conditional w.r.t. expenditures of group a)
$\delta_{(a)(b)}$	dummy equal to 1 if $a = b$ and 0 else
$E_{(b)s}$	conditional expenditure elasticity of sub-group s (conditional w.r.t. expenditures of group b)
$e_{(a)(b)}$	price elasticity of group a w.r.t. group b
w_b	budget share of group b
$E_{(a)}$	expenditure elasticity of group a

For the same stage, the unconditional expenditure elasticity for good i which belongs to the sub-group r that belongs to group a, is given by
$E_i = E_{(a)(r)i}\, E_{(a)r}\, E_{(a)}$
where

$E_{(a)(r)i}$	conditional expenditure elasticity of good i (conditional w.r.t. expenditures of group r)
$E_{(a)r}$	conditional expenditure elasticity of sub-group r (conditional w.r.t. expenditures of group a)
$E_{(a)}$	expenditure elasticity of group a

Price and expenditure elasticities for a two-stage budgeting process are obtained in a similar manner, with $a = b$. A derivation can be found in CARPENTIER and GUYOMARD (2001):

Appendix B: Tables

Stage 1

Table B1. Simultaneity and model restriction tests for the 1st stage

Null Hypothesis	*Chi²*	p-Value	df	Result
Hausman Test GODDS				
H_0: prices and expenditure exogenous	3.79	0.15	2	Not rejected
Nested Parameter Restriction Tests				
H_0: $\varphi_1 = \varphi_2 = 0$ (FDLAIDS)	3.79	0.15	2	Not rejected
H_0: $\varphi_1 = -1\ \varphi_2 = 1$ (Rotterdam)	105.19	0.00	2	Rejected
H_0: $\varphi_1 = 0;\ \varphi_2 = 1$ (CBS)	9.23	0.01	2	Rejected
H_0: $\varphi_1 = -1;\ \varphi_2 = 0$ (NBR)	2.85	0.24	2	Not rejected
Hausman Test NBR				
H_0: prices and expenditure exogenous	5.50	0.06	2	Not rejected

Source: author's own calculations

Table B2. 1st Stage parameter estimates for food in the NBR demand model

Regressor	Demand for food	
	Coefficient	(t value)
Constant	0.000	(0.671)
*d*ln(price food)	0.074***	(4.430)
*d*ln(price non-food)	-0.074***	(4.430)
*d*ln*Q*	0.069***	(5.210)
Trend	-0.000	(-1.275)
R^2	0.631	

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Table B3. Uncompensated price and expenditure elasticities for the 1st Stage, NBR model

	Food	Non-food	Expenditure
Food	-0.44**	0.07	0 37**
Non-food	-0.10***	-1.01***	1.12***

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Stage 2

Table B4. Simultaneity and model restriction tests for the 2nd stage

Null Hypothesis	*Chi²*	p-value	df	Result
Hausman Test GODDS				
H_0: prices and expenditure exogenous	36.18	0.05	24	Not rejected
Nested Parameter Restriction Tests				
H_0: $\varphi_1 = \varphi_2 = 0$ (FDLAIDS)	1.60	0.45	2	Not rejected
H_0: $\varphi_1 = -1\ \varphi_2 = 1$ (Rotterdam)	1129.96	0.00	2	Rejected
H_0: $\varphi_1 = 0;\ \varphi_2 = 1$ (CBS)	6.62	0.04	2	Rejected
H_0: $\varphi_1 = -1;\ \varphi_2 = 0$ (NBR)	21.10	0.00	2	Rejected
Hausman Test FDLAIDS				
H_0: prices and expenditure exogenous	29.02	0.22	24	Not rejected

Source: author's own calculations

Table B5. 2nd Stage parameter estimates for product groups in the FDLAIDS demand model

Variable	Demand for			
	Milk products Coefficient (t value)	**Oils and fats** Coefficient (t value)	**Fruits** Coefficient (t value)	**Meat** Coefficient (t value)
Constant	-0.021*** (-6.161)	-0.003*** (-2.449)	-0.007*** (-3.019)	0.021*** (5.960)
*d*ln (price milk products)	0.032 (1.293)	0.037*** (3.479)	-0.023** (-2.118)	-0.011 (-0.596)
*d*ln (price oils and fats)	0.037*** (3.479)	-0.017* (-1.844)	0.002 (0.471)	-0.006 (-0.832)
*d*ln (price fruits)	-0.023** (-2.118)	0.002 (0.471)	0.044*** (4.294)	-0.013 (-1.277)
*d*ln (price meat)	-0.011 (-0.596)	-0.006 (-0.832)	-0.013 (-1.277)	0.011 (0.511)
*d*ln (price vegetables)	-0.034*** (-3.141)	-0.017*** (-3.550)	-0.009 (-1.329)	0.020** (2.024)
$d\ln Q$	-0.042*** (-2.605)	-0.011* (-1.933)	0.008 (0.678)	0.062*** (3.728)
DM_2	0.022*** (4.633)	0.002 (1.207)	0.004 (1.111)	-0.019*** (-3.690)
DM_3	0.028*** (6.652)	0.004** (2.205)	0.005* (1.602)	-0.034*** (-7.705)
DM_4	0.017*** (3.743)	0.002 (1.371)	-0.002 (-0.529)	-0.021*** (-4.454)
DM_5	0.013*** (2.943)	0.001 (0.755)	0.016*** (4.943)	-0.020*** (-4.328)
DM_6	0.021*** (4.427)	0.002 (1.223)	0.029*** (8.575)	-0.026*** (-5.544)
DM_7	0.030*** (6.091)	0.005*** (2.575)	0.006* (1.778)	-0.019*** (-3.893)
DM8	0.034*** (7.580)	0.008*** (4.706)	-0.007** (-2.177)	-0.011*** (-2.422)
DM_9	0.024*** (4.492)	0.001 (0.601)	-0.017*** (-4.705)	-0.008* (-1.615)
DM_{10}	0.024*** (5.946)	0.009*** (6.218)	0.010*** (3.438)	-0.019*** (-4.441)
DM_{11}	0.006 (1.220)	0.010*** (5.807)	0.019*** (5.722)	-0.016*** (-3.222)
DM_{12}	0.041*** (8.562)	-0.007*** (-3.529)	0.023*** (7.249)	-0.068*** (-13.500)
D_{BSE}	0.001 (0.139)	0.003 (0.903)	0.004 (0.660)	-0.010 (-1.148)
R^2	0.743	0.742	0.832	0.800

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Stage 3

Meat

Table B6. Simultaneity and model restriction tests for the 3rd stage, meat products

Null Hypothesis	*Chi²*	p-Value	df	Result
Hausman Test GODDS				
H_0: prices and expenditure exogenous	15.03	0.06	8	Not rejected
Nested Parameter Restriction Tests				
H_0: $\varphi_1 = \varphi_2 = 0$ (FDLAIDS)	0.86	0.65	2	Not rejected
H_0: $\varphi_1 = -1\ \varphi_2 = 1$ (Rotterdam)	114.07	0.00	2	Rejected
H_0: $\varphi_1 = 0;\ \varphi_2 = 1$ (CBS)	5.46	0.07	2	Not rejected
H_0: $\varphi_1 = -1;\ \varphi_2 = 0$ (NBR)	17.52	0.00	2	Rejected
Hausman Test FDLAIDS				
H_0: prices and expenditure exogenous	13.41	0.10	8	Not rejected

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Table B7. 3rd Stage parameter estimates for meat types in the FDLAIDS demand model

	Demand for			
Regressor	**Beef**		**Pork**	
	Coefficient	(t value)	Coefficient	(t value)
Constant	-0.043***	(-5.062)	0.034**	(3.369)
*d*ln(price beef)	-0.119***	(-4.922)	0.075***	(3.501)
*d*ln(price pork)	0.075***	(3.501)	-0.075**	(-2.241)
*d*ln(price poultry)	0.044*	(1.905)	-0.000	(-0.002)
$d\ln Q$	0.025	(1.152)	0.080***	(3.369)
DM_2	-0.063***	(-6.143)	-0.042***	(-3.700)
DM_3	-0.037***	(-3.159)	-0.041***	(-3.026)
DM_4	-0.034***	(-3.327)	-0.015	(-1.313)
DM_5	0.020**	(-1.833)	-0.006	(-0.517)
DM_6	-0.032***	(-3.177)	-0.024**	(-2.087)
DM_7	0.050***	(-4.753)	-0.033***	(-2.747)
DM8	-0.046***	(-4.151)	-0.026**	(-2.105)
DM_9	0.072***	(6.398)	-0.082***	(-6.495)
DM_{10}	0.046***	(-3.722)	-0.042 ***	(-3.089)
DM_{11}	0.040***	(-3.725)	-0.056***	(-4.721)
DM_{12}	0.064***	(4.690)	-0.053***	(-3.389)
D_{BSE}	-0.043**	(-2.453)	0.012	(0.619)
R^2	0.454		0.379	

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Milk

Table B8. Simultaneity and model restriction tests for the 3rd stage, milk products

Null Hypothesis	*Chi*^{2}	p-Value	df	Result
Hausman Test GODDS				
H_0: prices and expenditure exogenous	14.19	0.08	8	Not rejected
Nested Parameter Restriction Tests				
H_0: $\varphi_1 = \varphi_2 = 0$ (FDLAIDS)	16.38	0.00	2	Rejected
H_0: $\varphi_1 = -1$ $\varphi_2 = 1$ (Rotterdam)	311.74	0.00	2	Rejected
H_0: $\varphi_1 = 0$; $\varphi_2 = 1$ (CBS)	1.00	0.61	2	Not rejected
H_0: $\varphi_1 = -1$; $\varphi_2 = 0$ (NBR)	61.88	0.00	2	Rejected
Hausman Test CBS				
H_0: prices and expenditure exogenous	16.46	0.04	8	Rejected

Source: author's own calculations using ITSUR with homogeneity and symmetry constraints

Table B9. Third stage parameter estimates for milk products in the CBS demand model

Variable	Demand for			
	Drinking Milk		Cheese	
	Coefficient	(t value)	Coefficient	(t value)
Constant	-0.026***	(-6.213)	0.031***	(10.135)
*d*ln(price drinking milk)	-0.236*	(-1.895)	0.072	(0.897)
*d*ln(price cheese)	0.072	(0.897)	-0.228***	(-3.042)
*d*ln(price other milk)	0.164*	(1.935)	0.156	(2.651)
$d\ln Q$	-0.026	(-1.013)	0.039**	(2.085)
DM_2	0.021***	(3.682)	-0.026***	(-6.292)
DM_3	0.020***	(4.768)	-0.034***	(-10.856)
DM_4	0.026***	(4.929)	-0.033***	(-8.480)
DM_5	0.017***	(3.292)	-0.029***	(-7.638)
DM_6	0.026***	(4.220)	-0.034***	(-7.548)
DM_7	0.024***	(4.756)	-0.030***	(-7.814)
DM8	0.034***	(6.338)	-0.031***	(-7.738)
DM_9	0.037***	(5.702)	-0.028***	(-6.222)
DM_{10}	0.034***	(5.974)	-0.036***	(-9.082)
DM_{11}	0.022***	(3.210)	-0.025***	(-4.965)
DM_{12}	0.044***	(7.362)	-0.054***	(-12.397)
R^2	0.654		0.760	

Source: author's own calculations using IT3SLS with homogeneity and symmetry constraints