The Estimation of a Linear Demand System for Basic Types of Meat

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Abstract

This paper empirically investigates the relevance of the standard economic theory of demand, as expressed in the concept of elasticities, in the period of economic transition from a centrally planned to a market economy. From the econometric point of view, the technical subject of this paper is an application of the multivariate regression model in the context of estimation of the linear system of demand equations. The results of this article confirm that in accordance with standard stylized facts the demand for a wide group of food such as meats is price inelastic. In a deeper disaggregation to the level of individual kinds of meat, there exists the potential for changes in demand dependent on price changes. The results of this project show that the Czech retail meat market behaved during the years of economic transition in a way consistent with the behaviour of a market economy as postulated by intuition, by economic theory and by empirical results from developed market economies.

Key words: regression analysis, demand system, elasticities, meat market.

Shrnutí

Cílem článku je empirické posouzení použitelnosti standardní ekonomické teorie poptávky, vyjádřené prostřednictvím příjmových a cenových pružností, v podmínkách ekonomického přechodu od centrálně plánované k tržní ekonomice. Z ekonometrického hlediska se jedná o aplikaci multivariatního regresního modelu v kontextu odhadu parametrů lineárního systému poptávkových rovnic.

Teoretickým základem práce je Stoneho výdajový systém, který byl uveden Stonem [1954] a dále byl rozvinut především Deatonem a Muellbauerem [1980a, 1980b].

V teoretické části práce je zavedena třída obecných Marshallovských poptávkových funkcí

$$q_i = g_i(m,p), \tag{2}$$

[číslování rovnic odpovídá jejich číslování v anglicky psaném hlavním tělese článku] vyjadřujících poptávku po zboží q_i jako funkci celkových výdajů m a vektoru cen p.

Výsledná rovnice použitá pro odhad parametrů je odvozena ve tvaru

$$\log q_i=\alpha_i + e_i (\log m/P) + \Sigma_{k\varepsilon K} e_{ik}^* \log (p_k/P), \tag{19}$$

kde

q_i....poptávka po zboží i,
α_i....regresní konstanta,
m/P...celkové reálné výdaje,
p_k/P..reálná cena zboží k,
e_{ik}^*..cenová pružnost zboží i vzhledem k ceně zboží k,
e_i....příjmová pružnost zboží i.
Množina K je v empirické části článku omezena na indexy k označující: k=1...vepřové, k=2...hovězí, k=3...drůbež.

Výraznou praktickou výhodou logaritmické specifikace modelu je konstantnost elasticit, které jsou proto použitelné na všech úrovních poptávky.

Hlavním zdrojem dat byly měsíční údaje z šetření statistiky rodinných účtů ČSÚ za období 1991-92. Základní popisné charakteristiky logaritmické transformace výchozích dat jsou uvedeny v tabulkách 1 a 2.

Odhad parametrů byl proveden pro dva základní případy- pro odhad pružností tří druhů masa bez zavedení omezení na symetrii elasticit a pro poptávkový systém odhadovaný za podmínky symetrie elasticit, tzn. $e_{ik}^*=e_{ki}^*$.

Výsledky odhadů parametrů bez zavedení omezení na symetrii jsou uvedeny v tabulkách 3 a 4. Odhadnuté koeficienty jsou stejné pro všechny tři použité metody- metodu maximální věrohodnosti, metodu zdánlivě nezávislých rovnic a pro individuální odhad jednotlivých rovnic metodou nejmenších čtverců. Rozdíl mezi odhady získanými různými metodami je v rozdílné velikosti standardních chyb.

Výsledky odhadu parametrů systému za podmínky symetrie pružností jsou uvedeny v tabulce 5. Statistickým testováním byla podmínka symetrie odmítnuta na 5% hladině významnosti.

V tabulce 6 jsou uvedeny 95% intervaly spolehlivosti pružností pro jednotlivé druhy masa a pro maso jako celek. Intervaly spolehlivosti pro složené zboží [maso celkem] a pro jednotlivé druhy masa se částečně překrývají, takže nelze říci, že pružnost složeného zboží je nižší než pružnosti individuálních zboží.

Provedená empirická analýza potvrdila, že v souladu se standardními stylizovanými fakty je poptávka po mase, jako široké skupině zboží, cenově nepružná [absolutní hodnota vlastní cenové pružnosti je nižší než 1]. Při hlubší dezagregaci na úroveň jednotlivých druhů masa se objevuje možnost pro výraznější změny v poptávce v závislosti na změnách cen. V poptávkovém systému bez zavedení podmínky symetrie dva ze tří druhů masa dosáhly bodový odhad vlastní cenové elasticity nižší než -1 : vepřové [-1.44] a hovězí [-1.31].

Alternativní použitá specifikace poptávkového systému za předpokladu exogeneity výdajů na maso nezměnila kvalitativně výsledky získané v prvotním modelu. Z hlediska testování ekonometrickými testy jsou však celkové výsledky alternativního modelu horší než u modelu původního.

Výsledky článku ukazují, že se český maloobchodní trh masa choval během rozhodujících let ekonomického přechodu v souladu s chováním tržní ekonomiky, tak jak je tržní ekonomika chápána intuicí, ekonomickou teorii a empirickými výsledky z rozvinutých zemí.

1. Introduction

The task of this paper is to empirically investigate the relevance of the standard economic theory of demand, as expressed in the concept of elasticities, in the period of economic transition from a centrally planned to a market economy.

The technical subject of this paper is an application of the multivariate regression model in the context of estimation of the linear system of demand equations.

2. Theory

As a basis of my paper I use Stone's expenditure system as introduced by Stone (1954) and further developed by Deaton and Muellbauer (1980a, 1980b). The necessary econometric background for estimation and hypothesis testing in the context of the system of demand functions can be found, for example, in Greene (1993). The expenditure system approach to estimation of income and demand elasticities in the conditions of Czech agricultural economy during the transition period was pioneered by Ratinger (1993).

Starting from assumptions, I will assume that prices are given exogenously. I will also make the assumption that the total disposable income is exogenously given to consumers.

I will use the simple linear budget constraint

$$m = \Sigma_k \; p_k q_k \; ,$$

where (1)

m... total expenditure,
p_k...price of good k,
q_k...quantity of good k,
k... index of good; in further analysis I will index different goods also by indexes i and j.

The consumer has a Marshallian demand function which gives the quantity demanded as a function of exogenously given prices and total expenditure which is equal to income:

$$q_i = g_i(m,p) \tag{2}$$

The fact that the demand function satisfies the budget constraint (1) immediately places a constraint on the functions g_i. This constraint is called the adding-up restriction

$$\Sigma_k\ p_k g_k(m,p) = m. \tag{3}$$

The other restriction of the demand function is the homogeneity restriction, which states that demand is homogeneous of degree zero in prices and total expenditure:

$$g_i(\theta m,\ \theta p) = g_i(m,\ p), \tag{4}$$

where $\theta>0$.

Restrictions (3) and (4) can be also expressed as restrictions on the derivatives of the demand functions, rather than on the functions themselves. The adding-up restriction (3) implies that, for i = 1,...,n

$$\Sigma_k\ p_k\ \ \partial g_k/\ \partial m = 1;\ \ \Sigma_k\ p_k\ \ \partial g_k/\ \partial p_i + q_i = 0. \tag{5}$$

Restrictions (5) intuitively mean that changes in m and p cause rearrangements in purchases that do not violate the budget constraint.

Because of homogeneity restriction (4) a proportionate change in m and p will cause no change in g_i, that is if $dm/m = dp_j/p_j = \alpha$ for all j=1,...,n, then $dq_i = 0$.

After taking total differential of (4) I obtain

$$dq_i = \partial g_i/\partial m\ dm + \Sigma_k \partial g_i/\partial p_k\ dp_k. \tag{6a}$$

I substitute $dq_i = 0$, $dm = \alpha m$ and $dp_k = \alpha p_k$ into (6a) and I obtain

$$\Sigma_k\ p_k\ \ \partial g_i/\ \partial p_k + m\ \partial g_i/\ \partial m = 0. \tag{6b}$$

Intuitively this means that a proportionate change in p and m will leave purchases of good i unchanged.

As a specific functional form the log-linear model in parameters α_i, β_{i0}, and β_{ik} is considered:

$$\log q_i = \alpha_i + \beta_{i0} \log m + \Sigma^n_{k=1}\ \beta_{ik} \log p_k. \tag{7}$$

The parameters β_{i0} and β_{ik} are determined according to the following steps:

I define budget shares

$$w_i = p_i q_i / m \tag{8}$$

as the fractions of the total expenditure going to each good.

The logarithmic derivatives of the Marshallian demands are the total expenditure elasticities and price elasticities:

$$e_i = \partial \log g_i(m, p) / \partial \log m, \tag{9}$$
$$e_{ij} = \partial \log g_i(m, p) / \partial \log p_j.$$

The Marshallian elasticities are also called uncompensated or gross elasticities.

It is possible to show that (5) is equivalent to

$$\Sigma_k\, w_k\, e_k = 1; \;\; \Sigma_k\, w_k e_{ki} + w_i = 0; \tag{10a}$$

and that (6) is

$$\Sigma_k\, e_{ik} + e_i = 0. \tag{10b}$$

With the previously established notation, I can define the logarithmic demand function (7) as

$$\log q_i = \alpha_i + e_i \log m + \Sigma_{k=1}^{n} e_{ik} \log p_k \, . \tag{11}$$

With a limited number of observations it is not possible to consider a large number of different commodities in the summation on the right hand side of the equation (11). It must be simplified. The obvious procedure, that of setting the majority of the cross-price elasticities to zero, is not a good one. Uncompensated price elasticities contain income as well as substitution effects and while substitution effects may be set to zero for "an unrelated good", the income effect should be supposed to be nonzero.

This problem can be solved by a transition to compensated elasticities. In order to achieve that, I decompose cross-price elasticities according to the Slutsky equation

$$e_{ik} = e_{ik}^{*} - e_i w_k, \tag{12}$$

where e_{ik}^* is compensated cross-price elasticity.

Substitution of (12) into (11) allows me to write

$$\log q_i = \alpha_i + e_i (\log m - \Sigma_k w_k \log p_k) + \Sigma_{k=1}^n e_{ik}^* \log p_k. \tag{13}$$

The expression $\Sigma w_k \log p_k$ can be thought of as the logarithm of a general index of prices log P, so that (13) becomes

$$\log q_i = \alpha_i + e_i (\log m/P) + \Sigma_{k=1}^n e_{ik}^* \log p_k. \tag{14}$$

The logarithmic price index log P is used as an approximation for theoretical Muellbauer's logarithmic price index log P^*.

The logarithmic price index log P^* is derived on the basis of the preferences of the consumer, which are assumed to be of PIGLOG class (Price independent generalized loglinear) as defined by Muellbauer (1976):

$$\log c(u,p) = (1-u) \log[a(p)] + u \log[b(p)], \tag{15}$$

where u... utility 0<u<1, a(p), b(p)... positive linearly homogeneous functions expressing the cost of subsistence and saturation, respectively.

Specific functional forms for log a(p) and log b(p) are given in the first order approximation by

$$\begin{aligned} \log a(p) &= a_0 + \sum_k \alpha_k \log p_k \\ \log b(p) &= \log a(p) + \beta_0 \prod_k p_k^{\beta_k} \end{aligned} \tag{16}$$

where α_i and β_i are parameters such that $\Sigma_i \alpha_i = 1$, $\Sigma_j \beta_j = 0$.

For a utility- maximizing consumer, total expenditure m is equal to cost c(u,p).

Deaton and Muellbauer (1980b) showed that the utility function defined in this way allows the logarithmic price index to be expressed by a first order Taylor expansion as

$$\log P^* = \alpha_0 + \Sigma_k \alpha_k \log p_k. \tag{17}$$

Following Deaton and Muellbauer (1980a) the theoretical price index log P^* with unknown parameters α_i is approximated by price index log P with weights of liner combination of price logarithms log p_k given as budget shares w_k.

Equation (14) gives demand in terms of real expenditure, on the one hand, and "compensated" prices on the other. Intuitively it is possible to say that going from (11) to (14) means going from Marshallian to Hicksian demand functions, at least approximately.

Further simplification is achieved in Stone’s model by enforcing the homogeneity restriction with the use of equations (10) and (12), which can be written as

$$\Sigma_k \, e_{ik}^{*} = 0. \tag{18}$$

Equation (18) can then be used to allow the deflation of all prices in (14) by the general index P. According to (9), the following is approximately equivalent to (14):

$$\log q_i = \alpha_i + e_i \,(\log m/P) + \Sigma_{k\varepsilon K} \, e_{ik}^{*} \log (p_k/P). \tag{19}$$

The important feature of equation (19) is that the range of summation is restricted to some set K of close substitutes and complements. This is now acceptable since there is no reason not to rule out zero substitution between unrelated goods.

Equation (19) allows the modelling of three demand equations for three kinds of meat depending on real income and real prices of three analyzed meats.

So, in (19) the set K is restricted to indexes of good k such that k=1...pork, k=2...beef, k=3...poultry.

3. Variables specification

Up to July 1990, there were in Czechoslovakia in effect stable, administratively created prices of food which were created under the system of a centrally planned economy. In July 1990 a one-shot increase in food prices was made, which changed both the relative and absolute prices. These changed prices were still considered to be official and were not changed until the end of 1990. From 1 January 1991, government set prices of food were abolished and price setting was more or less left to market forces. Subsequently, meaningful demand analysis can use only data from 1991 onwards.

The main source of data is a household budget survey which is carried out on a representative sample of households. I used data for a subsample of households of employees. (The other subsamples are subsamples of farmers and retired people). The data were given in average form, that is as an average monthly consumption of pork per person, and so on.

Monthly data from household budget surveys were available only up to the end of 1992. In 1993, data continue to be collected monthly, but are publicly available only quarterly. As a result of these restrictions on data availability I used time series with 24 observations on all independent and dependent variables.

From the household budget survey I obtained data on the monthly consumption of pork, meat and poultry per capita. I have used these quantities as a q_i i=1,2,3, specified in the theoretical section of this paper. I have also obtained there the data on the average prices of these products, as faced by the surveyed households.

I was not able to obtain monthly data on total expenditures, so I used as a proxy the average monthly income for employees. As a proxy for general price index P specified in the theoretical part, I used the CPI published by the Czech Statistical Office.

4. Description of the data

All descriptive statistics and all estimations in this paper were computed by Time Series Processor (TSP) program version 4.2. The core of the program is in Appendix 1.

The basic descriptive statistics of the data set I used are summarized in the Table 1. The values in both Table 1 and following Table 2 are based on the data before a logarithmic transformation.

From the consumption data we can see that the major share of the consumption of meat belongs to pork, which also has the highest average price. The consumption of poultry is probably, besides other factors, influenced by its lower price when compared to beef and pork.

The rather low values of consumption are caused by the fact that household budget survey reports so called differentiated consumption which is lower than the global consumption. The explanation of relations between these two approaches to the estimation of food consumption is given in Štiková et al (1993).

The variability of the data as described by the mean range [MEAN RANGE= (MAXIMUM-MINIMUM)/MEAN] and by the coefficient of variation exhibits the same trends. Both consumption and price of poultry are the most stable from the investigated kinds of meat. The price of beef exhibits the highest dispersion over the investigated period. On the other side the most variable consumption is observed for pork.

The information contained in Table 1 can be supplemented by the fact that the real retail prices of pork and beef follow a slight upward trend; the real price of poultry does not exhibit a noticeable trend over the investigated period.
From the correlation matrix in Table 2 it is possible to see that for pork and beef there exists an intuitively expected negative correlation between price and quantity demanded. The positive correlation coefficient for poultry price and quantity signals the departure from the standard assumptions of demand theory, according to which we could expect negative correlation between the price and quantity demanded. The negative sign of the correlation coefficient between beef consumption and income signals possibility of countrintuitive results of regression analysis with respect to beef.

Quite high values of correlation coefficients between prices signal a potential danger of the harmful influence of collinearity on the possibility of the isolation of the separate effects of individual explanatory variables in the estimated model.

5. Empirical results

In my empirical study I have used some proxies for variables defined in the theoretical part. I have used income as a proxy for m and I have used CPI instead of general price index P.

The results of the estimation of three demand equations are given in Table 3 and Table 4. The results are given for maximum likelihood joint estimation with TSP procedure FIML, for joint seemingly unrelated equation estimation with TSP procedure SUR, and for individual estimations of equations, one at a time, with TSP procedure OLSQ.

The estimated coefficients are the same for all three methods since on the right hand side of all three demand equations there are the same regressors and the values of independent variables are also the same. The difference between the methods of estimation used is in the standard errors, which are smallest in the SUR case. The high standard errors for maximum likelihood estimation (which cause the insignificance of regression coefficients) are not the problem of the values of the utilised data but it is a result which is generally true in small samples with high number of regressors. There is only 24 observation which are used for maximum likelihood estimation of the system with 15 estimated parameters. Resulting nine degrees of freedom is simply not enough relative to high number of regressors. Statistically significant estimates of coefficients in individually estimated equations reflects substantially higher degree of freedom (19 degrees of freedom for equation with 5 estimated coefficients).

The gain in efficiency of estimates in SUR as compared to maximum likelihood and OLS estimates is due to the exploiting the additional information concerning cross correlations among equation errors without decreasing the number of degrees of freedom as in the maximum likelihood method.

By testing for autocorrelated error I have found out that for the equations for pork and poultry we do not reject null hypothesis of no autocorrelation and for the beef equation the value of Durbin-Watson statistic falls into inconclusive region. (The critical values for Durbin-Watson statistic for a 5% significance level for N=24, K=5 are d_L=1.013 and d_U=1.775.)

The income elasticities for all three meats agree with economic intuition that food is a normal good. Moreover, for all three meats the percentage increase in consumption is less than proportional to the increase in income. The most sensitive is pork, whose consumption increases only a little less than proportionally. The least sensitive is beef, whose consumption responds by only a half percent increase to a one percent increase in disposable income.

Own price elasticities have expected negative signs for pork and beef. The magnitude of the demand response to the change of the own price is approximately equal for both ($e_{11}^* = -1.4$, $e_{22}^* = -1.3$).

The own price elasticity doesn't conform to prior expectations for poultry. But, it is important to notice that the positive own price elasticity for poultry is not statistically significantly different from zero on any conventional level. Moreover, the p-value of the F test (p=0.058) shows that we cannot reject on the level of significance α = 0.05 null hypothesis that all elasticities are jointly equal to zero. So I cannot say that the empirical data shows that demand for poultry increases with an increase in poultry price. One of a reasons for the absence of negative own price elasticity for poultry may be the existence of some other important determinants of poultry consumptions, such as conceptions of healthy diet. One should also bear in mind the possible problems caused by the multicollinearity between prices which was already mentioned in the section devoted to the description of the data. The problems with estimation of equation for poultry can also be related to the low sample variability of both a price and a consumption of poultry.

From the signs of the cross price elasticities in the demand equation of pork we can infer that both beef and poultry are substitutes to pork. This inference is statistically significant only for poultry, whose price exhibits a quite strong substitute influence on pork demand.

In the beef demand equation neither of the two cross-price elasticities is statistically significant. Point estimations of cross-price elasticities suggest that pork is a complement and poultry a substitute to beef.

From analysis of the poultry demand equation it follows that on the 10% level of significance we can reject the hypothesis that the price of beef does not influence the demand for poultry. According to my data, beef and poultry are substitutes. The result of complementarity of poultry and pork is not statistically significant.

The evaluation of complementarity and substitutability according to approach used here is not consistent. According to the equation for pork, both beef and poultry are substitutes to pork. On the contrary, pork is a complement to beef and poultry according to demand equations for beef and poultry. Clearly, if complementarity and substitutability are to be measured in a consistent way, an alternative approach must be adopted.

5.1.2. Estimation with symmetry restrictions

The problem of substitutes and complements does not show up in the restricted symmetric system. But the main reason for the imposition of the symmetry restriction usually is the requirement to conserve the degrees of freedom in the estimation of a large number of demand equations.

In the restricted symmetric system $e_{ij}^* = e_{ji}^*$. Symmetry cannot be tested on an equation-by-equation basis. Instead the required test is a large sample likelihood ratio test for the system as a whole.

The results of the estimation of the restricted system are given in the Table 5. By comparison with the data in the Table 3 we can see that twice the logarithm of the likelihood is 153.9568 for the system without symmetry restriction and falls to 142.7442 under symmetry restriction. Since symmetry in this model embodies three constraints, the appropriate test statistic is asymptotically valid chi^2 with three degrees of freedom. So LR = 11.2126 means that I have to reject a null hypothesis of applicability of symmetry constraints (the 5% critical value of chi^2 is 7.81).

The rejection of the symmetry constraint is in line with empirical results usually obtained in literature, see Deaton and Muellbauer (1980a).

Because of the rejection of the symmetry restriction, I will provide only a short assessment of the restricted model. In a restricted system, all income elasticities have the expected positive signs. The ordering of intensities of income elasticities is the same as in an unrestricted model - the most intensive response is in pork, the least in beef. The size of income elasticities in a restricted model is diminished in comparison with the unrestricted model, which signals a lower response of demand to the change in disposable income.

Own price elasticities in the restricted model are uniformly negative and in this way conform to the expectations economic theory. Only beef exhibits more the proportional change in demand in response to own price changes.

From the cross-price elasticities restricted by the symmetry constraint, I obtained an intuitively plausible classification of complementarity and substitutability between investigated kinds of meats. According to the presented analysis, pork and beef are complements and poultry is a substitute both to pork and beef.

5.2. The composite good

I have also aggregated all three kinds of meat into one composite good and investigated its income and price elasticity. In the equation for the composite good I have defined the quantity of meat as the sum of individual quantities:

$$QF = Q1 + Q2 + Q3,$$

and I have defined the price of meat as a weighted average of individual prices:

$$PF = (Q1\ P1 + Q2\ P2 + Q3\ P3)/QF.$$

The sign of elasticities were as would be expected; price elasticity was negative and income elasticity was positive.

The 95% confidence intervals for elasticities values for composite good and individual goods are contained in the following Table 6. (The standard deviations for individual goods are those from individual OLS estimates).

Confidence intervals for elasticities of the composite good overlap with confidence intervals of individual products. So we cannot say that elasticities of the composite good are strictly lower than elasticities of individual goods as intuition would suggest.

6. Alternative model specification

In this alternative model specification I made the rather heroic assumption that the total income disposable for expenditures on meat is exogenously given to consumers. Under this assumption I used the results of the theoretical part to model demand for three kinds of meat under a budget restriction given by total expenditures on meat so that from equation (1) I defined the expenditure variable m as the total expenditure on meat.

This specification allowed me to compute budget shares w_i directly from (8) and subsequently to compute the general price index P as specified in the theoretical section. I used this P as a deflator of prices and expenditure in equation (19).

6.1. Empirical results under alternative specification

The results of the estimation of alternative model are given in Table 7 for the system estimation by maximum likelihood method and in Table 8 for estimation by ordinary least squares method.

As far as income elasticities are concerned, there was no qualitative difference between alternative and original specifications. In both specifications all three kinds of meats can be classified as normal goods with positive income elasticities. Also a comparison of own price elasticities between the original and alternative models shows no qualitative difference - own price elasticities for pork and beef are negative and for poultry they are positive.

Higher absolute values of price elasticities in the alternative model imply a large sensitivity of demand to own price changes. The examination of cross-price elasticities shows a different pattern of substitutability and complementarity relations than in the original specification.

The results of testing for autocorrelation in this alternative model were less favourable than in the original model. The null hypothesis of no autocorrelation was rejected for the OLS equation for pork and the value of Durbin-Watson statistic falls into inconclusive region in the beef equation. Only for poultry equation we do not reject on a 5% level of significance hypothesis of no autocorrelation.

The symmetry restriction in alternative specification was rejected on a higher level of significance than in the original model (LR= 46.948). So I just show in the Table 9 without any comments the results of estimation of restricted system by maximum likelihood TSP procedure FIML.

7. Conclusions

I have confirmed that in accordance with standard stylized facts the demand for a wide group of food such as meats is price inelastic (the absolute value of own price elasticity is less than 1). In a deeper disagregation to the level of individual kinds of meat, there exists the potential for changes in demand dependent on price changes. In the demand system without the symmetry restriction two of the three kinds of meat investigated exhibited the point estimate of own price elasticity smaller than -1: pork(-1.44), beef(-1.31).

I have also rejected the intuitive result, that both income and own price elasticities for a composite good are lower than those for the individual goods which compose the composite good.

The alternative specification of a demand system under the assumption of exogenously given expenditures on meat did not qualitatively change the results obtained by the original model, but the overall performance, as measured by econometric tests, of the alternative specification model was worse than that of the original model.

The results of this project show that the Czech retail meat market behaved during the years of economic transition in a way consistent with the behaviour of a market economy as postulated by intuition, by economic theory and by empirical results from developed market economies. Of course, there still remains the task of proving similar assertions with respect to the whole meat market as experienced by farmers and manufacturers. Nevertheless the wellknown discrepancies in farmer and manufacturer prices of meat products in 1991 and 1992 were not primarily caused by irrational or inconsistent behaviour in the retail market of meat.

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Data used in the paper were obtained from the materials of Czech Statistical Office.

Table 1: Basic Descriptive Statistics

	Mean	Standard Deviation	Minimum	Maximum	Mean range	coeff. of variation
P1	29.23	3.24	21.87	34.36	0.43	0.11
P2	27.70	3.76	22.81	41.24	0.66	0.14
P3	22.19	1.28	19.09	25.39	0.28	0.06
Q1	0.74	0.12	0.55	1.16	0.82	0.17
Q2	0.48	0.07	0.29	0.63	0.71	0.16
Q3	0.58	0.09	0.48	0.81	0.56	0.16
M	2413.12	197.99	2097.68	2910.30	0.34	0.08

P1...real price of pork,
P2...real price of beef,
P3...real price of poultry,
Q1...consumption of pork (kg per month per person),
Q2...consumption of beef (kg per month per person),
Q3...consumption of poultry (kg per month per person),
M ...real income.
Real prices and real income are given in Czechoslovak crowns in prices of January 1989.

Table 2: Correlation matrix

	P1	P2	P3	Q1	Q2	Q3
P1	1.00000					
P2	0.42241	1.0000				
P3	0.49140	0.28560	1.0000			
Q1	-0.44969	-0.091988	0.12096	1.00000		
Q2	0.47137	-0.84490	-0.23903	0.36022	1.00000	
Q3	0.15783	0.42364	0.21913	0.50576	-0.21180	1.00000
M	0.48194	0.33757	0.20143	0.065680	-0.17090	0.46887

Table 3: Unrestricted System Estimated by Maximum Likelihood Method (ML) and by Seemingly Unrelated Equations Method (SUR)

Parameter	Estimate	Standard Error		t-statistic		P-value	
		ML	SUR	ML	SUR	ML	SUR
α_1	-7.45740	17.1859	2.43590	-.433925	-3.06146	[.664]	[.002]
e_1	.911881	3.19021	.313650	.285838	2.90732	[.775]	[.004]
e_{11}^*	-1.44349	2.78327	.261574	-.518632	-5.51849	[.604]	[.000]
e_{12}^*	.032050	3.64270	.205762	.008799	.15576	[.993]	[.876]
e_{13}^*	1.55150	2.91934	.443431	.531456	3.49885	[.595]	[.000]
α_2	-1.00279	5.13418	1.55926	-.195316	-.64311	[.845]	[.520]
e_2^*	.508904	1.08841	.200773	.467565	2.53472	[.640]	[.011]
e_{21}^*	-.131952	1.36078	.167438	-.096968	-.78806	[.923]	[.431]
e_{22}^*	-1.30706	1.70228	.131712	-.767826	-9.92356	[.443]	[.000]
e_{23}^*	.346361	3.30086	.283849	.104931	1.22023	[.916]	[.222]
α_3	-8.35717	16.8158	2.74253	-.496982	-3.04725	[.619]	[.002]
e_3^*	.874475	2.96928	.353132	.294507	2.47634	[.768]	[.013]
e_{31}^*	-.499847	1.06182	.294501	-.470746	-1.69727	[.638]	[.090]
e_{32}^*	.476206	1.47618	.231664	.322593	2.05559	[.747]	[.040]
e_{33}^*	.357294	2.97043	.499251	.120283	.71566	[.904]	[.474]

Log of Likelihood Function = 76.9784

Table 4: Individual Estimations of Three Demand Equations by OLS

1. PORK adjusted R-squared = .498822, D.W. statistic = 2.19578, F-statistic (zero slopes) = 6.72297 [.002]				
Parameter	Estimated Coefficient	Standard Error	t-statistic	P-value
α_1	-7.45740	2.73771	-2.72395	[.013]
e_1	.911881	.352512	2.58681	[.018]
e_{11}^*	-1.44349	.293983	-4.91011	[.000]
e_{12}^*	.032050	.231257	.138592	[.891]
e_{13}^*	1.55150	.498374	3.11313	[.006]
2. BEEF Adjusted R-squared = .803898, D.W. statistic = 1.45824, f-statistic (zero slopes) = 24.5714 [.000]				
Parameter	Estimated Coefficient	Standard Error	t-statistic	P-value
α_2	-1.00279	1.75246	-.572216	[.574]
e_2	.508904	.225650	2.25528	[.036]
e_{21}^*	-.131952	.188184	-.701186	[.492]
e_{22}^*	-1.30706	.148032	-8.82955	[.000]
e_{23}^*	.346361	.319019	1.08571	[.291]
3. POULTRY Adjusted R-squared = .233427 D.W. statistic = 1.97746, F-statistic (zero slopes) = 2.75091 [.058]				

Table 5: Restricted System Estimated by Maximum Likelihood Method

Parameter	Estimate	Standard Error	t-statistic	P-value
α_1	-3.82379	11.6662	-.327766	[.743]
e_1	.719475	1.96280	.366555	[.714]
e_{11}^*	-.837235	.739754	-1.13178	[.258]
e_{12}^*	-.065554	.285379	-.229709	[.818]
e_{13}^*	.307289	.706478	.434959	[.664]
α_2	-.647068	2.32643	-.278137	[.781]
e_2	.488134	.292388	1.66947	[.095]
e_{22}^*	-1.32215	.379075	-3.48782	[.000]
e_{23}^*	.227674	.466595	.487948	[.626]
α_3	-4.65776	12.2393	-.380559	[.704]
e_3	.626469	2.04259	.306704	[.759]
e_{33}^*	-.825451	.699614	-1.17987	[.238]
Log of Likelihood function = 71.3721				

Table 6: Elasticities for Composite and Individual Goods

	Income Elasticity	Own Price Elasticity
Pork	(0.17; 1.65)	(-2.06; 0.83)
Beef	(0.04; 0.98)	(-1.62; -1.00)
Poultry	(0.04; 1.71)	(-0.82; 1.53)
Meat	(-0.01; 1.27)	(-1.41; -0.11)

Table 7: Unrestricted System Estimated by Maximum Likelihood Method

Parameter	Estimate	Standard Error	t-statistic	P-value
α_1	-.936752	.157392	-5.95173	[.000]
e_1	1.17680	.173939	6.76557	[.000]
e_{11}^*	-3.36949	1.88644	-1.78616	[.074]
e_{12}^*	-1.26845	.996674	-1.27268	[.203]
e_{13}^*	-1.63275	1.32742	-1.23002	[.219]
α_2	-.880869	.620359	-1.41993	[.156]
e_2	.499585	.784289	.636991	[.524]
e_{21}^*	-2.36166	4.57289	-.516448	[.606]
e_{22}^*	-2.45066	2.59164	-.945600	[.344]
e_{23}^*	-.809961	2.79568	-.289719	[.772]
α_3	-1.45027	.462036	-3.13886	[.002]
e_3	1.15677	.656205	1.176282	[.078]
e_{31}^*	6.11483	2.97100	2.05817	[.040]
e_{32}^*	3.46541	1.44393	2.39998	[.016]
e_{33}^*	2.42875	1.20679	2.01258	[.044]
Log of Likelihood Function = 177.367				

Table 8: Individual OLS Estimations of Three Demand Equations

1. PORK
adjusted R-squared = .950501 D.W. statistic = .998735 F-statistic (zero slopes) = 111.414 [.000]

Parameter	Estimated Coefficient	Standard Error	t-statistic	P-value
α_1	-.936752	.063090	-14.8479	[.000]
e_1	1.17680	.077087	15.2659	[.000]
e_{11}*	-3.36949	.671034	-5.02133	[.000]
e_{12}*	-1.26845	.342354	-3.70508	[.002]
e_{13}*	-1.63275	.433686	-3.76482	[.001]

2. BEEF
Adjusted R-squared = .765979 D.W. statistic = 1.20870 F-statistic (zero slopes) = 19.8205 [.000]

Parameter	Estimated Coefficient	Standard Error	t-statistic	P-value
α_2	-.880869	.140379	-6.27491	[.000]
e_2	.499585	.171523	2.91264	[.009]
e_{21}^*	-2.36166	1.49310	-1.58172	[.130]
e_{22}^*	-2.45066	.761763	-3.21709	[.005]
e_{23}^*	-.809961	.964982	-.839353	[.412]

3. POULTRY
Adjusted R-squared = .927346 D.W. statistic = 1.84507 F-statistic = (zero slopes) = 74.3921 [.000]

Parameter	Estimated Coefficient	Standard Error	t-statistic	P-value
α_3	-1.45027	.069583	-20.8423	[.000]
e_3	1.15677	.085020	13.6059	[.000]
e_{31}^*	6.11483	.740094	8.26223	[.000]
e_{32}^*	3.46541	.377588	9.17775	[.000]
e_{33}^*	2.42875	.478319	5.07768	[.000]

Table 9: Restricted System Estimated by Maximum Likelihood Method

Parameter	Estimate	Standard Error	t-statistic	P-value
α_1	-.909854	.086426	-10.5275	[.000]
e_1	1.16438	.093214	12.4915	[.000]
e_{11}^*	-1.40226	.346968	-4.04147	[.000]
e_{12}^*	-.292760	.352532	-.830450	[.406]
e_{13}^*	-.355179	.325609	-1.09082	[.275]
α_2	-.924904	.347001	-2.66542	[.008]
e_2	.546377	.486112	1.12397	[.261]
e_{22}^*	-1.47463	.742762	-1.98533	[.047]
e_{23}^*	.315601	.415197	.760123	[.447]
α_3	-1.45333	.424140	-3.42654	[.001]
e_3^*	1.12693	.622968	1.80898	[.070]
e_{33}^*	-1.51559	.673484	-2.25073	[.024]
Log of Likelihood function = 153.893				

APPENDIX 1

THE CORE OF THE TSP PROGRAM USED FOR PROCESSING DATA IN THIS PAPER

```
      1  freq n;
      2  READ(FORMAT=LOTUS,file='D:\JANDA.2\MEAT\MEAT33.WK1');
      3  ?=====================================;
      3  ?INDIVIDUAL GOODS;
      3  ?
      3  list ALLVAR P1 P2 P3 Q1 Q2 Q3 M;
      4  msd (CORR) ALLVAR;
      5  GENR LP1=LOG(P1);
      6  GENR LP2=LOG(P2);
      7  GENR LP3=LOG(P3);
      8  GENR LQ1=LOG(Q1);
      9  GENR LQ2=LOG(Q2);
     10  GENR LQ3=LOG(Q3);
     11  GENR LM=LOG(M);
     12  REGOPT(PVPRINT)ALL;
     13  ?
     13  ? FIML SYSTEM OF EQUATIONS ESTIMATION;
     13  FRML EQ1 LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
     14  FRML EQ2 LQ2=A2+N2*LM+N21*LP1+N22*LP2+N23*LP3;
     15  FRML EQ3 LQ3=A3+N3*LM+N31*LP1+N32*LP2+N33*LP3;
     16  PARAM A1 A2 A3
     16        N1 N2 N3
     16        N11 N12 N13
     16        N21 N22 N23
     16        N31 N32 N33;
     17  FIML(ENDOG=(LQ1, LQ2, LQ3)) EQ1 EQ2 EQ3;
     18  ?
     18  ? SUR SYSTEM OF EQUATIONS ESTIMATION;
     18  FRML EQ1 LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
     19  FRML EQ2 LQ2=A2+N2*LM+N21*LP1+N22*LP2+N23*LP3;
     20  FRML EQ3 LQ3=A3+N3*LM+N31*LP1+N32*LP2+N33*LP3;
     21  PARAM A1 A2 A3
     21        N1 N2 N3
     21        N11 N12 N13
     21        N21 N22 N23
     21        N31 N32 N33;
     22  SUR EQ1 EQ2 EQ3;
     23  ?
     23  ?ESTIMATIONS OF SEPARATE EQUATIONS;
     23  OLSQ LQ1 C LM LP1 LP2 LP3 ;
     24  OLSQ LQ2 C LM LP1 LP2 LP3 ;
     25  OLSQ LQ3 C LM LP1 LP2 LP3 ;
     26  ?
     26  ? RESTRICTED FIML SYSTEM OF EQUATIONS ESTIMATION;
     26  FRML EQ1R LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
     27  FRML EQ2R LQ2=A2+N2*LM+N12*LP1+N22*LP2+N23*LP3;
     28  FRML EQ3R LQ3=A3+N3*LM+N13*LP1+N23*LP2+N33*LP3;
     29  PARAM A1 A2 A3
     29        N1 N2 N3
     29        N11 N12 N13
     29            N22 N23
     29                N33;
     30  FIML(ENDOG=(LQ1 LQ2 LQ3)) EQ1R EQ2R EQ3R;
     31  ?
     31  ? RESTRICTED SUR SYSTEM OF EQUATIONS ESTIMATION;
     31  FRML EQ1R LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
     32  FRML EQ2R LQ2=A2+N2*LM+N12*LP1+N22*LP2+N23*LP3;
     33  FRML EQ3R LQ3=A3+N3*LM+N13*LP1+N23*LP2+N33*LP3;
     34  PARAM A1 A2 A3
     34        N1 N2 N3
     34        N11 N12 N13
     34            N22 N23
     34                N33;
     35  SUR EQ1R EQ2R EQ3R;
     36  ?
     36  ?=====================================;
     36  ?COMPOSITE GOOD;
     36  ?
     36  GENR QF=Q1+Q2+Q3;
     37  GENR PF=(P1*Q1+P2*Q2+P3*Q3)/QF;
     38  GENR LQF=LOG(QF);
     39  GENR LPF=LOG(PF);
     40  ?
```

```
40  ?ESTIMATION OF OLSQ OF COMPOSITE GOOD;
40  OLSQ LQF C LM LPF;
41  ?
41  ?ALTERNATIVE SPECIFICATION;
41  freq n;
42  READ(FORMAT=LOTUS,file='D:\JANDA.2\MEAT\MEAT23.WK1');
43  ?===================================;
43  ?TRANSFORMATION FOR "GENERALIZED PRICE INDEX";
43  ?INDEX P CREATION ;
43  GENR W1=NP1*Q1/NM;
44  GENR W2=NP2*Q2/NM;
45  GENR W3=NP3*Q3/NM;
46  GENR LNP1=LOG(NP1);
47  GENR LNP2=LOG(NP2);
48  GENR LNP3=LOG(NP3);
49  GENR P=EXP(W1*LNP1+W2*LNP2+W3*LNP3);
50  ?TRANSFORMATION OF DATA;
50  GENR M=NM/P;
51  GENR P1=NP1/P;
52  GENR P2=NP2/P;
53  GENR P3=NP3/P;
54  ?
54  list ALLVAR P1 P2 P3 Q1 Q2 Q3 M;
55  msd (CORR) ALLVAR;
56  GENR LP1=LOG(P1);
57  GENR LP2=LOG(P2);
58  GENR LP3=LOG(P3);
59  GENR LQ1=LOG(Q1);
60  GENR LQ2=LOG(Q2);
61  GENR LQ3=LOG(Q3);
62  GENR LM=LOG(M);
63  REGOPT(PVPRINT)ALL;
64  ?
64  ? FIML SYSTEM OF EQUATIONS ESTIMATION;
64  FRML EQ1 LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
65  FRML EQ2 LQ2=A2+N2*LM+N21*LP1+N22*LP2+N23*LP3;
66  FRML EQ3 LQ3=A3+N3*LM+N31*LP1+N32*LP2+N33*LP3;
67  PARAM A1 A2 A3
67        N1 N2 N3
67        N11 N12 N13
67        N21 N22 N23
67        N31 N32 N33;
68  FIML(ENDOG=(LQ1, LQ2, LQ3)) EQ1 EQ2 EQ3;
69  ?
69  ? SUR SYSTEM OF EQUATIONS ESTIMATION;
69  FRML EQ1 LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
70  FRML EQ2 LQ2=A2+N2*LM+N21*LP1+N22*LP2+N23*LP3;
71  FRML EQ3 LQ3=A3+N3*LM+N31*LP1+N32*LP2+N33*LP3;
72  PARAM A1 A2 A3
72        N1 N2 N3
72        N11 N12 N13
72        N21 N22 N23
72        N31 N32 N33;
73  SUR EQ1 EQ2 EQ3;
74  ?
74  ?ESTIMATIONS OF SEPARATE EQUATIONS;
74  OLSQ LQ1 C LM LP1 LP2 LP3 ;
75  OLSQ LQ2 C LM LP1 LP2 LP3 ;
76  OLSQ LQ3 C LM LP1 LP2 LP3 ;
77  ?
77  ? RESTRICTED FIML SYSTEM OF EQUATIONS ESTIMATION;
77  FRML EQ1R LQ1=A1+N1*LM+N11*LP1+N12*LP2+N13*LP3;
78  FRML EQ2R LQ2=A2+N2*LM+N12*LP1+N22*LP2+N23*LP3;
79  FRML EQ3R LQ3=A3+N3*LM+N13*LP1+N23*LP2+N33*LP3;
80  PARAM A1 A2 A3
80        N1 N2 N3
80        N11 N12 N13
80            N22 N23
80                N33;
81  FIML(ENDOG=(LQ1 LQ2 LQ3)) EQ1R EQ2R EQ3R;
82  ?
82  ?
82  STOP;
83  END;
```