Estimating Food Demand Behaviour
- The Case of India

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Abstract

Demand for food is a field that has spurred much activity in economic research and has a long history within the economics profession. In recent years focus has been on changing agricultural policies due to trade negotiations in GATT and WTO and their effects on developing countries access to food. Often, the outcome of these negotiations are analysed in GE models such as GTAP. However, the results on food demand in such analyses are highly dependent upon the formulation of the demand system and assumed responsiveness of food demand with respect to prices and income, most often measured in the form of elasticities. For developing countries in particular but also for other country groups food demand elasticities are scarce and existing elasticities quite often have been derived without fulfilling basic requirements of demand systems and statistical properties of econometric estimates are questionable as pointed out by Ohri-Vachaspati, Rogers, Kennedy and Goldberg (1998).

In this paper, a food demand system comprising demand for vegetabilia, animalia and other goods in the form of an almost ideal demand system is estimated. Consumers demand in India is the particular case here primarily because of availability of data and because according to SOFI (1999) approximately 200 million out of 790 million undernourished people in the world live in India. Data is primarily obtained from FAO. The estimation technique employs recent results in time series analysis. The demand system is nested in the cointegrated vector autoregressive model and estimated using Johansen's maximum likelihood procedure. Thus, the demand system is interpreted as a long run equilibrium towards which the stochastic processes aspire. Testing for nonstationarity properties in the form of I(2), I(1) and cointegration is carried out. Likewise, the system is rigorously tested for statistical performance.

The resulting econometric estimates of the parameters show that the system fulfils the theoretical properties of a demand system. Thus, the number of cointegration vectors and their appearance are in accordance with economic theory. Price and income elasticities have signs and magnitudes in accordance with common sense and other studies of demand elasticities. Recursive analysis shows that the dynamic system has constant parameters. Dynamic analysis reveals that Indian consumers adjust fairly quickly to changed conditions. The data is organised in such a way that disaggregation to lower levels of goods all the way down to approximately 100 different goods is readily possible. Furthermore, the model set-up and econometric techniques can be readily used on other countries.

1. Introduction

Demand for food is a field that has spurred much activity in economic research and has a long history within the economics profession. At least, ever since Malthus (1798) there has been a recurring focus on availability of food. The particular concern of Malthus was that the growth in population would eventually produce demands for food exceeding supply. On a global basis although population has been growing ever since Malthus published his theory supply has grown even faster. This has resulted in decreasing food prices in real terms contrary to what would be the consequence of Malthus' hypothesis. However, even though the food supply at the global level is sufficient for the present population the distribution of food among countries and income classes is highly unequal. That is, the prevailing source of insufficient food consumption is lack of access due to low income as stated by the World Bank (1981) although it is not the only cause according to SOFI (1999). Therefore, the effect of income on the demand for food has been the focus of many studies; see e.g. Behrman and Deolalikar (1987); Alderman (1986).

A major problem in econometric research concerning less-developed countries is lack of data. In particular, time series analysis requires consistent data at a reasonable time span, which often is not available. However, India has been the focus of quite many studies concerning demand analysis so for this country some time series are available. Likewise, results obtained from this study can be compared with other studies conducted. Furthermore, approximately 200 million of around 790 million undernourished people in the world in 1999 live in India according to SOFI (1999). Thus, India is of particular interest in this respect.

The traditional methods of calculating the responsiveness of food demand with respect to income has a number of drawbacks as pointed out by Ohri-Vachaspati, Rogers, Kennedy and Goldberg (1998). Several sources of bias such as simultaneity bias and collinearity are present when using traditional econometric methods. Furthermore, the functional form used in the demand study affect estimates. Demand and income elasticities are not necessarily constant across groups. Indeed, food income elasticities generally decrease with increasing income, see Ravaillon (1990) and Timmer (1991). If this property is not allowed for in the functional form, it inevitably results in bias. Similarly, if changes in relative prices are not accounted for omitted variables bias is incurred.

Muellbauer and Pashardes (1992) point out that most studies of demand systems use static models, which seldom accept the hypotheses of symmetry and homogeneity derived from consumer theory. Furthermore, serial correlation is often found in the residuals. These findings obviously call for a dynamic specification of the demand system. One way to overcome the problem with serial correlation is to estimate the system in first order differences. However, this "solution" discards the long run information in the data as pointed out by Davidson, Hendry, Srba and Yeo (1978), see also Hendry (1995). Another approach is to use a dynamic demand system to represent consumers' behaviour as in Muellbauer and Pashardes (1992) where habit formation and durability are employed to induce dynamics. Likewise, dynamic consumer behaviour is generated by the "traditional" macroeconomic models due to intertemporal substitution and the consumption-savings choice; see e.g. Blanchard and Fischer (1989) and Barro and Sala-i-Martin (1995).

A different approach is to embody the demand system in a dynamic statistical model. Thus, the demand system is not necessarily dynamic per se but the stochastic specification produces this behaviour. A versatile and often used dynamic statistical model is the cointegrated VAR (Vector

AutoRegressive) as in Johansen and Juselius (1990), Juselius (1998a), Juselius (1998b) and Nørgaard, Lind and Agger (1999). Accordingly, the economic model is treated as an equilibrium towards which the dynamic processes aspire. Thus, the dynamic system is generally in disequilibrium but the system is constantly aiming at offsetting the disequilibrium. In case of consumer demand, the interpretation is that the consumers overall objective is utility maximisation. However, because consumers are constantly subject to changes in the information set they base their decisions upon such as changes in prices and income, they seldom if ever attain exact utility maximisation. Thus, even though the information set is unchanged in subsequent periods the remaining disequilibria induce changes in demands for goods until utility maximisation, the long run equilibrium, is achieved. In the VAR model, the long run equilibria are described by cointegrating processes. Thus, if and only if the dynamic stochastic processes converge toward a common attractor set, long run equilibrium, the processes are cointegrating. To be of use, this common attractor set must be given an economic interpretation such as a consumer demand system derived from utility maximising agents. As such, the cointegrating relations, interpreted as describing a consumer demand system, must obey the restrictions and properties derived from the corresponding economic model. The short run dynamics on the other hand describe the movements around the long run equilibrium. Economic theory seldom provides a direct interpretation of the movements out of equilibrium, as economic theory is mostly preoccupied with the equilibrium per se. Therefore, the short run dynamics are seldom subjected to the same scrutiny, as is the long run equilibrium. An example of a consumer demand system analysed in this way is Dawson and Tiffin (1998) where aggregate demand for calories is explained by real GDP and a real food price index.

In the paper a static consumer demand system is nested in a dynamic statistical model, in casu, the AIDS model is nested in the cointegrated VAR, applied on Indian consumers. The estimation method is Johansen’s maximum likelihood procedure, which takes account of simultaneous equations. Thus, this approach addresses the problems of simultaneity, omitted variables, non-constant elasticities and serial correlation as described above.

The next section describes the economic model and the statistical model are presented. Section 3 describes the data employed. The subsequent section contains estimation and testing of the statistical model. Presentation and interpretation of the results are in section 5. The paper concludes in section 6.

2. Models

The AIDS model of Deaton and Muellbauer (1980) is derived from utility maximising consumers using the PIGLOG class of utility functions. From the behaviour of utility maximising agents is derived a system of equations describing expenditure shares dependent on prices of the consumer goods and total expenditure.

The expenditure shares for goods in the AIDS model are explained by,

(1) $$s_i = \kappa_i + \sum_{j=1}^{n} \lambda_{ij} \log(p_j) + \rho_i \log\left(\frac{M}{P}\right), \text{ i, j = 1,2,…,n,}$$

where p_j is the price of the j'th good, M is total expenditure on the n goods and P is an aggregated price index. The expenditure share on the i'th good, s_i, is given by $s_i = p_i x_i / M$, where x_i is the amount consumed of the i'th good. Adding up, homogeneity and symmetry yields the conditions,

$$\text{(2)} \qquad \sum_{i=1}^{n} \kappa_i = 1, \sum_{i=1}^{n} \lambda_{ij} = 0, \sum_{i=1}^{n} \rho_i = 0, \lambda_{ij} = \lambda_{ji} .$$

This implies,

$$\sum_{j=1}^{n} \lambda_{ij} = 0 .$$

Behavioural characteristics of the consumer demand system are measured in the form of elasticities. Thus, consumers response to price changes are summarised in own and cross price elasticities. Furthermore, a focal point in consumer studies is the response to income change, particularly in studies of food demand. In a dynamic model response to changes generally takes place over time. Thus, a change in an exogenous variable initiates a course of the endogenous variables that only settles down to a steady state after a plethora of interactions have taken place during the passage of time. Therefore, the effects are divided into the immediate effect measured by the impact multiplier, the intermediate effects measured by interim multipliers and the long run effect measured by the total multiplier, see Hendry (1995). The elasticities showing the long run effect are the same as the elasticities in an ordinary static consumer demand system. Below these elasticities derived from the AIDS model are shown[1].

The dynamic formulation of the consumer demand system is carried out through the vector autoregressive model. For heuristic purposes the procedure is illustrated using the univariate formulation of the VAR, the autoregressive distributed lag (ADL) formulation. Using one lag on each variable the ADL form of the expenditure shares derived from the AIDS model is,

$$\text{(3)} \qquad s_{it} = \kappa_i + \theta_i s_{it-1} + \sum_{j=1}^{n} \lambda_{ij} \log(p_{jt}) + \sum_{j=1}^{n} \eta_{ij} \log(p_{jt-1}) + \rho_i \log\left(\frac{M_t}{P_t}\right) + \phi_i \log\left(\frac{M_{t-1}}{P_{t-1}}\right)$$

In principle, the system of expenditure shares could be estimated using traditional estimators. However, if the time series for the variables in the system are nonstationary this property has to be accounted for in the estimation process. One way to do this is to apply the principle of cointegration. If the time series are nonstationary, ordinary OLS produces invalid inference and in small samples parameter estimates are biased. Furthermore, spurious or nonsense regression is a possibility.

As Engle and Granger (1987) showed cointegration are equivalent to error correction. Taking first order differences and reordering derives the ADL model in error correction form,

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[1] It should be noted that the elasticities are derived under the assumption that the aggregated price index remains unchanged due to a change in an exogenous variable. This approximation is of course only valid for "small" price changes. It is not particularly difficult to incorporate changes in the aggregate price index, however, the derived equations becomes much less tractable and dependent upon the particular index formulae employed in aggregating the prices.

$$(4)\qquad \Delta s_{it} = a_i\left[s_{it-1} - b_{i0} - \sum_{j=1}^{n} b_{ij}\log(p_{jt-1}) - b_{iM}\log\widetilde{M}_{t-1}\right] + \sum_{j=1}^{n} g_{ij}\Delta\log(p_{jt}) + g_{iM}\Delta\log\widetilde{M}_t$$

where $\Delta s_{it} = s_{it}\text{-}s_{it\text{-}1}$, $a_i = \theta_i\text{-}1$, $b_{i0} = \kappa_i/(1\text{-}\theta_i)$, $b_{ij} = (\lambda_{ij}+\eta_{ij})/(1\text{-}\theta_i)$, $b_{iM} = (\rho_i+\varnothing_i)/(1\text{-}\theta_i)$, $g_{ij} = \lambda_{ij}$, $g_{iM} = \rho_i$ and $\widetilde{M}_t = M_t/P_t$.

The term in brackets in eq. (4) is the cointegration relation or the long run equilibrium. If the series for expenditure shares, prices and expenditure in the form expressed by the AIDS model cointegrate, the term in brackets in the error correction model constantly aims at zero. That is, if the value of the cointegration relation is different from zero this "error" is "corrected" by the error correction model, hence the name. Thus, a_i shows how quickly the deviations from long run equilibrium are corrected. Short-term dynamics are generated by the first order difference terms on the right hand side of eq. (4). Economic theory is mostly preoccupied with the long run. Thus, economic theory is best suited to characterise properties of an equilibrium whereas behaviour outside equilibrium is less well understood. Therefore, the terms describing the short run dynamics can often not given a direct interpretation. Hence, the focus in the following is on the long run. Nevertheless, it is important that short run dynamics are treated in the estimation procedure to be able to identify the true long run relationships. If no long run equilibrium exists between the series as expressed by the AIDS model a proper estimation procedure such as and foremost the Johansen procedure will not produce a corresponding cointegration relation.

From the error-correction form, behavioural measures in the form of dynamic multipliers and elasticities are derived. In the appendix, these measures are calculated.

The statistical model employed is the Vector Autoregressive Model (VAR-model),

$$(5)\qquad Z_t = \Pi_1 Z_{t-1} + \Pi_2 Z_{t-2} + \ldots + \Pi_k Z_{t-k} + \psi + \phi D_t + \varepsilon_t, \quad t = 1,\ldots,T$$

that often provide a good description of real data, see e.g. Johansen (1995). The elements in the vector Z_t are observations at time t of the p variables considered in the analysis. The matrices Π_i, i = 1,2,…,k, of dimension p x p contain parameters. The number of lags in the VAR-model is denoted k. Deterministic components are modelled though the p-dimensional vector of intercept parameters ψ and other deterministic variables contained in D_t with parameter matrix ϕ. Initial values $Z_{-k+1},\ldots,Z_0$ are fixed and $\varepsilon_1,\ldots,\varepsilon_T$ are independent p-dimensional Gaussian variables.

In cointegration analysis the VAR-model is rewritten as a Vector Error Correction Model (VECM),

$$(6)\qquad \begin{aligned} &\Delta Z_t = \Pi Z_{t-1} + \sum_{i=1}^{k-1}\Gamma_i \Delta Z_{t-i} + \psi + \phi D_t + \varepsilon_t, \quad t = 1,\ldots,T \\ &\Pi = -I + \sum_{i=1}^{k}\Pi_i, \quad \Gamma_i = -\sum_{j=i+1}^{k}\Pi_j, \quad \Pi = \alpha\beta' \end{aligned}$$

where I is an identity matrix. The hypothesis of cointegration implied by error correction, Engle and Granger (1987), is an hypothesis that the rank of the matrix Π equals r less than p and greater than zero yielding r cointegration relations. This implies that Π can be written as the product of the matrices α and β' of dimension p x r and r x p respectively. The cointegration relations, given by $\beta' Z_{t-1}$, measure the equilibrium errors while α measures the speed of adjustment toward steady-state caused by disequilibrium from steady-state.

3. Data

Time series data for consumption, prices, income etc. for developing countries are not in abundant supply. Most often, only a limited span of observations over time are available. The primary data source is FAOSTAT CD-ROM 1998. This data collection, which also can be obtained from http://apps.fao.org/, contains time series of annual observations of supply and demand of a large number of food items and a large number of countries.

Prices on these items are likewise obtained from FAOSTAT CD-ROM 1998. Time series of annual observations span the period 1967-1997. A problem with these data is that the correspondence between quantities and prices is not perfect. For items in real terms with no obvious corresponding price, the price of the closest substitute is used.

FAOSTAT's prices on agricultural products are producer prices, whereas the system to be estimated is a consumer demand system. Thus, the mark-up at the retail level is not considered. This does not pose a problem in the cointegration analysis if relative prices for consumers equal relative prices for producers, apart from a constant reflecting the mark-up. However, if relative consumer prices differ much from producer prices then using producer prices yields incorrect estimates. If this is the case then the econometric tests of the demand system will prove the model an incorrect representation of the data.

FAOSTAT does not provide producer prices on fish. However, the value and amount exported of varies species are provided. The data for fish are stated in US$ whereas the prices on agricultural products are in Indian Rupee. To convert the data for fish to Indian Rupee the exchange rate is obtained from PENN World Tables for the period 1961-1992. For the remaining years, the exchange rate is obtained from http://america.oanda.com/index.shtml.

The data provides information on 138 different items. Some of these items are aggregates of other items and some are not used for food consumption. The individual items used for food consumption are aggregated into 21 composites according to the aggregation used by FAO. Prices are aggregated using the Törnquist index apart from the initial year where the Stone index is used. These aggregates are again aggregated into two composites, one for vegetabilia and one for animalia, again using the Törnquist and Stone indices. Hence, the consumption of food in India has been divided into two groups.

In order to carry out a demand analysis, data for the consumer demand for non-food products have to be provided because substitution between food and non-food products is expected. In particular, it is expected that the composition of food demand between vegetabilia and animalia are sensitive to demand for other products. Thus, animalia is a relatively high price product compared to vegetabilia, therefore, changes in demand for other product could influence the composition of food demand if not total level of food demand. Penn World Tables (PWT), Heston and Summers (1991), http://arcadia.chass.utoronto.ca/pwt/, provide time series on 29 macro variables for 152 countries for the period 1950-1992. Aggregate demand for private consumption is calculated using PWT. From this figure, the aggregate consumption of food is subtracted yielding private consumption of non-food products.

The resulting series on the shares of food consumption out of total consumption is compared to a similar but shorter series form USDA by means of cointegration analysis. The analysis shows that the series for food consumption produced by aggregating the many individual food items in FAO's food balance sheets through the data for quantities, prices and exports stated therein and using the PWT private consumption as total consumer expenditure displays essentially the same characteristics as the corresponding series in USDA's statistics. Thus, this gives some assurance about the quality of the series.

5. The empirical analysis of the consumer demand system

The statistical analysis of the consumer demand system as represented by the AIDS model in (1) employs the VAR model. In this case, the vector Z_t contains six elements, the expenditure share of vegetabilia, the expenditure share of animalia, the real price of vegetabilia, the real price of animalia, the real price of other goods and real expenditure. Only two of the three expenditure shares are used in the estimation because of the identity between the three. Thus, inclusion of all three would produce a singular design matrix. Therefore, the elements of the Z_t vector consists of annual observations on the variables, $Z_t = (s_{1t}, s_{2t}, p_{1t}, p_{2t}, p_{3t}, E_t)'$, where the variables are defined in table 1.

Table 1.
The variables in the demand analysis

Variable	Description
s_1	expenditure share of vegetabilia
s_2	expenditure share of animalia
p_1	log of real price on vegetabilia
p_2	log of real price on animalia
p_3	log of real price on other goods
M	log of real expenditure per capita

The time series cover the period 1967-1992, thus, 26 observations are available for the empirical analysis. Admittedly, more observations would be desirable. To conduct a thorough empirical analysis of the demand system more observations would be desirable in light of the fact that most of the results on the cointegrated VAR-model are based on asymptotic properties. However, longer time spans of data for developing countries for a large number of variables are not available. In light of the limited number of observations in relation to the number of parameters generated by the demand model and the VAR-model a bold assumption is employed, namely, that prices and income are weakly exogenous with respect to the expenditure shares. In this way, the number of parameters to be interpreted is reduced. However, the statistical model still has to pass diagnostic and other tests. Likewise, estimated parameter values must yield behavioural characteristics in line with consumer theory.

To check the adequacy of the model set-up, diagnostic tests are displayed in table 2. The tests are generated by a VAR-model with a lag of one. More lags imply the possibility of more flexible dynamic properties, but the limited number of observations restricts the number of parameters in the VAR. Thus, degrees of freedom are quickly exhausted with increasing lags. Nevertheless, the Schwartz information criterion accepts the choice of one lag with a value of –19.85 at one lag against a value of –19.45 at two lags. Diagnostic tests do not reject the model set-up as seen in the table. Thus, the analysis proceeds with the VAR-model using one lag.

Table 2.

Tests for statistical performance

Test	Distribution and test value		Probability value		
Ljung-Box (6) H_0: no auto- or crosscorrelation	$\chi^2(20)$	= 36.027	p	=	0.02
LM (1) H_0: no first order autocorrelation	$\chi^2(4)$	= 1.771	p	=	0.78
Doornik-Hansen H_0: normality	$\chi^2(4)$	= 2.632	p	=	0.62
$ARCH_1$ H_0: no ARCH	$\chi^2(1)$	= 4.661	p	=	0.03
$ARCH_2$ H_0: no ARCH	$\chi^2(1)$	= 2.479	p	=	0.12

Note. See notes to table 3.

Deterministic components in the chosen VAR-model are restricted to a constant in the cointegration space only. Thus, deterministic trends in the level of the variables and in the cointegration space are not present. Therefore, the trending behaviour often seen in consumer and income data are "explained" by the stochastic trends in the model. Johansen rank tests for the cointegrated VECM displayed in table 3 imply two cointegration vectors.

Because prices and expenditure in real terms are used and these are found to be I(1) then by construction prices and expenditure in nominal terms, that is not in real terms, is I(2). So, in principle, an I(2) system has been transformed to an I(1) system by deflating with a price index. In the AIDS model prices and income are in natural logarithms, thus, the deflation is done by subtracting the log of the price index from the log of the prices and the expenditure. This transformation, however, yields the possibility of multi or polynomial cointegration. Multi or polynomial cointegration occurs when I(1) variables cointegrate with differenced I(2) variables. In the present case, the possibility is that the first order difference of the general price index cointegrates with one or more of the variables in the AIDS model. This is tested with a null-hypothesis of no multi or polynomial cointegration using a normalisation of $s_1 = 1$, $s_2 = 0$ in the first cointegration vector and $s_1 = 0$, $s_2 = 1$ in the second cointegration vector. The null-hypothesis is accepted with $\chi^2(2) = 1.91$, p-value = 0.39. Thus, no multi or polynomial cointegration is present in the system.

In order for the two cointegration vectors to correspond to consumer demands derived from the AIDS-model in the form of equations for expenditure shares, symmetry and homogeneity restrictions must be satisfied. Otherwise, the model does not give an adequate description of a consumer demand system. In eq. (1) $\lambda_{ij} = \lambda_{ji}$, which in the cointegrated VECM eq. (6) corresponds to $\beta_{12} = \beta_{21}$. Both of these estimated parameters are very close to zero according to their standard errors. Therefore, this restriction is tested together with a normalisation that sets s_2 to zero in the first cointegration vector, and s_1 to zero in the second. The symmetry restriction together with normalisation is accepted with $\chi^2(2) = 4.01$. In the appendix figures A1 and A2 some residual analyses are shown. Evidently, the estimated model is in quite good accordance with statistical assumptions and the fitted values of the first order differences track the observations quite well.

Table 3.

Johansen's rank test

Eigenvalue	Test value	r	90% critical value
0.7890	38.90	0	10.29
0.3885	12.30	1	7.50

Homogeneity then corresponds to $\beta_{11} = -\beta_{13}$ and $\beta_{22} = -\beta_{23}$. This restriction is imposed simultaneously with normalisation and symmetry yielding $\chi^2(4) = 4.95$. Thus, the restrictions are accepted. The estimated model with restrictions imposed is subsequently tested for constancy. This is performed by estimating the model recursively on the last ten observations and then test for changes. The model successfully passes the recursive tests. Two recursive graphs are shown in figure A3 in the appendix. The left diagram displays the evolution of the log-likelihood function with 95% confidence intervals for the last ten observations. Evidently, the log-likelihood does not change much. In the right diagram is displayed a test for constancy of the cointegration vectors where one is the 5% critical value. It is readily seen that the cointegration vectors are quite constant, as the test value does not exceed 0.5 at any time.

The final VECM with expenditure shares conditioned on prices and income is written as,

$$Z_t = [Y_t : X_t] \Rightarrow \Delta Y_t = \alpha\beta' Z_{t-1} + \delta \Delta X_t$$

$$\Downarrow$$

$$\begin{bmatrix} \Delta s_1 \\ \Delta s_2 \end{bmatrix}_t = \begin{bmatrix} -1.288 & -0.585 \\ 0.010 & -0.310 \end{bmatrix} \begin{bmatrix} 1.000 & 0.000 & -0.190 & 0.000 & 0.190 & 0.156 & 2.510 \\ 0.000 & 1.000 & 0.000 & -0.040 & 0.040 & 0.010 & 0.093 \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \\ p_1 \\ p_2 \\ p_3 \\ M \\ 1 \end{bmatrix}_{t-1}$$

$$+ \begin{bmatrix} 0.186 & -0.028 & -0.145 & -0.237 \\ -0.014 & 0.067 & -0.024 & -0.058 \end{bmatrix} \begin{bmatrix} \Delta p_1 \\ \Delta p_2 \\ \Delta p_3 \\ \Delta M \end{bmatrix}_t$$

where the vector Z_t has been decomposed into the endogenous variables denoted by the vector Y_t and the weakly exogenous variables denoted by the vector X_t.

6. Interpretation of results

The estimated model passes the statistical tests, but if the model is to be presented as a description of Indian consumers demand for food, the implied behavioural measures must be in accordance with the theory of demand. Specifically, demand elasticities must have appropriate signs and magnitudes. In table 4 the derived long-run price elasticities of demand are presented.

Table 4.
Long-run price elasticities of demand

	p_1	p_2	p_3
e_{1j}	-0.18	0.04	-0.44
e_{2j}	0.24	-0.92	0.10
e_{3j}	0.04	0.05	-0.48

Table 5.
Long-run income elasticities of demand

	M
e_{1M}	0.42
e_{2M}	0.88
e_{3M}	1.26

Own price elasticities are negative as required. Vegetabilia are much less sensitive to own price changes compared with the demand for animalia. This is in concurrence with the fact that vegetabilia comprises the bulk of Indian food consumption. Thus, in a low income country animalia is to some extent a luxury good. Inspecting the income elasticities in table 5 this is confirmed since the income elasticity of demand for animalia is quite close to one, whereas the corresponding elasticity for vegetabilia is much smaller. As income increase, animalia is destined to comprise a larger proportion of total food demand. Nevertheless, both food income elasticities are less than one implying that food demand will comprise a smaller proportion of total demand as income rises.

Animalia and vegetabilia are substitutes in food demand as the respective cross price elasticities show. This result is not surprising, more difficult it is to interpret the cross price elasticities between food and other goods. Other goods is a conglomerate of a large number of goods some of which are quite essential such as housing, clothing, schooling and health expenditures whereas others are less vital. Anyhow, other goods are overall luxury goods as the income elasticity, significantly bigger than one, indicates.

Rising income decreases the share of food out of total consumption, which is a well-known effect. Likewise, the share of animalia in food consumption has been observed to increase with rising income, which is also supported by the income elasticities in table 5. Figure 1 displays the income elasticities sorted after the observations on income in real terms. The income elasticity for animalia seems fairly constant over the income intervals whereas the elasticity for vegetabilia is clearly declining with increasing income. Other goods also display a declining tendency although not so pronounced as for vegetabilia. In the diagram is also displayed the income elasticity for food, which is an aggregate of the income elasticities for vegetabilia and animalia according to the homogeneity restrictions[2]. Not surprisingly, the income elasticity for food is declining with increasing income. The last observation in the diagram, which is for 1992, seems to display a reverse in the course. This phenomenon is generated by quite a large increase in the price of animalia.

Figure 1.

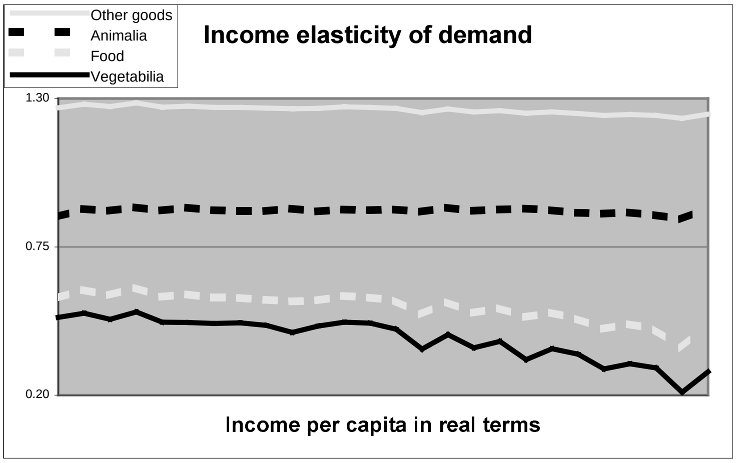
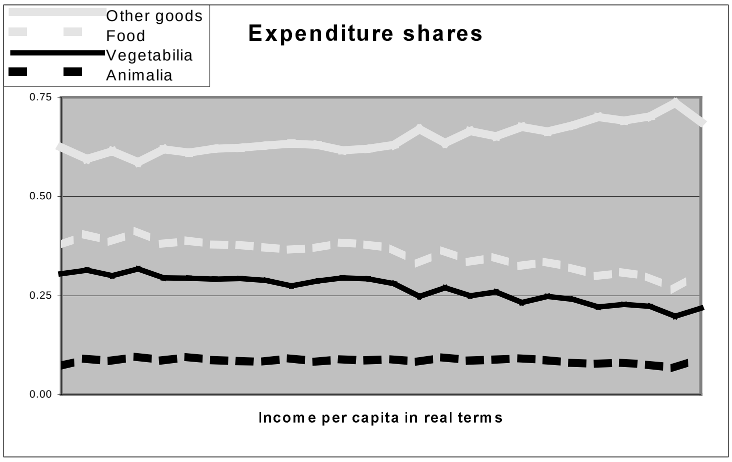


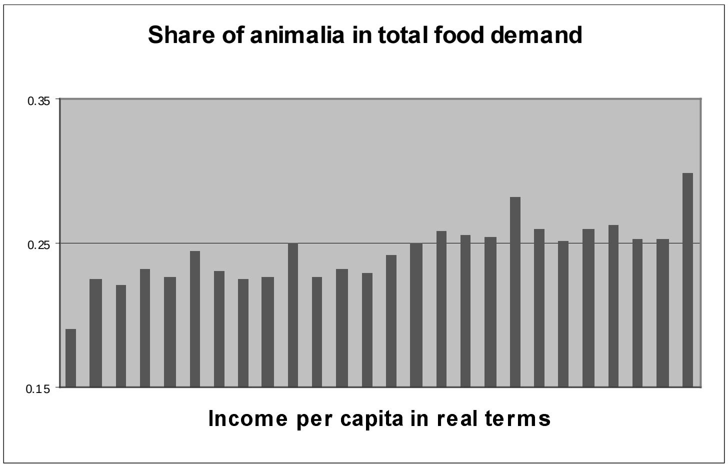
Figure 2.



The expenditure shares shown in figure 2 where they are sorted after and plotted against income display the same tendency as the income elasticities. As income increases the share of food decreases and the share of other goods increase corresponding to the income elasticities with other goods being an overall luxury. Furthermore, the composition of food demand changes. Figure 3 show the share of animalia in total food demand plotted against income. Naturally, the share also depends on the relative price of animalia but the figure shows a clear tendency towards a larger proportion of animalia in food demand with increasing income.

[2] The restrictions imply that the sum of the income elasticities multiplied by the respective expenditure shares equal one, see e.g. Mas-Colell, Whinston and Green (1995). By summing the expenditure shares for vegetabilia and animalia and using the income elasticity and expenditure share for other goods together with the sum restriction just mentioned the income elasticity for food is calculated.

Figure 3.



7. Concluding remarks

The paper has addressed some of the concerns raised by Ohri-Vachaspati, Rogers, Kennedy and Goldberg (1998) and shown that a thorough dynamic analysis leads to much better properties of the estimated demand system. Thus, homogeneity often rejected in demand analysis is fulfilled in the present study. Likewise, serial correlation instead of being a problem is utilised in the cointegration analysis of the system resulting in identification of dynamic properties and long run equilibria. The derived comparative statics of the Indian consumers demand are in accordance with common sense. Thus, the age-old contention that food comprises a declining proportion of total demand as income increase is corroborated by the study. Likewise, the results propose that vegetabilia is substituted for animalia in food consumption as income increase. The estimated demand functions in the form of equations for expenditure shares are quite constant over time suggesting that the underlying structure of Indian consumer demand is unchanged as the economy progresses. This would not be the case if say preferences shifted over time or because of some structural changes in the economy etc. Although stability as suggested by the recursive analysis is not a sufficient but only a necessary condition for constancy of the underlying structure, major shifts in preferences would be expected to show in the recursive analysis, which show no sign thereof.

The favourable statistical properties of the model yield some assurance about the estimated behavioural measures. Thus, to the extent that the study can be generalised to other developing countries this would help in assessing the impacts of the ongoing trade negotiations. In particular, since such effects have been a moot point concerning the outcome of the Uruguay round and has been a focal point in the present ongoing trade negotiations under the WTO auspices. However, the level of aggregation in the study is quite high and in particular, the variable containing all non-food products is highly heterogeneous. Therefore, the behavioural measures relating to this variable should be interpreted with caution. Future analyses of food demand behaviour along the lines presented in this study could consider disaggregating the non-food variable. Disaggregation of the two food variables would also be of interest since the composition of animalia and vegetabilia can vary quite a lot form country to country as well as region to region.

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Appendix

The short run own price elasticity is calculated via the impact multiplier,

(7)
$$\frac{\partial x_{it}}{\partial p_{it}} = \frac{\partial (M_t s_{it} / p_{it})}{\partial p_{it}} = \frac{x_{it} s_{it}}{p_{it}} - \frac{M_{it}}{p_{it}} \frac{s_{it}}{p_{it}} + \frac{M_{it}}{p_{it}} \frac{\partial s_{it}}{\partial p_{it}}$$
=>
$$\frac{p_{it}}{x_{it}} \frac{\partial x_{it}}{\partial p_{it}} = s_{it} - 1 + \frac{p_{it}}{s_{it}} \frac{\partial s_{it}}{\partial p_{it}} = s_{it} - 1 + \frac{p_{it}}{s_{it}} \left[\frac{\lambda_{ii}}{p_{it}} + \frac{\rho_i x_{it}}{M_t} \right] = s_{it} - 1 + \frac{\lambda_{ii}}{s_{it}} + \rho_i$$
$$\frac{p_{it}}{x_{it}} \frac{\partial x_{it}}{\partial p_{it}} = s_{it} - 1 + \frac{g_{ii}}{s_{it}} + g_{iM}$$

The short run cross price elasticity,

(8)
$$\frac{\partial x_{it}}{\partial p_{jt}} = \frac{\partial (M_t s_{it} / p_{it})}{\partial p_{jt}} = \frac{x_{jt} s_{it}}{p_{it}} + \frac{M_{it}}{p_{it}} \frac{\partial s_{it}}{\partial p_{jt}}$$
=>
$$\frac{p_{jt}}{x_{it}} \frac{\partial x_{it}}{\partial p_{jt}} = s_{jt} + \frac{p_{jt}}{s_{it}} \frac{\partial s_{it}}{\partial p_{it}} = s_{jt} + \frac{p_{jt}}{s_{it}} \left[\frac{\lambda_{ij}}{p_{jt}} + \frac{\rho_i x_{jt}}{M_t} \right] = s_{jt} + \frac{\lambda_{ij}}{s_{it}} + \frac{\rho_i s_{jt}}{s_{it}}$$
$$\frac{p_{jt}}{x_{it}} \frac{\partial x_{it}}{\partial p_{jt}} = s_{jt} + \frac{g_{ij}}{s_{it}} + \frac{g_{iM} s_{jt}}{s_{it}}$$

The short run income elasticity,

(9)
$$\frac{\partial x_{it}}{\partial M_t} = \frac{\partial (M_t s_{it} / p_{it})}{\partial M_t} = \frac{s_{it}}{p_{it}} + \frac{M_{it}}{p_{it}} \frac{\partial s_{it}}{\partial M_t}$$
=>
$$\frac{M_t}{x_{it}} \frac{\partial x_{it}}{\partial M_t} = 1 + \frac{M_t}{s_{it}} \frac{\partial s_{it}}{\partial M_t} = 1 + \frac{M_t}{s_{it}} \left[\frac{\rho_i}{M_t} \right] = 1 + \frac{\rho_i}{s_{it}}$$
$$\frac{M_t}{x_{it}} \frac{\partial x_{it}}{\partial M_t} = 1 + \frac{g_{iM}}{s_{it}}$$

The medium run own price elasticities are calculated via the interim multipliers, see e.g. Hendry (1995),

(10)

$$\frac{\partial x_{it}}{\partial p_{it-k}} = \frac{M_t}{p_{it}} \frac{\partial s_{it}}{\partial p_{it-k}}$$

=>

$$\frac{p_{it-k}}{x_{it}} \frac{\partial x_{it}}{\partial p_{it-k}} = \frac{1}{s_{it}} \theta_i^{k-1} [\theta_i \lambda_{ii} + \eta_{ii} + \theta_i \rho_i s_{it-k} + \phi_i s_{it-k}]$$

$$\frac{p_{it-k}}{x_{it}} \frac{\partial x_{it}}{\partial p_{it-k}} = \frac{1}{s_{it}} a_i (1+a_i)^{k-1} [g_{ii} - b_{ii} + (g_{iM} - b_{iM}) s_{it-k}], \quad for\ k = 1,2,...$$

The medium run cross price elasticities,

(11)

$$\frac{\partial x_{it}}{\partial p_{jt-k}} = \frac{M_t}{p_{it}} \frac{\partial s_{it}}{\partial p_{jt-k}}$$

=>

$$\frac{p_{jt-k}}{x_{it}} \frac{\partial x_{it}}{\partial p_{jt-k}} = \frac{1}{s_{it}} \theta_i^{k-1} [\theta_i \lambda_{ij} + \eta_{ij} + \theta_i \rho_i s_{jt-k} + \phi_i s_{jt-k}]$$

$$\frac{p_{jt-k}}{x_{it}} \frac{\partial x_{it}}{\partial p_{jt-k}} = \frac{1}{s_{it}} a_i (1+a_i)^{k-1} [g_{ij} - b_{ij} + (g_{iM} - b_{iM}) s_{jt-k}], \quad for\ k = 1,2,...$$

The medium run income elasticities,

(12)

$$\frac{\partial x_{it}}{\partial M_{t-k}} = \frac{M_t}{p_{it}} \frac{\partial s_{it}}{\partial M_{t-k}}$$

=>

$$\frac{M_{t-k}}{x_{it}} \frac{\partial x_{it}}{\partial M_{t-k}} = \frac{1}{s_{it}} \theta_i^{k-1} [\phi_i + \theta_i \rho_i]$$

$$\frac{M_{t-k}}{x_{it}} \frac{\partial x_{it}}{\partial M_{t-k}} = \frac{1}{s_{it}} a_i (1+a_i)^{k-1} [g_{iM} - b_{iM}], \quad for\ k = 1,2,...$$

Long run own price elasticity calculated via the total multiplier,

$$\frac{\partial \bar{x}_i}{\partial \bar{p}_i} = \frac{\partial (\bar{M} \bar{s}_i / \bar{p}_i)}{\partial \bar{p}_i} = \frac{\bar{x}_i \bar{s}_i}{\bar{p}_i} - \frac{\bar{M}_i}{\bar{p}_i} \frac{\bar{s}_i}{\bar{p}_i} + \frac{\bar{M}_i}{\bar{p}_i} \frac{\partial \bar{s}_i}{\partial \bar{p}_i}$$

=>

(14)

$$\frac{\bar{p}_i}{\bar{x}_i} \frac{\partial \bar{x}_i}{\partial \bar{p}_i} = \bar{s}_i - 1 + \frac{\bar{p}_i}{\bar{s}_i} \frac{\partial \bar{s}_i}{\partial \bar{p}_i} = \bar{s}_i - 1 + \frac{\bar{p}_i}{\bar{s}_i} \left[\frac{\lambda_{ii} + \eta_{ii}}{1-\theta_i} \frac{1}{\bar{p}_i} + \frac{\rho_i + \phi_i}{1-\theta_i} \frac{1}{\bar{M}} x_i \right] = \bar{s}_i - 1 + \frac{\lambda_{ii} + \eta_{ii}}{1-\theta_i} \frac{1}{\bar{s}_i} + \frac{\rho_i + \phi_i}{1-\theta_i}$$

$$\frac{\bar{p}_i}{\bar{x}_i} \frac{\partial \bar{x}_i}{\partial \bar{p}_i} = \bar{s}_i - 1 + \frac{\bar{p}_i}{\bar{s}_i} \frac{\partial \bar{s}_i}{\partial \bar{p}_i} = \bar{s}_i - 1 + \frac{\bar{p}_i}{\bar{s}_i} \left[\frac{b_{ii}}{\bar{p}_i} + \frac{b_{iM}}{\bar{M}} \frac{\partial \bar{M}}{\partial \bar{p}_i} \right] = \bar{s}_i - 1 + \frac{b_{ii}}{\bar{s}_i} + b_{iM}$$

where a bar indicate the long run equilibrium value.

Long run cross price elasticity calculated via the total multiplier,

$$\frac{\partial \bar{x}_i}{\partial \bar{p}_j} = \frac{\partial(\overline{M}\bar{s}_i / \bar{p}_i)}{\partial \bar{p}_j} = \frac{\bar{x}_j \bar{s}_i}{\bar{p}_i} + \frac{\overline{M}}{\bar{p}_i}\frac{\partial \bar{s}_i}{\partial \bar{p}_j}$$

=>

(15) $$\frac{\bar{p}_j}{\bar{x}_i}\frac{\partial \bar{x}_i}{\partial \bar{p}_j} = \bar{s}_j + \frac{\bar{p}_j}{\bar{s}_i}\frac{\partial \bar{s}_i}{\partial \bar{p}_j} = \bar{s}_j + \frac{\bar{p}_j}{\bar{s}_i}\left[\frac{\lambda_{ij}+\eta_{ij}}{1-\theta_i}\frac{1}{\bar{p}_j} + \frac{\rho_i+\phi_i}{1-\theta_i}\frac{1}{\overline{M}}\bar{x}_j\right] = \bar{s}_j + \frac{\lambda_{ij}+\eta_{ij}}{1-\theta_i}\frac{1}{\bar{s}_i} + \frac{\rho_i+\phi_i}{1-\theta_i}\frac{\bar{s}_j}{\bar{s}_i}$$

$$\frac{\bar{p}_j}{\bar{x}_i}\frac{\partial \bar{x}_i}{\partial \bar{p}_j} = \bar{s}_j + \frac{b_{ij} + b_{iM}\bar{s}_j}{\bar{s}_i}$$

Long run income elasticity calculated via the total multiplier,

$$\frac{\partial \bar{x}_i}{\partial \overline{M}} = \frac{\partial(\overline{M}\bar{s}_i / \bar{p}_i)}{\partial \overline{M}} = \frac{\bar{s}_i}{\bar{p}_i} + \frac{\overline{M}}{\bar{p}_i}\frac{\partial \bar{s}_i}{\partial \overline{M}}$$

=>

(16) $$\frac{\overline{M}}{\bar{x}_i}\frac{\partial \bar{x}_i}{\partial \overline{M}} = 1 + \frac{\overline{M}}{\bar{s}_i}\frac{\partial \bar{s}_i}{\partial \overline{M}} = 1 + \frac{\overline{M}}{\bar{s}_i}\left[\frac{\rho_i+\phi_i}{1-\theta_i}\frac{1}{\overline{M}}\right] = 1 + \frac{\rho_i+\phi_i}{1-\theta_i}\frac{1}{\bar{s}_i}$$

$$\frac{\overline{M}}{\bar{x}_i}\frac{\partial \bar{x}_i}{\partial \overline{M}} = 1 + \frac{b_{iM}}{\bar{s}_i}$$

Figure A1

Residual analysis of the first order differences of the expenditure share of vegetabilia

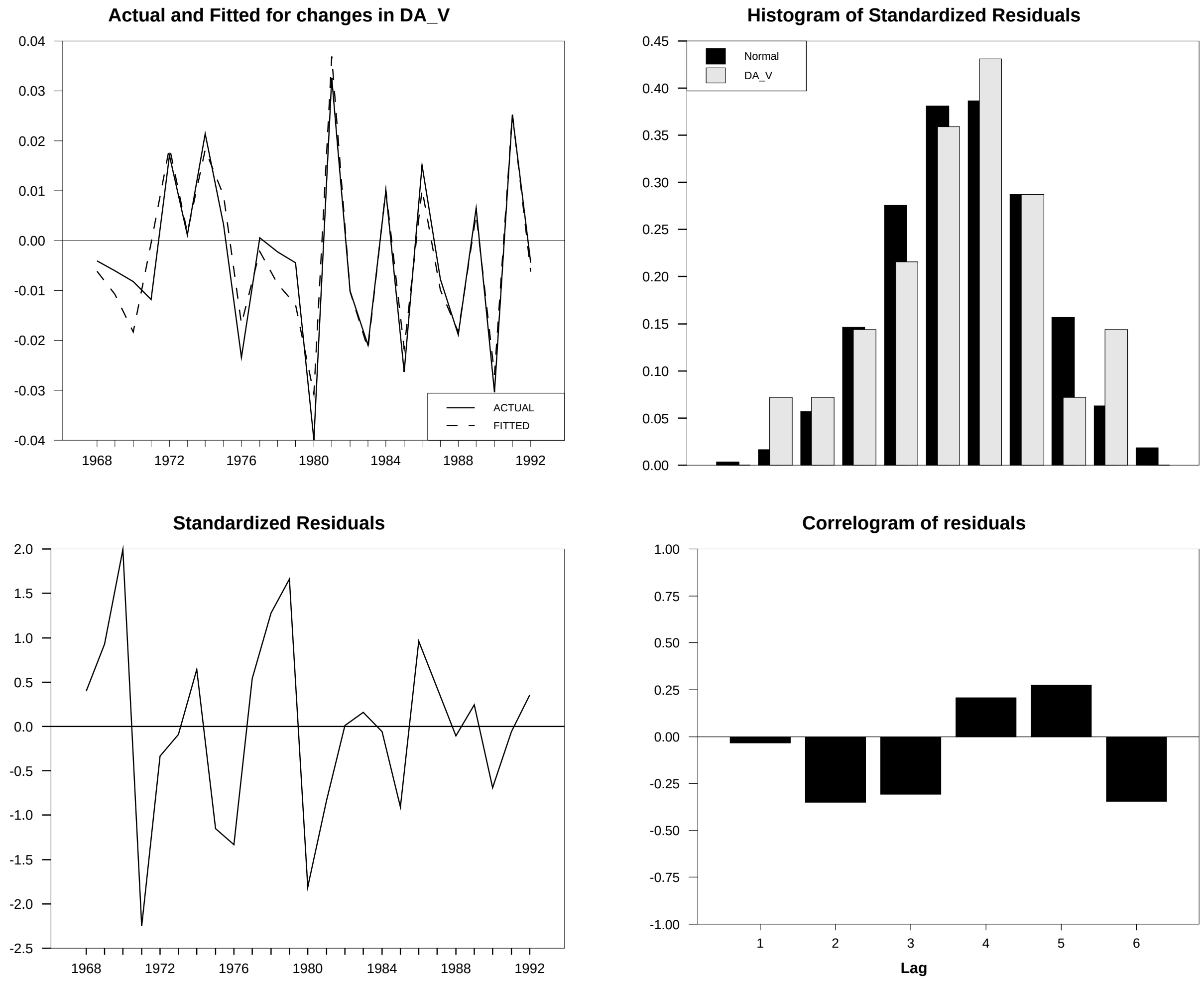

Figure A2
Residual analysis of the first order differences of the expenditure share of animalia

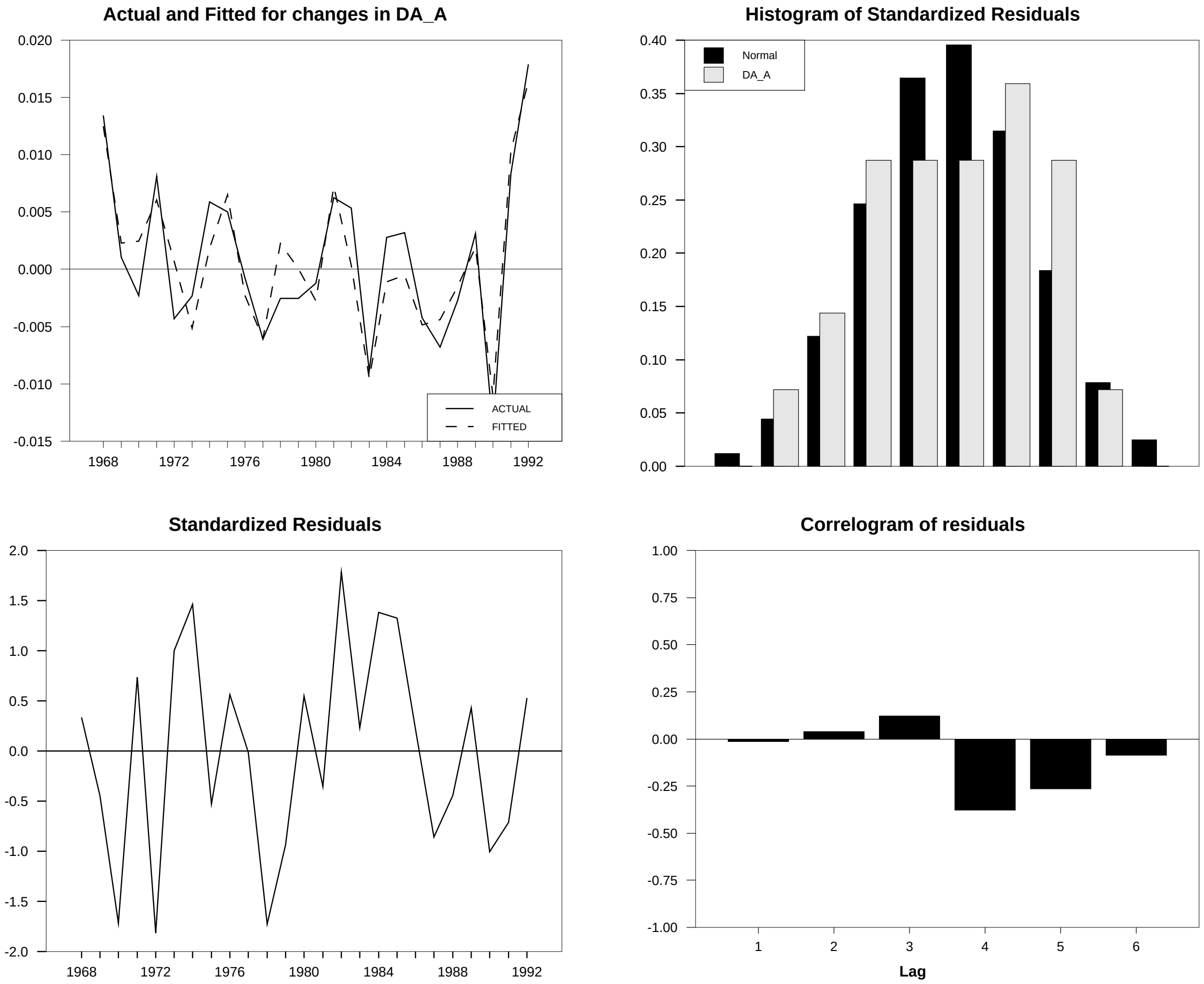

Figure A3

Recursive analysis of the estimated VAR model