Ind. Jn. of Agri. Econ.
Vol.71, No.2, April-June 2016

ARTICLES

Consumer Demand System for Long Term Projections

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ABSTRACT

Policy analysis in a number of areas requires long term projections requiring some sectoral detail. We present a non-linear demand system and price and income elasticities suitable or projections extending over 30 years that involve large increases in income. Elasticities are calculated for 22 consumption commodities of which 14 are agricultural goods. The approach is extendable to many more commodities. We also present piece-wise linear approximations of the demand system that can be incorporated into a long term policy model. Thus we estimate a Linear Expenditure system (LES) for each of ten rural and ten urban expenditure classes of consumers.

Keywords: Food demand, Demand elasticities, Expenditure system, Projections, India

JEL: Q11, Q18, E2

I

THE IMPORTANCE OF DEMAND SYSTEMS FOR LONG TERM ECONOMIC MODELS

Policy analysis and strategic planning in a number of areas require long term projections requiring some sectoral detail. Long term economy wide projection models over a time horizon of around 30 to 50 years often have a fairly large disaggregation of commodities. One of the challenging tasks in such long term exercises is to project the changing demand structure over such a long period spanning wide income changes. In the case of a developing country like India such long time interval involves transformation of the economy from a developing to a developed one. The levels of per capita consumptions in India will exceed by far what has been observed. The expenditures of even the richest class in the National Sample Survey round of 2004-05, were around Rs. 15,000 (US $ 335 in 2004-05 prices) for rural consumers and Rs. 35,000 (US $ 780) for the urban consumers. With the desired growth rates of 8 per cent to 9 per cent over thirty years, per capita expenditures of many persons would exceed Rs. 100,000 (US $ 2,230). Such a transformation would involve reducing share of food and agriculture, initially rising

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The authors thank IRADe for supporting this work and two anonymous referees for their valuable and constructive comments on an earlier draft.

and further stabilising share of industry and a rising share of services in both the private consumption demand and gross domestic product (GDP). This would imply introducing non-linear changes in consumption shares of various commodities with increasing levels of income.

In this paper we present a non-linear demand system and price and income elasticities suitable for projections extending over 30 years that involve large increases in income. Elasticities are calculated for 22 consumption commodities of the 28 sectors of the economy, of which 14 are agricultural goods. The utility of the method is that it can be extended to as many commodities as required. Compared to past estimates of expenditure system our approach covers the entire economy and many commodities and is extendable to many more commodities.

We also present piece-wise locally linear approximations of the demand system that can be incorporated into a long term projection model. Thus we estimate a Linear Expenditure System (LES) for each of different expenditure classes (ten in our case) of rural and urban consumers. These class-wise expenditure systems are consistent as they are based on a common underlying non-linear demand system and can be easily included in an economy-wide model.

We test the demand system by out of sample projection and by comparing it with actual data.

Finally we demonstrate the use of estimated LESs in a long term economy wide model and to project long term food demand for India.

The structure of the paper is as follows. Section II presents a brief literature review to situate our work. Section III presents the methodology and estimation of the non-linear demand system. Section IV gives income and price elasticities. Section V tests the system with out of sample projections. Section VI gives locally linear approximation in to LES at different levels of household consumption for rural and urban consumers and Section VII presents the results of food demand projection using the system within a macro economic model.

II

LITERATURE REVIEW

Literature Review on Demand Systems Estimation

Demand systems have been estimated by a large number of recent empirical studies for many countries. The estimated demand systems include Linear Expenditure System (LES), (Geary 1950, Stone 1954), Almost Ideal Demand System (AIDS), (Deaton and Muellbauer, 1980), Price Independent Generalised Logarithmic model (PIGLOG), (Muellbauer, 1976), exactly aggregable Translog model of Jorgenson *et al*. (1982) and Quadratic AIDS (QUAIDS), (Banks *et al*., 1997). All but Quaids have Engel curves, which are linear in log of total expenditure ‘m’ QUAIDS introduces a quadratic term $(\ln m)^2$ which permits some Engel curves to be non-linear in log of m (real total expenditure).

The Exact Affine Stone Index (EASI), introduced by Lewbel and Pendakur (2008) incorporates higher order terms beyond the quadratic for log m in their demand system in the implicit Marshallian framework. The estimation of this system involves use of instrumental variable and two stage least square. Because of the difficulty of finding an appropriate instrumental variable for the system we have not used it for estimation. We use a Transcendental Logarithmic Demand System (TLDS), with a quadratic term $(\ln m)^2$ as suggested by Swamy and Binswanger (1983). While their system is not strictly compatible with utility maximisation, it is lot simpler to estimate compared to QUAIDS. Also Blundell *et al*. (1993) obtain good fit using similar specification with quadratic term but not compatible with utility maximisation.

In India, most demand projection studies have been based on LES type demand system. Some of the earliest studies done for India using LES were by Rudra (1964), Paul and Rudra (1964), Bhattacharya (1967) and Joseph (1968). Rudra (1964) and Paul and Rudra (1964) use time series of domestic consumption data of India to estimate a simple form of LES demand function using three commodities and six commodities specification. Bhattacharya (1967) applied LES to a cross section data from NSS sample survey. Joseph (1968) compares LES based projection with projection based on constant elasticity model and concludes that LES performs far better in projections of demand. In recent times also there have been many studies that have either used LES demand system or a modified version of LES to project demand using Indian data. Narayana *et al*., (1991) use piecewise LES in their general equilibrium model for agricultural policy analysis. Narayana and Vani (2000) use a modified version of the LES to analyse the consumption pattern of the agricultural and non-agricultural labour households in rural India to examine the impact of different welfare programmes on rural households. LES for 5 expenditure classes each by rural and urban areas was separately estimated by Radhakrishna and Murthy (1980) and do not conform to a common underlying demand system. Radhakrishna (2007) has shown that instead of estimating a single LES for the whole population it is better to estimate separate LES systems for different income groups.

Some of the studies that have tested LES on Indian data are Mazumdar (1986), Condoo and Mazumdar (1987), Ray (1982) and Ray (1985). Mazumdar (1986) compares the performance of LES with that of AIDS. Condoo and Mazumdar (1987) overcome the restrictions of LES using a modified version of the simple non-additive model suggested by Deaton (1975).

Ray (1982) tests the impact of introducing non-linear behaviour in income responses in LES and in demand systems that are already non-linear generalisations of LES like the quadratic expenditure system (QES). Mittal (2010) has used QUAIDS (Quadratic AIDS) system to estimate food demand for seven food items using NSS data of four rounds. Ganesh Kumar *et al*. (2012) also use QUAIDS based on NSS data. The elasticities in these two papers are not comparable with what are estimated here as their elasticities are with respect to food expenditure and ours refer to total expenditure.

III

GENERAL APPROACH

We want to estimate a complete expenditure system for India involving 22 consumption items for a number of rural and urban expenditure classes with expenditure and own and cross price elasticities changing with increasing levels of expenditure.

The estimation is based on data from National Sample Surveys (NSS) of household expenditure from 51st Round (1994-1995) to 64th Round (2007-08) and data from the Central Statistical Organisation (CSO) of national level consumer expenditures over these years.

A complete demand system is generally derived from a utility function. However, as Swamy and Binswanger (1983) have shown, it is also possible to derive demand functions of real expenditure and nominal prices by differentiating a consumption cost function. Various functional forms can be used: normalised quadratic demand functions, generalised Leontief demand functions, transcendental logarithmic demand functions, Linear Expenditure demand system and Almost Ideal Demand System (AIDS). We have chosen to use the transcendental logarithmic demand functions.

The choice of using a non-linear demand function like transcendental logarithmic demand function when extended to a complete demand system with large number of commodities requires estimation of large number of parameters and reduces greatly the degrees of freedom. In order to overcome this problem we apply the multistage budgeting procedure to our demand system and assume a transcendental logarithmic demand function at each stage of budgeting.

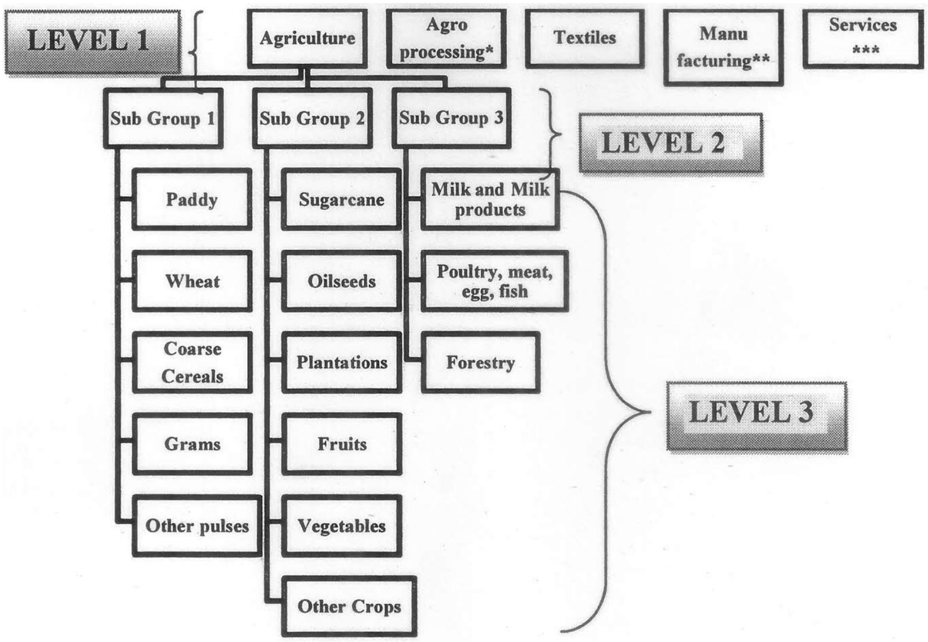
Strotz (1957, 1959) has justified the use of a two-stage estimation based on the concept of a utility tree. Though this procedure assumes strong separability, it reduces the number of parameters that needs to be estimated for a demand system that covers a large number of commodities. Edgerton (1997) extended the two stage budgeting procedure to a multi stage procedure and showed that weak separability and low variability of price indices with utility level as the necessary condition for multi stage budgeting. This is assured in the methodology this paper uses by appropriate choice of groups and use of price deflators, which like Paasche index and Laspeyres index, as Edgerton (1997) says, can be considered to be invariant with the consumer's utility function.

A number of researchers have used a two-stage demand system. Michalek and Keyzer (1992) have used a two-stage budgeting procedure for estimating a consumer demand system for eight EC countries, which uses AIDS in upper level and LES in lower level. Fan *et al*., (1995) also use an LES in the first stage and AIDS in the second stage system for estimating a complete demand system for Chinese rural households. Yen and Roe (1989), assuming a strongly separable conditional indirect utility function, have analysed consumption for Dominica households at different levels of income. Ramezani *et al*., (1995) have used AIDS and translog function to explore the influence of alternative grouping scheme for US data on the role of income, prices and demographic factors on food and nutrient demand.

The two-stage budgeting procedure basically implies that the consumer while making his expenditure decisions does not necessarily simultaneously decide for all commodities together. The two stage budgeting involves a process where the consumer first decides on the expenditure it wants to make on broad groups of commodities and services. Given the expenditure that is decided upon on a broad head or broad group of commodities or services the consumer in the second stage decides the expenditure on each commodity or services in that broad group. Thus the expenditure on each commodity in the second stage is conditional on the expenditure allotted to the broad category to which it belongs in the first stage. It follows that the demand function for commodities in the second stage is a function of the total expenditure allotted in the first stage from the consumer's budget to the broad group or category to which the commodity belongs. Thus the income elasticities and price elasticities of the demand function for each commodity in the second stage are conditional to the expenditure allotted to the broad commodity group in the first stage. Edgerton (1997) extended the two stage budgeting procedure to a multi stage budgeting and also calculates the unconditional elasticities from the conditional elasticities arrived at each stage of budgeting. We follow the same logic and compute the mathematical formulas for calculating the unconditional and conditional elasticities for each commodity or commodities. The advantage of using the multistage budgeting is that it implies that the non-linear demand functions like trancedental logarithmic demand function at each stage can be estimated for a small group of commodities thus reducing the number of parameters to be estimated for each set of estimation and yet being able to cover a large number of commodities.

For the purpose of estimation and to reduce the number of parameters to be estimated, the consumption side of the economy was divided into various groups and sub-groups. We follow a hierarchical approach here. The twenty two consumption items were aggregated into three hierarchical levels of groups and sub-groups. The scheme is shown in Figure 1. The Transcendental logarithmic demand system (TLDS) is estimated for each level. Here we assume the transcendental logarithmic demand system (TLDS) to hold at every stage of budgeting.

The expenditure elasticity of each commodity was worked out by combining the estimated elasticity for the commodity and the elasticity of the higher level sub-sector. The detailed methodology, estimations, results and elasticities are presented below.



*Beverages, pan, tobacco and intoxicants; **includes coal and lignite, petroleum products, crude petroleum, manufacturing products and non-metallic, water supply, electricity ***includes transport services, other services.

Figure 1. The Hierarchy of Commodities for Estimating the Demand System

Choice of Complete Demand System for the Economy

The methodology that is being proposed in the paper does not depend on the choice of the functional form of the complete demand system. The method can be repeated with any choice of demand function. In this paper we estimate a transcendental logarithmic demand system (TLDS) which is almost similar to AIDS but with an additional squared income term (see Swamy and Binswanger (1983)) for the complete expenditure system covering the entire consumption basket of 22 consumption items (out of the 28 commodities that cover the entire economy, 22 have final consumption by private households) of which 14 are agricultural goods and 10 non-agricultural goods. It is possible that the quality of estimated elasticities may vary with the choice of the demand function. The utility of the proposed method is that it makes it possible to estimate and project expenditure and price elasticities over a large number of goods and over a long income range in an economy wide model.

The functional form for the estimated transcendental demand system (TLDS) is as shown below,

$$S_i = a_i + b_{i1} \log m + b_{i2} (\log m)^2 + \sum_{j=1}^{N} C_{ij} \log P_j \quad i = 1, N \qquad ....(1)$$

Here $S_i = \frac{X_i P_i}{\sum_{j=1}^{N} X_j P_j}$ is the share of the value of commodity 'i' at current prices in total private final consumption expenditures, 'm' is the real total expenditure at constant prices. It is obtained by deflating the total expenditure at current prices from NSS data by the Consumption deflator, $\overline{P}$ *which* is the ratio of Private Final Consumption Expenditure (PFCE) at current prices to constant prices from National Accounts Statistics (NAS**).** P_j denotes the price of commodity 'j' and P_j is computed as the ratio of consumption of j-th commodity at current price to consumption of j-th commodity at constant prices obtained from National Accounts Statistics (NAS) reports.

As this estimation is a non-linear estimation, hence to get rational values of expenditure elasticities the following constraints have been imposed,

1) Symmetry implies $C_{ij} = C_{ji}$

2) Homogeneity of degree zero implies that $\sum C_{ij} = 0$ for all 'i'.

At each level the demand system of transcendental equations ensures homogeneity of degree zero in total expenditure, symmetry and negative definiteness of the compensated cross price terms and share-weighted sum of expenditure elasticities equaling to 1. The expenditure elasticities using the coefficients for the TLDS equation is then given by the formula below (see Swamy and Binswanger (1983))

$$\eta_{im} = \{\frac{[b_{i1} + 2 * b_{i2}\log(m)]}{S_i}\} + 1, \ (i < N), \text{ for the N-th sector}$$

$$\eta_{Nm} = \frac{\left[1 - \sum_{i=1}^{N-1} S_i \ \eta_{im}\right]}{S_N} \qquad ....(2)$$

where η_{im} are the expenditure elasticities and m is per capita total consumption expenditure.

It may be noted that we have not used demographic variables in our specification. NSS data shows that average household size and average number of children are strongly correlated with household expenditure level. For example in 2009-10 the average household in the lowest MPCE decile had 5.83 persons in rural and 5.95 persons in urban areas. Compared to that the highest MPCE decile household had 3.37 and 2.73 persons in rural and urban areas respectively. The average number of children also falls across deciles from 2.47 to 0.65 in rural and from 2.30 to o.36 in urban areas (NSSO, 2011). Since while using the system for projection we shift population from lower to higher expenditure class as consumption expenditure increases, the impact of demographic shifts is implicitly captured in the estimated demand system.

IV

ESTIMATION OF THE TRANSCENDENTAL LOGARITHMIC DEMAND SYSTEM (TLDS)

The twenty two consumption commodities covering the entire economy was aggregated into three hierarchical levels of groups and sub-groups separately for rural and urban areas as shown in Figure 1 below. A transcendental equation was estimated for each broad group and sub-groups listed in Figure 1, separately for rural and urban areas.

We have used the expenditure class wise data of monthly per capita consumption expenditure of food and non-food items for a period of 30 days for both rural and urban India from National Sample Survey (NSS) 51st Round (1994-95) till 64th Round (2007-08). The item wise NSS data was then aggregated to correspond to the sectors and sub-sectors of the hierarchical scheme, shown in Figure 1, separately for rural and urban consumers. For all rounds of survey except for the last round (2007-08) there were 12 rural and urban expenditure classes, but this number was reduced to 10 in the last (64th) round. Thus each panel consisted of 166 observations. For the prices we have used the price deflators for each commodity or commodity group from the national accounts statistics (NAS) series of private final consumption.

The estimation procedure used both the across and within survey rounds variations, because a within estimator would have dramatically reduced the expenditure variation with which to estimate the expenditure coefficients. Since estimation of expenditure coefficients across a very wide range of expenditures was the single most important consideration, the pooled data was used directly.

Step 1: TLDS is estimated for 5 aggregate commodities (marked in blue) i=agriculture, agro processing, textiles, manufacture and service. Here m is the real per capita total consumption of the economy. P_j is the price of the j-th commodity. Because of the adding up constraint the services sector is left out of the estimation and its parameters are estimated residually.

TABLE 1. ESTIMATED COEFFICIENTS FOR LEVEL 1 (AGRICULTURE, AGRO PROCESSING, TEXTILES, MANUFACTURING, SERVICES) FOR RURAL AND URBAN CONSUMERS

		Rural		Urban	
	Parameters	Coefficient	t statistic	Coefficient	t statistic
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	b_{i1}	0.39	6.79	0.090	2.35
	b_{i2}	- 0.04	- 9.16	- 0.018	- 6.44
Agro-processing	b_{i1}	0.06	4.60	0.031	4.02
	b_{i2}	- 0.005	- 4.26	- 0.002	- 3.91
Textiles	b_{i1}	0.166	3.04	0.125	3.71
	b_{i2}	- 0.013	- 2.82	- 0.009	- 3.54
Manufacturing	b_{i1}	- 0.24	- 6.87	- 0.10	- 3.99
	b_{i2}	0.021	7.58	0.0089	4.75

Using equation 2 and the estimated coefficients we compute the expenditure elasticity of agriculture, agro processing, textiles, manufacture and services.

Step 2: TLDS is estimated for 3 commodities i= sector 1, sector 2 and sector 3. Here ‘m’ is the real per capita total consumption expenditure on agriculture. Because of the adding up constraint sub-sector 3 is left out of the estimation and its parameters are estimated residually.

TABLE 2. ESTIMATED COEFFICIENTS FOR THREE AGRICULTURAL SUBGROUPS OF LEVEL 2 (SECTOR 1, 2 AND 3) FOR RURAL AND URBAN CONSUMERS

		Rural		Urban	
	Parameters	Coefficient	t statistic	Coefficient	t statistic
(1)	(2)	(3)	(4)	(5)	(6)
Sub-sector 1	b_{i1}	0.053	0.700	0.1622	15.11
	b_{i2}	- 0.023	- 3.39	- 0.027	- 18.28
Sub-sector 2	b_{i1}	0.096	2.29	- 0.413	- 12.29
	b_{i2}	- 0.005	- 1.35	0.038	13.17

Using equation 2 and the estimated coefficients we compute the conditional expenditure elasticity of sector 1, sector 2 and sector 3 consumption w.r.t an increase in total expenditure on agriculture.

Step 3: TLDS is estimated for 5 commodities i=rice, wheat, coarse cereals, grams and other pulses. Here ‘m’ is the real per capita total consumption expenditure on sector 1.

TABLE 3. ESTIMATED COEFFICIENTS FOR SUB-SECTOR 1 OF LEVEL THREE FOR RURAL AND URBAN CONSUMERS

		Rural		Urban	
Sub-sector 1*	Parameters	Coefficient	t statistic	Coefficient	t statistic
(1)	(2)	(3)	(4)	(5)	(5)
Other crops	b_{i1}	-0.173	-1.52	-0.30	-182.8
	b_{i2}	0.029	2.41	0.043	78.9
Wheat	b_{i1}	2.12E-02	0.08	-0.45	-105.3
	b_{i2}	0.0017	0.06	0.039	27.9
Coarse cereals	b_{i1}	-3.36E-10	-002	-0.03	0
	b_{i2}	-3.16E-09	-0.19	3.27E-07	0
Grams	b_{i1}	-1.11E-10	-0.24	0.03	23.15
	b_{i2}	1.13E-03	1.40E+01	-0.002	-27.90

*Sub-sector 1 (Paddy, Wheat, Coarse Cereals, Grams, and Other Pulses).

Using equation 2 and the estimated coefficients we compute the conditional expenditure elasticity of rice, wheat, coarse cereals, grams and other pulses consumption w.r.t increase in total expenditure on sector 1.

Step 4: TLDS is estimated for 5 commodities i=sugarcane, oilseeds, plantations, fruits, vegetables, other crops. Here ‘m’ is the real per capita total consumption expenditure on sector 2.

TABLE 4. ESTIMATED COEFFICIENTS FOR SUB-SECTOR 2 OF LEVEL THREE FOR RURAL AND URBAN CONSUMERS

Sub-sector 2*	Parameters	Rural		Urban	
		Coefficient	t statistic	Coefficient	t statistic
(1)	(2)	(3)	(4)	(5)	96)
Sugarcane	b_{i1}	0.22	12.18	0.055	20.28
	b_{i2}	-0.024	-11.56	-0.009	-55.24
Oilseeds	b_{i1}	-0.0008	-0.017	0.225	4.96
	b_{i2}	-0.003	-0.65	-0.028	-5.96
Plantations	b_{i1}	0.14	3.6	0.003	0.052
	b_{i2}	-0.011	-2.5	0.008	1.22
Fruits	b_{i1}	0.008	0	0.01	288.23
	b_{i2}	0	0	0	0
Vegetables	b_{i1}	-0.13	-20.06	-0.14	-28.97
	b_{i2}	0	0	0	0

*Sub sector 2: (Sugarcane, Oilseeds, Plantations, Fruits, Vegetables, and Other Crops).

Using equation 2 and the estimated coefficients we compute the conditional expenditure of sugarcane, oilseeds, plantations, fruits, vegetables and other crops consumption w.r.t increase in total expenditure on sector 2.

Step 5: TLDS is estimated for 5 commodities (marked in green) i=milk and milk products, poultry meat egg and fish, forestry. Here ‘m’ is the real per capita total consumption expenditure on sector 3.

TABLE 5. ESTIMATED COEFFICIENTS FOR SUB-SECTOR 3 OF LEVEL THREE FOR RURAL AND URBAN CONSUMERS

Sub-sector 3*	Parameters	Rural		Urban	
		Coefficient	t statistic	Coefficient	t statistic
(1)	(2)	(3)	(4)	(5)	(6)
Milk and milk products	b_{i1}	0.460	11.44	0.40	14.41
	b_{i2}	-0.037	-7.49	-0.03	-10.74
Poultry	b_{i1}	0.052	1.81	0.193	8.65
	b_{i2}	-0.0077	-2.17	-0.02	-9.39

*Sub-sector 3: (Milk and Milk Products; Poultry, Meat, Egg, Fish; Forestry).

Using equation 2 and the estimated coefficients we compute the conditional expenditure elasticity of milk and milk products, poultry - meat egg and fish, forestry consumption w.r.t increase in total expenditure on sector 3.

The Estimation of Expenditure Elasticities

If the TLDS was estimated simultaneously with 22 commodities then the price elasticities and expenditure elasticities could have been calculated from the normal formula of the elasticities used for the transcendental logarithmic demand function as shown in equation 2. However to overcome the problem of degrees of freedom due to large number of parameters that would be needed to be estimated, the demand function are being estimated separately for different groups and aggregations, therefore the usual formulas for estimation of own price and cross price elasticities are not valid here. For example rice would be considered in the demand function for sector 1 commodities while fruits will be considered for demand functions of sector 2 commodities hence the cross price elasticities cannot be directly estimated from the conventional formula. Similar is the argument for own price elasticity and expenditure elasticity.

The estimated TLDS parameters from step 1 to step 5 give us the conditional expenditure elasticities for a commodity or sub-sector given the allotted expenditure of the group or sub-group to which it belongs. To estimate the unconditional expenditure elasticities of a commodity with respect to real total expenditure using conditional elasticities we use the method as shown in Edgerton (1997). The method is explained below.

Expenditure elasticity of each commodity w.r.t. real per capita total consumption is calculated using the expenditure elasticities calculated in step 1-5 (section 3.1). We explain this using the example of rice.

$$\eta_r^{agg} = \eta_r \times \eta_{s1} \times \eta_{Agr}$$

Where,

η_r = elasticity of rice w.r.t a change in expenditure of sector 1

η_{s1} = elasticity of sector 1 consumption w.r.t a change in expenditure of agriculture

η_{Agr}= elasticity of agriculture consumption w.r.t a change in aggregate expenditure

η_r^{agg} = elasticity of rice consumption w.r.t a change in aggregate consumption expenditure.

The Tables 6 and 7 provide the expenditure elasticities for all commodities for rural and urban consumers.

The Estimation of the Price Elasticities:

To estimate the unconditional own and cross price elasticities of a commodity we use the mathematical formulae using conditional elasticities as shown in Edgerton (1997) for multi stage budgeting.

The own price elasticities of commodities for rural and urban consumers are given in Tables 8 and 9 respectively for households with different expenditure levels:

Cross price elasticities can be calculated as per the procedure given in Edgerton (1997) for any given level of total expenditure. Since they also vary with the level of total expenditure, for the twenty expenditure classes we have considered here it would lead to 20 tables of size 22x22. Due to size limitation these are not presented here.

TABLE 6 : EXPENDITURE ELASTICITIES FOR 22 CONSUMPTION COMMODITIES FOR RURAL CONSUMERS

(1)	RH1 (2)	RH2 (3)	RH3 (4)	RH4 (5)	RH5 (6)	RH6 (7)	RH7 (8)	RH8 (9)	RH9 (10)	RH10 (11)
m (Rs./person/ year)	2996	5441	10077	16442	21423	28922	41159	54031	70147	102589
Paddy	0.5545	0.4220	0.3190	0.2452	0.2087	0.1672	0.1240	0.0948	0.0712	0.0417
Wheat	0.7915	0.6530	0.5388	0.4486	0.3986	0.3422	0.2767	0.2273	0.1843	0.1219
Coarse cereals	0.6767	0.5559	0.4567	0.3783	0.3352	0.2866	0.2307	0.1888	0.1525	0.1004
Grams	3.2248	2.0983	1.7125	1.4154	1.2484	1.0712	0.8636	0.7061	0.5703	0.3742
Other pulses	1.0470	0.9039	0.9244	0.8547	0.7974	0.7341	0.6403	0.5549	0.4736	0.3358
Sugarcane	1.6100	1.1962	0.8989	0.7071	0.6126	0.4984	0.3752	0.2877	0.2114	0.1052
Oilseeds	1.0009	0.8516	0.7294	0.6287	0.5719	0.5104	0.4392	0.3854	0.3423	0.2820
Plantations	2.1656	1.5918	1.2272	1.0027	0.8947	0.7817	0.6641	0.5832	0.5231	0.4474
Fruits	1.3500	1.1128	0.9386	0.8116	0.7437	0.6756	0.5993	0.5432	0.5028	0.4503
Vegetables	0.7217	0.6377	0.5397	0.4560	0.4082	0.3570	0.2970	0.2513	0.2128	0.1573
Other crops	1.3567	1.4800	1.5777	1.6002	1.5943	1.6320	1.6733	1.7049	1.7811	1.9248
Milk and milk products	0.0861	0.0971	0.1069	0.1112	0.1115	0.1143	0.1160	0.1162	0.1200	0.1252
Animal services and products	1.6943	1.4096	1.2120	1.0296	0.9244	0.8176	0.6934	0.6006	0.5266	0.4254
Forestry	0.8747	0.8508	0.7935	0.7431	0.7174	0.7571	0.8391	0.9343	1.0919	1.4203
Coal lignite crude oil	0.6815	0.7581	0.7961	0.8049	0.8018	0.7861	0.7557	0.7228	0.7414	0.7684
Agro processing	1.4100	1.2284	1.0783	0.9467	0.8673	0.7720	0.6493	0.5444	0.4428	0.2791
Textiles	1.5170	1.2864	1.0953	0.9278	0.8266	0.7054	0.5491	0.4154	0.2862	0.0777
Manufacturing and Non metallic	1.0653	1.2229	1.3473	1.4362	1.4826	1.5270	1.5762	1.6125	1.6749	1.7748
Electricity	0.5630	0.5910	0.5651	0.5078	0.4615	0.3937	0.2922	0.1958	0.1719	0.1284
Water supply and gas	1.8345	1.6557	1.5287	1.4760	1.4631	1.4431	1.4315	1.4301	1.4583	1.5167
Other transport services	1.1223	1.9146	2.6366	3.3002	3.7619	4.4708	5.4412	6.3116	7.1915	8.6781
Other services	1.7888	2.4148	2.5889	2.5199	2.4398	2.6498	2.9167	3.1421	3.3308	3.6320

TABLE 7. EXPENDITURE ELASTICITIES FOR 22 CONSUMPTION COMMODITIES FOR URBAN CONSUMERS

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
m (Rs./person/ year)	3223	7758	18663	37519	52678	73519	104553	139073	178951	285800
Paddy	0.8996	0.6285	0.3813	0.2382	0.1833	0.1385	0.0992	0.0732	0.0539	0.0271
Wheat	0.3874	0.3375	0.2605	0.2360	0.2335	0.2434	0.2416	0.2317	0.2171	0.1790
Coarse cereals	0.3742	0.3890	0.3050	0.2325	0.1975	0.1691	0.1411	0.1199	0.1021	0.0720
Grams	4.8340	2.3132	1.3111	0.7976	0.6110	0.4839	0.3692	0.2904	0.2294	0.1386
Other pulses	0.8386	0.7614	0.7410	0.7405	0.7336	0.6949	0.6389	0.5835	0.5272	0.4116
Sugarcane	0.6545	0.6082	0.4742	0.3179	0.2809	0.2479	0.2119	0.1824	0.1563	0.1089
Oilseeds	0.7755	0.7154	0.5801	0.4309	0.3736	0.3231	0.2698	0.2273	0.1906	0.1260
Plantations	1.2460	1.2568	1.1695	1.0921	1.0695	1.0512	1.0190	0.9794	0.9369	0.8284
Fruits	0.9006	0.8784	0.8169	0.7803	0.7613	0.7454	0.7193	0.6888	0.6565	0.5764
Vegetables	0.4149	0.4360	0.4044	0.3722	0.3365	0.3000	0.2548	0.2133	0.1747	0.0996
Other crops	1.0248	1.3879	1.7219	2.0614	2.3392	2.6728	3.0552	3.3673	3.6459	4.0782
Milk and milk products	2.1692	1.4776	1.0420	0.7775	0.6743	0.5873	0.5016	0.4363	0.3810	0.2851

(Contd.)

TABLE 7. (CONCLD.)

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
Animal services and products	1.7507	1.1505	0.7337	0.4696	0.3649	0.2764	0.1932	0.1343	0.0966	0.0419
Forestry	0.6556	0.7577	0.8121	0.8550	0.8763	0.8959	0.9039	0.8966	0.8837	0.8262
Coal lignite crude oil	0.8365	0.8865	0.9054	0.8823	0.8585	0.8287	0.7946	0.7619	0.7289	0.6574
Agro processing	1.1948	1.0731	0.9912	0.9332	0.9083	0.8846	0.8610	0.8427	0.8269	0.7989
Textiles	2.2560	1.3866	1.0055	0.7844	0.6786	0.5715	0.4570	0.3625	0.2770	0.1131
Manufacturing and non metallic	1.0223	1.1862	1.3134	1.3975	1.4325	1.4660	1.4980	1.5218	1.5419	1.5760
Electricity	0.7720	0.7721	0.7113	0.5904	0.5042	0.4008	0.3207	0.2479	0.1770	0.0284
Water supply and Gas	2.0236	1.6378	1.4387	1.3129	1.2632	1.2243	1.1835	1.1436	1.1023	1.0109
Other transport services	1.5132	1.6512	1.6216	1.7330	1.8228	1.9188	2.0222	2.1079	2.1886	2.3450
Other services	2.2224	1.8129	1.6181	1.6073	1.6348	1.6682	1.7038	1.7341	1.7610	1.8134

TABLE 8. OWN PRICE ELASTICITIES FOR 22 CONSUMPTION COMMODITIES FOR THE TEN RURAL CLASSES

(1)	RH1 (2)	RH2 (3)	RH3 (4)	RH4 (5)	RH5 (6)	RH6 (7)	RH7 (8)	RH8 (9)	RH9 (10)	RH10 (11)
m (Rs./person/ year)	2996	5441	10077	16442	21423	28922	41159	54031	70147	102589
Paddy	-0.71	-0.75	-0.73	-0.72	-0.71	-0.70	-0.69	-0.68	-0.67	-0.66
Wheat	-0.42	-0.43	-0.44	-0.44	-0.44	-0.44	-0.44	-0.44	-0.44	-0.45
Coarse cereals	0.06	-0.16	-0.17	-0.17	-0.17	-0.17	-0.18	-0.18	-0.18	-0.18
Grams	-0.23	-0.47	-0.53	-0.56	-0.58	-0.60	-0.63	-0.64	-0.66	-0.68
Other pulses	-0.48	-0.54	-0.49	-0.51	-0.51	-0.53	-0.54	-0.55	-0.56	-0.57
Sugarcane	-1.57	-1.50	-1.47	-1.46	-1.45	-1.45	-1.44	-1.43	-1.43	-1.44
Oilseeds	-0.88	-0.82	-0.81	-0.80	-0.78	-0.77	-0.74	-0.72	-0.69	-0.63
Plantations	-0.78	-0.84	-0.88	-0.90	-0.92	-0.93	-0.94	-0.94	-0.94	-0.94
Fruits	-1.92	-1.58	-1.40	-1.32	-1.30	-1.28	-1.27	-1.28	-1.29	-1.31
Vegetables	-0.84	-0.83	-0.83	-0.82	-0.82	-0.81	-0.79	-0.77	-0.75	-0.71
Other crops	-1.09	-1.14	-1.19	-1.24	-1.26	-1.29	-1.33	-1.36	-1.39	-1.43
Milk and milk products	0.23	-0.04	-0.22	-0.31	-0.34	-0.36	-0.38	-0.38	-0.37	-0.34
Animal services and products	-1.45	-1.43	-1.43	-1.45	-1.46	-1.49	-1.52	-1.55	-1.59	-1.65
Forestry	-0.76	-0.83	-0.88	-0.91	-0.93	-0.96	-0.99	-1.01	-1.03	-1.06
Coal lignite crude oil	-0.31	-0.33	-0.31	-0.28	-0.26	-0.23	-0.19	-0.15	-0.15	-0.14
Agro processing	-1.93	-1.85	-1.89	-1.96	-2.00	-2.04	-2.09	-2.14	-2.18	-2.24
Textiles	-1.81	-1.74	-1.78	-1.84	-1.88	-1.92	-1.97	-2.02	-2.05	-2.11
Manufacturing and non metallic	-0.03	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.11	-0.10	-0.09
Electricity	-0.83	-0.87	-0.89	-0.91	-0.92	-0.93	-0.93	-0.94	-0.94	-0.94
Water supply and gas	-10.21	-7.47	-5.54	-4.45	-3.99	-3.54	-3.10	-2.82	-2.48	-2.09
Other transport services	-1.52	-1.77	-2.17	-2.65	-2.99	-3.01	-3.03	-3.04	-3.06	-3.08
Other services	-1.09	-1.02	-0.95	-0.89	-0.85	-0.84	-0.82	-0.81	-0.80	-0.78

TABLE 9. OWN PRICE ELASTICITIES FOR 22 CONSUMPTION COMMODITIES FOR THE TEN URBAN CLASSES

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
m (Rs./person/ year)	3223	7758	18663	37519	52678	73519	104553	139073	178951	285800
Paddy	-0.90	-0.92	-0.84	-0.76	-0.72	-0.67	-0.63	-0.59	-0.56	-0.51
Wheat	-0.54	-0.56	-0.51	-0.41	-0.33	-0.35	-0.36	-0.38	-0.39	-0.41
Coarse cereals	0.53	-0.05	-0.21	-0.29	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
Grams	0.34	-0.19	-0.34	-0.41	-0.44	-0.44	-0.44	-0.44	-0.44	-0.43
Other pulses	-0.69	-0.76	-0.75	-0.72	-0.70	-0.72	-0.73	-0.75	-0.76	-0.78
Sugarcane	-1.35	-1.42	-1.54	-1.65	-1.62	-1.58	-1.55	-1.53	-1.51	-1.48
Oilseeds	-0.92	-0.91	-0.90	-0.88	-0.87	-0.85	-0.84	-0.83	-0.82	-0.79
Plantations	-0.70	-0.79	-0.85	-0.90	-0.91	-0.93	-0.94	-0.95	-0.96	-0.98
Fruits	-1.67	-1.37	-1.20	-1.16	-1.16	-1.15	-1.15	-1.15	-1.14	-1.14
Vegetables	-0.65	-0.66	-0.66	-0.66	-0.65	-0.64	-0.63	-0.62	-0.60	-0.57
Other crops	-1.00	-1.04	-1.08	-1.12	-1.14	-1.16	-1.18	-1.20	-1.21	-1.24
Milk and milk products	0.00	-0.09	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.15	-0.14
Animal services and products	-0.97	-0.93	-0.90	-0.87	-0.86	-0.85	-0.83	-0.82	-0.81	-0.79
Forestry	-0.76	-0.85	-0.93	-1.00	-1.03	-1.06	-1.10	-1.13	-1.15	-1.20
Coal lignite crude oil	-0.25	-0.29	-0.27	-0.25	-0.23	-0.21	-0.19	-0.16	-0.14	-0.10
Agro processing	-2.51	-2.19	-2.14	-2.05	-2.01	-1.98	-1.95	-1.93	-1.91	-1.88
Textiles	-3.68	-2.61	-2.16	-2.15	-2.15	-2.15	-2.16	-2.17	-2.18	-2.20
Manufacturing and non metallic	0.05	-0.04	-0.06	-0.10	-0.12	-0.13	-0.14	-0.15	-0.16	-0.17
Electricity	-0.80	-0.86	-0.89	-0.91	-0.92	-0.93	-0.93	-0.93	-0.93	-0.94
Water supply and gas	-6.58	-4.99	-3.90	-3.27	-3.02	-2.81	-2.91	-3.00	-3.08	-3.25
Other transport services	-1.99	-2.07	-2.12	-1.81	-1.82	-1.83	-1.83	-1.84	-1.84	-1.85
Other services	-1.02	-0.92	-0.83	-0.82	-0.81	-0.81	-0.80	-0.80	-0.80	-0.79

V

SAMPLE VALIDATION

For validating the estimated demand system we do an out of sample forecasting. The demand system was estimated using data up to 2006-07. The latest available NSS data of consumption is for 2011-12. The period between 2006 and 2011 was a period of rapid economic growth and also high level of inflation particularly of food items. We use the estimated coefficients derived from the non-linear demand system to project class wise shares of the commodities for the different expenditure decile classes of NSS household expenditure survey for 2011-12. We assess the validity of the system by measuring how accurately it projects the commodity shares for different expenditure classes of the NSS household expenditure survey of 2011-12. The transcendental demand function makes the share of individual commodity as a function of real total expenditure and prices of each commodity (see equation 1 above). To project the expenditure class wise shares of commodities from the expenditure levels of the 68th Round of NSS for Household Consumer Expenditures

(2011-12) we divided the decile class wise total expenditure from the NSS 68th Round by the aggregate private final expenditure deflator obtained from the NAS 2011-12. This gave us the class wise real total expenditure for each of the decile class of the NSS 68th Round. Using the broad commodity wise data of private final expenditure deflator of the NAS 2011-12, we compute commodity wise price deflators. The commodity wise price deflators and the class wise real expenditures thus obtained is then substituted in equation 1 to project class wise shares of the broad 5 commodities (Level 1). The accuracy of the class wise forecasts and goodness of fit for the estimated equation is tested using the Root Mean Square Method. RMS is defined as the square root of the average difference between estimates and true parameter (Heckelei and Wolff, 2003). RMS have been extensively used for predictions of time series [(Szkuta *et al*. (1999), Heckelei and Wolff (2003)]. The ratio of expenditure of each commodity by total expenditure in the NSS 68th Round gives the actual share of that commodity. This was compared for each decile class to the forecasted shares from the estimated demand systems for validation. The exercise was done for both urban and rural expenditure classes separately. Root Mean Squares (RMS) errors between the forecasted shares and that of the actual shares for the ten decile classes were used to test the accuracy of the presented method. The results of the RMS for each commodity in level 1 across the decile classes for both rural and urban areas is presented below (Tables 10 and 11).

TABLE 10. RMS OF FORECASTED AND ACTUAL SHARES FOR RURAL EXPENDITURE DECILE CLASSES FOR NSSO SURVEY OF 2011-12

Rural (1)	Agriculture (2)	Agro-processing (3)	Textiles (4)	Manufacturing (5)	Services (6)
	0.032	0.005	0.052	0.048	0.026

TABLE 11. RMS OF FORECASTED AND ACTUAL SHARES FOR URBAN EXPENDITURE DECILE CLASSES FOR NSSO SURVEY OF 2011-12

Urban (1)	Agriculture (2)	Agro-processing (3)	Textiles (4)	Manufacturing (5)	Services (6)
	0.035	0.009	0.058	0.044	0.043

RMS errors for all the commodities for both rural and urban are close to zero. Therefore, the forecasted shares do approximate the actual shares. This validates the methodology used.

VI

COMPUTATION OF LES PARAMETERS

Having estimated a non-linear demand function and computed the income, own price and cross price elasticities we now proceed to incorporate this non-linear demand system into a linear model. Using these elasticities for different expenditure ranges, we make a locally linear approximation of the underlying non-linear demand function with a Linear Expenditure System (LES) for each expenditure level. These class-wise expenditure systems are consistent as they are based on a common underlying non-linear TLDS. The particular advantage of our approach is that compared to past estimates of expenditure system it covers the entire economyand many commodities and is extendable to as much commodity disaggregation and as many expenditure classes as required.

We use the IRADe activity analysis model, which is a linear programing model with the consumption side of the economy divided into rural and urban areas. The model assumes 10 expenditure classes each for rural and urban areas. In simulations as income changes, income distribution shifts population from one class to another. Therefore even when demand system for each class is a local approximation of the underlying utility function as an LES, the resulting aggregate demand system for the population shows changing price and income elasticities.

For the model projections we have stipulated consumption expenditure classes as shown in Table 12. The table also shows the percent of population in each class in the year 2003-04 based on 2003-04 populations and log normal distribution.

TABLE 12. CONSUMPTION EXPENDITURE IN RS. PER PERSON PER YEAR AT 2003-04 PRICES FOR THE EXPENDITURE CLASSES OF THE IRADE ACTIVITY ANALYSIS MODEL

	Rural			Urban		
	Class limits	m (Rs./person)	PP*	Class limits	m (Rs./person)	PP*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	0 - 4000	2996	0.129	0 - 5000	3223	0.122
2.	4000 - 6800	5441	0.225	5000 - 10800	7758	0.225
3.	6800 -14200	10077	0.397	10800 - 31000	18663	0.399
4.	14200 - 19175	16442	0.115	31000 - 46000	37519	0.109
5.	19175 - 24150	21423	0.059	46000 - 61000	52678	0.055
6.	24150 - 36225	28922	0.053	61000 - 91500	73519	0.05
7.	36225 - 48300	41159	0.014	91500 - 122000	104553	0.02
8.	48300 - 62375	54031	0.005	122000 - 162500	139073	0.011
9.	62375 - 82450	70147	0.002	162500 - 200000	178951	0.004
10.	82450 - INF	102589	0.00071	200000 - INF	285800	0.006

*Proportion of persons in the class.

To introduce the demand projection from the non-linear TLDS estimated in the earlier section into the linear model we make a linear approximation of the demand at different expenditure levels using Linear Expenditure System (LES) and use these demand parameters in the linear model.

The Linear Expenditure System equation is given by

$$X_i = COMC_i + MRBS_i(m - \sum_j COMC_j) \quad ....(3)$$

Where i, j is the commodity and cl is the expenditure class and ‘m’ is real per capita expenditure (PCTC). However since the demand side is divided into rural and urban with 10 expenditure classes each, hence the LES parameters are estimated for each expenditure class in rural and urban areas separately. The algebraic expression (3) is then modified as below.

$$X_{cl,i} = COMC_{cl,i} + MRBS_{cl,i}(m_{cl} - \sum_{j} COMC_{cl,j}) \qquad ....(4)$$

We use the methodology as suggested by de Boer and Missaglia (2006) to estimate marginal budget shares, $MRBS_{cl,i}$ for each expenditure class. The marginal budget share for a LES is related to the expenditure elasticity using the equation $MRBS_i = S_i * \eta_{im}$, where S_i is the budget share of the i-th commodity in total expenditure at constant prices and η_{im} is the expenditure elasticity of a commodity w.r.t to total real per capita expenditure.

To estimate marginal budget share for each expenditure class we would need to make a class wise estimate of η_{im} and S_i. η_{im} being a function of real per capita expenditure 'm', (see equation 2) we obtain class wise estimates of $\eta_{im}$by solving for unconditional elasticities η_{im} from the TLDS using the values of class wise per capita total consumption expenditure (PCTC) listed in Table 12. To compute expenditure class wise estimate of S_i for each commodity, the relation between share in total expenditure and the log of real total consumption expenditure was estimated using the NSS data from 51st to 64th rounds that converges asymptotically to a non-negative constant as income increase. This is done by estimating a double log (or semi-log) function of shares on expenditures, as shown in the following equations later. The marginal budget shares were computed as = Si* unconditional expenditure elasticity of each consumption item in total.

The marginal budget shares for both rural and urban consumers are shown in Tables 13 and 14 for all commodities:

TABLE 13. MARGINAL BUDGET SHARES FOR ALL 22 CONSUMPTION COMMODITIES FOR RURAL CONSUMERS

(1)	RH1 (2)	RH2 (3)	RH3 (4)	RH4 (5)	RH5 (6)	RH6 (7)	RH7 (8)	RH8 (9)	RH9 (10)	RH10 (11)
m (Rs./person/ year)	2996	5441	10077	16442	21423	28922	41159	54031	70147	102589
Paddy	0.1192	0.0658	0.0474	0.0342	0.0279	0.0216	0.0153	0.0112	0.0082	0.0046
Wheat	0.0661	0.0450	0.0354	0.0276	0.0235	0.0195	0.0150	0.0118	0.0093	0.0059
Coarse cereals	0.0488	0.0436	0.0341	0.0265	0.0225	0.0186	0.0143	0.0112	0.0088	0.0055
Grams	0.0031	0.0024	0.0021	0.0017	0.0015	0.0013	0.0011	0.0009	0.0007	0.0005
Other pulses	0.0403	0.0323	0.0268	0.0232	0.0208	0.0185	0.0154	0.0128	0.0106	0.0071
Sugarcane	0.0331	0.0252	0.0170	0.0119	0.0096	0.0074	0.0051	0.0037	0.0025	0.0012
Oilseeds	0.0458	0.0301	0.0212	0.0152	0.0124	0.0100	0.0075	0.0059	0.0048	0.0034
Plantations	0.0254	0.0221	0.0177	0.0146	0.0130	0.0114	0.0097	0.0085	0.0077	0.0066
Fruits	0.0087	0.0110	0.0125	0.0134	0.0137	0.0142	0.0147	0.0149	0.0155	0.0164
Vegetables	0.0496	0.0409	0.0283	0.0198	0.0159	0.0124	0.0090	0.0068	0.0053	0.0034
Other crops	0.0346	0.0350	0.0301	0.0252	0.0224	0.0204	0.0182	0.0165	0.0156	0.0145
Milk and milk products	0.0861	0.0971	0.1069	0.1112	0.1115	0.1143	0.1160	0.1162	0.1200	0.1252

(Contd.)

TABLE 13. (CONCLD.)

(1)	RH1 (2)	RH2 (3)	RH3 (4)	RH4 (5)	RH5 (6)	RH6 (7)	RH7 (8)	RH8 (9)	RH9 (10)	RH10 (11)
Animal services and products	0.0353	0.0363	0.0340	0.0301	0.0274	0.0250	0.0218	0.0192	0.0173	0.0145
Forestry	0.0410	0.0383	0.0300	0.0238	0.0208	0.0200	0.0196	0.0198	0.0213	0.0244
Coal lignite crude oil	0.0313	0.0379	0.0379	0.0360	0.0343	0.0325	0.0298	0.0273	0.0272	0.0269
Agro processing	0.0498	0.0471	0.0394	0.0325	0.0285	0.0245	0.0196	0.0158	0.0125	0.0075
Textiles	0.1106	0.1019	0.0827	0.0657	0.0561	0.0462	0.0343	0.0249	0.0167	0.0043
Manufacturing and non metallic	0.1025	0.1552	0.1990	0.2334	0.2514	0.2758	0.3045	0.3262	0.3295	0.3323
Electricity	0.0147	0.0158	0.0136	0.0109	0.0092	0.0074	0.0051	0.0032	0.0026	0.0018
Water supply and Gas	0.0019	0.0030	0.0043	0.0057	0.0066	0.0080	0.0099	0.0117	0.0143	0.0190
Other transport services	0.0217	0.0402	0.0528	0.0620	0.0677	0.0777	0.0902	0.1003	0.1111	0.1276
Other services	0.0304	0.0738	0.1269	0.1754	0.2033	0.2134	0.2239	0.2313	0.2384	0.2474

TABLE 14. MARGINAL BUDGET SHARES FOR ALL 22 CONSUMPTION COMMODITIES FOR URBAN CONSUMERS

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
m (Rs./person/ year)	3223	7758	18663	37519	52678	73519	104553	139073	178951	285800
Paddy	0.1509	0.0680	0.0394	0.0247	0.0191	0.0144	0.0102	0.0075	0.0055	0.0027
Wheat	0.0466	0.0264	0.0110	0.0064	0.0051	0.0053	0.0052	0.0050	0.0046	0.0037
Coarse cereals	0.0088	0.0105	0.0078	0.0060	0.0051	0.0044	0.0036	0.0031	0.0026	0.0018
Grams	0.0055	0.0030	0.0016	0.0010	0.0008	0.0006	0.0005	0.0004	0.0003	0.0002
Other pulses	0.0420	0.0293	0.0182	0.0132	0.0113	0.0106	0.0097	0.0088	0.0079	0.0061
Sugarcane	0.0217	0.0146	0.0068	0.0032	0.0028	0.0025	0.0021	0.0018	0.0015	0.0010
Oilseeds	0.0473	0.0347	0.0186	0.0103	0.0090	0.0078	0.0064	0.0054	0.0045	0.0029
Plantations	0.0257	0.0302	0.0272	0.0257	0.0254	0.0250	0.0242	0.0232	0.0221	0.0194
Fruits	0.0092	0.0138	0.0163	0.0156	0.0153	0.0149	0.0143	0.0136	0.0129	0.0112
Vegetables	0.0323	0.0285	0.0184	0.0132	0.0106	0.0084	0.0062	0.0047	0.0035	0.0016
Other crops	0.0325	0.0334	0.0261	0.0225	0.0218	0.0212	0.0203	0.0195	0.0186	0.0164
Milk and milk products	0.1258	0.1088	0.0807	0.0605	0.0527	0.0457	0.0388	0.0336	0.0291	0.0215
Animal services and products	0.0554	0.0376	0.0206	0.0121	0.0091	0.0066	0.0044	0.0029	0.0021	0.0009
Forestry	0.0365	0.0397	0.0331	0.0298	0.0284	0.0267	0.0247	0.0228	0.0211	0.0174
Coal lignite crude oil	0.0321	0.0392	0.0382	0.0374	0.0366	0.0351	0.0335	0.0319	0.0303	0.0270
Agro processing	0.0461	0.0519	0.0498	0.0504	0.0509	0.0510	0.0511	0.0511	0.0510	0.0508
Textiles	0.0574	0.0579	0.0570	0.0447	0.0388	0.0325	0.0259	0.0204	0.0155	0.0062
Manufacturing and non metallic	0.0615	0.1004	0.1296	0.1624	0.1807	0.1986	0.2187	0.2357	0.2513	0.2816
Electricity	0.0173	0.0178	0.0140	0.0107	0.0088	0.0067	0.0053	0.0041	0.0029	0.0005
Water supply and Gas	0.0054	0.0078	0.0100	0.0129	0.0147	0.0166	0.0160	0.0154	0.0147	0.0133
Other transport services	0.0315	0.0660	0.1029	0.1656	0.1751	0.1834	0.1922	0.1992	0.2054	0.2169
Other services	0.1083	0.1805	0.2726	0.2719	0.2779	0.2822	0.2866	0.2900	0.2926	0.2969

Next we estimate committed coefficients $COMC_i$ as in Boer and Missaglia (2006) using the following relationship.

$COMC_{cl,i} = X^r_{cl,i} + MRBS_{cl,i} * m_{cl} / FP$ where $X^r_{cl,i}$ represents the per capita consumption of i-th commodity in the cl-th class for rural and urban areas, m_{cl} is per capita total consumption and FP is Frisch parameter.

$X^r_{cl,i}$ is the per capita consumption of i-th commodity in the cl-th class for region r (rural or urban areas) which is consistent with the Social Accounting Matrix (SAM) of 2003-04 of India used in the IRADe's activity analysis model, The idea is to derive $COMC_{cl,i}$ and $MRBS_{cl,i}$ such that is able to gives us per capita consumption ($X^r_{cl,i}$) that is consistent with the base year values of the model. We use the commodity consumption as given in the SAM and an average estimated Frisch parameter (the expenditure elasticity of the marginal utility of expenditure).

To estimate the Frisch parameter we use NSS data from 51st to 64th Rounds. A LES demand system at current prices for five broad commodity groups was estimated and the Frisch parameter was computed for each class for rural and urban separately using the relation stated below.

$$\varphi = -\frac{m}{m - \sum_j P_j COMC_j}$$

The Frisch parameter for each observation and for each expenditure class was plotted against m (real per capita expenditure) which is the per capita expenditure level (PCTC).

A best fit equation was obtained and used to forecast the FP for the expenditure levels of the classes assumed in our model. The forecasted Frisch parameter for rural and urban are provided in the Tables 15 and 16.

TABLE 15. FORECASTED FRISCH PARAMETERS FOR RURAL EXPENDITURE DECILES

Class	RH1	RH2	RH3	RH4	RH5	RH6	RH7	RH8	RH9	RH10
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
m	2996	5441	10077	16442	21423	28922	41159	54031	70147	102589
Frisch parameter	-3.158	-2.75	-2.34	-2.01	-1.83	-1.63	-1.386	-1.203	-1.026	-0.769

TABLE 16. FORECASTED FRISCH PARAMETERS FOR URBAN EXPENDITURE DECILES

Class	UH1	UH2	UH3	UH4	UH5	UH6	UH7	UH8	UH9	UH10
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
m	3223	7758	18663	37519	52678	73519	104552	139073	178951	285800
Frisch parameter	-5.48	-3.269	-1.607	-1.292	-1.278	-1.27	-1.27	-1.27	-1.27	-1.28

Tables 17 and 18 show committed consumptions for all commodities for rural and urban consumer classes respectively:

TABLE 17. COMMITTED CONSUMPTION FOR ALL 22 CONSUMPTION COMMODITIES FOR RURAL CONSUMERS

(1)	RH1 (2)	RH2 (3)	RH3 (4)	RH4 (5)	RH5 (6)	RH6 (7)	RH7 (8)	RH8 (9)	RH9 (10)	RH10 (11)
m (Rs./person/year)	2996	5441	10077	16442	21423	28922	41159	54031	70147	102589
Paddy	262	326	316	272	236	184	114	58	-6	-73
Wheat	110	161	188	190	182	157	110	64	-6	-101
Coarse cereals	98	79	32	-36	-84	-154	-253	-338	-443	-587
Grams	13	20	27	33	35	37	37	37	34	30
Other pulses	10	11	-6	-49	-83	-147	-247	-342	-472	-669
Sugarcane	26	52	99	153	189	239	311	381	461	629
Oilseeds	137	223	328	423	479	538	607	656	686	697
Plantations	-22	-39	-68	-106	-134	-180	-257	-343	-478	-818
Fruits	39	71	120	165	187	194	159	65	-169	-1013
Vegetables	29	69	161	285	379	506	700	888	1094	1469
Other crops	6	7	13	20	23	4	-51	-138	-334	-969
Milk and milk products	-15	-17	-16	-19	-27	-128	-438	-984	-2351	-7423
Animal services	97	173	291	416	496	581	675	732	714	494
Forestry	99	109	102	70	37	-59	-270	-566	-1126	-2913
Coal lignite crude oil	-10	-28	-55	-93	-12	-183	-293	-428	-803	-2000
Agro processing	447	722	1104	1471	1691	1946	2263	2528	2787	3282
Textiles	110	193	330	481	588	721	944	1223	1617	2890
Manufacturing and non metallic	16	-51	-305	-935	-1637	-3103	-6437	-11239	-18112	-37983
Electricity	-3	-4	4	27	51	96	189	317	429	670
Water supply and Gas	0	-2	-10	-31	-56	-112	-252	-471	-901	-2423
Other transport services	160	362	806	1437	1903	2481	3145	3414	2979	-1059
Other services	438	1031	2306	4077	5375	7507	10720	13590	16187	17072

TABLE 18. COMMITTED CONSUMPTION FOR ALL 22 CONSUMPTION COMMODITIES FOR URBAN CONSUMERS

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
m (Rs./person/year)	3223	7758	18663	37519	52678	73519	104553	139073	178951	285800
Paddy	144	173	-41	-256	-310	-338	-340	-315	-264	-100
Wheat	177	235	248	237	229	148	36	-71	-173	-360
Coarse cereals	69	39	-43	-139	-181	-226	-276	-316	-347	-391
Grams	12	20	22	23	27	29	33	36	41	51
Other pulses	22	12	-88	-226	-289	-418	-583	-732	-867	-1094
Sugarcane	60	91	107	146	148	147	144	143	144	161
Oilseeds	146	242	307	410	440	470	507	549	600	762
Plantations	-13	-66	-300	-717	-1008	-1386	-1911	-2439	-2993	-4186
Fruits	107	208	255	220	179	106	-22	-164	-321	-655
Vegetables	164	324	509	712	881	1089	1363	1641	1934	2632

(Contd.)

TABLE 18. (CONCLD.)

(1)	UR1 (2)	UR2 (3)	UR3 (4)	UR4 (5)	UR5 (6)	UR6 (7)	UR7 (8)	UR8 (9)	UR9 (10)	UR10 (11)
Other crops	73	118	62	-99	-233	-426	-720	-1034	-1380	-2151
Milk and milk products	31	91	71	423	944	1762	3085	4654	6557	11915
Animal services	124	244	376	579	745	953	1228	1502	1756	2337
Forestry	144	9	-329	-833	-1146	-1521	-2011	-2476	-2946	-3896
Coal lignite crude oil	19	44	-15	-97	-47	100	384	782	1329	3128
Agro processing	379	692	837	581	304	-141	-930	-1905	-3103	-6520
Textiles	100	153	-117	-459	-585	-657	-659	-538	-264	989
Manufacturing and non metallic	51	69	-568	-2595	-4346	-6965	-11385	-16860	-23745	-44437
Electricity	15	39	68	182	337	595	952	1384	1924	3524
Water supply and Gas	4	6	-50	-237	-413	-693	-940	-1191	-1453	-2044
Other transport services	143	407	504	-1003	-1674	-2615	-4204	-6166	-8654	-16123
Other services	664	2233	5239	11633	17478	25959	38955	53723	71093	118532

VII

APPLICATION OF THE LINEAR EXPENDITURE DEMAND SYSTEMS FOR LONG TERM MODEL PROJECTIONS

The demand systems were used in a multi-sectoral, inter-temporal activity analysis model of India to explore alternative strategies for agricultural development and agriculture's role in economic development (Parikh *et al.*, 2013). The model distributed population into different rural and urban expenditure classes for each period based on average per capita expenditure in rural and urban areas and prescribed Lorenz ratios for the log-normal consumption distribution functions. The reference scenario covered the period from 2007 to 2039 and had a compound annual GDP growth rate of 8.4 per cent. The projected expenditure levels and quantities of some selected food items are shown in Figure 2.

In converting expenditure on food grains in to kilograms, adjustment for quality and processing consumption by different expenditure classes based on NSS data was accounted for. These levels look credible and are comparable to East Asian economies that have undergone rapid development.

The increase in the share of animal products is striking. By 2039 milk and milk products accounts for most of this increase, as it alone accounts for 31 per cent. The share of meat, eggs, fish and animal services rises by 1 per cent. The sector is heterogeneous and also includes animal services and consumption of dung.[1] The high increase in the consumer expenditures on animal products is consistent with the differences in consumption across expenditure classes in the NSS data of today.

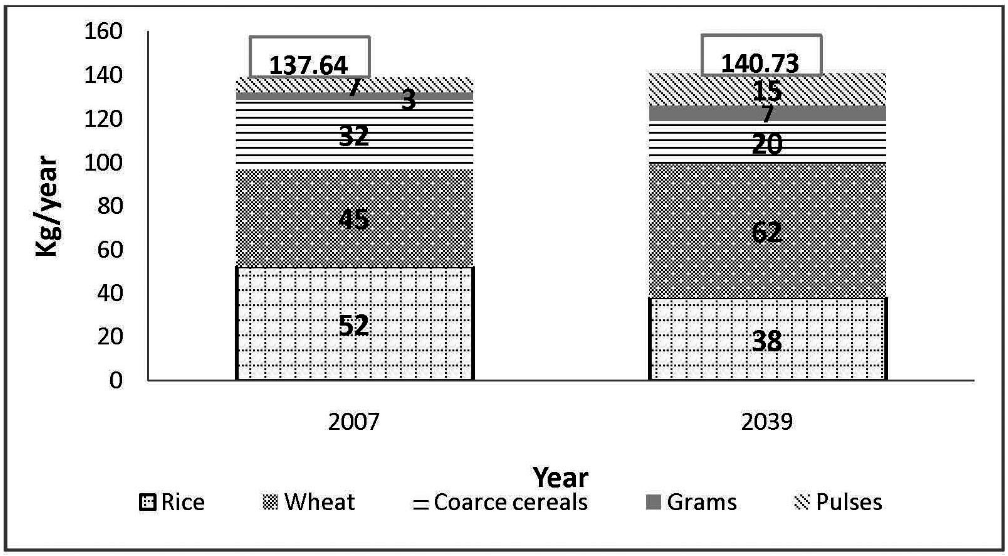


Figure 2. Changes in Per Capita Foodgrains Consumption

TABLE 19. PER CAPITA CONSUMPTION OF SELECTED AGRICULTURAL ITEMS IN RS. PER PERSON

Year (1)	Sugar (2)	Oilseeds (3)	Plantations (4)	Fruits (5)	Vegetables (6)	Other crops (7)	Milk and milk products (8)	Animal services, poultry (9)	Forestry (10)
2007	191	476	14	282	458	232	726	537	207
2011	236	564	23	372	601	307	1046	689	218
2031	544	1076	171	1111	1677	930	3915	1850	355
2039	609	1186	320	1391	1966	1182	4952	2148	481

In the NSSO survey of 2007-08 consumers in the highest decile expenditure class in both rural and urban areas consumed 16 and 10 times as much milk as the lowest decile expenditure class consumer respectively. The share of milk and milk products consumption in total food consumption in both urban and rural areas of the highest decile consumer was around 22 per cent in 2007-08. Compared to that, the share of milk consumption in 2039 is still somewhat higher but is in line with the much higher incomes in 2039.

We conclude that the estimated demand systems give credible results even for long term projections that involve much larger expenditure levels.

Received March 2015. *Revision accepted July 2016.*

NOTE

1. We could not disaggregate this sector further for want of consistent data for estimating the demand system.

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