Food Price Elasticities from Household Survey Data in India: An Application of Single Equation and System Demand Models

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Abstract
The effectiveness of any policy measure to control food prices, especially subsidy, should depend on the recognition and knowledge of the structure of food demand. This paper intends to analyse food consumption patterns from household survey data and the performances of single equation and system demand models. Un-tabulated NSS data for Mizoram State, India, has been analysed using Working-Lesser (WL) and Almost Ideal Demand System (AIDS) models. It was found that all food items have negative own price elasticities supporting the proposition of the traditional ‘law of demand’. The two demand models showed slightly different results in respect of cross price elasticities, and it was concluded that WL model could be successfully adopted to analyse even small sample survey data as its admits frequency weigh. At the same time, AIDS model provides more comprehensive results because it takes into account all desirable properties of demand system; however, its computational complication setbacks its universal applicability.

Key words: Elasticities, food, demand, AIDS, cross price.
1. Introduction

The rapid increase in prices of rice, wheat, corn and other food staples has sent a shock wave through poor households around the world, as well as through governments and international policy makers. While food prices are always volatile, recent increases are of a magnitude last seen in the 1970s (Polaski, 2008). India is among the developing countries which are seriously affected by the rise in food price. Food prices remains the major political issues of the country till today since the rising food price seriously affected the poor and is even considered as a ‘political good’ (Pangaribowo and Tsegai, 2011). Therefore, controlling the prices of food items would have significant impact in an attempt to reduce poverty and hunger in the country. At the same time, the effectiveness of the public policy measures on the control of food prices, especially subsidy, should depend on the recognition and knowledge of the demand structure while formulating such policies. That is, it is important for public policy to be well informed on how consumers change their expenditure in response to changes in prices and income level. Thus, an in-depth analysis of food demand provides better insights about important factors such as prices, including prices of related goods, and income that will affect food consumption.

The knowledge of demand structure and consumer behaviour is essential for a wide range of development policy questions like improvement in nutritional status, food subsidy, sectoral and macroeconomic policy analysis, etc., (Mittal, 2006). It is understood that various demand models give different results for food demand, price elasticities in particular. Meanwhile, the market demand structures are generally analysed using time series data (Thanga, 2010); while the household demand structures are usually analysed using survey data by fitting the functional relationship between expenditure on particular item and total expenditure or income. So, household consumer expenditure survey data is usually used to study the pattern of household expenditure with the changes in income level, without taking into consideration the effect of prices. So, it is tried, in this paper, to analyse and evaluate the performances of single equation and system demand models to explain household food demand pattern using cross sectional survey data in the state of Mizoram, India. The entire analysis being made in this paper is based on the un-tabulated primary data of the various rounds of the National Sample Survey Organization (NSSO), Ministry of Statistics and Programme Implementation, Government of India. The pertinent question that needs to be answered, in using survey data to analyse household food demand pattern, is whether price variations can be obtained from these surveys to estimate a complete demand system (Koç and Alpay, 2000). However, Deaton (1988) states that these household surveys contain information on
the spatial distribution of prices, and thus, by covering this information in a useful form one can easily obtain the impact of prices on quantity demanded. The rest of the paper is organized as follows, Section-II: overview of related literature, Section – III: Methodology, Section-IV: results and discussion, and Section-V: conclusion.

2. Overview of Related Literature

Different food demand patterns have evolved on account of different socio-economic, demographic and institutional factors. These differences within a food distribution network can be detected from the values of various food price and expenditure elasticities (E. Erjavec, et.al, 1998). Broadly, two basic approaches are used in demand analysis. The first is the traditional one, which is based on the estimation of Engel curves where food expenditure and income elasticities are subsequently derived. Another way to perform econometric estimation is to construct a demand system and from it to compute uncompensated (Marshallian) price and compensated (Hicksian) and expenditure elasticities.

Since the pioneering work of Engel in 1857, the estimation of Engel curves and expenditure elasticities has been an important part in family budget studies with estimated expenditure elasticities having been the main behavioural parameter. The Log-Linear, or sometimes called Double-Log (DL) function, has been the most commonly adopted functional form to estimate Engel’s curve and found its place in the study by Stuvel & James (1950), Houthakker (1957), Iyengar (1960), Liviatan (1964), Theil (1965), Iyengar, et al (1968), NSS, Bhattacharya (1973), Coondoo, et al (1981). The apparent advantages of log-linear Engel’s curve over any other functional form is its assumption of constant elasticity of expenditure and the possibility of introducing an additional variables, generally family size, enabling the estimation of economies of scale in consumption. However, the general problem with this approach to household demand is model misspecification due to the exclusion of price terms and other demographic factors affecting food demand. Consequent upon the theoretical limitations of the traditional Engel’s curve, there come a number of attempts to reconstruct the demand model. The new models give emphasis on utility-based approaches as a system of equations which satisfies the condition of adding-up, non-negativity of consumptions, etc. The Working-Leser (WL) model proposed by Working (1943) and Leser (1963) and the almost ideal demand system (AIDS) of Deaton and Muellbauer (1980) have become the most popular new demand models, the former being single equation while the latter is considered as system model.

3. Methodology
3.1 Data Source

The whole analysis is based on the ungrouped primary data of National Sample Survey (NSS) and the study used the consumer expenditure survey data of the 45th, 51st, 55th, 61st and 66th NSS Rounds covering the period of 1989-90, 1994-95, 1999-00, 2004-05 and 2009-10 respectively. Price for each food item was worked out by dividing the total monetary expenditure by total quantity consumed. However, there are some food items which have no data on quantity consumption, resulting in our inability to determine their prices. So, it was decided to drop all these items, and finally, only 6 items were included in the analysis, namely, cereals, edible oils, pulses & products, salt, spices and sugar.

3.2 Analytical Methods

Two models are adopted in the study, namely, Working-Leser (WL), i.e. single equation model, and Almost Ideal Demand System (AIDS), i.e. system model. They are given as follows:

\[ w_i = \alpha_o + \alpha_i \log x + \sum_j \beta_{ij} \log p_j + \sum_k \gamma_{ik} H_k + \epsilon_i \]  
(WL Model)  
Eq. (1)

\[ w_i = \alpha_i + \sum_j \gamma_{ij} \log(p_j) + \beta \frac{x}{P} + \epsilon_i, \quad i = 1, 2, ..., 11 \]  
(AIDS Model)  
Eq. (2)
where \((i,j) = \text{food items}, \ w_i = \text{expenditure share of food } i \ \text{among six food items}, \ p_j = \text{price of food } j, \ x = \text{total expenditure on all food items}, \ P = \text{price index}, \ H_k \ \text{includes other variables like log of household size and regional dummy (urban or rural)} \ \text{and } \ e_i \ 's & \ u_j \ \text{are random disturbances. The following restrictions were imposed while estimating AIDS Model:}

\[
\sum_i w_i = 1 \quad \text{for all } j; \ \gamma_{ij} = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ij}^*) = \gamma_{ij}, \quad j = 1, \ldots, 11
\]

\[
\sum_i \alpha_i = 1, \ \sum_i \beta_i = 0 \ \text{and} \ \sum_k \gamma_{ij} = 0
\]

As the price index in Eq.(2) raises the estimation difficulties due to non-linearity in parameters, Stone index is widely used for AIDS estimation (Asche and Wessel, 1997). Present study also adopt Stone index so that the model may be called Linearly Approximated AIDS model (LA-AIDS). The Stone index is given by

\[
\log(P^*) = \sum_i w_i \log(p_i) \quad i = 1, \ldots, 11. \quad \text{Eq. (3)}
\]

where \(w\) is budget share among six selected commodities. The Stone index is an approximation proportional to the translog, i.e. \(P = \phi P^*\) where \(E(\log \phi) = \alpha_0\). The AIDS model with the Stone index can be seen as follows:

\[
w_i = \alpha_i + \sum_j \gamma_{ij} \log(p_j) + \beta_i \log\left(\frac{x}{P^*}\right) + u_i^* \quad \text{Eq. (4)}
\]

where \(\alpha_i^* = \alpha_i - \beta_i\alpha_i\) \ \text{and} \ \(u_i^* = u_i - \beta_i (\log(\phi) - E(\log(\phi)))\).

Expenditure and price elasticities corresponding to these models are:

i) \textbf{Expenditure Elasticities:}

\begin{align*}
\text{WL Model} & : \quad e_i = 1 + \left( \frac{\alpha_i}{w_i} \right) \\
\text{AIDS Model} & : \quad e_i = 1 + \left( \frac{1}{w_i} \right) \left( \frac{\partial w_i}{\partial \log(x)} \right) = 1 + \left( \frac{\beta_i}{w_i} \right)
\end{align*}

ii) \textbf{Price Elasticities:}

\begin{align*}
\text{WL Model} & : \quad e_{ij} = -\delta_{ij} + \left( \frac{\beta_{ij}}{w_i} \right) \\
\end{align*}
\[ e_{ij} = -\delta_{ij} + \left( \frac{y_j}{w_i} \right) - \left( \frac{\beta_j}{w_i} \right) w_j \quad \forall i = 1..n \]

where \( \delta_{ij} \) is the Kronecker delta that is unity if \( i=j \) and zero otherwise. AIDS model was estimated by Full Information Maximum Likelihood Method (FIML) and the sample means were adopted to be the point of normalization.

4. Results and Discussion

4.1 Expenditure Elasticities

Table 1 shows expenditure elasticities for six food items calculated from WL and AIDS models. Cereals have shown unitary elasticities for both models that percentage expenditure for this item would increase at the same rate as the increase in income level. In view of the high budget share, this item shows itself to be the staple food item of the study area whose demand would have been inelastic. So, the magnitude of this elasticity may be taken to reflect the weak purchasing power of the people to purchase even their basic necessities of life. It may also be stated that large proportion of the population in rural areas are rearing livestock and are feeding their animal with rice and wheat; and hence, this may led to the increasing expenditure with the increase in income level.

<table>
<thead>
<tr>
<th>Items</th>
<th>Average Budget Share* (%)</th>
<th>WL Model</th>
<th>AIDS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>62.04</td>
<td>1.00**</td>
<td>1.0233</td>
</tr>
<tr>
<td>Edible Oils</td>
<td>13.5</td>
<td>1.19**</td>
<td>0.8661**</td>
</tr>
<tr>
<td>Pulse &amp; Products</td>
<td>10.5</td>
<td>0.95**</td>
<td>0.8121**</td>
</tr>
<tr>
<td>Salt</td>
<td>1.2</td>
<td>0.63**</td>
<td>0.6759**</td>
</tr>
<tr>
<td>Spices</td>
<td>5.23</td>
<td>1.11**</td>
<td>1.2369**</td>
</tr>
<tr>
<td>Sugar</td>
<td>7.54</td>
<td>0.66**</td>
<td>0.8508**</td>
</tr>
</tbody>
</table>

*percentage share in the total expenditure of the six items included in the model  
**Significant at 5% level of significance

As expected, the calculated expenditure elasticity is found to be lowest in case of salt for both models for being the most inelastic items of consumption; while spices are most volatile with respect to price change as its elasticities are more than unity for both models. Thus, spices may be taken as superior items whose consumption tended to increase with the increase in income levels.
It may be noted that normal goods are those whose demand (expenditure) increases with the increase in income levels but less than proportionately; while demand are increasing more than proportionately with the increase in income levels for superior goods. Meanwhile, the two models (WL and AIDS) showed different elasticities in respect of edible oils. That is, it may be called superior good in case of WL model while it is normal for AIDS model.

4.2 Own Price Elasticities

By own price elasticity we mean the changes in quantity demand of a commodity due to a change in its price. Estimating the own price elasticities for various food items will enable us to assess the sensitivity of the consumption or demand for particular item on the price change. The estimates of Marshallian own price elasticities for both models are given in Table 2. The own price elasticities are all found to be negative as expected for both WL and AIDS models. That is, there is an inverse relationship between quantity demand and its own price for all items under consideration in conformity with the traditional ‘Law of Demand’. For WL model, the value of elasticity is found to be lowest for cereals followed by salt; while it is highest in case of spices followed by edible oils. At the same time, for AIDS model, the absolute value of price elasticities is lowest for pulse & products while it is highest for cereals. In a nutshell, all six food items considered in the study are highly volatile, spices being the most volatile, with respect to price change. Any increase in food price would result in significant decrease in its demand/consumption.

<table>
<thead>
<tr>
<th>Items</th>
<th>Average Budget Share$^+$ (%)</th>
<th>WL Model</th>
<th>AIDS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>62.04</td>
<td>-0.7803**</td>
<td>-0.8933**</td>
</tr>
<tr>
<td>Edible Oils &amp; Pulse &amp; Products</td>
<td>13.5</td>
<td>-0.93908**</td>
<td>-0.8564**</td>
</tr>
<tr>
<td>Salt</td>
<td>1.2</td>
<td>-0.83123**</td>
<td>-0.8347**</td>
</tr>
<tr>
<td>Spices</td>
<td>5.23</td>
<td>-1.02415**</td>
<td>-0.8562**</td>
</tr>
<tr>
<td>Sugar</td>
<td>7.54</td>
<td>-0.87916**</td>
<td>-0.8266**</td>
</tr>
</tbody>
</table>

$^+$percentage share in the total expenditure of the six items included in the model

**Significant at 5% level of significance

4.3 Cross Price Elasticities

The sensitivity of the demand for one commodity to a change in the price of other commodities is known as cross price elasticities. Analysis of the cross price elasticities is very useful in determining the nature of goods and services for their substitutability and complementarity. So, an
attempt is made here to study the nature of cross price elasticities for the six food items being considered in the analysis. If cross elasticity for two goods are negative, they are said to be complementary; while they may be called competitive or substitutes if they have positive cross elasticities. The results are shown in Table 3 and Table 4 for WL and AIDS models respectively. It is found that cross price elasticities are significantly lower than own price elasticities for all items and the cross price elasticities of demand are all below 10 percent of the total price variation. So, prices of other food items do not have much impact upon the demand of the commodity in question, and hence, own price remains the main determinant of food demand in the study area.

Table: 3 Estimated Own and Cross Price Elasticities (WL Model)

<table>
<thead>
<tr>
<th>Items</th>
<th>Cereals</th>
<th>Edible Oils</th>
<th>Pulses</th>
<th>Salt</th>
<th>Spices</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>-0.7803**</td>
<td>-0.00864**</td>
<td>-0.03963**</td>
<td>-0.02481**</td>
<td>0.00782**</td>
<td>-0.02208**</td>
</tr>
<tr>
<td>Edible Oils</td>
<td>-0.93908**</td>
<td>0.07714**</td>
<td>0.02066**</td>
<td>0.02112**</td>
<td>0.00952**</td>
<td></td>
</tr>
<tr>
<td>Pulse &amp; Products</td>
<td>-0.86492**</td>
<td>0.04246**</td>
<td>-0.00789**</td>
<td>0.04339**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>-0.83123**</td>
<td>-0.04767**</td>
<td>0.04637**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spices</td>
<td>-1.02415**</td>
<td>0.02278**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td>-0.87916**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at 5% level of significance

Table: 4 Marshallian Cross Price Elasticities, after imposing symmetric restriction (AIDS Model)

<table>
<thead>
<tr>
<th>Items</th>
<th>Cereal</th>
<th>Edible Oils</th>
<th>Pulse</th>
<th>Salt</th>
<th>Spices</th>
<th>Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal</td>
<td>-0.0304**</td>
<td>-0.0384**</td>
<td>-0.0057**</td>
<td>-0.0219**</td>
<td>-0.0390**</td>
<td></td>
</tr>
<tr>
<td>Edible Oils</td>
<td>0.0504**</td>
<td>-0.0063**</td>
<td>0.0176**</td>
<td>0.0311**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse &amp; Products</td>
<td>-0.0053**</td>
<td>0.0153</td>
<td>0.0445**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>-0.0624**</td>
<td>0.0530**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spices</td>
<td>-0.0349**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at 5% level of significance

The above tables showed slightly different result on the nature of cross price elasticity that edible oils are competitive with pulses, salt, spices, and sugar for WL model; while it is complementary to salt in case of AIDS model. First, in WL model, pulses is competitive to salt and sugar; while it is complementary with spices, and, cereal is substitute items to all other food items except sugar. Similarly, salt is found to be complementary to spices while it is substitute with sugar, and, spices
are complementary to sugar. Second, in AIDS model, cereal is found to be competitive with the remaining food items, and pulse is complementary with salt; while it is competitive with salt and sugar. Further, salt is complementary to spices; while it is competitive to sugar and spices is also found to be competitive items to sugar.

5. Conclusion

The analysis of expenditure elasticities shows that the item groups of cereals and spices have characteristics of normal goods whose consumption tended to increase with the increase in family income. It may be argued that the population at lower income bracket has been stayed away from consuming spices and even for their staple food, i.e. cereals, which have shown volatility in the face of price rise affecting the family’s real income. This phenomenon can also be taken to reflect the impoverishment of the society which cannot afford to make certain food items universally accessible.

All food items considered in the analysis are found to have negative own price elasticities supporting the proposition of the traditional ‘law of demand’. The result shows that food demands in the study area are significantly sensitive to the changes in prices that, specifically, any 10 percent increase in food price would result in the reduction of its consumption by more than 6 percent. The result, therefore, suggests controlling prices for food items shall have unequivocal impact upon the standard of living, especially, of the relatively poorer sections of the society, and which will indirectly results in the reduction of poverty ratio.

Two models, Working-Leser (WL) Model and Almost Ideal Demand System (AIDS) Model, applied in the study to analyse food demand from household survey data have shown their own advantages and disadvantages. As it takes into account the effects of income, prices, and other demographic factors in estimating individual demand function, WL model shows its wide applicability in demand analysis with impressive goodness of fit. Like any other single equation model its estimation ensures the possibility of applying frequency weight, which is usually generated in a systematic survey by various survey organizations. This enables us to have better estimates even in case of small sample. However, its theoretical limitation to take into account certain desirable properties of demand models, including adding-up, symmetry, homogeneity, etc, impedes its wider applications in advanced empirical research. AIDS model being more flexible nature, which satisfies all these theoretical requirements, has attracted the attentions of many researchers. However, its inappropriateness to lend itself suitable for applying frequency weight
usually leads the results of test for small sample size to be insignificant. Further, its computational complicacy should have also been a serious setback for its application.

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References


