9.0 INTRODUCTION

In the previous chapter, the data, sources and analysis was discussed. This chapter deals with the methodology used for the various calculations and the types of regressions establishing the energy ladder concept. For the present study, OLS (Ordinary Least Squares) method is adopted for testing the suitable specifications of regression equations. An attempt is made with Engel Curve Analysis to estimate the variation in fuel and light expenditure for changes in the income (total expenditure). The study will attempt to establish the existence of Engel Curve to support the Energy Ladder concept.

9.1 REGRESSION ANALYSIS

In the present study, three sets of regression calculations have been done, with different sets of variables. The three sets of equations are -

1) Fuel & Light = a + \beta \text{ Total Expenditure}
2) Fuel = a + \beta \text{ Fuel & Light}
3) Fuel & Light = a + \beta \text{ Total Expenditure + } \gamma \text{ Family Size}

Each of the three sets of regressions were tried with six
different specifications. The specifications tried were -

1) Linear : \( F&L = a + \beta \ TE \)

2) Log Linear : \( \log F&L = a + \beta \ \log TE \)

3) Semi Log : \( \log F&L = a + \beta \ TE \)

4) Semi Log : \( F&L = a + \beta \ \log TE \)

5) Inverse : \( F&L = a + \beta \ TE + \gamma \ \frac{1}{TE} \)

6) Quadratic : \( F&L = a + \beta \ TE + \gamma \ TE^2 \)

where, \( F&L \) is Fuel and Light, and \( TE \) is Total Expenditure.

The regressions have been carried out for rural, urban areas, and a combination of the two as Total (Rural + Urban) areas. Thus each regression set was carried out with six specifications and for rural, urban and total. The data used here has been explained. The analysis was done for 4 rounds of NSS for 15 states (15 x 4 = 60 observations). This was carried out by pooling cross section data by the respective rounds.

The method used for carrying out the regressions was the OLS (Ordinary Least Squares) method, with the six specifications mentioned above. In case of the first set of equations, Fuel and Light is taken as a dependent variable, and the independent variable being the total expenditure (here, total expenditure is assumed to be same as total income) or total expenditure. In the case of second set of regression equations, consumption of particular fuels are taken to be dependent on the total expenditure on fuel and light by a particular household. For the
third set, the expenditure on fuel and light is taken according to four expenditure (or income) categories (which differ from round to round, as seen earlier). The expenditure on fuel and light is taken to be not only dependent on the total expenditure, but also on the size of the family (that is, the average number of members in a particular household).

The size of the family has been included in the case of the regressions with income / expenditure categories because there are distinct differences in the family size of the lowest and the highest categories. It has been found that the lowest income groups tend to have larger families than compared to those of the higher income groups. The per capita expenditure on fuel and light and its corresponding total consumption expenditure, with the given household size will be used to observe the impact of the household size on the expenditure patterns on fuel and light. As was observed in the previous chapter, the household size makes a significant impact on the amount of money spent on fuel and light.

9.2 ENERGY LADDER

In this context of income categories, the concept of Energy Ladder is introduced. The concept of energy ladder, as seen earlier, states that with the increase in income of a household, there is a shift from lower quality fuels to higher quality fuels. The qualitative difference in fuels is on the basis of price, energy output, and efficiency. The fuels at the lower ‘rungs’ of the
energy ladder are the traditional *gathered* fuels like twigs, fuelwood, agricultural wastes, cow dung, etc. Then comes coal, charcoal, and kerosene. Higher up in importance and demand comes LPG and natural gas (not used in domestic sector in India), and finally at the top of the ladder is electricity. In India, electricity is used extensively for lighting only. The use of electricity for cooking is negligible and is limited to very high income groups, which is not taken into account in the present study.

The second and third set of regression equations are carried out to observe the presence of an energy ladder in the context of India, using the NSS data. The family size is taken into account in the case of the third set of equations as with the increasing in the number of family members, the expenditure on items like food assumes more importance, and energy is directly linked to the category of food, as most of the energy consumed is for cooking. As the income / expenditure per household increases, there is proportionately less amount out of the total income spent on energy. Another feature which can be observed from the different rounds of energy consumption data is that there is a decline in the usage of traditional fuels in the higher expenditure class and more of kerosene, LPG and electricity is used. This trend is more obvious in the urban areas. This change is visible in the estimated second and third sets of regressions.
Consumer surveys like the NSS surveys are mainly concerned with the direct observation of the economic behaviour of households of varying social and economic conditions. The main usage of the data in econometrics is for the estimation of income elasticities of particular commodities. In this context, the Engel curve studies the relation of any category of expenditure to income in a cross-section sample of households of varying income levels. Thus, the relation of any characteristic of consumer behaviour to the consumer's income, ceteris paribus, is studied in Engel Curve Analysis. Since most of the data on consumer behaviour is to be found in household surveys, Engel curves are specifically identified with the relations that emerge from the analysis of household surveys.

The term Engel Curve derived its name from German statistician Ernst Engel. One of his major conclusions was that food expenditure increases with income, but at a lesser rate, that is, food demand is inelastic with respect to income. This is called Engel's (first) law, which is found to be still valid.

For the present study, instead of the income data (income categories), total expenditure (TE) is used. The estimates derived, thus would be called total expenditure coefficients, and not income coefficients. In terms of elasticities, the difference between the two is slight, as the elasticity of total expenditure
in respect of income is usually close of unity. Thus, Engel curves studies the effect of income on consumer behaviour in respect of distinct commodities or expenditure categories, and the presence of a particular commodity in a household's budget is an attribute of the household concerned.

Consumer demand for any good depend upon the income of that consumer (or household), its price and prices of other commodities. The Engel curve is concerned with the issue of how sensitive is demand for a good to changes of income on the one hand, and prices on the other. The most direct measure of the sensitivity of a consumer's purchase of a good X to changes on income (I) would be the ratio \( \frac{\Delta a}{\Delta I} \). For small changes \( \Delta x \) and \( \Delta I \), this ratio can be interpreted as the slope of the Engel Curve. This can be written as the derivative \( \frac{\partial a}{\partial I} \), where 5 is partial effect of varying one of the underlying parameters with all other variables held constant.

At very low incomes, consumption is restricted to a small number of goods; as income increases, new commodities enter the household consumption basket. At and near 'threshold income' (a level where a large variety of goods are available to a household, and at which level the household or individual adds a commodity concerned to his budget), the commodity in question is a luxury which is just coming within the consumer's reach. At this stage, when the income continues to rise, expenditure will at first continue to rise steeply. But the expenditure on this good (which is entering
the budget) will be affected in the same as it is succeeded by other newly introduced goods. Because of this, the slope of the Engel curve will decline with increasing income until it becomes zero at the stage of saturation. An average Engel curve thus would assume the shape of the letter ‘S’ as shown in the Fig. 9.1.

Expenditure,

Income

Fig. 9.1 – An Average Engel Curve

At this level, after the demand for a commodity has reached saturation, expenditure may continue to rise as highly priced varieties are substituted for the cheaper kind (the concept reflects the idea behind Energy Ladder). It depends on the commodity classification how this affects the Engel Curve.

As an example of the above mentioned Engel curve analysis, here, data for the 28th round of NSS for two states, namely Gujarat and Haryana is taken. In the table, TP represents Total Persons per household, which is an average figure, FL is the per capita amount spent per month for Fuel and Light, and TCE is the Total Consumption Expenditure per capita, for one month, for different expenditure classes.
In both cases, it can be seen that in the lower-income group (Rs. 0-43 class), the family size is largest and with the increase in the household income (or expenditure) the number of persons per household is decreasing. This sociological feature is an important aspect of the vicious cycle of poverty, that the poorer the household, the more the family members and, more the family members, the relative poverty is more. As seen in the Engel curve analysis, in case of per capita expenditure on fuel and light, there is an increase in the expenditure, but at a decreasing rate. The rate of increase, from the lowest category onwards is, for Gujarat, Rs. 4.42, Rs. 3.23 and Rs. 1.59, and for Haryana, it is Rs. 4.16, Rs. 3.16, and Rs. 2.97. Thus it can be clearly seen that with the increase in income, the expenditure on a particular commodity increases with a decreasing rate. If a graph is drawn with the data on fuel and light on Y axis and MPCE classes on X
axis, we will get a curve which is very steep and if further data on expenditure is available, and with the trend, the curve may become backward bending.

Based on the above estimation the regression equations have been calculated for linear, logarithmic, and for semi-log forms.

9.4 ELASTICITIES

Elasticity is a measure of relationship in which the changes in both numerator and denominator are expressed in proportionate or percentage terms. In the case of the present study, the elasticities are calculated for the relationship between expenditure on fuel and light and total expenditure for one set and for the other (second set of equations), the relationship between the expenditure on different fuels and total expenditure on fuel and light. The elasticities are calculated only for the linear equations. The formula used for calculating the elasticity is as follows:

\[
\text{Elasticity} = \frac{\text{Mean of dependent variable}}{\text{Mean of independent variable}} \times \text{Coefficient of independent variable}
\]

where, \( b \) is the derived (calculated) coefficient of the independent variable, and \( X \) is the mean of the independent variable and \( Y \) is the mean of the dependent variable in a regression equation like \( Y = a + bX + u \).
9.5 CONCLUSION

All the sets of regression equations were calculated using the simple Ordinary Least Squares (OLS) method. An attempt was made to study the relation between the income (or expenditure) and the expenditure on the item - fuel and light. An attempt was also made to study the relation between the different fuels and the total expenditure on fuel and light.

All the sets of regression equations was tried with six above mentioned specifications. Three types of equations - for rural, urban and total areas of all India, was calculated. An attempt was also made to study whether Engel curve analysis holds good in case of expenditure on fuel and light and income (taken as total expenditure). Elasticities were also calculated for the linear equations to see the relation between the independent variable (total expenditure or total expenditure on fuel and light) and the dependent variable (expenditure on fuel and light or different fuels).

The results of the regressions, and the elasticities are presented in the following chapter.