CHAPTER V

A NON LINEAR DEMAND MODEL FOR STD CALLS

5.0 Introduction

In chapter III, an attempt was made to estimate the elasticity of access demand with respect to real GDP at the aggregate level. In chapter IV, residential and non-residential demand functions for various types of telephone calls were estimated using specially designed survey data. Due to data constraint and uniform tariff structure across subscribers, only income elasticities were computed. In this chapter, we make an attempt to estimate own price elasticities of the demand for STD calls.

The variability in the spatial and time of day prices of pulses for STD tariff has been exploited to compute the own price elasticities for STD calls in terms of durations. This chapter proceeds as follows: Section 5.1 deals with the tariff structure for STD calls in India and shows how it gives an opportunity to measure the price sensitivity of STD calls from cross sectional data with a fixed tariff. In section 5.2, a micro model is constructed in which consumers differ with respect to tastes for using telephone service and income. The derived demand function is used to estimate own and cross price elasticities, and the Slutsky equation. Estimation method data source and descriptive analysis are explained in section 5.3. The empirical results are reported in section 5.4 and the final section covers the conclusion part of this chapter.
5.1 Tariff structure of STD calls

As per the STD (Subscriber Trunk Dialing) system the telephone subscribers can directly dial their counterpart to any other stations in India. STD calls are metered in terms of local pulses which are based on full rate or concessional rates as per the following three tier tariff in week days and two tier tariff in sundays and national holidays, depending upon the time of making the calls as shown in Table 5.1.

**TABLE 5.1**

<table>
<thead>
<tr>
<th>Radial distance between two exchanges</th>
<th>Full rate 8-19 hrs T1</th>
<th>Concessional rates 06-8s 19-22 hrs T2</th>
<th>22-06hrs T3</th>
<th>Sundays &amp; National Holidays Concessional rates 06-22hrs T4</th>
<th>22-06 hrs T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-50</td>
<td>36</td>
<td>48</td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>50-100</td>
<td>12</td>
<td>24</td>
<td>48</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>100-200</td>
<td>8</td>
<td>16</td>
<td>36</td>
<td>16</td>
<td>36</td>
</tr>
<tr>
<td>200-500</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>500-1000</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Above 1000</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>


The pulses (local) were charged at the rate of 0.80 paise per pulse if the subscriber's total number of pulses for different type of calls (Local/STD/IDS)
did not exceed 1000 pulses during a bimonthly period. For those with pulses above 1000 the first 1000 pulses were charged at the rate of 0.80 paise and the rest of the pulses were at the rate of Rs.1.10. We could not identify how many of the pulses relating to the total STD calls were charged at the lower rate. Since majority of the sample subscribers had made more than 1000 pulses, we assume that the marginal price of a pulse is Rs.1.10 for both residential and non-residential category of subscribers STD calls.

Table 5.1 shows that the duration of pulse varies with time and distance zones. Hence the price per second varies both across different distance zones and across different tariff periods. The price per second of a call can be computed by dividing the price per pulse (Rs.1.10) by the duration of pulse (in seconds). For example, the price per second in the higher distance zone (ie above 1000 kms) during day time (ie 8 to 9 hrs) is 55 paise (=1.10/2). Similarly, the price per second in different distance zones at different tariff can be computed. It is evident that day time calls (8-19 hrs) are more expensive than night time calls (22-6 hrs) and long distance calls (ie above 1000 kms) are more expensive than short distance ones. However the ratio between say calls in day time (T1) and calls in the evening (T2) in working days would be the same across distance zones (except in the lowest distance zone 20 to 50 kms). Hence a subscriber who contemplates making a call to a particular zone has to decide which time to make the call, takes into account prices for different distance zone calls at various points in time, but not explicitly the distance zone that is, longer the distance, the higher the price per second and hence higher the benefit of substituting a day time call for an evening call (or a nighttime call).
These variations in prices per second give an opportunity to measure the price sensitivity of STD calls even using cross-sectional data.

5.2 A demand model for STD calls

Though there is a vast literature on pricing principles for telephone services, the empirical works on estimating demand relation are limited due to data constraint. However a few works made use of from tariff experiments (eg Park et al 1983) data or data generated from tariff options given to consumers in a few countries (eg Train et al 1987). One notable study by Lang and Lundgren (Economic Letters, 1991) estimates price elasticities of residential demand for telephone in Sweden with a fixed tariff by utilising the price variations in calling time as in the present case.

In this section we use the demand model derived by Lang and Lundgren to derive the demand function, and own and cross price elasticity equations. The model focusses on the two dimensions of the telephone services those on subscription and on calling time.

Suppose that the utility function of the consumer is

$$U = U (x, y; \theta, S) \quad (1)$$

where \( x \) represents telephone calling time, \( y \) consumption of other goods, \( \theta \) is a 'taste' parameter and \( S \) is the total number of subscribers.

let \( x = x_j (t) \), where \( x_j (t) \) is a telephone call in distance zone \( j \) at time period \( i \) of duration \( t \). Given the price on good \( y \) (Py) and on subscriptions \( s \) (Ps),
income (I) and the phone call tariff, \( P_{\mu} (t) \), the consumer chooses to subscribe if and only if the utility when subscribed \( (u^*) \) is greater than or equal to utility when not subscribed \( (u^n) \).

\[ \text{(ie) } u^* \geq u^n \text{ where} \]

\[
u^* (p, p_s, \theta, I, S) = \max_{x,y} U (x,y; \theta, S) \quad \text{subject to} \]

\[
\int_{0}^{P_{\mu} (t)} x(t) \, dt + P_y y + P_s = I \quad (2)
\]

\[
U^n (\theta, I, S) = \max_{y} U (0,y; \theta, S) \quad \text{subject to} \]

\[
P_y y = I \quad (3)
\]

We define \( v = u^* - u^n \) which is assumed to be increasing in taste parameter \( \theta \). This means that the consumer subscribes if \( \theta \geq \theta_o (I) \) where \( \theta_o (I) \) is defined by:

\[
v (p, p_s, \theta_o, I, S) = 0 \quad (4)
\]

For simplicity let \( x \) = demand for telephone call time and \( P_x \) price on calling time.
The subscribers are supposed to be distributed in \( \theta \) and \( I \) according to the density function \( g(\theta, I) \). Hence the aggregate demand for calling time is

\[
X = \int \int x(\theta, I) g(\theta, I) \, d\theta \, dI \tag{5}
\]

and for the total number of subscriber can be

\[
S = \int \int g(\theta, I) \, d\theta \, dI \tag{6}
\]

It is important to notice that \( S \) enters the utility function.

Differentiating equation (6) with respect to \( P_* \) gives

\[
\frac{\partial S}{\partial p_*} = -\int g(\theta, I) \frac{\partial \theta_0}{\partial p_*} \, dI
\]

\[\text{Full derivation of the model is given in Swedesh version of Lang and Lundgren (1991). Here our focus is on the derivation of demand and elasticity equations which are of direct interest to us.}\]
and from equation (4)²
\[
\frac{\partial \theta_o}{\partial p_a} - v_p + v_S \frac{\partial S}{\partial p_a}
\]

\[
\frac{\partial S}{\partial p_a} = \frac{v_p + v_s \frac{\partial S}{\partial p_a}}{v_\theta_o}
\]

hence
\[
\frac{\partial S}{\partial p_a} = \int_{0}^{\infty} \frac{v_p + v_s \frac{\partial S}{\partial p_a}}{v_\theta_o} \, dI
\]

Let \( H = \int_{0}^{\infty} \frac{v_s}{v_\theta_o} \, dI \)

Substituting equation (9) in (8), we get,

\[
(1-H) \frac{\partial S}{\partial p_a} = \int_{0}^{\infty} \frac{v_p}{v_\theta_o} \, dI
\]

Define \( h(I) = \int g(\theta_o, I) \frac{v_p}{v_\theta_o} \, dI \)

\[
(1-H) \frac{\partial S}{\partial p_a}
\]

² Totally differentiating (4) with respect to \( p_a \) gives

\[
\frac{\partial v}{\partial p} + \frac{\partial v}{\partial p_a} + \frac{\partial v}{\partial p_a} - \frac{\partial v}{\partial \theta_o} - \frac{\partial v}{\partial I} + \frac{\partial v}{\partial s} = 0
\]

Since \( \frac{\partial p_a}{\partial p_a} = \frac{\partial I}{\partial p_a} = 0 \) and rearranging the above become

\[
\frac{\partial \theta_o}{\partial p_a} = \frac{(\partial v/\partial p_a + \partial v/\partial S \cdot \partial S/\partial p_a)}{(\partial v/\partial \theta_o)} = \frac{v_p + v_s \frac{\partial S}{\partial p_a}}{v_\theta_o}
\]
which is thus a density function: it integrates to 2 and is positive since both numerator and denominator are negative.

Adopting the same procedure as derived by (10), the following formula can be derived.

\[
\frac{\partial S}{\partial p_x} = - \int_0^\infty \frac{v_{p_x}}{v_{\theta_o}} g(\theta_o, I) \, dI \quad (12)
\]

By Roy's identity

\[ v_{p_x} = - u_1^* x; \quad v_{p_x} = - u_1^* \]

(ie), \[ v_{p_x} = u_p x \quad (13) \]

Inserting equation (13) into (12), and using equation (11), we get

\[
\frac{\partial S}{\partial p_x} = \int_0^\infty \frac{v_{p_x} x}{v_{\theta_o}} g(\theta_o, I) \, dI
\]

\[
= (1-H) \int_0^\infty h(I) x (\theta_o, I) \, dI \quad (14)
\]

Hence the last integral is a weighted average of marginal consumer's demand for calling time.

Let \[ x_m = \int_0^\infty h(I) x \, dI \quad (15) \]

Using (10) and (14), we get

\[
\frac{\partial S}{\partial p_x} = \frac{\partial S}{\partial p_o} x_m
\]
Similarly differentiating (5) with respect to \( p_s \) and then to \( p_x \) and adopting the same procedure described above, one can show that,

\[
\frac{\varepsilon x}{\varepsilon p_x} = 2 \frac{\varepsilon S}{\varepsilon p_x} \cdot \frac{x_m}{x} \tag{17}
\]

In equations (16) and (17), \( x \) is the average calling time for all subscribers and \( x_m \) is a weighted average of calling time over marginal subscribers. These formulae give us the cross elasticities, once the own price elasticity \( \varepsilon S/\varepsilon p_s \) and the level of \( x \) and \( x_m \) are known.

The own price elasticity \( \varepsilon x/\varepsilon p_x \) can be estimated using the data generated for the study stated below, when the number of subscribers is held constant. Demand is assumed to show substitution effects across points in time but not across distance zones. This makes it possible to compute \( \varepsilon x/\varepsilon p_x \). However the total demand \( x \) is also influenced via \( s \) so, from the above model (assuming that \( x = x_m \)), the total effects is

\[
\frac{\varepsilon x}{\varepsilon p_x} = \frac{\varepsilon x}{\varepsilon p_x} + 2 \frac{\varepsilon S}{\varepsilon p_x} \cdot \frac{x.p_x}{p_s} \tag{18}
\]
5.3 Estimation and Data Source

We define a subscriber's telephone demand for STD calls as the amount of calling time he uses during some period of time say two months, because telephone bill is charged bimonthly. The calling pattern of the subscribers is distributed on different distance zones as well as on different tariff periods when the calls are made.

Let \( x(d,t) \) denote the expected calling time in distance zone 'd' at time period 't' and let \( p(d,t) \) denote the price per second of calling time in distance zone \( d \) at time \( t \). It is assumed that there is no price induced substitution of demand between different distance zones. Also it is assumed that the elasticity for calling time is increasing in price, elasticity is proportional to price (see Park et al 1983). In other words, the demand is assumed to be exponential. If there were no cross price effects, these assumptions would yield the specification \( x(d,t) = a_d b_t e^{\theta p(d,t)} \) for expected demand in zone \( d \) at time \( t \). Lang and Lundgren (1991) assume that income effect is negligible; it may not be the case in developing countries. Also it is difficult to incorporate the income effect in the aggregate demand model. But we can adjust the income by grouping samples according to income levels for residential subscribers. Once subscribers are grouped, then the income effect would be negligible within each income group with the Slutsky symmetry restrictions, the demand function is specified as

\[
x(d,t) = a_d e^{\theta p(d,t)} (b_t - c e^{-\theta s(d)})
\]

where \( s(d) = \sum_{\tau=t} p(d,\tau) \) and \( a_d, b_t, c \) and \( \theta \) are parameters to be estimated.
c to be a constant to avoid an over parameterisation problem as in Lang and Lundgren (1991).

Taking into account the stochastic demand, the above equation (19) takes the following form,

$$x(d,t) = a_d e^{-g_{d,t}} (b_t - ce^{-g_t(d)}) + \epsilon_{d,t}$$  \hspace{1cm} (20)

where $\epsilon_{d,t}$ is the difference between sample mean and the moment mean of demand at time $t$ and distance zone $d$. Since the demand function specified is exponential and not transformable, it should be estimated using non-linear least square method.

To estimate equation (20), the study utilises the data drawn from both primary and secondary sources. The selection of samples subscribers has been already discussed in chapter IV. Out of 128 residential subscribers, 69 of them have STD connections. Among the 172 non-residential subscribers, 93 subscribers have STD facility. For each of these STD subscribers, the information on number of STD calls, duration and number of pulses charged for each STD call, the day and time at which each call is made etc., are generated from the exchange selected for the study during the bimonthly period from 26th February to 25th April, 1993. By dividing duration of each call by its corresponding pulses charged, one can identify the distance zones to which the calls are made.

From Table 5.1, it is evident that STD tariff has 6 distance zones and 3 tariff periods for working days which divides the duration of pulse into 18
distance-time zones, 12 distance-time zones are accounted for holidays. In total 30 distance-time zones are defined by 6 distance zones across 5 different tariff periods. Then the residential STD subscribes are classified into two income groups where Low Income Group consists of 35 subscribers whose bimonthly family income or household income is upto Rs.18,000/- while the High Income Group contains 34 subscribers whose bimonthly household income is above Rs.18,000/-.

Similarly, the non-residential STD subscribers are classified into two groups according to bimonthly sales turnover. The reason for grouping non-residential subscribers according to sales turnover is given in Chapter IV. The Low Income Group contains 53 subscribers whose sales turnover is upto Rs.10 lakhs bimonthly where as the High Income Group has 40 subscribers whose bimonthly sales turn over is more than Rs.10 lakhs.

The distribution of the total number of STD calls and mean duration of calls (in seconds) across tariff periods by distance zones are given in Table 5.2 for each income group of residential subscribers.

From Table 5.2 it is observed that more than 90% of calls are made to the longest distance zones, namely D1, D2 and D3 (i.e. 2750 calls out of total of 2984 calls). Of the total 2984 calls, 1177 calls are made to D3 zone (200-500 kms) alone. Next to D3, Low Income Group makes more calls to D2 zone (500- 1000 kms), while the High Income Group to D1 zone (Above 1000 kms). Also, it is noticed that both income groups made more number of calls in day time than in night time even on working days which is contrary to our expectation. Also it is noticed that for both groups, longer the distance, higher would be the number of calls.
TABLE 5.2: DISTRIBUTION OF MEAN DURATION PER RESIDENTIAL STD CALLS FOR DIFFERENT TARIFF PERIODS BY DISTANCE ZONES

<table>
<thead>
<tr>
<th>Distance zones</th>
<th>Bimonthly household income upto Rs.18,000/- (Low income group)</th>
<th>Bimonthly household income above Rs.18,000/- (High income group)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Working Days 08-19 hrs</td>
<td>06-08 hrs &amp; 19-22 hrs</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>Above 1000 kms (D1)</td>
<td>152.40 (30)</td>
<td>96.92 (52)</td>
</tr>
<tr>
<td>500 - 1000 kms (D2)</td>
<td>92.83 (69)</td>
<td>82.89 (65)</td>
</tr>
<tr>
<td>200 - 500 kms (D3)</td>
<td>82.29 (77)</td>
<td>120.86 (84)</td>
</tr>
<tr>
<td>100 - 200 kms (D4)</td>
<td>78.0 (16)</td>
<td>160.00 (10)</td>
</tr>
<tr>
<td>50 - 100 kms (D5)</td>
<td>204.0 (4)</td>
<td>282.0 (4)</td>
</tr>
<tr>
<td>20 - 50 kms (D6)</td>
<td>144.0 (1)</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>99.09 (197)</td>
<td>108.41 (215)</td>
</tr>
</tbody>
</table>

Figures in parentheses are number of STD calls in the respective distance zones.
Considering duration, it is found that for working days, the mean duration of night calls are longer for both income groups. The longest mean duration of calls is found in day time, while the longest mean duration of calls by High Income Group are in night time during holidays. For Low Income Group, the longest mean duration of calls is in D5 zone (50-100 kms) followed by D1 zone during day time. In the evening hours, the longer mean duration of calls is found in D4 zone (100-200 kms). Where as in night time no calls have gone to D5 and D6 distance zones. In general, more number of calls are made to longer distance zones (200 - 1000 and above kms) by the residential subscribers irrespective of the day of the week.

For the residential subscribers in High Income Group, STD calls to short distance zone (D6 zone) are having the longer mean duration at the full rate (T1) tariff period followed by calls to D1 zone in working days. In the rest of the tariff periods, longer distance zone (D1) has the longest mean duration where as in holidays, day time calls to D6 zone (20 - 50 kms) are having the longest mean duration of calls.

Table 5.3 presents the calling pattern of Non-Residential (Business) subscribers who have STD facility. From the Table 5.3, it is seen that both sales turn over groups make large number of calls in day time. For both groups, the mean duration of STD calls are longer during night time (22-06 hours) Also it is noted that

i) For Low Sales Turnover Group (Sales turnover upto Rs.10 Lakhs bimonthly)
   a) In working days more number of day time calls (08-19 hours) go to D3 zone (200 - 500 kms) followed by calls to D1, D2 and D6 zones. In holidays, more number of calls go to D1 zone.
TABLE 5.3: DISTRIBUTION OF MEAN DURATION PER NON-RESIDENTIAL STD CALLS FOR DIFFERENT TARIFF PERIODS BY DISTANCE ZONES

<table>
<thead>
<tr>
<th>Distance zones</th>
<th>Bimonthly sales turnover upto Rs. 10 lakhs</th>
<th>Bimonthly sales turnover above Rs. 10 lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Working Days</td>
<td>Holidays</td>
</tr>
<tr>
<td></td>
<td>06-19 hrs 06-06 hrs &amp; 19-22 hrs 22-06 hrs</td>
<td>06-22 hrs 22-06 hrs</td>
</tr>
<tr>
<td></td>
<td>T1   T2   T3   T4   T5</td>
<td>T1   T2   T3   T4   T5</td>
</tr>
<tr>
<td>Above 1000 kms (D1)</td>
<td>124.17 (844) 172.86 (318) 232.07 (229) 134.17 (380) 274.61 (49)</td>
<td>164.25 (3710) 216.96 (383) 325.71 (149) 206.50 (740) 238.0 (28)</td>
</tr>
<tr>
<td>500 - 1000 kms (D2)</td>
<td>110.72 (544) 110.72 (172) 126.86 (98) 87.54 (100) 271.20 (20)</td>
<td>129.01 (2467) 169.98 (236) 343.68 (75) 145.50 (95) 461.25 (16)</td>
</tr>
<tr>
<td>200 - 500 kms (D3)</td>
<td>99.57 (1033) 110.77 (234) 240.16 (102) 145.75 (137) 216.47 (17)</td>
<td>132.20 (3350) 161.45 (337) 222.44 (72) 140.78 (154) 192.70 (23)</td>
</tr>
<tr>
<td>100 - 200 kms (D4)</td>
<td>94.25 (251) 93.71 (49) 154.91 (33) 90.78 (46) 193.85 (13)</td>
<td>123.59 (294) 171.80 (61) 277.18 (11) 144.97 (33) 0 (0)</td>
</tr>
<tr>
<td>50 - 100 kms (D5)</td>
<td>40.21 (171) 60.52 (46) 321.0 (16) 88.39 (104) 277.33 (9)</td>
<td>47.39 (39) 66.0 (4) 96.0 (1) 101.54 (13) 336.0 (1)</td>
</tr>
<tr>
<td>20 - 50 kms (D6)</td>
<td>166.45 (465) 234.81 (74) 0 (84) 225.71 (84) 0 (84)</td>
<td>199.66 (163) 181.33 (161) 0 (161) 274.29 (7) 0 (7)</td>
</tr>
<tr>
<td>Total Mean</td>
<td>113.53 (3308) 139.62 (893) 209.87 (478) 131.65 (851) 255.33 (108)</td>
<td>143.79 (10023) 184.46 (1030) 296.09 (308) 188.38 (1043) 276.65 (68)</td>
</tr>
</tbody>
</table>

Figures in parentheses are number of STD calls in the respective distance zones.
b) In working days, longest mean duration is found in D6 zone followed by D1 zone for day time calls (08-19 hours).

ii) For High Sales Turnover Group (Sales turnover above Rs.10 Lakhs bimonthly)
   a) The order of distance zones to which more calls are made by this group is D1 followed by D3, D2, D4, D6 and D5 zones respectively during all tariff time periods.
   b) The mean duration of calls in the distance zones D6, D1 and D3 are relatively longer than in other zones in the day time period (08-19 hours) for working day.
   c) In holidays, the mean duration of day time calls are longer in D6 zone followed by D1 zone where as in night time the mean duration is longer in D2 zone for the same period.

5.4 **Empirical results**

The empirical estimation of the model consists of estimating the demand equation of the following form.

\[ X = e^{\sum_{i=1}^{5} D_i (e^{T_j} - C e^{-\theta p})} \]

where X is the average duration of calls per day, D_i are the dummies for distance zones i=1,2,3,4,5; T_j are dummies for the different tariff time periods j=1,2,3,4, (\beta_5=0, \alpha_5=0)^3. As explained above, non-linear least square technique is used to estimate the above equation separately for 2 groups of residential and 2 groups of non-residential subscribers. The estimated coefficients for residential subscribes are reported in Table 5.4.
### TABLE 5.4

**NON LINEAR ESTIMATION OF RESIDENTIAL SUBSCRIBERS DEMAND FUNCTIONS FOR STD CALLS (IN DURATION)**

Dependent variable = Duration of STD pulses per subscriber per day

<table>
<thead>
<tr>
<th>Explanatory Dummies and their parameters</th>
<th>Bimonthly Household income upto Rs.18,000/- (Low Income Group)</th>
<th>Bimonthly Household income above Rs.18,000/- (High Income Group)</th>
<th>Aggregate (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 1000 kms ($\alpha_1$)</td>
<td>3.3655 (0.4137)</td>
<td>2.7851 (5.2567)</td>
<td>2.8158 (4.4423)</td>
</tr>
<tr>
<td>500-1000 (a$_2$)</td>
<td>3.7111 (0.4492)</td>
<td>2.2789 (4.1558)</td>
<td>2.4717 (3.8062)</td>
</tr>
<tr>
<td>200-500 kms ($\alpha_3$)</td>
<td>4.0518 (0.4875)</td>
<td>3.0818 (5.5606)</td>
<td>3.1478 (4.8058)</td>
</tr>
<tr>
<td>100-200 kms ($\alpha_4$)</td>
<td>2.7430 (0.3281)</td>
<td>1.3907 (2.3841)</td>
<td>1.4868 (2.1819)</td>
</tr>
<tr>
<td>50-100 kms ($\alpha_5$)</td>
<td>2.2033 (0.2624)</td>
<td>-1.0284 (-0.6023)</td>
<td>-0.4051 (-0.3364)</td>
</tr>
<tr>
<td>08-19 hrs $\beta_1$</td>
<td>0.0595 (0.1153)</td>
<td>0.9176 (2.6339)</td>
<td>0.5587 (1.920)</td>
</tr>
<tr>
<td>06-08hrs &amp; 19-22 hrs $\beta_2$</td>
<td>0.0626 (0.1169)</td>
<td>0.3617 (2.0824)</td>
<td>0.2468 (1.6849)</td>
</tr>
<tr>
<td>22-06 hrs $\beta_3$</td>
<td>0.0347 (0.1159)</td>
<td>0.2210 (1.9088)</td>
<td>0.150 (1.5997)</td>
</tr>
<tr>
<td>06-22 hrs $\beta_4$</td>
<td>0.0450 (0.1157)</td>
<td>0.4920 (2.2335)</td>
<td>0.2947 (1.7298)</td>
</tr>
<tr>
<td>Price</td>
<td>0.007 (0.1126)</td>
<td>0.0016 (1.3603)</td>
<td>0.0013 (1.2762)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.0344</td>
<td>1.0690</td>
<td>1.0483</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.8409</td>
<td>0.9846</td>
<td>0.9826</td>
</tr>
<tr>
<td>$P$ (Price per second)</td>
<td>12.235</td>
<td>12.235</td>
<td>12.235</td>
</tr>
<tr>
<td>Elasticity ($\Theta P$)</td>
<td>0.0086</td>
<td>0.0196</td>
<td>0.0159</td>
</tr>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Figures in parantheses are ‘t’ statistics

**Note:**

i. Left distance dummy is $\alpha_6$ (20-50 kms)

ii. Left out Time dummy is $\beta_5$ (22-06 hrs in Holidays)
For the Low Income Group, all the estimated distance dummy coefficients are positive but they are not statistically significantly different from zero at the 5 percent level. In all subsequent discussion we assume that probability of type I error (level of significance) is 0.05. The null hypothesis in every test is that the relevant parameter is zero. Similarly, all the estimated time dummy coefficients are positive but they are not statistical significant. The same picture emerges in the case of price coefficients. But the results for High Income Group are entirely different from that for the Low Income Group. Except the short distance zone dummy coefficient, all the other distance dummy coefficient in High Income Group have positive signs which are significantly different from zero. Different tariff time period dummy coefficients are also influencing the demand positively; their coefficients are also statistically significant with one exception i.e., that for (22-06 hrs) working days. The estimated parameter for price variable is negatively related with demand, as expected for both the groups but they are not statistically significant from zero. The estimated own price elasticities for Low Income Group and High Income Group are approximately 0.01 and 0.02 respectively. For the combined groups the results more or less similar to the results of High Income Group. The own price elasticity estimated for the combined group of STD residential subscribes is 0.16.

The non-linear least square estimates for non-residential subscribes are presented in Table 5.5. For the subscribers whose sales turnover is upto Rs.10 lakhs, the coefficients of dummies for longer distance zones ($\alpha_1$, $\alpha_2$ and $\alpha_3$) are positive and are statistically significant. However, shorter distance zone dummies ($\alpha_4$, & $\alpha_5$) coefficients values are negative. Hence it is evident that non-residential subscribes make use of STD facility mainly for making long distance calls. All the tariff period time dummy coefficients are also positive
and significant. These results indicates that the non-residential subscribers have made higher number of STD calls in all the tariff periods of week days and day and evening time (06-22 hrs) of holidays relative to nighttime of holidays (22-06 hrs). The price variable is negatively associated with demand for calling time and this result is strongly supported by high ‘t’ value.

**TABLE 5.5**

**NON LINEAR ESTIMATION OF NON-RESIDENTIAL SUBSCRIBERS DEMAND FUNCTIONS FOR STD CALLS (IN DURATION)**

Dependent variable = Duration of STD pulses per subscriber per day

<table>
<thead>
<tr>
<th>Explanatory Dummies and their parameters</th>
<th>Bimonthly Sales turnover upto Rs.10 lakhs (Low Sales turnover group)</th>
<th>Bimonthly Sales turnover above Rs.10 lakhs (High sales turnover group)</th>
<th>Aggregate (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 1000 kms ($\alpha_1$)</td>
<td>2.1771 (8.3743)</td>
<td>3.3300 (11.8330)</td>
<td>2.6157 (13.0323)</td>
</tr>
<tr>
<td>500-1000 ($\alpha_2$)</td>
<td>0.8583 (4.3629)</td>
<td>2.4623 (7.8229)</td>
<td>1.6724 (10.1154)</td>
</tr>
<tr>
<td>200-500 kms ($\alpha_3$)</td>
<td>1.1098 (7.6446)</td>
<td>2.7008 (8.0690)</td>
<td>1.9120 (912.6301)</td>
</tr>
<tr>
<td>100-200 kms ($\alpha_4$)</td>
<td>-0.8264 (-4.0290)</td>
<td>0.0782 (0.1397)</td>
<td>0.4696 (-1.4049)</td>
</tr>
<tr>
<td>50-100 kms ($\alpha_5$)</td>
<td>-1.9683 (-3.8037)</td>
<td>-2.9328 (-3.5933)</td>
<td>-2.3941 (-1.2372)</td>
</tr>
<tr>
<td>08-19 hrs $\beta_1$</td>
<td>3.3759 (48.3403)</td>
<td>2.9522 (7.5488)</td>
<td>3.1964 (19.7728)</td>
</tr>
<tr>
<td>06-08hrs &amp; 19-22 hrs $\beta_2$</td>
<td>1.6759 (11.6239)</td>
<td>1.0037 (9.2722)</td>
<td>1.2743 (7.6639)</td>
</tr>
<tr>
<td>22-06 hrs $\beta_3$</td>
<td>1.1416 (5.6964)</td>
<td>0.4700 (1.9295)</td>
<td>0.7658 (3.6222)</td>
</tr>
<tr>
<td>06-22 hrs $\beta_4$</td>
<td>1.5410 (10.1728)</td>
<td>1.1649 (4.4326)</td>
<td>1.3619 (2.7025)</td>
</tr>
<tr>
<td>Price $\Theta$</td>
<td>0.0366 (7.1593)</td>
<td>0.0122 (2.5165)</td>
<td>0.0164 (3.7818)</td>
</tr>
<tr>
<td>Constant (C)</td>
<td>1.1017</td>
<td>2.7279</td>
<td>3.0034</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.9740</td>
<td>0.9880</td>
<td>0.9879</td>
</tr>
<tr>
<td>P (Price per second)</td>
<td>12.235</td>
<td>12.235</td>
<td>12.235</td>
</tr>
<tr>
<td>Elasticity ($\Theta P$)</td>
<td>0.4478</td>
<td>0.1493</td>
<td>0.2007</td>
</tr>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Figures in parantheses are ‘t’ statistics

Note: i. Left distance dummy is $\alpha_6$ (20-50 kms)

ii. Left out Time dummy is $\beta_5$ (22-06 hrs in Holidays)
For High Sales Turnover Group of (Sales turnover above Rs.10 lakhs bimonthly) non-residential subscribers, all distance zone dummies, except $\alpha_6$, are positive and except $\alpha_4$, all the estimated coefficients are significant considering tariff period time dummy coefficients all are positive and statistically significant, except $\beta_3$. The estimates of price parameter is also significant in this group. These results for both sales turnover groups (total non-residential STD subscribers) are more or less similar to those of high sales turnover group. The estimated own price elasticities for low and high sales turnover groups are 0.45 and 0.15 respectively. For the combined case, it is 0.20. These results imply that the Low Sales Turnover Group is relatively more sensitive to price than the other group.

5.5 CONCLUSION

Though the two groups of residential and non-residential subscribers made more number of STD calls in daytime (08-19 hrs), their mean duration of calling time of night calls (22-06 hrs) are longer than day time calls. Also it is observed that for both categories of subscribers (residential and non-residential) longer the distance, higher would be the number of calls. For residential subscribers, the estimated parameters of price variables of both groups are negative but are not statistically significantly different from zero. For the non-residential subscribers, the estimated coefficients of the price variables have the right signs and they are statistically significant. Non-linear least square method is used for each category of subscribers separately for working days and holidays and the estimates are not satisfactory. Hence we did not present the results.