CHAPTER III
CHAPTER III

METHODOLOGICAL ASPECTS OF THE STUDY

3.1 INTRODUCTION

It becomes an important aspect of finance in which federal finance may be considered into different categories. The FIRST category relates to the issues of financial relationship with the Center and state government. These questions step-up the inter-federal political relationship provided in the constitution. The SECOND category includes the issues of federal finance consisting of welfare economics. Thus, the federal finance issues of choice are free for determining the priorities of different Governments. These issues would remain, even if there is no federal constitution. The THIRD type of issues are specifically mentioned in the constitution and they do not mix up with the above stated federal finance issues. They are intimately related to intra-federal political relationship within the framework of the country's constitution. For this study, the THIRD category of intra-financial relationship is more important. Since last 40 years the researchers have been writing abundantly about federal financial relationship which has emerged since India has become republic. The budgets that transferred with the passage of time at different levels e.g at the Central and state level show the changing pattern of federal finance.

3.1.1 CHANGES IN THE APPROACH

As per the constitution, the states should take and make resource efforts within the sources allocated to them. Finance commissions are of the opinion that the states should not remain behind the Centre with regard to tax efforts, eventhough there are noticable differences
between the sources of the two. This creates imbalance with the resources in the hands of the states. Total resources of the Centre and the states should make the command on the Central authority and the distribution should be made on the basis of the responsibilities and not on the basis of the commitments or liabilities of the units. Centre should distribute and get share from this pool, as per the provisions of the constitution. The Finance Commission is not committed to the proper devolution. Under such circumstances, let the Planning Commission finalise it and determine the financial requirement, before the statutory award is to be made, and the results should also be finalised by placing it before the parliament. Thus, there should be co-ordination between the two commissions as the ultimate goal of both the commissions is oriented towards growth of the state economy.

3.1.2 EQUITY AND PRESENT MODE OF DISTRIBUTION

The planning commission approach is development oriented, so that it always allocates the amounts on the basis of development programmes within a state. In this approach, the institutional and political factors have a better say and Centre's indicators are more favourable towards the developed states. Again the regressive approach of sharing from the revenue transferred by the Centre to the states shows that the percentage share has increased, though marginally. Due to inflation, such an increase is considered to be negligible. The states get non-tax collection on their per capita basis. Thus for poor states amount due to their less per capita income in turn receive much less share, whereas the states with higher per capita income receive more & more. Thus, it generates a greater inequality in the receivable amount and
METHODOLOGICAL ASPECTS OF THE STUDY

also inequality in the development of states is increasing year by year.

The approach of removing the deficit is through the Finance and the Planning Commission. This is done by transfers (statutory or not) and the planning dimensions have not broken through their ways from this approach. For inter-state allocation (as the plan transfers are made on the basis of the size of the plan of the individual state) plan transfers have not helped to balance the budget. Hence it should be noted that the discretionary transfers which amount to 30% transfers are not statutory transfers and also they are non-plan transfers to the states. These transfers are made from the Centre to the states in which the Planning Commission plays an important role depending upon the political and institutional factors (Patel Mathukant 1991). Thus the planning commission has also played a decisive role in providing financial assistance by means of transfers. The inter-state allocative transfers are bit less regressive as compared to the early periods particularly up to the sixth plan or seventh finance commission.

3.1.3 NEW EQUITY APPROACH IS NECESSARY

The Centre-state financial relation and allocation of resources should be based upon the efficiency of the budgeting. Thus the present institutional change should be as under:

1. The change should be such that the arrangements in the prevailing mode are restructured.

2. The instruments provided by the constitution are not appropriate as the statutory transfers were not based upon the efficiency and neither expensed equity among states, which should be enhanced between the states.
METHODOLOGICAL ASPECTS OF THE STUDY

If the disparities among various states for their fiscal capacity at the levels of income and development are to be considered, something is to be done with the existing framework of the financial arrangement without disturbing the constitutional section behind it, so that the Centre does not depart from the present arrangement. Importance of sharing has definitely been more after the sixth plan as compared to the earlier plans. Eighth Finance Commission first time brought its element of buoyancy in grants by providing an annual growth rate of 5% in grants (Eighth Finance Commission Report). This was the first step towards neutralising the grant transferred by any Finance Commission. Ninth Finance Commission has also continued and modified this approach by concentrating upon the equality of the states.

3.2 OBJECTIVES OF THE STUDY

We may briefly mention some of the objectives of this study as under:

1. To examine the trend component for each of the variables concerned for the study.
2. To examine the indices at the constant prices as per the layout of the study.
3. To estimate and interprets the growth pattern emerging from the data analysis.
4. To postulate the relationship between the concerned variables of the system by means of regression study and to apply the statistical tests of significance to interprets on the basis of such analysis.
5. To make statistical projections pertaining to the relevant variables for future course of time.

3.3 HYPOTHESIS OF THE STUDY

We postulate some hypothesis for this study as under:
ME THEOLOGICAL ASPECTS OF THE STUDY

1. While analysing the data concerning the financial as well as non-financial variables, we assume a linear trend which can be measured by means of the moving average method, considering the appropriate period as the periodicity for computing such a moving average.

2. Growth rate for the relevant data can be estimated on the basis of annual growth rate (AGR). However, it would be more appropriate to consider the well-known semi-log trend equation on the basis of which the percentage growth rate of the series can be computed, interpreted and projections can be made on its basis for inter-regional as well as for inter-period comparisons.

3. We assume linearity (or non-linearity, as the case may be) as an appropriate relation to examine the effect of a set of explanatory variables upon the endogenous variable.

4. The per capita total expenditure incurred by the group of states is related to the corresponding population density, literacy ratio, per capita non-developmental expenditure, per capita total revenue, per capita loan payment and total labour force.

5. The per capita developmental expenditure incurred by the group of states is also assumed to be related with the corresponding population density, literacy ratio, per capita expenditure on social and communication services, per capita expenditure on economic services and per capita total revenue.

6. The variation in per capita total revenue of the group of states is found to be due to the corresponding change in the population density, literacy ratio, per capita total tax revenue, per capita grant received, per capita loan received and total labour force.
METHODOLOGICAL ASPECTS OF THE STUDY

7. Per capita total tax revenue of the group of the states is dependent upon the corresponding population density, literacy ratio, per capita state's share from the central taxes and per capita total revenue.

8. Per capita total SDP of the group of the states is related with the corresponding population density, literacy ratio, per capita SDP from agriculture sector, and labour force of agriculture sector.

9. The variation in per capita SDP for the group of the states is due to the corresponding population density, literacy ratio, per capita SDP from non-agriculture sector and labour force of non-agriculture sector.

3.4 DATA BASE

To-day in India there are 25 states. It would be worthwhile to consider only the major states representing the development status as well as their actual financial position, which is measured in terms of their per capita income or per capita SDP. We may regard such a criterion as a criterion for potential growth representing economy viability as well as financial position for the relevant states for the economy as a whole. Thus, we have listed sixteen states (out of the republic of India) as the major states and we regard the group of all the sixteen states as the group of major states or group of all the states, so far as our study is concerned and it reflects the financial behaviour of the major states in India.

3.4.1 GROUP DIVISION OF THE STATES

With the above criterion for the major states, now we shall consider the method of grouping as applied to the financial and non-financial data collected from the different states. The grouping of states
considered for this study is done by keeping in view the per capita income or per capita SDP of the states. Naturally richer states have higher per capita SDP or per capita income, whereas poorer states may have lower per capita SDP or per capita income. On the basis of per capita SDP, the states are arranged in the descending order of magnitude, so that the state having the highest per capita SDP is put at the top and state having the lowest per capita SDP is placed at the bottom. According to this structure, the group classification is made to distinguish one state from the other in the following manner.

<table>
<thead>
<tr>
<th>Group</th>
<th>Economic Position</th>
<th>Ranking criterion (per capita SDP in Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>Richer states</td>
<td>More than 750</td>
</tr>
<tr>
<td></td>
<td>(More developed states)</td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td>Semi developed states</td>
<td>600 to 750</td>
</tr>
<tr>
<td>Group III</td>
<td>Poorer states</td>
<td>Less than 600</td>
</tr>
<tr>
<td></td>
<td>(Less developed states)</td>
<td></td>
</tr>
<tr>
<td>Group IV</td>
<td>Over all view</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(All the states)</td>
<td></td>
</tr>
</tbody>
</table>

3.4.2 Period of Analysis

Once the above grouping method is finalised, the question is of data collection in the form of time series. For this purpose, we have considered the data pertaining to financial and non-financial variables corresponding to different states from the period 1960-61 to 1986-87. The above time series can be reviewed as a whole. However, considering a longer span of twenty seven years, it is quite possible that there are fluctuations in the series. To account for the sudden
METHODOLOGICAL ASPECTS OF THE STUDY

abrupt changes that may occur in the series, we have divided the period of twenty-seven years into two parts as under:

<table>
<thead>
<tr>
<th>Period</th>
<th>Years</th>
<th>Time series</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST</td>
<td>1960-61 to 1973-74</td>
<td>T1</td>
</tr>
<tr>
<td>SECOND</td>
<td>1974-75 to 1986-87</td>
<td>T2</td>
</tr>
<tr>
<td>WHOLE</td>
<td>1960-61 to 1986-87</td>
<td>T3</td>
</tr>
</tbody>
</table>

A detailed discussion on the grouping of states as well as for the time series data will be given along with the data analysis, commencing from Chapter IV.

3.4.3 SOURCES OF DATA

All the informational data have been made available through RBI Bulletins and reports on Currency & Finance of different years and various Finance Commissions and Planning Commission outlays. Demographic and infrastructural data have been available through various censuses and socio-economic reviews of different government publications of different years.

The figures of state domestic product (SDP) have been made available through central statistical organisation (C.S.O.) publications and economic and statistical publications of the states. Other available data are collected from the relevant sources such as various journals, etc. Some discussions on the centre-state financial relations and inter-regional balances are taken from the writings by the experts on the subject and their comments have been regulated.

The main source has been the SECONDARY DATA which are reliable as these data are published by the central authorities. A detailed list
METHODOLOGICAL ASPECTS OF THE STUDY

for the sources for such enormous data can be found in the Bibliography given at the end of the study.

3.3.4 VARIABLES CONSIDERED UNDER THE STUDY

We have made an attempt to collect the data pertaining to some of the financial and non-financial variables, which may be mentioned briefly in the following manner. The share of taxes and the grants and loans given to the states are considered for this study. With the help of the available data from different sources, an attempt is made to consider some of the major heads under the EXPENDITURE SIDE as well as REVENUE SIDE for representing the financial situation of the states. The data for the developed and less-developed states and their commitments and receipts are taken in the study. A brief account for all such variables for which the relevant data for different states as well as for the respective time series are collected can be summarised as under:

[A] FINANCIAL DATA

(A.1) REVENUE SIDE

(i) Statewise total revenue (ii) Statewise total tax revenue (iii) Statewise state's own tax revenue (iv) Statewise state's share in central taxes (v) Statewise total non-tax revenue (vi) Statewise state's own non-tax revenue (vii) Statewise grant received from the centre.

(A.2) EXPENDITURE SIDE

(i) Statewise total expenditure, (ii) statewise total developmental expenditure (iii) Statewise expenditure on social and communication services, (iv) Statewise expenditure on economic services, and (v) Statewise total non-developmental expenditure.
METHODOLOGICAL ASPECTS OF THE STUDY

(A.3) CAPITAL RECEIPTS

(i) Statewise total capital receipts (ii) Statewise loan received from the centre.

(A.4) CAPITAL DISBURSEMENTS

(i) Statewise total disbursements (ii) Statewise total developmental disbursements (iii) Statewise total non-developmental disbursements (iv) Statewise repayments of the loans.

(A.5) BUDGETORY POSITION

(i) Statewise budgetory position on revenue Accounts (ii) Statewise budgetory position on capital accounts (iii) Statewise over all budgetory position.

[B] DEMOGRAPHIC DATA

(i) Statewise total population (ii) Statewise total urban population (iii) Statewise total rural population (iv) Statewise total workers (v) Statewise total workers in Agricultural sector, (vi) Statewise total workers in primary sector, (vii) Statewise total workers in secondary sector (viii) Statewise total workers in tertiary sector (ix) Statewise literacy ratio.

[C] STATE DEMOSTIC PRODUCT

(i) Statewise total SDP. (ii) Statewise per capita SDP (iii) Statewise SDP from Agricultural sector (iv) Statewise SDP from primary sector (v) Statewise SDP from secondary sector (vi) Statewise SDP from tertiary sector.

[D] STATEWISE TOTAL GEOGRAPHICAL AREA

[3.5] METHODOLOGY

Specially while applying the methodology, the growth performance of all the major states in India will be examined over the whole period.
METHODOLOGICAL ASPECTS OF THE STUDY

and also in the two periods as discussed above. An attempt is also made to obtain micro economic indicators for each group of states for the relevant time series data. These indicators are per capita income and expenditure for all states, per capita SDP, literacy ratio, population density and other financial and non-financial variables considered etc. and they are used for the measurement of growth in the group of states as defined earlier.

On the basis of the statistical findings obtained for the collected information, inter-regional and inter-period comparisons are made to have a comparative view for our study, under the given limitations as explained in the next section. The stability of growth performance will be examined by adopting statistical tests in linearity of estimates for the sub-periods. This involves the estimation of trend equations along with the testing of the parameters. Here constant price series will be used to carry out the analysis. The study of revenue and expenditure (for both the accounts) and the change in them will be examined by working over within groups of states.

The data base will be adjusted for homogeneity by taking three yearly moving averages.

The determination of the state finance would differ from one group to the other group of states in terms of the variation of social economic and political factors persisting in each group of states. Thus, this work intends to identify the crucial features affecting the government's revenue and expenditure, for various alternatives. The hypothesis will be posed for each group of states and it will be tested statistically for its viability. Moreover, the stability of the results by drafting statistical test would be examined after examining.
METHODOLOGICAL ASPECTS OF THE STUDY

Analysis of the state finance by taking in order the alternative government revenue and expenditure. Homogenous group of states in terms of the pattern of revenue and expenditure will be indicated and separate analysis would be carried out for each group of states. It would help in adopting a uniform policy for the group of state policy to improve its economic conditions.

Analysis will be carried out to identify the factors responsible for the government expenditure separately for each group as well as for group of all the states taken together.

The trend component and growth pattern have been examined in chapter VI and the methodological aspects are presented in that chapter. The methodology for regression study on the basis of relevant tools of econometric analysis is given briefly in the Appendix given at the end of this chapter. The data analysis about the concerned variables of the system is given in chapter IV and V. Statistical testing and their interpretations based upon the proposed regression study are given in chapter VII, VIII and IX. Whereas some projections based upon the estimated growth rate approach are given in chapter X along with the over all conclusions based upon this study.

3.6 LIMITATIONS OF THE STUDY

We can give a brief account about the limitations of our study as under:

1. In this study we have considered the time series data commencing from the year 1960-61 to 1986-87. The financial data are available for next 1 or 2 years but the data on SDP were not available beyond the period 1986-87, that is why only the time series data upto the year 1986-87 are considered. One way to deal with such a limitation
METHODOLOGICAL ASPECTS OF THE STUDY

Of data can be to extrapolate the data with appropriate projection method and then use the relevant series. The other way is to use the provisional data. This may affect the overall conclusions in general and hence we have limited our study up to the year 1986-87 only.

2. While collecting the data at some of the places, the relevant data for some variables are not available (or found to be missing) only for one or two years and for one or two states under consideration. This missing gap is filled in by interpolation considering the trend as well as the growth of respective series to establish a sort of consistency in the data.

3. In the study, we have considered only secondary data, which are available from the standard publications, reports, etc., as such data are considered to be standardised and authorised.

4. We have considered the financial and non-financial data pertaining to the sixteen major states in India out of total of twenty-five states in the republic of India. However, these Sixteen states represent the major economic activities and changes in the pattern of the development throughout the country and they reflect and represent the economy of the country as a whole.

5. The method of grouping applied to the data can be made by using PQLI (Physical quality of life index) technique, which is considered to be one of the latest developed technique. However, in our study, we have grouped them according to their development ranks on the basis of per capita SDP and per capita income.

6. Out of number of variables as well as number of indicators representing the financial behaviour and growth in general, we have concentrated only upon some major variables and looking to the large
METHODOLOGICAL ASPECTS OF THE STUDY

Volume of data and our limitation for the study, we have restricted our study to the data at macro level and not at micro level for each of the states pertaining to the different sub-heads of the financial and non-financial variable.

7. While considering the trend component for the data analysis, we have used the moving average method which is the simplest method to consider the trend component of the relevant series.

8. The growth pattern for the data is based upon the semi-log trend equation representing the relevant variables related with time.

9. Some of the projection are carried out on the basis of the estimated growth rate, using the time series pertaining to the second period (1974-75 to 1986-87). Here it may be noted that the variation during the first period shows (in general) some uneven pattern during the early period. Hence the projection based upon the second period can be considered to be more reliable to establish the consistency of the data.

10. On the basis of the above hypothesis, we formulated multiple regression study between the considered variables. Here linear or non-linear models can be considered to quantify the data analysis. For each case of regression, such linear or log-linear models were considered. It was found in our analysis that log-linear models might be more suitable. That is why such models are considered to be appropriate for regression studies. An advantage for considering log-linear model is that it gives smaller emphasis to larger observation which facilitates the computational aspects. Also it may be helpful to tackle certain problems like Heteroscedasticity, Multicollinearity, Autocorrelation etc. However, one may also consider different ap-
METHODODOLOGICAL ASPECTS OF THE STUDY

approaches to deal with such problems.

11. For statistical inference to be drawn from the statistical analysis it may be worthwhile to consider the appropriate statistical tests of significance. This is done at some desired level of significance. The significance level is left to our choice. Generally it is 1% or 5% level. However, one may modify this level of significance depending upon the type of situation of problems under study. In this academic work, we have considered 10% level of significance for carrying out the test of significance throughout our analysis.
Econometrics concerns itself with the estimation and testing of economic relationships. Economic relationships are of the following three types:

(A) Behavioural Relationship which are derived from theories, which postulate certain kind of behaviour on the part of certain agents. For example, consumers maximise utility or firms maximise profits or investors are risk averse etc. Examples are demand equation, consumption function etc.

(B) Technological Relationship which reflects the underlying technologies. An example is the production function of production theories.

(C) Accounting Identities such as those in national income accounts, financial accounting, etc.

These relationships are generally cast in the form of algebraic equations or inequalities etc. Which contain a set of variables.

The collection of exact or deterministic autonomous equations with specified numerical values for the parameters is called a structural equation which contains the structural parameters. When the numerical values of the parameters are left unspecified, we get deterministic model. A deterministic model can be defined as a collection of autonomous relationship. A deterministic model, thus specifies the variables being dealt with and the functional form of the relationships. When further a prior assumptions reflecting some institutional features and the economic environment are added, we have a maintained
DETERMINISTIC OR EXACT MODEL AND STOCHASTIC OR INEXACT MODELS:

The models of economic theory are exact or deterministic models i.e. equations in such models are supposed to hold exactly e.g. the relationship between a family's expenditure on food $E$ and its income $Y$ known as Engel's curve $E = f(Y)$, where $f(.)$ denotes some function.

Such deterministic models cannot be carried over to econometric description of the real world. This is because of the fact that a number of factors other than income also affect the family's expenditure pattern.

These functions are ignored and this causes discrepancy between the actual value and the value calculated from relation. Similarly error can also result because we have chosen an incorrect specification for $f(.)$. The form of $f(.)$ is not completely indicated in the theory. Eventhough, this might be exact relation between $E$ and $Y$ and we have correctly specified if we might make an error in measuring the variables. Thus, the way out is to specify a model. We convert a deterministic model into a stochastic model.

$$Y = f(X, X, \ldots, X) + U$$

$Y$ being the dependent variable $X, X, \ldots, X$ the independent variables and $U$ is called the random disturbance term. Thus, a stochastic model contains a deterministic model as the systematic part and in addition it specifies how random disturbances enter and how they are generated and identify their probability distributions. For the purpose of estimation and testing of hypothesis, the stochastic assumptions of the model about the random disturbance are to be stated with the model.
METHODOLOGICAL ASPECTS OF THE STUDY

A/2 METHODOLOGY

A/2.1 GENERAL LINEAR MODEL

Let us consider the general linear model (GLM) concerning k variables as under:

\[ Y = X\beta + \epsilon \quad \quad \quad (1) \]

Where \( Y = \) \( n \times 1 \), 
\( X = \) \( n \times k \).

We have the following assumptions:

(i) \( E(\epsilon) = 0 \)

(ii) \( E(\epsilon \epsilon') = \sigma^2 I_n \)

(iii) Data matrix \( X \) is fixed and

(iv) Rank of \( X \) is equal to \( K (K' \times n) \)

Under these assumptions OLS estimators of \( \beta \) are given by

\[ \hat{\beta} = (X'X)^{-1}X'Y \quad \quad \quad (3) \]

with \( V(\hat{\beta}) = (X'X)^{-1} \sigma^2 \quad \quad (4) \)

It may be noted that these estimators of \( \hat{\beta} \) are BLUE for \( \beta \).

A/2.2 GENERALISED LEAST SQUARES METHOD

If we remove the assumption (ii) in (2) stated above and write it as

\[ E(\epsilon \epsilon') = \sigma^2 V = \Sigma \quad \quad (5) \]
then we can obtain the generalised least squares estimators of $\beta$ given by -

$$\hat{\beta} = (X'X + C) \left( X'X \right)^{-1} X'Y \quad \ldots \ldots \quad (8)$$

with

$$V(\hat{\beta}) = \sigma^2 (X'X + C) \left( X'X \right)^{-1} \quad \ldots \ldots \quad (9)$$

where $C$ is an arbitrary constant. Note that

$$V(\hat{\beta}) = \sigma^2 (X'X + C) \left( X'X \right)^{-1} \quad \ldots \ldots \quad (9)$$

Such estimators are biased but more efficient as compared to OLS estimators.

A/2.4 HETEROSCADASTICITY

In assumption (ii) of (2), if we further assume that

$$E(U_i U_j) = \sigma^2 \sum_{i=1}^{2} \left[ \frac{1}{\lambda_i} ; \frac{1}{\lambda_i} ; \ldots ; \frac{1}{\lambda_i} \right]$$

where $\Lambda = \text{diag} \left[ \frac{1}{\lambda_1} ; \frac{1}{\lambda_2} ; \ldots ; \frac{1}{\lambda_n} \right]$,

$$V(U_i) = \sigma^2 \sum_{i=1}^{2} \left[ \frac{1}{\lambda_i} ; \frac{1}{\lambda_i} ; \ldots ; \frac{1}{\lambda_i} \right]$$

then

$$V(U_i) = \sigma^2 \sum_{i=1}^{2} \left[ \frac{1}{\lambda_i} ; \frac{1}{\lambda_i} ; \ldots ; \frac{1}{\lambda_i} \right]$$

and $\text{Cov}(U_i, U_j) = 0$ for $i = 1, 2, \ldots, n$, $(i \neq j)$

which is the problem of heteroscedasticity. A number of techniques
METHODOLOGICAL ASPECTS OF THE STUDY

such as park test, Spearman's rank correlation test etc, can detect this problem. Under the heteroscedastic disturbances, the OLS estimators are less precise & they generate larger standard errors & hence the inferences drawn on them may also be less reliable. To tackle this problem, various techniques can be used such as transformation of data by way of considering data on differences, logarithmic transfer, two stage least squares method for using transformed regressions etc. can be used.

A/2.4 AUTO CORRELATION

If we improve the condition (11) of GLM given in (2) and state that

\[ \text{COV} (U_t, U_j) = \delta \neq 0 \] .... (12)

\( i = 1,2,...,n \)

\( j = 1,2,...,n \) \( (i \neq j) \)

Then we can write the first order auto regressive series of the type

\[ U_t = \phi U_t \downarrow + \varepsilon_t \] .... (13) \( (t = 1,2,...,n) \)

with the assumptions

(a) \( \text{E}(\varepsilon_t) = 0 \) for all \( t = 1,2,...,n \)

(b) \( \text{E}(\varepsilon_t, \varepsilon_{t-1}) = 0 \) for all \( t = 1,2,...,n \) ....(14)

(c) \( \text{V}(\varepsilon_t) = \sigma^2 \) for all \( t = 1,2,...,n \)

(d) \( \text{cov}(\varepsilon_t, \varepsilon_{t+s}) = \phi^s \) for all \( t = 1,2,...,n \) \( S \neq 0 \)

Here we have the problem of autocorrelation

We have \( \text{E}(U_t) = 0 \) for all \( t \& \)

\[ \text{V}(U_t) = \sigma^2 = \frac{\sigma^2}{(1-\phi^2)} \] .... (15)

\[ \text{cov}(U_t, U_{t+s}) = \sigma^2 \cdot \phi^s \]

Where \( \phi \) = Autocorrelation coefficient.

The serial correlation of order \( S \) is given by
METHODOLOGICAL ASPECTS OF THE STUDY

\[ S = \sum_{i=1}^{n} (b_i = 1,2,...,n) \] .................(17)

Thus we have \[ V = \mathbb{E}(U U) \]

\[
\begin{bmatrix}
1 & g & \ldots & g \\
g & 1 & \ldots & g \\
\vdots & \vdots & \ddots & \vdots \\
g & \ldots & g & 1
\end{bmatrix}
= g^2 \begin{bmatrix}
1 & g & \ldots & g \\
g & 1 & \ldots & g \\
\vdots & \vdots & \ddots & \vdots \\
g & \ldots & g & 1
\end{bmatrix}^{n-1} \] .................(18)

Under the effect of autocorrelation

\[ \mathbb{E}(e'e) = 2g^2 \left( \frac{n-1+g}{1-g^2} \right) \] .................(19)

So that \[ gU \leq \mathbb{E}(e'e) \left( \frac{n-1}{n-2} \right) \] .................(20)

The presence of autocorrelation can be detected by Durbin Watson test (DW) statistic & the problem can be tackled by the method such as the Cochran Or cutt iterative procedure in the case of unknown value of \( g \).

A/3 STATISTICAL INFERENCE :

We can use the following results for statistical inference based upon the relevant linear model.

(1) Tests of significance of \( b_i \).

\( H_0 : b_i = b_0 \) Vs \( H_1 : b_i \neq b_0 \)

We define \[ t = \frac{b_i - b_0}{\sqrt{\mathbb{V}(b_i)}} \] .................(21)

With degrees of freedom \( (n-k) \). As usual, if observed \( t \) is significant, it leads to the correct specification of the model.

(2) Multiple coefficient of determination (adjusted & unadjusted) We compute \( R^2 \) by the formula

\[ R^2 = \frac{\sum (y_i - \bar{y})^2}{\sum (y_i - \bar{y})^2} \] .................(22)

Also note that the corresponding adjusted value of the multiple coefficient of determination is given by
METHODOLOGICAL ASPECTS OF THE STUDY

\[
\hat{R}^2 = 1 - \left(1 - R^2 \right)^{\frac{1}{n-1}}
\]  \hspace{1cm} \text{......... (23)}

(3) Testing the significance of \( R \)

We can use \( F \) statistic as defined below

\[
F = \begin{cases} 
\frac{R^2}{\frac{1}{n-1}} & \text{if } R^2 > 0 \\
\frac{1-R^2}{\frac{1}{n-1}} & \text{if } R^2 < 0 
\end{cases}
\]  \hspace{1cm} \text{......... (24)}

With degrees of freedom given by

\( \nu_1 = k - 1 \)

\( \nu_2 = n - k \) respectively.

4. Analysis of variance (ANOVA):

To test the significance of the observed multiple regression model, we can carry out the analysis of variance as under

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>k-1</td>
<td>S_{Y}^2 - \hat{\beta}Y = \hat{\alpha}</td>
<td>\frac{A}{K-1}</td>
<td>\frac{A}{B}</td>
</tr>
<tr>
<td>Error</td>
<td>n-k</td>
<td>\sum (Y - \bar{Y})^2 = B</td>
<td>\frac{B}{n-1}</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>n-1</td>
<td>\sum Y^2 - \bar{Y}^2 = C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the observed \( F \) is significant then we may conclude that the proposed model is appropriate for the data.