CHAPTER – III

DATA BASE AND RESEARCH METHODOLOGY

The present chapter ‘Data Base and Research Methodology’ refers to the methods and data sources used to carry out the study to evaluate the research questions. This chapter covers methods of sample selection, size of sample, process of developing the questionnaire, data processing and analysis.

Sample-size and Sampling Methods:

Sample has been selected in two stages. In first stage sample organisations have been purposively selected so as to cover leading information technology organisations representing all the three segments of information technology industry i.e. software, BPO and hardware. In the second stage sample units have been selected from the sample information technology organisations. The selection of employees depended upon cooperation of the organisations and their response rate. Broadly employees selected in the sample are on the basis of conveniences.

All the sample information technology organisations are located in India in different locations. Organisations were chosen purposively to include all types of organisations. Tata Consultancy Services, Infosys, Wipro were chosen for being leading organisations in the industry. The organisations have been selected from all the sectors i.e. software, BPO and hardware, so as to represent entire industry. Some organisations are foreign MNCs, Indian MNCs and some are in private sector. One organisation is a public sector organisation. In order to collect the data and the information about human resource development practices and climate of different organisations, an introductory letter was issued by the Guru Nanak Dev University (Amritsar). This introductory letter states that the objective of research is purely academic.

The sample is a subset of population. In the present study, the sample-size is of 500 employees belonging to information technology organisations. Cooperation of the organisations in general was minimal. As a result, I had to use convenience sampling. Infact 750 questionnaires were distributed but I could get only 500 filled questionnaires through interview method. Some of the questionnaires were filled through e-mails. Overall response rate was around 66 percent. The sample-size is different in different organisations. It ranges from 25 to 50. Sample-size for each organisation depends upon the response rate of the organisation.
Table 3.1

The Sample-size of Purposively Selected Information Technology

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Organisations</th>
<th>Nature of Organisations</th>
<th>Sample Size</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Tata Consultancy Services</td>
<td>Software</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Wipro Technologies</td>
<td>Software</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Infosys Technologies Ltd.</td>
<td>Software</td>
<td>30</td>
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<tr>
<td>4</td>
<td>Hindustan Computer Ltd.(HCL)</td>
<td>BPO</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Dell International</td>
<td>BPO</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Birlasoft</td>
<td>Software</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>Pyramid Consulting Inc</td>
<td>BPO</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Semi-Conductor Laboratory (SCL)</td>
<td>Hardware</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td>Alcatel-Lucent Technologies</td>
<td>Software</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>Attra</td>
<td>Software</td>
<td>35</td>
</tr>
<tr>
<td>11</td>
<td>Kanbay International Inc.</td>
<td>Software</td>
<td>40</td>
</tr>
<tr>
<td>12</td>
<td>Omnia Technologies</td>
<td>BPO</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>Quark</td>
<td>Software</td>
<td>50</td>
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Source: Primary Survey
**Geographical Locations Covered:**

The geographical locations covered in the present study are - Delhi (Noida), Chandigarh, Mohali, Pune and Bangalore, which are the IT hubs in India. The present study covers 13 information technology organisations located in different areas of India. The name of the surveyed different information technology organisations are - Tata Consultancy Services, Wipro Technologies, Infosys Technologies Ltd., Hindustan Computer Ltd. (HCL), Dell International, Birlasoft, Pyramid Consulting Inc., Semi-Conductor Laboratory (SCL), Alcatel-Lucent Technologies, Attra, Kanbay International Inc., Omnia Technologies and Quark.

Out of total 13 information technology organisations, eight organisations are software, four are BPOs and one is hardware. Table 3.1 depicts that from Tata Consultancy Services - 30, Wipro Technologies - 30, Infosys Technologies Ltd - 30, Alcatel - Lucent Technologies - 50, Hindustan Computer Ltd. (HCL) - 30, Dell International - 50, Birlasoft - 25, Pyramid Consulting Inc. - 50, Semi-Conductor Laboratory - 30, Attra - 35, Kanbay International Inc. - 40, Omnia Technologies - 50 and Quark - 50 complete questionnaires have been collected. The present study tried to cover other information technology organisations like - Mphasis, Tech-Mahindra, R.K. Mantra etc., but they did not complete even single questionnaire and refused to provide any information. Various employees of information technology organisations do not show much interest in providing any information. Senior employees directly refused to fill the questionnaire.

**Development of the Questionnaire:**

Data can be divided into three categories – primary, secondary and tertiary. Primary data is collected for the first time by the researcher according to the requirement of the study. Reports, thesis, conference reports, company reports, market research reports, unpublished manuscripts are its examples. Whereas secondary data are collected by someone else and is used by researchers. It includes – newspapers, books, journals, government publications, corporate reports, international publications etc. Tertiary data includes information from index, abstracts, catalogues, encyclopedias, bibliographies and dictionaries. In the present study all categories of data have been used but according to the requirement of our study emphasis has been given on the primary data. In order to collect primary data, researchers mostly use questionnaire method in social sciences.
research. It is treated as the ‘heart of the survey operation’. It is a list of well formulated questions, through which information is collected. Questionnaire is a tool used for securing answers to questions by using a form that a respondent fills in himself and which obtains standardized results that can be tabulated and treated statistically.

In the present study, structured questionnaire is used which poses definite, concrete and preordered questions. The form of the questionnaire is closed form, with a limited number of answers for a respondent to choose from. In a closed questionnaire two types of questions are asked – (1) the dichotomous questions two alternatives of questions are given and the informant is to select one of them. Yes / no types of answers of questions are its example. (2) Multiple-choice questions include many alternative answers and informant is asked to choose any one out of them. In information technology industry, most of employees are educated and have good command in English language, that’s why questionnaire is in English language. The questionnaire used in the study, has been divided into three parts. Part (a) includes personal data, which is used to obtain the data, facts and figures and information of employees working in the organisation. It includes the information about the name and nature of the organisation, name of employee, nature of job, age of employee, sex, educational qualification, marital status, work-experience, monthly income, nature of appointment and year of joining the organisation.

Part (b), includes mechanisms of human resource development practices prevailing in an organisation such as recruitment, selection procedure, training policies, performance and promotion policy, transfer policy, wages, compensation, social-security schemes and working conditions policy, recreational policy, employee-employee/employer/management relation, trade-union, health facility and other aspects. It includes ten human resource development mechanisms with 53 items to observe the human resource development practices in information technology organisations.

Part (c) consists of human resource development climate survey. It includes ten dimensions with 54 items. It observes the satisfaction level of employees with the prevailing human resource development climate in the selected organisations. Rigorous selection process, value-based induction, comprehensive training, team-based job-design, working conditions/ environment, development oriented performance appraisal compensation, career development and value-added incentives are the different dimensions covered. Respondents are required to state their satisfaction level in terms of five-point Likert-scale.
Questionnaire

(A) Personal Data

i. Name of organisation

ii. Nature of organisation

iii. Name of Employee (optional)

iv. Nature of job

v. Age of Employee

vi. Sex

vii. Edul. Qualification

viii. Marital Status

ix. Background

x. Work Experience

xi. Year of joining the organisation

xii. Monthly Income

xiii. Nature of appointment

(a) Trainee

(b) Trainee and likely to be permanent

(c) Permanent

(d) Purely temporary

(B) Human Resource Development Practices

(1) Selection Procedure

(A) What was selection procedure in your case?

(i) Through open interview/Test

(ii) Through placement agencies
(iii) Through campus interview
(iv) Through contacts
(v) If any other, specify,

(B) Do you think that selection/recruitment procedure in your organisation is?
(i) Totally Fair
(ii) Generally Fair
(iii) Not Fair

(C) Are you satisfied with selection policy of the organisation?
(i) Yes
(ii) No

(D) Is the selection procedure successful, that is, it is able to select the right person for the right job?
(i) Yes
(ii) No

(2) Training Policy

(A) Does your organisation provide training?
(i) Yes
(ii) No

(B) Does it provide multiple skill training to employees?
(i) Yes
(ii) No

(C) What are the different types of training, provided by organisation? Specify.

(D) Have you attended training in last two years? If yes, specify area.

(E) Multiple skill training is given to which level of employees?
(i) New
(ii) Junior Level
(iii) Middle Level
(iv) Senior Level

(F) Are these training programmes need based?
(i) Yes
(ii) No

(3) **Performance and Promotion Policy**

(A) Does the organisation provide adequate opportunities for career development of the employees?
(i) Yes
(ii) No

(B) Are you satisfied with promotion policy of your organisation?
(i) Yes
(ii) No

(C) Which type of performance evaluation exists in your organisation?
(i) Formal
(ii) Informal

(D) If formal, which method is being adopted?

(E) Which mechanisms are used by organisation for rewarding good performance of their workers? (You can choose more than one)
(i) Salary increments
(ii) Cash awards
(iii) Promotion
(iv) Foreign travel
(v) Appreciation
(vi) Advanced training at reputed institutions
(vii) Study tours
(viii) Any other, specify

(4) Transfer Policy
(A) Which type of transfer policy, the organisation has?
   (i) As per worker’s convenience
   (ii) Company’s requirement
   (iii) Both

(B) Are you satisfied with the transfer or placement policy of the organisation?
   (i) Yes
   (ii) No

(5) Wages, Compensation, Social Security and Working Conditions Policy
(A) Are you satisfied with the wages and perks provided by the organisation?
   (i) Yes
   (ii) No

(B) Would you like to change your job for? (you can choose more than one)
   (i) Higher Salaries and perks
   (ii) Better working conditions
   (iii) Better job satisfaction
   (iv) Better career growth
   (v) If any other, specify
   (vi) None

(C) Do you think that you have job security in this organisation?
   (i) Yes
   (ii) No

(D) Which type of social security benefits are provided by your organisation?
   (You can choose more than one)
(i) Pension
(ii) Provident Fund
(iii) Gratuity
(iv) Health insurance
(v) Compensation in case of major accident
(vi) Compensation in case of death
(vii) Any other, specify

(E) Does your organisation provide adequate paid leave facility and holidays?

(i) Yes
(ii) No

(F) What are the normal working hours specify?

(G) Do people in your organisation work after office working hours?

(i) Yes
(ii) No

(H) If yes, is it usual or in exceptional cases?

(6) **Recreational Policy**

(A) Does the organisation provide facilities for recreational activities?

(i) Yes
(ii) No

(B) If yes, which types of facilities are provided by the organisation? (You can choose more than one)

(i) Gym
(ii) Indoor /Outdoor games
(iii) Meditation/Yoga classes
(iv) Music/television facilities
(v) Library facility
(vi) Late night parties
(vii) Club facilities
(viii) If any other, Specify

(7) Employee-Employee/Employer/Management Relation

(A) Does your organisation encourage team-work?
   (i) Yes
   (ii) No

(B) Do you feel free to communicate with seniors and co-workers?
   (i) Yes
   (ii) No

(C) Do you participate in decision-making process in your department?
   (i) Yes
   (ii) No

(D) What is the management’s attitude towards employees?
   (i) Leadership by self example
   (ii) Co-operative and friendly
   (iii) Inspiring
   (iv) Dictatorial
   (v) Indifferent

(E) Does management encourage workers to experiment/risk-taking?
   (i) Yes
   (ii) No
### (8) **Trade Union**

(A) Does any trade union exist in your organisation?

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(B) Do you think that there should a worker’s union in your organisation?

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(C) If any type of conflict arises, how it is resolved?

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<tr>
<td>(i)</td>
<td>By informal discussion</td>
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<td>(ii)</td>
<td>By negotiation b/w workers and management</td>
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<td>(iii)</td>
<td>By HR department</td>
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<td>(iv)</td>
<td>By some formal committees</td>
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<td>(v)</td>
<td>If any other, specify</td>
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(D) Is there effective joint conflict management machinery?

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(E) Is there, grievances redressed machinery in your organisation?

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(F) If yes, are you satisfied with its functions?

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<td>(ii)</td>
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(G) If no, what are the problems? Specify.

### (9) **Health Facility**

(A) Does your organisation provide medical facilities?

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<td>(ii)</td>
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</table>
(B) In your opinion, which type of work related hazards are associated with your job?

(You can choose more than one)

(i) Obesity problem
(ii) Back pain problem
(iii) Joint pain
(iv) Neck pain
(v) Eyes stress
(vi) Any other, specify

(10) Other Aspects

(A) Is your organisation, an equal opportunity/ no bias institution?

(i) Yes
(ii) No

(B) Does your organisation encourage women workers and consciously promote no gender discrimination policy?

(i) Yes
(ii) No
(iii) Don’t know

(C) Does your organisation provide following facilities to women workers?

(i) Maternity leave
(ii) Hostel Facility
(iii) Creche facility
(iv) Exemption from night shifts
(v) Special convenience facility
(vi) If any other, specify

(D) Does your organisation provide other welfare measures for workers?

(i) Housing facility
(ii) Co-operatives
(iii) Schools
(iv) Hospital
(v) Sponsorship for higher education
(vi) Transportation

(vii) Any other, Specify.

(E) If you are un-married female worker, then will you like to continue your job after marriage?
   (i) Yes
   (ii) No

(F) If you are a married female worker then do you feel difficult to pull on with your job?
   (i) Yes
   (ii) No

(G) Does your organisation provide employee stock option?
   (i) Yes
   (ii) No

(H) Do you think, there is adequate staff in your organisation?
   (i) Yes
   (ii) No

(I) If no, please state reasons?

(J) Do you feel that your job is highly stressful?
   (i) Yes
   (ii) No

(K) If yes, indicate the causes of stress, specify.

(L) Any other, information, which you want to convey?
### (C) HRD CLIMATE SURVEY

Kindly Tick ( √) your agreement level in five point scaling:

| 5= Strongly Agree (AAT), 4 = Mostly True (MT), 3= Sometimes True (ST), 2= Rarely True (RT), 1= Not at All True (NAT) |
|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 |
| AAT | MT | ST | RT | NAT |

### (A) Rigorous Selection Process

1. Select the candidates, our company conducts
   (a) Written Test
   (b) Test On Programming Skills
   (c) Technical Interview
   (d) General Interview

2. Our company looks at candidate’s ability to work in a team.

### (B) Value-Based Induction

1. Our Company organizes a formal induction programme for new-comers very effectively

2. Induction training provides an excellent opportunity for new-comers to learn comprehensively about
   (a) This organisation in general
   (b) Its mission and goals
   (c) Its norms and values
   (d) Its customs

3. Induction training is used as an opportunity in our company to create bonds between the company and the new employees.

4. The new recruits find induction training very useful in this organisation.

### (C) Comprehensive Training

1. Each individual’s training needs are identified in order to develop critical skills needed for the assigned work.

2. When employees are sponsored for training, they take it seriously

3. The technical skills of the employees are constantly upgraded through a variety of training programmes, workshops and seminar

### (D) Team-Based Job Design

1. Self-managed work teams and semi-autonomous work groups are the building blocks of the work system

2. The actual job duties are shaped more by the employees than by a specific job description

3. Employees are given the details of the consumers and their requirements

4. Individuals and groups are involved in making decisions that affect their work

### (E) Working Conditions/Environment

1. The quality of physical conditions provided in the work-place is good.
2. Our company provider excellent infrastructure and support services for high performance.

3. Sources of frequent interruption or distraction that degrade the effectiveness of work environment are identified and minimized.

4. Periodic improvements are made to the work environment that increases effectiveness in performing work.

5. Sanitation, ventilation and furnishing facilities in the company are good.

6. Canteen and refreshment facilities arrangements are good.

7. Safety standards maintained by the department are good.

(F) Employee Friendly Work Environment

1. The top management believes that human sources are an extremely important resource and that they have to be treated more humanly.

2. The top management of this organisation goes out of its way to make sure that employees enjoy their work.

3. The top management is willing to invest a considerable part of their time and other resource to ensure the development of employees.

4. The top management of this organization makes efforts to identify and utilize the potential of employees.

5. Seniors guide their juniors and prepare them for future responsibilities/roles they are likely to take-up.

6. When seniors delegate authority to juniors, the juniors use it as an opportunity for development.

7. Employees are not afraid to express or discuss their feelings with their colleagues.

8. Employees are encouraged to take initiative and do things on their own without having to wait for instructions from supervisors.

9. Employees are not afraid to express or discuss their feelings with their superiors.

10. Employees are not afraid to express or discuss their feelings with their subordinates.

11. Employees are encouraged to experiment with new methods and try out creative ideas.

12. Weakness of employees is communicated to them in a non-threatening way.

13. Employees in this organisation are very informal and do not hesitate to discuss their personal problems with their superiors/subordinates.

14. Communication in the organisation is both at upwards and downward is effective.

15. People in this organisation don’t have any fixed mental impression about each other.

16. Team spirit is of high order in this organisation.
### (G) Development Oriented Performance Appraisal

1. Our performance appraisal system provides feedback from superiors.

2. There is high employee participation in the appraisal process.

3. Performance appraisal is based on
   - (a) Individual results
   - (b) Group results
   - (c) Quantifiable standards such as the value of project completed.
   - (d) Qualitative standards such as teamwork.

4. The objective of the appraisal process is employee’s development.

5. If performance problems occur they are discussed with the appropriate individuals or groups.

6. Performance appraisal reports in our organisation are based on objective assessment and adequate information and not on favoritism.

### (H) Compensation

1. Each individual’s compensation package is determined through a document procedure that is consistent with organisation’s compensation policy, strategy and plan.

2. Compensation is primarily determined by results achieved/contribution to the company.

3. Decisions regarding an individual’s compensation package are communicated to the individual.

4. In our company high performers are given higher pay package.

### (I) Career Development

1. In our company a personal development plan is created and maintained for each individual.

2. Company provides every employee with opportunities to choose a career path to suit the individual’s core competence.

3. An individual’s development plan and activities are periodically reviewed to determine whether organisational competency needs will be met.

4. Individuals in this company have clear career paths within the organisation.

5. Our company has created a learning environment in the organisation for both professional and personal growth.

6. Job rotation in this organisation facilitates employee development.

### (J) Value-Added Incentives

1. Employees are offered an extremely flexible compensation and benefits package like housing assistance, stock options, soft loans and asset acquisition assistance.

2. Extensive performance-based incentives and bonuses are available to all employees.
Pre-testing of Questionnaire:

Pre-testing enables a researcher to check the validity, reliability and accuracy of the questionnaire. It ensures that the data is collected by researcher without any bias. In our study, questionnaire was pre-tested on 20 respondents. After pre-testing, questionnaire was revised. Then revised questionnaire was used to attain the information about human resource development practices and climate in selected information technology organisations.

Data Collection Methodology:

For data collection from information technology industry, direct personal interview method was adopted. I met various information technology professionals personally for data collection. In case of three information technology organisations - Wipro, Kanbay and Attra, questionnaires were collected by e-mail method. For data collection, 750 questionnaires were distributed to different employees during lunch time and shifting of employees. I could get only 500 filled questionnaires from the different employees with a response rate of 66 percent. Most of the information technology organisations were not interested in disclosing the human resource policies and climate.

Statistical Tools:

After primary survey, master tables were prepared. From these master tables, data were converted in the form of tables on HRD practices and HRD climate survey. In case of HRD practices data, chi-square test has been applied. In case of HRD climate survey data has been collected in the form of five-point Likert-scale. Collected data of HRD climate has been analysed by calculating mean scores, percentage scores, standard deviation and ANOVA analysis.

Five-point Likert-Scale:

The survey used five-point Likert-scale, which was developed by Rensis Likert. It is frequently used in the study of social attitudes and other social sciences research. In this scale, the respondents indicate several degrees of agreement or disagreement with each item that constitutes the scale. Each response is given a numerical score-based on a
scale of five or seven points - indicating his degree of agreement or disagreement. The present study uses five point Likert-scale in which mean score 5 indicates - almost always true (AAT), mean score 4 indicates - mostly true (MT), mean score 3 indicates - sometimes true (ST), mean score 2 indicates - rarely true (RT) and mean score 1 indicates - not at all true (NAT). Mean score 4 indicates that employees in these organisations agreed that good human resource development climate is prevailing in the organisations. It indicates that human resource development climate is of a desirable level, whereas mean score 3 indicates an average human resource development and mean score 2 indicates poor human resource development climate on each dimension.

**Mean Scores:**

Mean scores have been calculated by using arithmetic mean $\bar{X}$.

$$\text{Mean value (} \bar{X} \text{)} = \frac{\sum FX}{\sum F}$$

$\sum FX$ = Sum of multiplication of FX

$\sum F$ = Sum of Frequency

It is used to find out item-wise average values of the human resource development climate in information technology industry.

**Percentage Scores:**

In the present study mean scores have been converted into percentage scores by using the formula, percentage score $= (\text{Mean Score}-1) \times 25$. As per this measure the score 1 represents - 0 percent, 2 represents - 25 percent, 3 represents - 50 percent, 4 represents - 75 percent and 5 represents - 100 percent. The percentage score indicates the degree to which a particular dimension exists in that organisation out of the ideal 100. The formula of percentage method is as given -

Percentage scores (% age) $= (\text{Mean Score}-1) \times 25$
Standard Deviation:

Standard deviation is the square root of variance. Standard deviation method is applied to know the nature of the variations in responses. It is used in human resource development climate to measure the variations in responses of different employees in information technology industry. The formula of standard deviation is as following -

\[ SD = \sqrt{\frac{1}{N} \sum F(x - \bar{x})^2} \]

SD = Standard deviation
\( \sum F (x - \bar{x})^2 \) = Squares of deviation multiplied with their respective frequencies.
N = \( \sum F \) = Sum of frequency

Chi-Square Test:

Chi-square test is also known as test of goodness of fit. Chi-square is a non-parametric test and is important in social sciences research. It is used to find out if difference between the observed distribution of data among categories and expected distribution is significant. It is denoted by \( \chi^2 \).

Chi-square test \( (\chi^2) \) = \( \sum_{i=1}^{n} \left[ \frac{(O - E)^2}{E} \right] \)

O = Observed value of frequency
E = Expected value of frequency
n - 1 = Degree of freedom

Hypothesis Testing:

Hypothesis testing means to test some hypothesis about parent population from which the sample is drawn. The conventional approach to hypothesis testing is not to construct a single hypothesis about the population parameter, but rather to set up two different hypotheses. These hypotheses must be so constructed that if one hypothesis is accepted, the other is rejected and vice-versa. These hypotheses are of two types – (1)
Null hypothesis is a very useful tool in testing the significance of difference. The word null means invalid, or amounting to nothing. In its simplest form the hypothesis asserts that there is no real difference in the sample and the population in the particular matter under consideration and that the difference found is accidental and unimportant arising out of fluctuations of sampling. It is usually denoted by $H_0$. (2) Alternative hypothesis is complementary to the null hypothesis. In it the difference is considered between the sample observations and it is denoted by $H_1$. In present study null hypothesis and alternative hypothesis are used in human resource development practices in personal data to know the significant difference between the two statements of different items.

Null hypothesis ($H_0$) = Sample means are equal

Alternative hypothesis ($H_1$) = Sample means are not equal

In this survey level of significance has been taken at 1%. If calculated value is greater than tabulated value, null hypothesis is rejected and it is significant at 1% level. On the other hand, if calculated value is less than tabulated value, so null hypothesis is rejected and it is not significant at 1% level.

**Degree of Freedom:**

Degree of freedom (d.f.) denotes the extent of freedom enjoyed by a given set of observed frequencies. Degree of freedom is usually denoted by the English alphabet ‘v’ of Greek language (Gupta, S.C., 2000, pp.1087-1130; Gupta, S.P., 2005, pp.882-885).

\[ V = (\text{Number of frequencies}) - (1) \]

\[ V = n-1 \]

\[ V = \text{Degree of freedom} \]

\[ n = \text{Number of frequencies} \]

**ONE-WAY ANOVA ANALYSIS:**

Analysis of Variance (ANOVA) is used to study the difference between the mean scores of each item of the human resource development climate in case of 13 information
technology organisations as well as in terms of three broad sectors of information technology industry viz software, BPOs and hardware.

The analysis of variance procedure or F-test is used to test for the significance of the difference among more than two sample means. In one-way classification, the data are classified according to only one criterion. In one-way ANOVA a single variable is controlled and it effects on the elementary units is controlled (Gupta, S.P., 2005, pp.1008-1013).

\[ H_0: \mu_1 = \mu_2 = \mu_3 = \mu_K \]

(Null Hypothesis: All means are equal)

\[ H_1: \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_K \]

(Alternative Hypothesis: All means are not equal)

**Steps involved in carrying out the analysis are**

1. **Calculate the variance between the samples:** The variance between samples measures the differences between the sample mean of each group and the overall mean weighted by the number of observations in each group. For calculating variance between the samples, the total of the square of the deviations of the means of various samples from the grand mean is divided by the degrees of freedom. Variance between samples is calculated as below.

   \[ \bar{X} = \frac{\sum FX}{\sum F} \]

   \( \bar{X} = \) Sample Mean Value

   \( X = \) Values of Observations

   \( F = \) Frequency

   \( \Sigma FX = \) Sum of multiplication of FX

   \( \Sigma F = \) Sum of Frequency
(b) Grand Mean Value \( \bar{X}_{GM} = \frac{n_1 \bar{X}_1 + n_2 \bar{X}_2 + \ldots + n_k \bar{X}_k}{N} \)

\( N = n_1 + n_2 + n_3 + \ldots + n_k \)

\( n_1, n_2, n_3, \ldots, n_k \) are the Sample Sizes

(c) Take the difference between the means of the various samples and the grand means. Square these deviations and obtain the total which will give sum of squares between the samples. Divide the sum of squares by degrees of freedom. The degrees of freedom will be less than the number of samples.

\[ \text{SSB} = (\bar{X}_1 - \bar{X}_{GM})^2 n_1 + (\bar{X}_2 - \bar{X}_{GM})^2 n_2 + (\bar{X}_3 - \bar{X}_{GM})^2 n_3 + \ldots \ldots \ldots \ldots (\bar{X}_k - \bar{X}_{GM})^2 n_k \]

\( \text{SSB} = \text{Sum of Squares between Samples} \)

\( V_1 = K-1 \)

\( V_1 = \text{Degrees of freedom} \)

\( K = \text{Number of Samples} \)

(d) \[ \text{MSB} = \frac{\text{SSB}}{V_1} \]

\( \text{MSB} = \text{Mean sum of Squares between Samples} \)

(2) **Calculate the variance within the samples:** The variance within samples measures the inter-sample differences due to chance only. The variance within samples measures variability around the mean of each group. For calculating the variance within the samples, take the total of the sum of squares of the deviation of various items from the means values of respective samples and divide the total by the degrees of freedom. Variance within samples is calculated as below.

(a) Calculate the mean value of each sample. Take the deviations of the various items in a sample from the mean values of the respective samples. Square these deviations and obtain the total which gives the sum of square within the samples.
SSW = \( \sum (x_{ni} - \bar{x}_1)^2 + \sum (x_{ni} - \bar{x}_2)^2 + \sum (x_{ni} - \bar{x}_3)^2 + \ldots \ldots \ldots + \sum (x_{ni} - \bar{x}_k)^2 \)

SSW = Sum of Squares within Samples

(b) Divide the sum of square within the samples by the degrees of freedom. The degrees of freedom is obtained by deduction from the total number of observations the number of samples that is,

\[ V_2 = N - K \]

\( V_2 \) = Degrees of Freedom

N = Total number of Observations

K = Number of Samples

(c) \( \text{MSW} = \frac{SSW}{V_2} \)

\( \text{MSW} \) = Mean sum of Squares within Samples

(3) **Calculate the ratio \( F \) ratio**: The F-distribution measures the ratio of the variance between groups to the variance within groups. The variance between the samples means is the numerator and the variance within the samples means the denominator.

\[ F = \frac{\text{MSB}}{\text{MSW}} \]

(4) **Compare the calculated value of \( F \) with the table value of \( F \) for the degrees of freedom at a certain critical level**

- If calculated value of \( F \) ratio is greater than tabulated value of \( F \) ratio at specified level of satisfaction then it is concluded that the difference in sample means is significant.
- If calculated value of \( F \) ratio is less than tabulated value of \( F \) ratio, then it is concluded that the difference in sample means is insignificant.
Table 3.2

Analysis of Variance – One Way ANOVA Classification Model

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>Variance ratio of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Samples</td>
<td>$SSB$</td>
<td>$V_1 = K-1$</td>
<td>$MSB = \frac{SSB}{K-1}$</td>
<td>$MSB$</td>
</tr>
<tr>
<td>Within Samples</td>
<td>$SSW$</td>
<td>$V_2 = N-K$</td>
<td>$MSW = \frac{SSW}{N-K}$</td>
<td>$MSW$</td>
</tr>
<tr>
<td>Total</td>
<td>$SST$</td>
<td>$N-1$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$SSB = \text{Sum of Squares between Samples}$

$MSB = \text{Sum of Squares between Samples}$

$SSW = \text{Sum of Squares within Samples}$

$MSW = \text{Mean sum of Squares within Samples}$

$SST = \text{Total sum of Squares of Variations}$