Chapter 11
Application of Factor Analysis: To Study the Factor Structure Among Variables

Learning Objectives

After completing this chapter, you should be able to do the following:

- Understand the factor analysis and its application.
- Learn the difference between exploratory and confirmatory factor analysis.
- Know the use of factor analysis in developing test batteries.
- Interpret different terms involved in factor analysis.
- Explain the situations where factor analysis can be used.
- Know the procedure of retaining the factors and identifying the variables in it.
- Explain the steps involved in factor analysis.
- Understand the steps involved in using SPSS for factor analysis.
- Discuss the outputs obtained in factor analysis.
- Learn to write the results of factor analysis in standard format.

Introduction

Buying decision of an individual depends upon large number of product characteristics. But the market strategy cannot be developed on the basis of all those parameters of a product that affect the buying behavior of an individual. The factor analysis, a multivariate technique, comes to our rescue in solving such problems. The factor analysis technique reduces the large number of variables into few underlying factors to explain the variability of the group characteristics. The concept used in factor analysis technique is to investigate the relationship among the group of variables and segregate them in different factors on the basis of their relationship. Thus, each factor consists of those variables which are related among themselves and explain some portion of the group variability. For example, personality characteristics of an individual can be assessed by the large number of parameters. The factor analysis may group these variables into different factors

J.P. Verma, *Data Analysis in Management with SPSS Software*,
DOI 10.1007/978-81-322-0786-3_11, © Springer India 2013

where each factor measure some dimension of personality characteristics. Factors are so formed that the variables included in it are related with each other in some way. The significant factors are extracted to explain the maximum variability of the group under study.

In marketing research, application of factor analysis provides very useful inputs to the decision makers to focus on few factors rather than a large number of parameters in making their products more acceptable in the market. For instance, consider an automobile company is interested to know as to what makes their customer to choose a particular model of the car. Several issues like mileage, easy loan facility, roof height, leg space, maintenance, road clearance, steering functionality, brakes, lighting, and luggage space may be investigated by taking the responses from the consumers. There may be endless issues on which the opinion of the customers can be taken. But by using the factor analysis, these variables may be clubbed in different factors like *economy* (mileage, easy loan facility), *comfort* (roof height, leg space, maintenance, luggage space), and *technology* (steering functionality, brakes, lighting, and road clearance). Thus, instead of concentrating on so many parameters, the authorities will make a strategy to optimize these three factors for the growth of their business. Further, these factors may be used to construct the perceptual maps and other product positioning.

Thus, in factor analysis, few factors are extracted out of the large set of variables. Since variables in each of the factors are associated among themselves, therefore they represent the same phenomenon. In this way, instead of studying all the parameters, few extracted factors are studied. These factors so extracted explain much of the variations of the group characteristics.

Factor analysis is used for both *exploratory* as well as *confirmatory* studies. In exploratory study, we do not know anything about the number of factors to be extracted, the number of variables included in each factor and percentage of variability explained by these extracted factors. The researcher takes all those variables under study which are suggested by the review studies or guided by the researchers own knowledge or experts opinion. Exploratory studies are just like mining important variables from a large number of variables to form factors. Unimportant variables do not figure in any of the identified factors. Such variables are excluded on the basis of their low communality. The process will be discussed later in the book. Thus, through exploratory study, a researcher can extract the factors underlying all prospective variables which have been selected on the pretext that they explain some or other dimension of the group behavior. Such study also reveals the number of variables which loads on each factor significantly and the percentage variability explained by each factor toward the group characteristics.

On the other hand in confirmative factor analysis, it is required to test the existing factor model. In other words, before starting the experiments, it is assumed that the factor analysis will produce only specified number of factors and specific number of variables are loaded on each factor and that the how much variability shall be explained by the identified factors. Thus, a factor model developed in an exploratory study is being tested in the confirmatory study to have its validity.

The factor analysis can be used to develop test battery for assessing group characteristics. To assess employee's performance, several variables like timeliness,

cost-effectiveness, absenteeism, tardiness, creativity, quality, adherence to policy, gossip and other personal habits, personal appearance, manager's appraisal, self-appraisal, and peer appraisal are usually measured. By using factor analysis, these variables can be clubbed into different factors. On the basis of variable's loading and their explainability, one or two variables from each factor can be selected to form the test battery. However, to validate the test battery, the confirmatory factor analysis must be done on similar but different sample groups.

Another application of factor analysis is in developing of a questionnaire. While doing item analysis, unimportant questions are removed from the questionnaire. Factor analysis may be used to indicate the loss in the measurement of variability in removing the unimportant questions from the final questionnaire. Further, it helps in classifying the questions into different parameters in the questionnaire.

What Is Factor Analysis?

Factor analysis is a multivariate statistical technique used to identify the factors underlying the variables by means of clubbing related variables in the same factor. It is a dimension reduction technique which reduces the large number of variables into few factors without sacrificing much, the power of explained variability by the variables. Variables are clubbed into different factors on the basis of their interrelation. In initial solution of factor analysis, variables may belong to more than one factor. But by using the factor rotation technique, these factors may be made mutually exclusive. Thus, instead of defining the group characteristics by the large number of variables, a few factors may do this job. The number of factors is identified by means of the criterion known as eigenvalue. The magnitude of variable's loading on the factor is used as a criterion for retaining that variable in the factor. Sufficient number of data set is required to run the factor analysis. As a thumb rule, number of data set should be at least five per variable. Thus, if there are 15 variables in the problem, the sample must be approximately 75. However, there is a procedure of testing the adequacy of sample size in running the factor analysis. This is done by using the KMO test. We shall discuss it in detail later in this chapter.

Terminologies Used in Factor Analysis

To understand the factor analysis technique, it is essential to know the meaning of various terms involved in it. It is assumed that the readers are familiar with the basic logic of statistical reasoning and the concepts of variance and correlation; if not, it is advised that they should read the basic statistics topic at this point, from the earlier chapters discussed in this book.

Principal Component Analysis

Principal component analysis (PCA) is closely related to factor analysis. It is used to reduce the large number of variables into smaller number of principal components that will account for most of the variance in the observed variables. In this method, the factor explaining the maximum variance is extracted first.

Principal component analysis method is used when the data on large number of variables are obtained and some of the variables are redundant. Here, redundancy means that some of the variables are correlated with one another, possibly because they are measuring the same construct. Because of this redundancy, one believes that it should be possible to reduce the observed variables into a smaller number of principal components that will account for most of the variance in the observed variables. In fact, principal component analysis is similar to the procedure used in exploratory factor analysis

One must understand that the principal component analysis and factor analysis are not same. In PCA, one performs a variance-maximizing rotation of the variable space, and it takes into account all variability in the variables. On the other hand, factor analysis is the procedure of estimating the amount of variability explained due to common factors (communality). These two methods become same if the error terms in the factor analysis model (the variability not explained by common factors) can be assumed to have the same variance.

Factor Loading

Factor loading can be defined as the correlation coefficient between the variable and factor. Just like Pearson's *r*, the squared factor loading of a variable indicates the percentage variability explained by the factor in that variable. As a rule of thumb, 0.7 or higher factor loading represents that the factor extracts sufficient variance from that variable. The percentage variance explained in all the variables accounted for by each factor can be computed by dividing the sum of the squared factor loadings for that factor divided by the number of variables and multiplied by 100.

Communality

The communality can be defined as the sum of the squared factor loadings of a variable in all the factors. It is the variance in that variable accounted for by all the factors. The communality of variable is represented by h^2. It measures the percentage of variance in a given variable explained by all the factors jointly and may be considered as the reliability of the variable. Low communality of a variable indicates that the variable is not useful in explaining the characteristics of the

group and the factor model is not working well for that variable. Thus, variables whose communalities are low should be removed from the model as such variables are not related to each other. Any variable whose communality is $<.4$ should usually be dropped. However, the communalities must be interpreted in relation to the interpretability of the factors. For instance a communality of .80 may seem to be high but becomes meaningless, unless the factor on which the variable is loaded is interpretable, normally it usually will be. On the other hand a communality of .25 may look to be low but becomes meaningful if the variable can well define the factor.

Hence, it is not the value of communality of a variable that is important, but the variable's role in interpretation of the factor is the important consideration. However, the variable whose communality is very high usually explain the factor well. If the value of communality is more than 1, then one must expect that something is wrong with the solution. Such situation indicates that either sample is too small or the researcher has identified too many or too few factors.

Eigenvalue

The eigenvalue for a given factor measures the variance in all the variables which is accounted for by that factor. It is also called as characteristics root. The sum of the eigenvalues of all the factors is equal to the number of variables. The decision about the number of factors to be retained in the factor analysis is taken on the basis of eigenvalues. If a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be dropped. Eigenvalues measure the amount of variation in the total sample accounted for by each factor.

Kaiser Criteria

While applying the factor analysis one needs to decide as to how many factors should be retained. As per the Kaiser's criteria only those factors having eigenvalue >1 should be retained in the factor analysis. Initially each variable is supposed to have its eigenvalue 1. Thus, it may be said that unless a factor extracts at least as much as the equivalent of one original variable, it is dropped. This criterion was proposed by Kaiser and is the most widely used by the researchers.

The Scree Plot

The scree plot is a graphical representation of the factors plotted along X-axis against their eigenvalues, on the Y-axis. As one moves toward the X-axis (factors), the eigenvalues drop. When the drop ceases and the curve makes an elbow toward

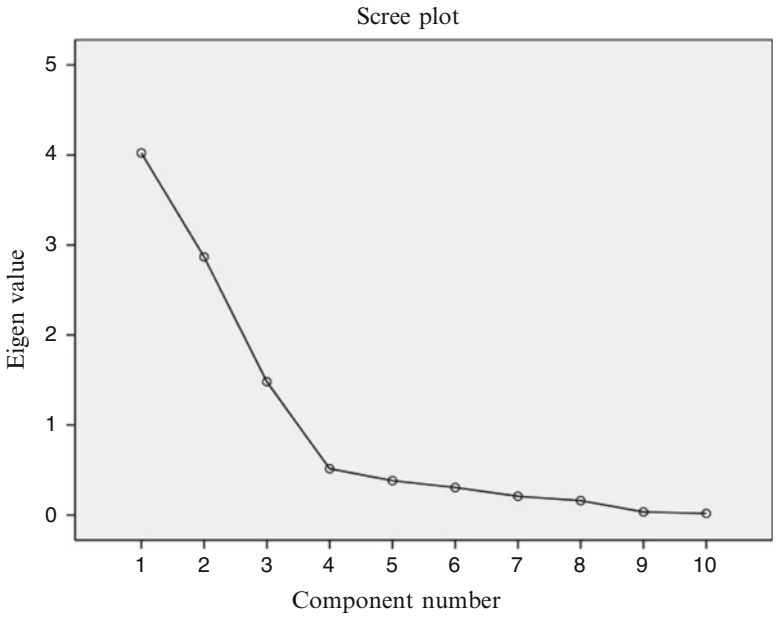


Fig. 11.1 Scree plot for the factors

less steep decline, Cattell's scree test says to drop all further components after the one starting the elbow. Thus, the factors above the elbow in the plot are retained. The *scree* test was developed by Cattell. "Scree" is a term used in geology. The scree is the rubble at the bottom of a cliff. In scree test, if a factor is important, it will have a large variance. The scree plot may look like Fig. 11.1.

Varimax Rotation

Unrotated factor solution obtained after applying the principal component analysis is rotated by using any of the rotational technique to enhance the interpretability of factors. The varimax rotation is the most widely used rotation technique in factor analysis. It is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor on all the variables in a factor matrix, which has the effect of relocating the original variables into extracted factor. After varimax rotation, each factor will tend to have either large or small loadings of any particular variable and thus facilitates a researcher to identify each variable in one and only one factor. This is the most common rotation option. Other rotational strategies are quartimax, equamax, direct oblimin, and promax methods which are not much used by the researcher.

What Do We Do in Factor Analysis?

The factor analysis involves different steps which are discussed below. You may not understand all the steps at a glance but do not lose heart and continue to read. After reading these steps, once you go through the solved example discussed later in this chapter, a full clarity of the concepts can be achieved. The steps discussed below cannot be done manually but may be achieved by using any statistical package. So try and relate these steps with the output of factor analysis.

1. Compute descriptive statistics for all the variables. Usually mean and standard deviation are provided by the standard statistical packages while running the factor analysis. However, you may run descriptive statistics program to compute other descriptive statistics like skewness, kurtosis, standard error, and coefficient of variability to understand the nature of the variables under study.
2. Prepare correlation matrix with all the variables taken in the study.
3. Apply KMO test to check the adequacy of data for running factor analysis. The value of KMO ranges from 0 to 1. The larger the value of KMO more adequate is the sample for running factor analysis. As a convention, any value of KMO more than .5 signifies the adequacy of sample for running the factor analysis. A value of 0 indicates that the distinct factors cannot be made and hence, the sample is not adequate. On the other hand, if its value is approaching 1, then the factor analysis yields distinct and reliable factors. Kaiser recommends accepting values >0.5 as acceptable (values below this should lead you to either collect more data or rethink which variables to include). Further, the values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great, and values above 0.9 are superb (Hutcheson and Sofroniou 1999).
4. Apply Bartlett's test of sphericity for testing the hypothesis that the correlation matrix is not an identity matrix. If the correlation matrix is an identity matrix, the factor analysis becomes inappropriate. Thus, if the Bartlett's test of sphericity is significant, it is concluded that the correlation matrix is not an identity matrix and the factor analysis can be run.
5. Obtain unrotated factor solution by using principal component analysis. This will provide you the number of factors along with their eigenvalues. We retain only those factors whose along with their eigenvalues. This can also be shown graphically by scree plot. This solution also provides the factor loadings of the variables on different factors, percentage variability explained by each factor, and the total variability explained by all the factors retained in the model.
6. Thus, this primary factor analysis solution can tell you the percentage of variability explained by all the identified factors together. However, it is not possible to identify the variables included in each factor because some of the variables may belong to more than one factor. This problem is sorted out by choosing the appropriate rotation technique.

7. Obtain final solution by using the varimax rotation option, available in SPSS. This will solve the problem of redundancy of variables in different factors. As a rule of thumb, if the factor loading of any variable on a factor is equal or more than 0.7, then it should belong to that factor. The reason for choosing 0.7 factor loading as a cut off point is that because factor loading represents correlation coefficient hence at least 49% ($= 0.7^2$) variability of the variable must be explained by the factor to which it belongs. However, other variables whose loadings are <0.7 can also be identified in that factor on the basis of its explainability.
8. Identified factors in step 6 are given names depending upon the nature of variables included in it.
9. If the purpose of the factor analysis is to develop a test battery also, then one or two variables from each factor may be selected on the basis of their magnitude of loadings. These variables so selected may form the test battery. Each variable in the test battery is assigned weight. The weights assigned to the variable in the test battery depend upon the percentage variability explained by the factor from which it belongs. Usually, the first factor explains the maximum variance, and therefore two or three variables may be kept from it depending upon the nature of the variables and its explainability. From rest of the factors, normally one variable per factor is selected, as the sole purpose of the factor analysis is to reduce the number of variables so that the maximum variance in the group may be explained.

Assumptions in Factor Analysis

While using the factor analysis, the following assumptions are made:

1. All the constructs which measure the concepts have been included in the study.
2. Sufficient sample size has been taken for factor analysis. Normally sample size must be equal to 5–20 times the number of variables taken in the study.
3. No outlier is present in the data.
4. Multicollinearity among the variables does not exist.
5. Homoscedasticity does not exist between the variables because factor analysis is a linear function of measured variables. The meaning of homoscedasticity between the variables is that the variance around the regression line is the same for all values of the predictor variable (X).
6. Variables should be linear in nature. Nonlinear variables may also be used after transforming it into linear variables.
7. Data used in the factor analysis is based on interval scale or ratio scale.

Characteristics of Factor Analysis

Following are some of the important features of factor analysis:

- The variables used in the factor analysis may be objective or subjective provided subjective variables can be expressed into scores.
- The factor analysis extracts the hidden dimensions among the variables which may not be observable from direct analysis.
- This analysis is simple and inexpensive to perform.

Limitations of Factor Analysis

Although the factor analysis is very useful multivariate statistical technique, however, it has some limitations as well.

- Much of the advantage of factor analysis technique can be achieved only if the researcher is able to collect a sufficient set of product attributes. If some of the important attributes are missed out, the results of factor analysis will not be efficient.
- If majority of the variables are highly related to each other and distinct from other items, factor analysis will assign a single factor to them. This will not reveal other factors that capture more interesting relationships.
- Naming the factors may require researcher's knowledge about the subject matter and theoretical concepts, because often multiple attributes can be highly correlated for no apparent reason.

Research Situations for Factor Analysis

Since factor analysis is used to study the group characteristics by means of identified factors out of the large number of variables, it has tremendous application in management, social sciences, and humanities. Few research applications are discussed below:

1. To understand the buying behavior of a particular product, several parameters like customer's age, education, job status, salary, exposure to product advertisement, and availability are responsible. Factor analysis may help the market analysts to identify few factors instead of large number of parameters to develop the marketing strategy for launching the product.
2. In a mall, it is interesting to see the buying behaviour of the customers. On the basis of the customer's purchase history, the articles may be clubbed together and kept in nearby counters to enhance the sale.

3. In an educational institution, the administration may be interested to know the factors that are responsible for enhancing the status of the institution. Such accomplishment can be achieved by controlling a large number of parameters. The factor analysis may extract the underlying factors like academic curriculum, student's facilities, counseling procedure, and placement opportunity on which the administration may concentrate to improve its image instead of large number of parameters.
4. To evaluate a product, a survey technique can be used to identify various parameters. Based on it, factor analysis can identify few factors on which management can take decisions to promote their product.
5. Factor analysis may be used to create a lifestyle questionnaire for evaluating the quality of life. After dropping the questions from the questionnaire on the basis of item analysis, factor analysis provides the insight as to how much efficiency has been sacrificed due to it.

Solved Example of Factor Analysis Using SPSS

Example 11.1

An industrial researcher wanted to investigate the climate of an organization. A set of 12 questions were developed to measure different parameters of the climate. The subject could respond these questions on five-point scale with 5 indicating strongly agree and 1 strongly disagree attitude towards the question. The responses obtained on the questionnaire are shown in Table 11.1 along with the description of the questions. Apply factor analysis technique to study the factor structure and suggest the test battery that can be used for assessing the climate of any industrial organization. Also apply the scree test for retaining factors graphically and KMO test for testing the adequacy of data.

Statements

1. Employees are encouraged to attend training programs organized by outside agencies.
2. Any employee can reach up to the top level management position during their carrier.
3. Employees are praised by the immediate boss for doing something useful in the organization
4. Medical facilities for the employees and their families are excellent
5. Employees are given preference in jobs announced by the group of companies.
6. For doing some creative work or working creatively, employees get incentives
7. Employee's children are honored for their excellent performance in their education.
8. Employees are cooperative in helping each other to solve their professional problems
9. Fees of employees children are reimbursed during their schooling

Table 11.1 Data on the parameters of organizational climate

S.N	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
1	3	2	4	1	3	5	4	2	2	4	3	4
2	3	3	5	2	3	4	5	1	3	5	4	5
3	5	3	4	2	2	5	5	2	3	4	3	4
4	3	4	4	1	3	4	4	1	2	5	3	4
5	4	3	4	2	2	5	4	2	3	4	2	4
6	3	2	5	2	3	4	5	1	4	5	5	5
7	5	3	4	2	2	4	4	2	3	4	2	4
8	4	4	5	1	1	4	4	1	2	4	3	2
9	5	3	4	2	3	4	4	3	3	3	2	4
10	5	3	5	2	2	5	5	2	4	4	4	5
11	4	4	4	1	3	5	5	2	3	4	3	3
12	4	2	5	2	4	5	4	1	2	5	2	2
13	3	2	4	1	3	4	4	1	3	2	3	3
14	5	3	5	2	2	5	4	2	3	5	2	4
15	4	3	4	1	3	4	5	1	2	4	3	4
16	4	2	4	3	2	4	5	2	3	3	2	5
17	2	3	4	2	3	4	4	2	4	4	3	3
18	4	2	5	2	4	5	4	3	3	5	2	4
19	3	3	4	1	3	3	4	2	2	4	3	4
20	4	3	4	2	2	4	5	3	3	3	2	5
21	5	4	4	1	3	4	5	2	2	4	3	3
22	4	3	5	2	4	5	4	1	3	5	4	4
23	3	2	4	1	3	5	4	2	2	5	3	5
24	4	3	4	2	2	4	4	1	3	4	2	4
25	5	2	5	3	3	5	5	2	4	5	3	3

10. Employees get fast promotion if their work is efficient and consistence
11. Senior managers are sensitive to the personal problems of their employees.
12. Employees get cheaper loan for buying vehicles.

Solution

By applying the factor analysis following issues shall be resolved:

1. To decide the number of factors to be retained and the total variance explained by these factors
2. To identify the variables in each factor retained in the final solution, on the basis of its factor loadings
3. To give names to each factor retained on the basis of the nature of variables included in it
4. To suggest the test battery for assessing the climate of any industrial organization
5. To test the adequacy of sample size used in factor analysis

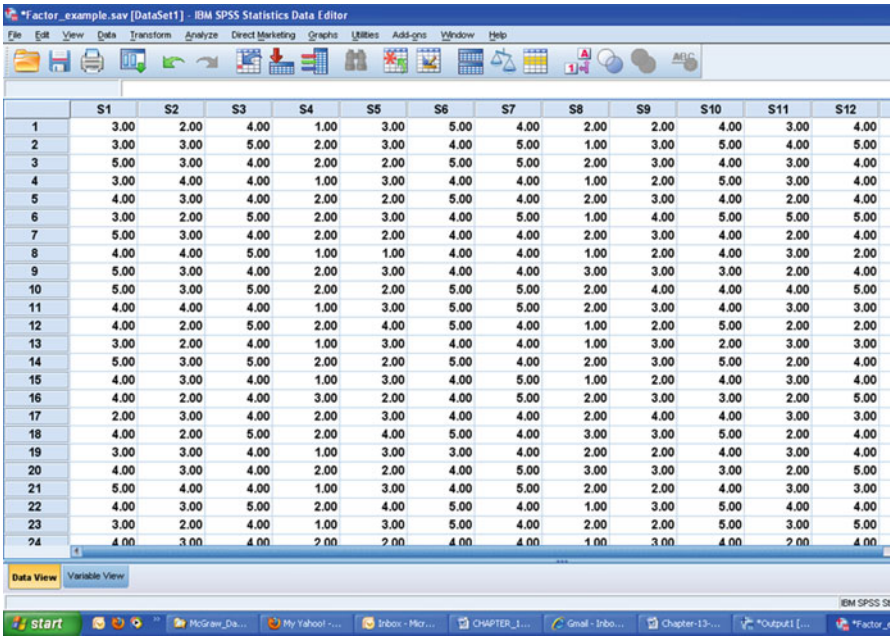
These objectives will be achieved by generating the output of factor analysis in SPSS. Thus, the procedure of using SPSS for factor analysis in the given example shall be discussed first, and thereafter the output shall be explained in the light of the objectives to be fulfilled in this study.

SPSS Commands for the Factor Analysis

Before running the SPSS commands for factor analysis, a data file needs to be prepared. By now, you must have been familiar in preparing the data file. If not, you may go through the procedure discussed in Chap. 1 in this regard. Do the following steps for generating outputs in factor analysis:

(i) *Data file*: In this problem, all 12 statements are independent variables. These variables have been defined as 'Scale' variable because they were measured on interval scale. Variables measured on interval as well as ratio scales are treated as scale variable in SPSS. After preparing the data file by defining variable names and their labels, it will look like Fig. 11.2.

(ii) *Initiating command for factor analysis*: Once the data file is prepared, click the following command sequence in the Data View:



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
1	3.00	2.00	4.00	1.00	3.00	5.00	4.00	2.00	2.00	4.00	3.00	4.00
2	3.00	3.00	5.00	2.00	3.00	4.00	5.00	1.00	3.00	5.00	4.00	5.00
3	5.00	3.00	4.00	2.00	2.00	5.00	5.00	2.00	3.00	4.00	3.00	4.00
4	3.00	4.00	4.00	1.00	3.00	4.00	4.00	1.00	2.00	5.00	3.00	4.00
5	4.00	3.00	4.00	2.00	2.00	5.00	4.00	2.00	3.00	4.00	2.00	4.00
6	3.00	2.00	5.00	2.00	3.00	4.00	5.00	1.00	4.00	5.00	5.00	5.00
7	5.00	3.00	4.00	2.00	2.00	4.00	4.00	2.00	3.00	4.00	2.00	4.00
8	4.00	4.00	5.00	1.00	1.00	4.00	4.00	1.00	2.00	4.00	3.00	2.00
9	5.00	3.00	4.00	2.00	3.00	4.00	4.00	3.00	3.00	3.00	2.00	4.00
10	5.00	3.00	5.00	2.00	2.00	5.00	5.00	2.00	4.00	4.00	4.00	5.00
11	4.00	4.00	4.00	1.00	3.00	5.00	5.00	2.00	3.00	4.00	3.00	3.00
12	4.00	2.00	5.00	2.00	4.00	5.00	4.00	1.00	2.00	5.00	2.00	2.00
13	3.00	2.00	4.00	1.00	3.00	4.00	4.00	1.00	3.00	2.00	3.00	3.00
14	5.00	3.00	5.00	2.00	2.00	5.00	4.00	2.00	3.00	5.00	2.00	4.00
15	4.00	3.00	4.00	1.00	3.00	4.00	5.00	1.00	2.00	4.00	3.00	4.00
16	4.00	2.00	4.00	3.00	2.00	4.00	5.00	2.00	3.00	3.00	2.00	5.00
17	2.00	3.00	4.00	2.00	3.00	4.00	4.00	2.00	4.00	4.00	3.00	3.00
18	4.00	2.00	5.00	2.00	4.00	5.00	4.00	3.00	3.00	5.00	2.00	4.00
19	3.00	3.00	4.00	1.00	3.00	3.00	4.00	2.00	2.00	4.00	3.00	4.00
20	4.00	3.00	4.00	2.00	2.00	4.00	5.00	3.00	3.00	3.00	2.00	5.00
21	5.00	4.00	4.00	1.00	3.00	4.00	5.00	2.00	2.00	4.00	3.00	3.00
22	4.00	3.00	5.00	2.00	4.00	5.00	4.00	1.00	3.00	5.00	4.00	4.00
23	3.00	2.00	4.00	1.00	3.00	5.00	4.00	2.00	2.00	5.00	3.00	5.00
24	4.00	3.00	4.00	2.00	2.00	4.00	4.00	1.00	3.00	4.00	2.00	4.00

Fig. 11.2 Screen showing data file for the factor analysis in SPSS

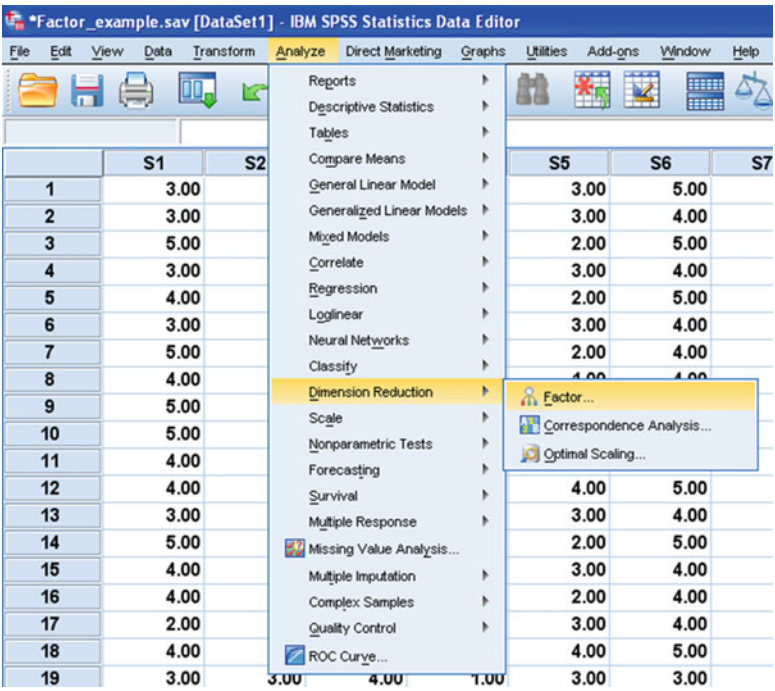


Fig. 11.3 Screen showing SPSS commands for factor analysis

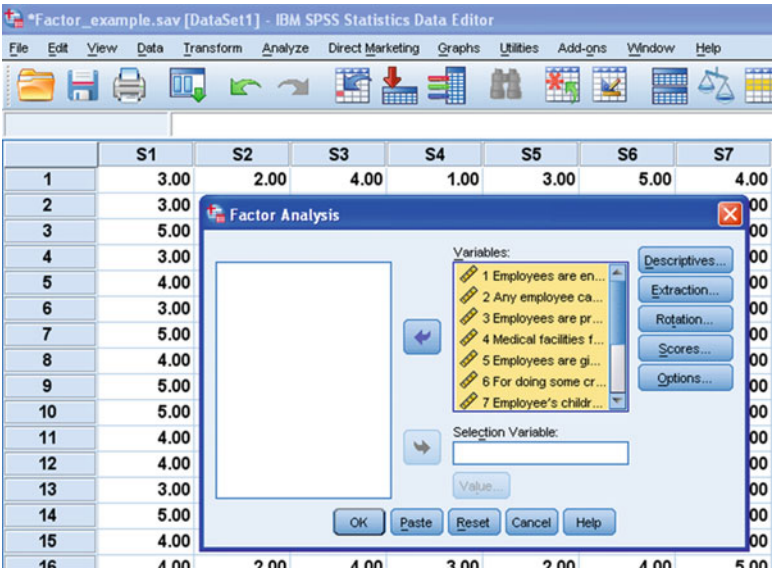


Fig. 11.4 Screen showing selection of variables for factor analysis

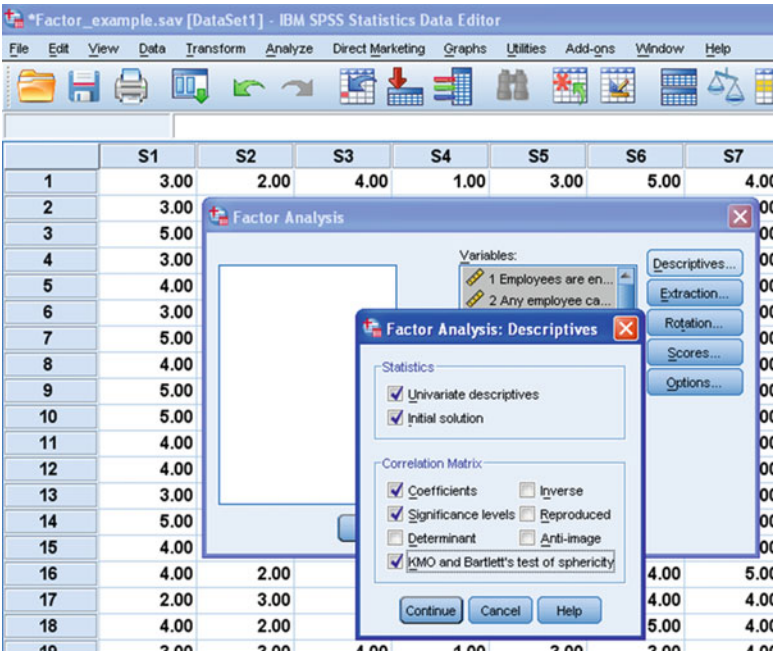


Fig. 11.5 Screen showing option for correlation matrix and initial factor solution

Analyze → Dimension Reduction → Factor

The screen shall look like as shown in Fig. 11.3.

(iii) *Selecting variables for factor analysis*: After clicking the **Factor** option, the SPSS package will take you to the next screen for selecting variables. Select all the variables from left panel to the "Variables" section of the right panel. The screen will look like Fig. 11.4.

(iv) *Selecting options for computation*: After selecting the variables, various options need to be defined for generating the output in factor analysis. Do the following:

- Click the tag **Descriptives** in the screen shown in Fig. 11.5 and
  - Check the option "Univariate descriptive" and ensure that the option "Initial Solution" is checked in the Statistics section by default.
  - Check the option "Coefficients," "Significance levels," and "KMO and Bartlett's test of sphericity" in "Correlation Matrix" section.

    The screen will look like Fig. 11.5.
  - Press ***Continue***. This will again take you back to the screen shown in Fig. 11.4.
- Now click the tag **Extraction** and then check "Scree plot." Let other options remain as it is by default.

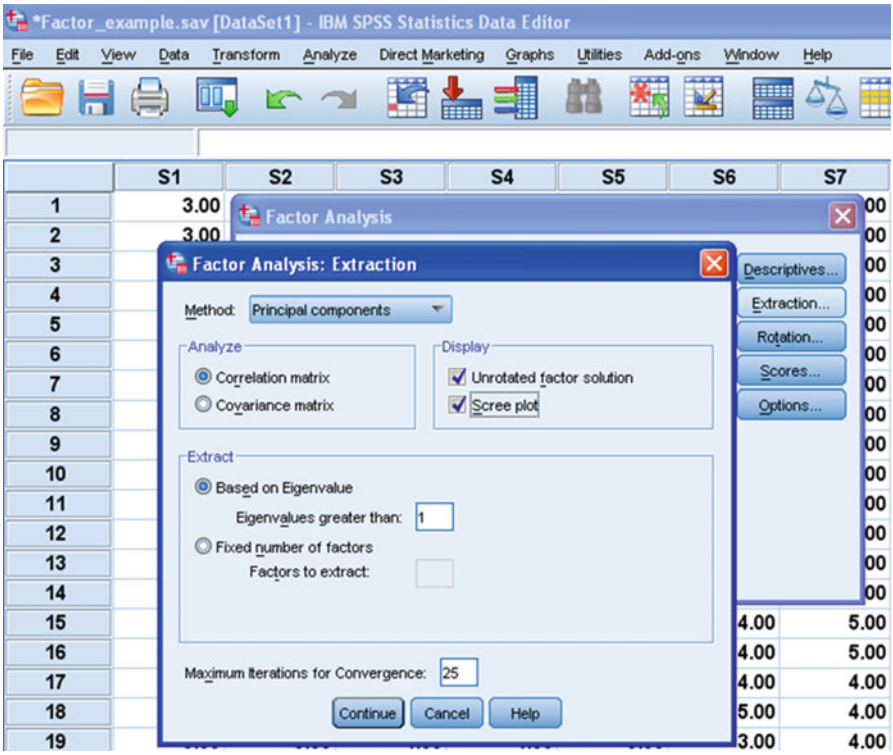


Fig. 11.6 Screen showing option for unrotated factor solution and scree plot

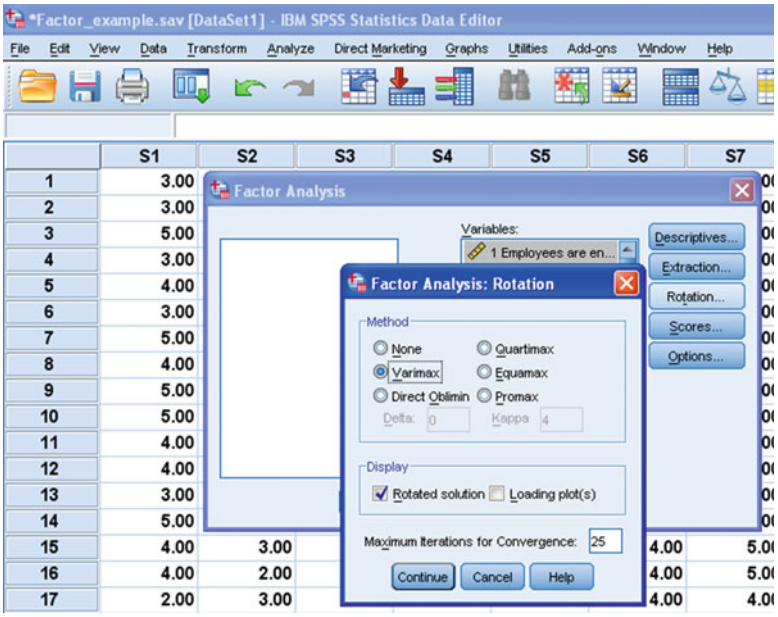


Fig. 11.7 Screen showing option for factor rotation

The screen shall look like Fig. 11.6.

- Press ***Continue***. This will again take you back to the screen shown in Fig. 11.4.
- Now click the tag **Rotation** and then check "Varimax" rotation option. Let other options remain as it is by default.
  - The screen shall look like Fig. 11.7.
  - Press ***Continue*** to go back to the main screen.
- Press **OK** for output.

(v) *Getting the output*: After pressing **OK** in the screen shown in Fig. 11.4, the SPSS will generate the outputs in the output window. These outputs can be selected by using the right click of the mouse and may be pasted in the word file. The SPSS shall generate many outputs, but the following relevant outputs have been selected for the discussion:

(a) Descriptive statistics
(b) Correlation matrix
(c) KMO and Bartlett's test
(d) Communalities of all the variables
(e) Total variance explained
(f) Scree plot
(g) Component matrix: unrotated factor solution
(h) Rotated component matrix: varimax-rotated solution

In this example, all the outputs so generated by the SPSS are shown in Tables 11.2–11.7 and Fig. 11.8.

Interpretation of Various Outputs Generated in Factor Analysis

The above-mentioned outputs generated in this example by the SPSS shall be discussed to provide the answers to various issues related to model developed in this study.

1. Table 11.2 shows the mean and SD for all the variables in the study. You may add some more statistics like coefficient of variation, skewness, kurtosis, and range to study the nature of variables. However, in that case, you have to use the SPSS option of **Descriptive** discussed in Chap. 2 of this book.
2. Table 11.3 is the correlation matrix of all the variables. This is the first step in factor analysis on the basis of which variables are grouped into factors. The SPSS provides significance value (p value) for each correlation coefficient. However, values of correlation coefficient required for its significance at 1% as well as 5% can be seen from Table A.3 in the Appendix. Meaningful conclusions can be drawn from this table for understanding relationships among variables.

Table 11.2 Descriptive statistics for the parameters of organizational climate

		Mean	Std. deviation	*N*
1	Employees are encouraged to attend training programs organized by outside agencies	3.9200	.86217	25
2	Any employee can reach up to the top level management position during their carrier	2.8400	.68799	25
3	Employees are praised by the immediate boss for doing something useful in the organization	4.3600	.48990	25
4	Medical facilities for the employees and their families are excellent	1.7200	.61373	25
5	Employees are given preference in jobs announced by the group of companies	2.7200	.73711	25
6	For doing some creative work or working creatively, employees get incentives	4.4000	.57735	25
7	Employee's children are honored for their excellent performance in their education	4.4000	.50000	25
8	Employees are cooperative in helping each other to solve their professional problems	1.7600	.66332	25
9	Fees of Employees children are reimbursed during their schooling	2.8400	.68799	25
10	Employees get fast promotion if their work is efficient and consistence	4.1600	.80000	25
11	Senior managers are sensitive to the personal problems of their employees	2.8400	.80000	25
12	Employees get cheaper loan for buying vehicles	3.8800	.88129	25

3. Table 11.4 shows the result of KMO test, which tells whether sample size taken for the factor analysis was adequate or not. It tests whether the partial correlations among variables are small. The value of KMO ranges from 0 to 1. The closer the value of KMO to 1, the more adequate is the sample size to run the factor analysis. Usually the value of KMO more than 0.5 is considered to be sufficient for doing factor analysis reliably. In this case, KMO value is 0.408, which is <.5; hence, the sample size is not adequate, and more samples should be taken for the analysis. Since this is a simulated example developed to make the procedure clear, hence less number of data set was taken.
   Further, Bartlett's test of sphericity is used to test the null hypothesis that the correlation matrix is an identity matrix. Since significance value (*p* value) of Bartlett's test is .002 in Table 11.4, which is <.01, hence it is significant, and the correlation matrix is not an identity matrix. Thus, it may be concluded that the factor model is appropriate.
4. Table 11.5 shows the communalities of all the variables. Higher communality of a variable indicates that the major portion of its variability is explained by all the identified factors in the analysis. If communality of variable is <.4, it is considered to be useless and should normally be removed from the model. From Table 11.5, it can be seen that the communalities of all the variables are more than .4; hence, all the variables are useful in the model.

Table 11.3 Correlation matrix for the parameters of the organizational climate

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
S1	1	0.188	0.17	0.35	−0.299	0.318	0.271	0.329	0.118	−0.041	−0.321	−0.068
S2	0.188	1	−0.193	−0.407*	−0.339	−0.252	0.073	−0.088	−0.232	−0.027	0.027	−0.239
S3	0.17	−0.193	1	0.349	0.175	0.354	0.068	−0.236	0.302	0.591**	0.366	−0.089
S4	0.35	−0.407*	0.349	1	−0.088	0.212	0.244	0.237	0.679**	0.095	−0.18	0.243
S5	−0.299	−0.339	0.175	−0.088	1	0.176	−0.136	−0.058	−0.092	0.362	0.203	−0.118
S6	0.318	−0.252	0.354	0.212	0.176	1	0	0.152	0.168	0.397*	−0.036	−0.066
S7	0.271	0.073	0.068	0.244	−0.136	0	1	0.05	0.315	−0.063	0.375	0.303
S8	0.329	−0.088	−0.236	0.237	−0.058	0.152	0.05	1	0.186	−0.239	−0.468	0.234
S9	0.118	−0.232	0.302	0.679**	−0.092	0.168	0.315	0.186	1	−0.027	0.254	0.242
S10	−0.041	−0.027	0.591**	0.095	0.362	0.397*	−0.063	−0.239	−0.027	1	0.302	0.028
S11	−0.321	0.027	0.366	−0.18	0.203	−0.036	0.375	−0.468	0.254	0.302	1	0.208
S12	−0.068	−0.239	−0.089	0.243	−0.118	−0.066	0.303	0.234	0.242	0.028	0.208	1

Value of "r" required for its significance at .05 level = 0.396, $d.f$ = N−2 = 23, * Significant at .05 level
Value of "r" required for its significance at .01 level = 0.505, $d.f$ = N−2 = 23, ** Significant at .01 level

Table 11.4 KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		.408
Bartlett's test of sphericity	Approx. chi-square	105.281
	df	66
	Sig.	.002

Table 11.5 Communalities of all the variables

		Initial	Extraction
1	Employees are encouraged to attend training programs organized by outside agencies	1.000	.810
2	Any employee can reach up to the top level management position during their carrier	1.000	.761
3	Employees are praised by the immediate boss for doing something useful in the organization	1.000	.764
4	Medical facilities for the employees and their families are excellent	1.000	.756
5	Employees are given preference in jobs announced by the group of companies	1.000	.597
6	For doing some creative work or working creatively, employees get incentives	1.000	.602
7	Employee's children are honored for their excellent performance in their education	1.000	.635
8	Employees are cooperative in helping each other to solve their professional problems	1.000	.613
9	Fees of employees children are reimbursed during their schooling	1.000	.665
10	Employees get fast promotion if their work is efficient and consistence	1.000	.680
11	Senior managers are sensitive to the personal problems of their employees	1.000	.868
12	Employees get cheaper loan for buying vehicles	1.000	.548

Table 11.6 Total variance explained

	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Component	Total	% of variance	cumulative %	Total	% of variance	cumulative %	Total	% of variance	cumulative %
1	2.721	22.677	22.677	2.721	22.677	22.677	2.312	19.266	19.266
2	2.360	19.668	42.345	2.360	19.668	42.345	2.232	18.601	37.867
3	1.728	14.403	56.748	1.728	14.403	56.748	2.083	17.355	55.222
4	1.488	12.397	69.144	1.488	12.397	69.144	1.671	13.923	69.144
5	.951	7.929	77.073						
6	.740	6.165	83.238						
7	.589	4.907	88.145						
8	.558	4.646	92.791						
9	.371	3.089	95.880						
10	.278	2.320	98.200						
11	.143	1.191	99.390						
12	.073	.610	100.000						

Extraction method: Principal component analysis

Table 11.7 Component matrix[a] unrotated factor solution

		Component			
		1	2	3	4
1	Employees are encouraged to attend training programs organized by outside agencies	0.303	0.549	−0.285	0.58
2	Any employee can reach up to the top level management position during their carrier	−0.467	0.057	0.172	0.715
3	Employees are praised by the immediate boss for doing something useful in the organization	0.681	−0.429	−0.15	0.306
4	Medical facilities for the employees and their families are excellent	0.763	0.4	−0.048	−0.109
5	Employees are given preference in jobs announced by the group of companies	0.156	−0.567	−0.282	−0.414
6	For doing some creative work or working creatively, employees get incentives	0.539	−0.071	−0.535	0.139
7	Employee's children are honored for their excellent performance in their education	0.386	0.21	0.601	0.285
8	Employees are cooperative in helping each other to solve their professional problems	0.131	0.689	−0.25	−0.243
9	Fees of employees children are reimbursed during their schooling	0.712	0.251	0.297	−0.082
10	Employees get fast promotion if their work is efficient and consistence	0.444	−0.615	−0.25	0.205
11	Senior managers are sensitive to the personal problems of their employees	0.279	−0.615	0.631	0.119
12	Employees get cheaper loan for buying vehicles	0.321	0.217	0.505	−0.377

Extraction method: Principal component analysis
[a]Four components extracted

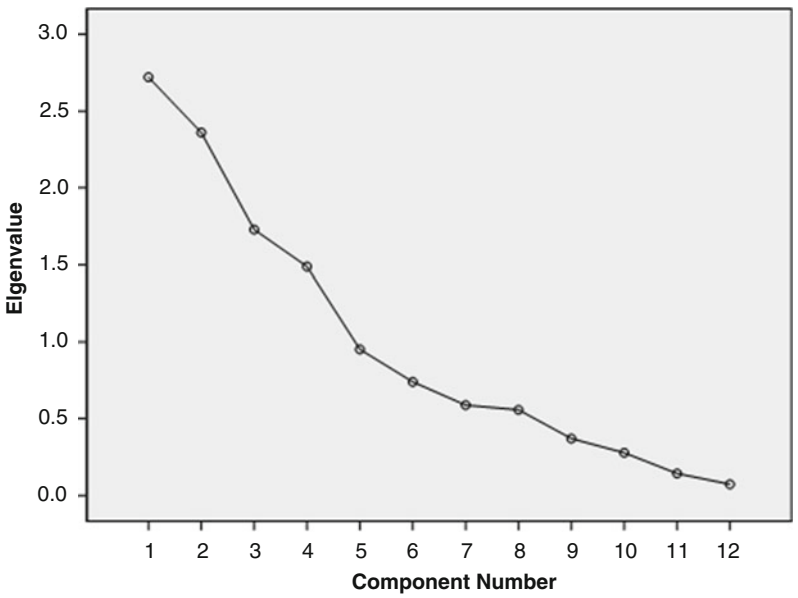


Fig. 11.8 Scree plot for the factors

5. Table 11.6 shows the factors extracted and the variance explained by these factors. It can be seen that after rotation, the first, second, third, and fourth factors explain 19.266, 18.601, 17.355, and 13.923% of the total variance, respectively. Thus, all these four factors together explain 69.144% of the total variance.
   The eigenvalues for each of the factor are shown in Table 11.6. Only those factors are retained whose eigenvalues are 1 or more than 1. Here, you can see that the eigenvalue for the first four factors are >1; hence, only four factors have been retained in this study.
   Figure 11.8 shows the scree plot which is obtained by plotting the factors (along X-axis) against their eigenvalues (along Y-axis). This plot shows that only four factors have eigenvalues above elbow bent; hence, only four factors have been retained in this study.
6. Table 11.7 shows the first initial unrotated solution of the factor analysis. Four factors have been extracted in this study. The factor loadings of all the variables on each of the four factors have been shown in this table. Since this is an unrotated factor solution, and therefore some of the variables may show their contribution in more than one factor. In order to avoid this situation, the factors are rotated. Varimax rotation has been used in this example to rotate the factors, as this is the most popular method used by the researchers due to its efficiency.
7. After using the varimax rotation, the final solution so obtained is shown in Table 11.8. Clear picture emerges in this final solution about the variables explaining the factors correctly. The rotation facilitates the variable to appear in one and only factor.
   Variables are usually identified in a factor if their loading on that factor is 0.7 or more. This ensures that the factor extracts sufficient variance from that variable. However, one may reduce this threshold value if sufficient variables cannot be identified in the factor. In this problem, the variables have been retained in a factor in which its loadings are greater than or equal to 0.6. Owing to this criterion variables have been grouped in each of the four factors, namely, welfare, motivation, interpersonal relation, and career which are shown in Tables 11.9, 11.10, 11.11, and 11.12.
   Factor 1 in Table 11.9 contains variables that measure the welfare of employees in an organization, and therefore it may be termed as "*Welfare Factor*." On the other hand, all items mentioned in Table 11.10 measure the motivation of employees; hence, factor 2 is named as "Motivation Factor." Similarly the items in Tables 11.11 and 11.12 are related with measuring relationships among employees and career-related issues; hence, factor 3 and factor 4 may be termed as "*interpersonal relation factor*" and "*career factor,*" respectively.
   In order to develop a test battery to measure the climate of an organization, one may choose variables from these identified factors. Since percentage contribution of each factor in the measurement of total variability are more or less same, hence one variable from each factor having highest loadings on the factor may be picked up to develop the test battery for measuring the climate of an organization. Thus, the test battery so developed is shown in Table 11.13. One may

Table 11.8 Rotated component matrix[a]: varimax-rotated solution

		Component			
		1	2	3	4
1	Employees are encouraged to attend training programs organized by outside agencies	0.124	0.385	−0.482	0.644
2	Any employee can reach up to the top level management position during their carrier	−0.382	−0.153	0.23	0.734
3	Employees are praised by the immediate boss for doing something useful in the organization	0.19	0.809	0.271	−0.021
4	Medical facilities for the employees and their families are excellent	0.689	0.365	−0.385	−0.016
5	Employees are given preference in jobs announced by the group of companies	−0.15	0.291	0.164	−0.68
6	For doing some creative work or working creatively, employees get incentives	0.038	0.722	−0.268	−0.084
7	Employee's children are honored for their excellent performance in their education	0.621	−0.01	0.256	0.429
8	Employees are cooperative in helping each other to solve their professional problems	0.252	−0.114	−0.732	0.012
9	Fees of employees children are reimbursed during their schooling	0.785	0.214	−0.051	0.025
10	Employees get fast promotion if their work is efficient and consistence	−0.079	0.725	0.339	−0.185
11	Senior managers are sensitive to the personal problems of their employees	0.307	0.125	0.87	−0.048
12	Employees gets cheaper loan for buying vehicles	0.671	−0.261	0.055	−0.159

Extraction method: Principal component analysis
Rotation method: Varimax with Kaiser normalization
[a]Rotation converged in seven iterations

Table 11.9 Factor 1: *welfare*

Items		Loadings
4	Medical facilities for the employees and their families are excellent	0.689
7	Employee's children are honored for their excellent performance in their education	0.621
9	Fees of employees children are reimbursed during their schooling	0.785
12	Employees get cheaper loan for buying vehicles	0.671

choose more than one variable from one or two factors also, depending upon their explainability.

Readers are advised to run the confirmatory factor analysis with more data set to these questions before using this instrument to measure the organizational climate because this was a simulated study.

Table 11.10 Factor 2: *motivation*

Items		Loadings
3	Employees are praised by the immediate boss for doing something useful in the organization	0.809
6	For doing some creative work or working creatively, employees get incentives	0.722
10	Employees get fast promotion if their work is efficient and consistence	0.725

Table 11.11 Factor 3: *interpersonal relation*

Items		Loadings
8	Employees are cooperative in helping each other to solve their professional problems	−0.732
11	Senior managers are sensitive to the personal problems of their employees	0.87

Table 11.12 Factor 4: *career*

Items		Loadings
1	Employees are encouraged to attend training programs organized by outside agencies	0.644
2	Any employee can reach up to the top level management position during their carrier	0.734
5	Employees are given preference in jobs announced by the group of companies	−0.68

Table 11.13 Test battery for measuring the climate of an organization

Items		Loadings
9	Fees of employees children are reimbursed during their schooling	0.785
10	Employees get fast promotion if their working is efficient and consistence	0.725
11	Senior managers are sensitive to the personal problems of their employees	0.87
2	Any employee can reach up to the top level management position during their carrier	0.734

Summary of the SPSS Commands for Factor Analysis

(i) Start SPSS and prepare data file by defining the variables and their properties in **Variable View** and typing the data column-wise in **Data View**.

(ii) In the data view, follow the below-mentioned command sequence for factor analysis:

Analyze → Dimension Reduction → Factor

(iii) Select all the variables from left panel to the "Variables" section of the right panel.

(iv) Click the tag **Descriptives** and check the options "Univariate descriptives," "Initial Solution," "Coefficients," "Significance levels," and "KMO and Bartlett's test of sphericity." Press ***Continue***.

(v) Click the tag **Extraction** and then check "Scree plot." Let other options remain as it is by default. Press ***Continue***.

(vi) Click the tag **Rotation** and then check "Varimax" rotation option. Let other option remains as it is by default. Press ***Continue***.
(vii) Click **OK** for output.

Exercise

Short Answer Questions

Note: Write answer to each of the following questions in not more than 200 words.

Q.1. What do you mean by a factor? What is the criterion of retaining a factor in a study and identifying the variables in it?
Q.2. How the factor analysis is useful in understanding the group characteristics
Q.3. Describe an experimental situation in which the factor analysis can be used.
Q.4. How factor analysis can be useful in developing a questionnaire?
Q.5. Discuss the procedure of developing a test battery to assess the lifestyle of employees of an organization.
Q.6. What is principal component analysis and how it is used in factor analysis?
Q.7. What do you mean by eigenvalue? How the Kaiser's criterion works in retaining factors in the model?
Q.8. What do you mean by scree test? How is it useful in identifying the factors to be retained through graph?
Q.9. What is the importance of communality in factor analysis?
Q.10. What is the significance of factor loadings? How it is used to identify the variables to be retained in the factors?
Q.11. Why the factors are rotated to get the final solution in factor analysis? Which is the most popular rotation method and why?

Multiple-Choice Questions

Note: Question no. 1–10 has four alternative answers for each question. Tick marks the one that you consider the closest to the correct answer.

1. Factor analysis is a technique for

   (a) Correlation analysis
   (b) Dimension reduction
   (c) Finding the most important variable
   (d) Comparing factors

2. Principal component analysis extracts the maximum variance in the

   (a) Last extracted factor
   (b) Second extracted factor
   (c) First extracted factor
   (d) Any extracted factor

3. In exploratory factor analysis,

   (a) The factors are identified among the large number of variables
   (b) The variables are clubbed into the factors
   (c) The variables that do not contribute to the factor model are removed
   (d) Factor model is tested

4. The sample is adequate in factor analysis if the value of KMO is

   (a) <0.5
   (b) $\geq 0.0.5$
   (c) 0
   (d) 1

5. The variable's variability is considered to be measured by the identified factors if its communality is

   (a) ≥ 0.3
   (b) ≥ 0.6
   (c) ≥ 0.4
   (d) 1

6. Choose the correct sequence of SPSS commands for factor analysis

   (a) Analyze → Dimension Reduction → Factor
   (b) Analyze → Factor → Dimension Reduction
   (c) Factor → Dimension Reduction → Analyze
   (d) Dimension Reduction → Factor → Analyze

7. Owing to Kaiser's criteria the factor is retained if its eigenvalue is

   (a) Less than 1
   (b) Equal to 1
   (c) More than 2
   (d) More than 1

8. Scree test is the graph between

   (a) Eigenvalues and factors
   (b) Percentage variance explained and factors
   (c) Maximum factor loadings in the factors and factors
   (d) Communality and factor

9. Conventionally a variable is retained in a factor if its loading is greater than or equal to

   (a) 0.4
   (b) 0.5
   (c) 0.7
   (d) 0.2

10. Varimax rotation is used to get the final solution. After rotation

    (a) Factor explaining maximum variance is extracted first
    (b) All factors whose eigenvalues are more than 1 are extracted
    (c) Three best factors are extracted
    (d) Non overlapping of variables in the factors emerges

11. Eigen value is also known as

    (a) Characteristics root
    (b) Factor loading
    (c) Communality
    (d) None of the above

12. KMO test in factor analysis is used to test whether

    (a) Factors extracted are valid or not?
    (b) Variables identified in each factor are valid or not?
    (c) Sample size taken for the factor analysis was adequate or not?
    (d) Multicolinearity among the variables exists or not?

13. Bartlett's test in factor analysis is used for testing

    (a) Same adequacy
    (b) Whether correlation matrix is identity matrix
    (c) Usefulness of variable
    (d) Retaining the factors in the model

14. While using factor analysis certain assumptions need to be satisfied. Choose the most appropriate assumption

    (a) Data used in the factor analysis is based on interval scale or ratio scale
    (b) Multicolinearity among the variables exist
    (c) Outlier is present in the data
    (d) Size of the sample does not affect the analysis.

Assignments

1. It is decided to measure the personality profile of the senior executives in a manufacturing industry. Eleven personality characteristics were measured on 30 senior executives chosen randomly from an organization. Marks on each of these characteristics were measured on a ten-point scale. The meaning for each of these characteristics is described below the table. The data so obtained are shown in the following table. Apply factor analysis using varimax rotation. Discuss your findings and answer the following questions:

    (a) Whether data is adequate for factor analysis?
    (b) Whether sphericity is significant?
    (c) How many factors have been extracted?
    (d) In your opinion, what should be the name of the factors?
    (e) What factor loadings you suggest for a variable to qualify in a factor?
    (f) Can you suggest the test battery for screening the personality characteristics of an executive?

Data on personality characteristics obtained on senior executives

S. N.	Friend	Achiev	Order	Auto	Domi	Sensit	Exhibit	End	Need	Help_Tem	Le_change
1	6	3	5	8	7	6	8	4	7	9	8
2	7	4	4	6	8	7	7	5	8	8	7
3	6	5	5	7	9	8	8	3	9	8	9
4	7	4	4	6	8	8	7	5	7	7	8
5	8	3	5	8	7	7	8	4	8	8	7
6	6	4	4	6	8	7	9	4	9	6	8
7	7	4	5	6	9	6	8	5	8	7	9
8	7	5	3	6	8	7	7	3	9	8	8
9	8	4	3	7	9	8	8	3	7	7	7
10	6	5	4	8	8	7	7	4	7	8	8
11	8	4	3	6	7	7	8	5	8	7	9
12	6	5	4	7	8	6	7	4	9	8	7
13	7	3	5	6	7	7	8	3	8	7	7
14	6	4	3	7	8	7	7	4	7	8	8
15	7	4	5	7	9	8	8	5	8	7	9
16	8	5	4	6	7	7	7	3	7	8	8
17	5	4	4	8	8	6	8	4	8	7	7
18	6	3	4	6	7	7	9	5	9	8	8
19	7	4	5	7	9	6	8	3	9	7	7
20	6	5	3	6	8	7	6	4	8	9	8
21	8	4	4	6	7	6	8	5	7	7	7
22	7	3	3	8	8	7	7	4	8	8	6
23	8	4	4	6	9	6	8	3	7	7	7
24	7	5	5	6	8	6	9	4	8	9	8
25	6	4	5	7	7	7	8	5	7	7	9
26	5	5	3	5	8	8	9	4	8	8	8
27	7	4	4	7	7	6	7	5	7	7	7
28	8	3	3	8	8	7	7	4	8	8	8
29	7	4	5	7	7	6	8	4	9	9	9
30	8	5	5	6	8	8	7	5	8	7	8

Friend Friendliness, *Achiev* Achievement, *Order* Orderliness, *Auto* Autonomy, *Domi* Dominance, *Sensit* Sensitiveness, *Exhibit* Exhibition, *End* Endurance, *Need* Neediness, *Help_Tem* Helping temperament, *Le_change* Learn to change

Explanation of Parameters

(a) *Friendliness*: Being friendly with others and try to be networked all the time.
(b) *Achievement*: Doing one's best or difficult tasks and achieving recognition
(c) *Orderliness*: Doing work systematically
(d) *Autonomy*: Lead your life the way you feel like.
(e) *Dominance*: Always ready to assume the leadership
(f) *Sensitiveness*: Understand the other's point of view in analyzing the situation.

(g) *Exhibition*: To showcase one's self by appearance, speech, and manner for attracting others.
(h) *Endurance*: Being focus toward work until it is completed and being able to work without being distracted.
(i) *Neediness*: Always ready to take support of others with grace and remains obliged for that.
(j) *Helping temperament*: Always ready to help the needy and less fortunate.
(k) *Learn to change*: Always ready to change due to change environment.

2. A researcher wants to know the factors that are responsible for people to choose the Rajdhani Express at different routes in India. Twenty respondents who recently traveled from this train were selected for getting their responses. These subjects were given a questionnaire consisting of ten questions mentioned below. They were asked to give their opinion on a seven-point scale where 1 indicates complete agreement and seven complete disagreements. The responses so obtained are shown in the following table.

Apply factor analysis and use varimax rotation to discuss your findings. Explain the factors so extracted in the study.

Questionnaire includes

1. The attendants are caring
2. The bedding provided in the train is neat and clean.

Response data obtained from the passengers on the services provided during journey in the train

S. N.	1. Caring	2. Bedding	3. Courteous	4. Food	5. Spray	6. Toilets	7. Timeliness	8. Seats	9. Clean	10. Snacks
1	2	2	1	2	3	4	2	2	4	1
2	3	1	2	3	2	5	4	2	5	2
3	4	2	4	4	3	6	4	3	6	3
4	1	1	2	3	2	4	3	2	4	2
5	2	2	3	4	2	4	4	3	3	3
6	3	2	2	3	3	3	3	2	3	2
7	4	1	3	6	2	5	5	1	5	5
8	5	1	5	5	3	6	5	2	6	4
9	5	1	2	2	2	5	3	2	5	1
10	3	2	3	2	2	5	3	3	5	2
11	6	1	4	4	2	4	4	2	6	3
12	6	2	6	3	3	6	3	3	6	2
13	2	5	3	4	6	5	4	6	4	3
14	1	2	3	3	3	4	4	3	2	2
15	3	1	2	4	3	5	5	2	3	3
16	4	5	3	4	5	4	5	6	4	3
17	2	2	2	1	3	3	3	3	5	1
18	2	1	3	3	2	3	4	2	6	2
19	1	2	2	3	3	4	3	3	2	2
20	3	1	1	1	4	2	2	2	3	1

3. The *ticket* checkers are very courteous.
4. The quality of food is good.
5. To done away the foul smell fresheners are sprayed.
6. Toilets are always clean.
7. Foods are provided timely during the journey.
8. Seats are very comfortable.
9. Surroundings are clean all the time clean.
10. Vendors keep providing fresh and hot snacks all the time.

Answers of Multiple-Choice Questions

Q.1 b	Q.2 c	Q.3 c	Q.4 b
Q.5 c	Q.6 a	Q.7 d	Q.8 a
Q.9 c	Q.10 d	Q.11 a	Q.12 c
Q.13 b	Q.14 a		