study unit nineteen

multivariate statistical techniques

T he statistical techniques that you have learnt so far will enable you to understand a lot of research reports and articles, but you will also come across many studies involving multivariate statistical techniques (descriptive and inferential). You will only study these techniques at postgraduate level in Industrial Psychology, but we introduce you to them here so that you are not completely ignorant about them.

Definition of multivariate statistics

Multivariate statistics are all statistical techniques that analyse multiple (more than two) measurements of each individual or object simultaneously. These techniques are actually just extensions of the following:

- univariate distributions, such as
  — mean
  — variance and standard deviation
  — *t*-tests (related and independent)
  — one-way ANOVA (one dependent variable)

  and

- bivariate analyses, such as
  — correlation
  — regression (simple regression with one independent variable)

The purpose of multivariate statistical analysis is to measure, explain and predict relations between variates (weighted combinations of variables).

Every type of multivariate statistical technique requires a special measurement scale. Do you still remember the names of the four kinds of measurement scales? (We dealt with them in study unit 4.) Ranked from the simplest to the most complex in terms of their characteristics, the four scales are

- nominal
- ordinal
- interval
- ratio

Note that in multivariate statistics these scales are further classified as follows:

- **Nominal and ordinal** measurement scales are known as **nonmetric** measurement scales.
- **Interval and ratio** measurement scales are known as **metric** measurement scales.

Definition of multivariate statistical techniques

The techniques to which you will be introduced in this study unit are the following:

- multiple regression
- multiple discriminant analysis
- multivariate ANOVA
- canonical correlation
- structural equation modelling
- factor analysis
- cluster analysis
- multidimensional scaling

The definitions of all these techniques are taken from Hair, Anderson, Tatham and Black (1995). We describe each technique briefly.

Multiple regression

This technique, also known as general linear modelling, analyses the relation between a single metric dependent variable (criterion) and various metric or nonmetric independent variables (predictors). The purpose is to predict changes in the dependent variable on the basis of changes in the independent variables.

Multiple discriminant analysis

This technique is used to determine the relationship between a single nonmetric dependent variable and various metric independent variables. The purpose is to predict group membership of an entity (person or object) by means of selected independent variables.

Multivariate ANOVA

This technique is an extension of one-way ANOVA to accommodate more than one dependent variable. It is used to study the relationship between several nonmetric independent variables (usually referred to as treatments) and two or more dependent variables.

Canonical correlation

The purpose of canonical correlation is to correlate several (a set of) metric or nonmetric dependent variables (criteria) with several (a set of) metric or

nonmetric independent variables (predictors) simultaneously. It is used to predict multiple dependent variables on the basis of multiple independent variables, as opposed to multiple regression equations which predict one dependent variable on the basis of multiple independent variables.

Structural equation modelling

This technique — also known as LISREL, the name of a popular statistical analysis package — determines separate relationships for each of a set of dependent correlations. It provides the most efficient estimation technique for a series of separate multiple regression equations estimated simultaneously. Often a dependent variable is used as an independent variable in subsequent dependent correlations. The dependent variable is metric and the independent variables are either metric or nonmetric.

Factor analysis

Factor analysis analyses the correlations between a large number of variables to determine common underlying dimensions (factors). The purpose is to condense data contained in a large number of original variables to a smaller, more manageable number of factors or components. The measurement scale is usually metric, but may be nonmetric provided the latter has been converted to a metric scale.

Cluster analysis

The purpose of cluster analysis is to identify significant subgroups of individuals, respondents or objects so that each cluster contains its own distinctive features that set it apart from other clusters. It entails the following two steps:

- measuring the correspondence between entities to determine how many groups a sample contains
- profile analysis of the persons or variables to identify their structure

The measurement scale is usually metric, but may be nonmetric provided the latter has been converted to a metric scale.

Multidimensional scaling

Multidimensional scaling, also known as perceptual mapping, consists of a series of techniques to identify certain key dimensions underlying respondents' evaluations of objects. It is often used in marketing to analyse consumer ratings of products, services and organisations. The measurement scale may be either metric or nonmetric.

Your learning objective in this study unit is to be able to identify the appropriate multivariate statistical technique to analyse data for the purpose of a specific research project.

Here is a chance to pursue this learning objective in practice.

activity

Identify the appropriate multivariate statistical technique for the purpose of each of 12 projects executed by an industrial psychologist in a fictitious organisation, FICTION. Write the name of the technique in the square below each project.

The **variables** concerned are listed below.

FICTION: CHARACTERISTICS AND MEASURES

- **Gender**

  1 = Male
  2 = Female

- **Department**

  1 = Management
  2 = Personnel
  3 = Production
  4 = Marketing

- **Employee's length of service**

  1 = Short (0 – 12 months)
  2 = Medium (13 – 60 months)
  3 = Long (61 months and longer)

- **Employee age categories**

  1 = 16 – 25 years
  2 = 26 – 35 years
  3 = 36 – 45 years
  4 = 46 – 55 years
  5 = 56 and older

- **Employee academic qualifications**

  1 = Less than matric
  2 = Matric
  3 = Technical certificate
  4 = Diploma
  5 = B-degree
  6 = M-degree
  7 = D-degree

- ***Quality of worklife* questionnaire scores**

   (80 items measured on a five-point scale)

- **Performance scores**

   (Supervisor's ratings)

PERCEPTION OF FICTION BY ITS CLIENT ORGANISATIONS

Measured on a graphic rating scale ranging from *Poor* to *Excellent* on five key attributes:

- **Price**
- **Service**
- **Market image**
- **Productivity**
- **Delivery speed**

CLIENT ORGANISATIONS' CHARACTERISTICS AND MEASURES

- **Leadership style**

   1 = Autocratic

   2 = Democratic

   3 = Laissez-faire

- **Size**

   0 = Small (up to 50 employees)

   1 = Large (more than 50 employees)

- **Satisfaction level with past purchases**

   Measured on a graphic rating scale ranging from *Poor* to *Excellent*.

- **Usage level**

   Percentage of the client firm's total product bought from FICTION.

The **purposes** of the 12 projects are the following:

1 to predict performance rating scores by means of *Quality of worklife* (QWL) questionnaire scores, length of service, age and academic qualifications

2 to determine whether there are significant differences between types of leadership styles and size of client organisations on the one hand, and the satisfaction level with and usage level of FICTION products on the other

3   to analyse the 80-item QWL questionnaire to determine which dimensions underlie the construct *Quality of worklife*

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4   to segment FICTION's clients into groups that share the same perception of the organisation in their ratings of key attributes so as to devise different sales strategies for the various groups

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5   to determine whether there is a relationship between the leadership style of the client organisation as a dependent variable and its perception of FICTION on the five key attributes

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6   to determine the correlation between all measurements of perceptions of FICTION as a set of independent variables and product use and satisfaction as a set of dependent variables

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7   to develop a theoretical model to help FICTION's management understand how clients' perceptions of FICTION affect their purchasing behaviour and attitudes

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8   to study the image and product position of FICTION and preference for its products, as opposed to those of its competitors in the market

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9   to predict the use of FICTION products by client organisations on the basis of these organisations' perceptions of the five key attributes

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10 to determine whether there is a significant difference between the performance of males and females and the department where they are employed for their scores on the QWL questionnaire and a performance rating instrument

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11 to study the five measures of perception to establish whether they can be grouped according to common attributes so as to reduce the number of variables that measure perception

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12   to compare the profiles in terms of QWL dimensions (eg motivation and job satisfaction) for various levels of academic qualifications, so as to determine whether the different groups have distinctive attributes in regard to these dimensions

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Compare your answers with the following:

1 and 9   Multiple regression
2 and 10   Multivariate ANOVA
3 and 11   Factor analysis
4 and 12   Cluster analysis
5   Multiple discriminant analysis
6   Canonical correlation
7   Structural equation model
8   Multidimensional scaling