PD ISO/TR 22914:2020

BSI Standards Publication

Statistical methods for implementation of Six Sigma — Selected illustration of analysis of variance

urrently in preview, click buy full vers

National foreword

This Published Document is the UK implementation of ISO/TR 22914:2020.

The UK participation in its preparation was entrusted to Technical Committee MS/6, Methodologies for business process improvement using statistical methods.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 04533 8

ICS 03.120.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 October 2020.

Amendments/corrigenda issued since publication

Date	Text affected

urrently in preview, click buy full versi

PD ISO/TR 22914:2020

TECHNICAL REPORT

ISO/TR 22914

First edition
2020-10

Statistical methods for implementation of Six Sigma — Selected illustration of analysis of variance

Méthodes statistiques pour la mise en œuvre du Six Sigma - Exemples choisis d'application de l'analyse de la variance

urrently in preview, click buy full versi

Reference number
ISO/TR 22914:2020(E)

© ISO 2020

urrently in preview, click buy full versi

COPYRIGHT PROTECTED DOCUMENT

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

currently in preview, click buy full version

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 7, *Applications of statistical and related techniques for the implementation of Six Sigma*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Currently in preview, click buy full version

 © ISO 2020 – All rights reserved

Introduction

Analysis of variance (ANOVA) is a collection of statistical models used to analyse the differences among group means and their associated procedures (such as "variation" among and between groups), developed by statistician and evolutionary biologist Ronald A. Fisher. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are equal, and therefore generalizes the t-test to more than two groups. ANOVA models are useful for comparing (testing) three or more means (groups or variables) for statistical significance. It is conceptually similar to multiple two-sample t-tests, but is more conservative (it results in less type I error) and is therefore suited to a wide range of practical problems. In Six Sigma, ANOVA is used to find out if there are differences in the performances of different groups, and ultimately to find out if these differences count, or are important enough that a significant change or adjustment should be made. It serves as a guide on which aspect(s) of a process improvements can, or should, be made.

ANOVA is the synthesis of several ideas and it is used for multiple purposes. As a consequence, it is difficult to define concisely or precisely. Classical ANOVA for balanced data does the three following things at once.

1) As exploratory data analysis, an ANOVA is an organization of an additive data decomposition, and its sums of squares indicate the variance of each component of the decomposition (or, equivalently, each set of terms of a linear model).

2) Comparisons of mean squares, along with an F-test allow testing of a nested sequence of models.

3) Closely related to the ANOVA is a linear model fit with coefficient estimates and standard errors.

In short, ANOVA is a statistical tool used in several ways to develop and confirm an explanation for the observed data. Additionally:

1) it is computationally elegant and relatively robust against violations of its assumptions;

2) it provides industrial strength by (multiple sample comparison) statistical analysis;

3) it has been adapted to the analysis of a variety of experimental designs.

As a result, ANOVA has long enjoyed the status of being the most used (some would say abused) statistical technique in psychological research. "ANOVA "is probably the most useful technique in the field of statistical inference. ANOVA is difficult to teach, particularly for complex experiments, with split-plot designs being notorious.

There are three main assumptions:

1) independence of observations — this is an assumption of the model that simplifies the statistical analysis;

2) normality — the distributions of the residuals are normal;

3) equality (or "homogeneity") of variances, called homoscedasticity — the variance of data in groups is expected to be the same.

If the populations from which data to be analysed by a one-way analysis of variance (ANOVA) were sampled violate one or more of the one-way ANOVA test assumptions, the results of the analysis can be incorrect or misleading. For example, if the assumption of independence is violated, then the one-way ANOVA is simply not appropriate, although another test (perhaps a blocked one-way ANOVA) can be appropriate. If the assumption of normality is violated, or outliers are present, then the one-way ANOVA is not necessarily the most powerful test available. A nonparametric test or employing a transformation can result in a more powerful test. A potentially more damaging assumption violation occurs when the population variances are unequal, especially if the sample sizes are not approximately equal (unbalanced). Often, the effect of an assumption violation on the one-way ANOVA result depends on the extent of the violation (such as how unequal the population variances are, or how heavy-tailed one or

currently in preview, click buy full versi

another population distribution is). Some small violations can have little practical effect on the analysis, while other violations can render the one-way ANOVA result uselessly incorrect or uninterpretable. In particular, small or unbalanced sample sizes can increase vulnerability to assumption violation.

urrently in preview, click buy full versi

© ISO 2020 – All rights reserved

Statistical methods for implementation of Six Sigma — Selected illustration of analysis of variance

1 Scope

This document describes the necessary steps of the one-way and two-way analyses of variance (ANOVA) for fixed effect models in balanced design. Unbalanced design, random effects and nested design patterns are not included in this document.

This document provides examples to analyse the differences among group means by splitting the overall observed variance into different parts. Several illustrations from different fields with different emphasis suggest the procedure of the analysis of variance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3534-1:2006, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-3:2013, *Statistics — Vocabulary and symbols — Part 3: Design of experiments*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-1, ISO 3534-3 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
response variable
variable representing the outcome of an experiment

[SOURCE: ISO 3534-3:2013, 3.1.3, modified — the notes have been removed.]

3.2
predictor variable
variable that can contribute to the explanation of the outcome of an experiment.

[SOURCE: ISO 3534-3:2013, 3.1.4, modified — the notes have been removed.]

3.3
model
formalized representation of outcomes of an experiment

[SOURCE: ISO 3534-3:2013, 3.1.2, modified — the notes and examples have been removed.]

urrently in preview, click buy full versi