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Abstract

While deciding on what technique to choose in a given situation, a statistical analyst often has to make a choice between a parametric method and a nonparametric method, especially when it comes to the choice of a hypothesis test. This article addresses this problem and explains the difference between these two paradigms with their strengths and weaknesses.

Parametric or Nonparametric Method: What is the Trade-Off?

- By T. Krishnan

Introduction

Most analysts have often encountered a situation where both parametric and nonparametric methods are applicable and wondered which one to use to analyze the same data in order to answer the same business question.

First let us try and understand the differences between these two methods. In statistical parlance, a "parameter" is a quantity associated with the population distribution of the variable(s) under investigation. For example, if the study variable is the sum assured in the policies of an insurance company, then the mean, median and standard deviation of the sum assured, based on all the policies, are examples of parameters. In a typical statistical inference problem, the values of the parameters are unknown and the purpose of the statistical analysis is to answer questions about them based on a random sample from the population. In parametic inference, certain assumptions are made on the nature of the distribution of the variables(s). For instance, if you want to test the hypothesis that the average sum assured in one insurance company is the same as in another based on random samples of policies from each company, you have the option to carry out a Student's t test or a Mann-Whitney test. The former is a parametric test based on the assumption that the distribution of the sum assured is normal in each of the companies.

The Mann-Whitney test, on the other hand, does not make any assumption on the nature of the distribution of the sum assured. It is a nonparametric test of the null hypothesis that two populations are the same against an alternative hypothesis, especially that a particular population tends to have larger values than the other.

Sometimes even if no distribution form, like normal, can be specified, a parametric method is justifiably applicable if the sample sizes are sufficiently large, the justification arising out of the Central Limit Theorem about the mean. The Student's t test is an example.

What is a Nonparametric Method?

It is rather difficult to define precisely what a nonparametric method is. Rather imprecisely, however, nonparametric statistical procedures may be defined as a class of statistical procedures that do not rely on assumptions about the shape or form of the probability distribution from which the data were drawn.

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Generally, nonparametric procedures do not use observed values of the variables as such, but quantities derived from them like order, rank, permutations, etc. Thus, in a sense, nonparametric procedures use less information than parametric procedures from the same data. For instance, a parametric correlation like Pearson's uses actual observed values of the variables, whereas a nonparametric correlation like Spearman's uses only the ranks of the observations. Thus, it uses less information from data. The Mann-Whitney two-sample test uses only the ranks and not the actual values.

It is not that no assumptions of any kind are required for nonparametric methods to be applicable. In most cases, randomness of samples and independence of observations are required. Some methods require the population distribution to be symmetric (one-sample Wilcoxon test) and some require that the population distributions should have the same shape and equal variances across groups (Kruskal-Wallis test).

Some authors make a distinction between distribution-free methods and nonparametric methods. If, for instance, you compare the means of two populations without assuming any form for the distributions, it is a distribution-free method but it is not a nonparametric method because you are dealing with the mean parameter.

What is the Trade-Off?

So it appears that nonparametric methods are always valid—at least more valid than parametric methods— since they make fewer assumptions about the data, whereas parametric methods are not always valid. Then one might ask: "Why not always use nonparametric methods?" There are at least three reasons for this:

1. When the assumptions are valid, the parametric methods are more powerful from a statistical perspective than the corresponding nonparametric methods. In a hypothesis context, power means the ability to reject the null hypothesis when it does not hold.
2. As a consequence of the above, nonparametric methods generally require larger samples to achieve the same power as the corresponding parametric methods if the assumptions hold.
3. Results of nonparametric methods are more difficult to interpret and use relative to parametric methods. For instance, the difference between the average ranks in two groups is less useful and interpretable than the difference between average scores in two groups.

Some Standard Nonparametric Tests and Procedures

The following table contains names of some of the standard nonparametric procedures including hypothesis tests, what they are used for and their relevant parametric analogs.

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Name of Test/Procedure	Its Use	Parametric Analog
Spearman's rank correlation	measures statistical association	Pearson's Correlation
Kendall's tau	measures statistical association	Pearson's Correlation
One-Sample Wilcoxon Signed Rank Test	tests for mediann	One-Way ANOVA
Mann-Whitney U Test or Wilcoxon Rank Sum Test	tests whether two samples are from same distribution	Two-sample t Test*
Paired-Sample Sign Test	tests whether matched pair samples are drawn from distributions with equal medians	Paired t Test
Paired-Sample Wilcoxon Signed Rank Test	tests whether matched pair samples are from populations with same sizes	Paired t Test
Kruskal-Wallis ANOVA	one-way analysis of variance by ranks: tests whether >2 independent samples are from same distribution	One-Way ANOVA
Friedman ANOVA	two-way analysis of variance by ranks	Two-Way ANOVA
Anderson-Darling Test	tests whether a sample is drawn from a given distribution	Goodness-of-fit chisquare Test
Kolmogorov-Smirnov Test	tests whether a sample is drawn from a given distribution or whether two samples are drawn from the same distribution	Goodness-of-fit chisquare Test
Squared Ranks Test	tests equality of variances in two or more samples	F-ratio Test; Bartlett Test

* This can be considered a "semi-parametric" test because it is held under the assumption that the two samples have the same scale parameter value.

References

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